THE NORTH CAROLINA TOXIC SUBSTANCES MANAGEMENT GUIDE

Developed and Edited
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PREFACE

The North Carolina Toxic Substances Management Guide is designed to provide accurate, useful information about toxic substances produced, used or transported in North Carolina. This, the first installment, is comprised of profiles of 50 substances or families of closely related substances. These profiles have been developed by the toxic substances project team under an EPA Section 28 TSCA grant to the State of North Carolina. The information contained in them is intended to assist state and local government officials, as well as industrial managers, as they address toxic substance concerns: insuring appropriate responses in emergency situations and the facilitation of planning, management and educational functions. Each individual profile of The Guide contains three separate, but related sections. These are:

1. The Executive Summary: Designed to give the reader an overview of a particular toxic substance. It includes a general introduction to the substance, a summary of adverse health effects, routes of human exposure, significant environmental data and a list of recommended reviews.

2. First Aid and Emergency Response Information: A summary of emergency response information, including directions for first aid, procedures for spills and leaks, fire and explosion information, reactivity data and protective measures.

3. The Substance Profile: A detailed review summarizing the particular chemical's properties, its toxic effects in humans, animals and plants (including carcinogenicity, mutagenicity and teratogenicity), its industrial uses and production information, environmental fate, federal/state regulations and concerned agencies, a bibliography, and a glossary.

All information and quantitative data provided in The Guide are abstracted from currently available resources judged to represent the most authoritative of the existing body of knowledge for each substance.

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Executive Summary

CAS Number 00107-02-08

Acrolein is a colorless or yellowish liquid with a disagreeable choking odor. It was first commercially produced in the United States in 1955; current production is by the catalytic vapor-phase oxidation of propylene. The primary interest in acrolein is its toxicity to aquatic organisms. Federal regulations require reporting of acrolein spills if the spill exceeds 1 pound (0.434 kilograms) or 0.14 gallons (0.53 liters). North Carolina requires the reporting of all spills if they occur near water.

Health Effects

ACUTE. Acrolein is highly toxic by all routes of administration. It is a powerful respiratory and eye irritant. Acute exposure to acrolein may cause bronchial inflammation, resulting in bronchitis or pulmonary edema. Serious skin or eye necrosis is produced by a 1% aqueous solution.

The eye irritation threshold for acrolein is approximately 0.2 ppm, and severe mucosal irritation occurs at 0.8 ppm. Exposure to acrolein in air at a level of 1 ppm (2.5 mg/cu m) is intolerable, causing lacrimation and marked eye, nose and throat irritation within a period of 5 minutes. The estimated lethal concentration by the respiratory route is 150 ppm (383 mg/cu m) after 10 minutes exposure.

CARCINOGENICITY. No tumors were detected in hamsters when exposed by inhalation to 4.0 ppm for 7 hours/day, 5 days/week for 52 weeks. However, there have been insufficient animal bioassays to estimate the carcinogenicity of acrolein.

MUTAGENICITY. Acrolein has been shown to be a weak mutagen in yeast, algae and the fruit fly. It is not mutagenic in E. coli with or without activation. It is negative in S. typhimurium and in the mouse dominant lethal test.

TERATOGENICITY AND EMBRYOTOXICITY. An inhalation study in rats at 0.55 ppm detected no embryotoxicity; however, since the fetuses were not examined for malformations, teratogenic potential was not addressed. No evidence of teratogenicity was observed in embryos from acrolein-treated chicken eggs.

CHRONIC. Acrolein, similar to many other aldehydes, causes an increase in blood pressure which usually rapidly returns to normal after exposure ceases.

Inhalation of acrolein at 0.22 - 0.75 ppm has generally resulted in a depressed respiratory rate due to its anesthetic effect.

Routes of Human Exposure

OCCUPATIONAL. Primary occupational exposure is in the production of glycerin, synthetic DL-Methionine, polyurethane resins, and in the welding of fat and oil cauldrons. Industrially, acrolein is expected to cause serious intoxication only rarely because of its irritating effects. NIOSH, in a 1972-74 survey, estimated that 7,300 workers in the United States were potentially exposed to acrolein.

AMBIENT. Exhaust gases from diesel engines (0.5 - 0.8 mg/cu m), cigarette smoke (51 - 230 micrograms/cigarette) and smoke from wood combustion (100 mg/cu m) contribute to general population exposures. Acrolein is highly volatile and reactive. The ambient atmospheric concentration of acrolein in Los Angeles in 1968 ranged from 0 to 10 ppb.

CONSUMER. The Food and Drug Administration permits both the addition of 0.6% acrolein in the modification of food starch and its use as a slimicide in the manufacture of paper and cardboard used in food packaging.

Environmental Significance

The half-life of acrolein in air is estimated to be 2 to 3 hours and less than 1 day in water. It is bioaccumulated in aquatic organisms 344-fold.

Acrolein is the most toxic of all the aldehydes tested for toxicity to aquatic organisms. For fish, the LC50 for 24 hour exposures ranges from 0.046 to 0.24 ppm and the 48-hour LC50 for marine shrimp is 0.1 ppm. Acrolein has been detected in industrial plant effluent, surface waters and drinking water.

North Carolina Production and Users

PRODUCTION: No known producers.

USERS: No information available.

Recommended Reviews

Formaldehyde and Other Aldehydes, Committee on Aldehydes, Board of Toxicology and Environmental Health Hazards, National Research Council, Washington, D.C. 1981

Documentation of the Threshold Limit Values, American Conference of Governmental Industrial Hygienists, Cincinnati, OH, Fourth edition, 1980, Acrolein.

IARC Monograph on the Evaluation of the Carcinogenic Risk of Chemicals to Humans, World Health Organization, Lyon France, Volume 19, 1979, Acrolein.

Occupational Diseases: A Guide to Their Recognition. Marcus M. Key, et al. U.S. Department of Health, Education and Welfare, 1977.

FIRST AID AND EMERGENCY RESPONSE INFORMATION

ACROLEIN

First Aid (NIOSH/OSHA Pocket Guide to Chemical Hazards)

Eyes: Wash with large amounts of water immediately. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH ACROLEIN.

Skin: Flush the contaminated skin promptly with water. Remove clothing if contaminated.

Inhalation: Move to fresh air at once. Perform artificial respiration if necessary. Seek immediate medical attention.

Ingestion: Induce vomiting by finger or by giving syrup of ipecac. Seek medical attention.

Procedures for Spills and Leaks (U.S. DOT Emergency Response Guidebook, 1980)

Isolate hazard area and restrict entry. Stay upwind and keep out of low areas. Wear positive pressure breathing apparatus and special protective clothing. Isolate for ½ mile in all directions if tank or tankcar is involved in fire. Evacuate in downwind direction as required by DOT.

No flares, smoking or flames in hazard areas. Do not touch spilled material. Stop leak, if possible without risk, and use water spray to reduce vapors.

SMALL SPILLS: Flush area with flooding amounts of water. Do not get water inside containers.

LARGE SPILLS: Dike far ahead of spill for later disposal.

Fire and Explosion Information

Will burn. May be ignited by heat, sparks and flames. Flammable vapor may spread away from spill. Container may explode in heat of fire. Vapor explosion and poison hazard indoors, outdoors and in sewers. Runoff to sewer may create fire or explosion hazard.

SMALL FIRES: Dry chemical, carbon dioxide water spray or foam.

LARGE FIRES: Water spray, fog or foam. Stay away from ends of tanks. Do not get inside of container. Cool containers exposed to flames with water from the side until well after fire is out.

FLASH POINT: -15°F

Reactivity

MATERIALS TO AVOID: Oxidizers, acid, alkali, ammonia.

CONDITIONS TO AVOID: Extreme heat.

Protective Measures

STORAGE AND HANDLING: Store large amounts in detached tanks. Small container storage should be in a detached building, protected against fire, with adequate ventilization. Compounds listed in "Materials to Avoid" should be stored separately. Indoor storage should be in a standard flammable storage room or cabinet.

ENGINEERING CONTROLS: Use with adequate ventilation. Showers, sinks and eyewash stations should be available.

PROTECTIVE CLOTHING (Should not be substituted for proper handling and engineering controls): Wear rubber coated overalls, gloves and chemicals goggles.

PROTECTIVE EQUIPMENT: At levels up to 10 ppm, wear a supplied-air respirator with self-contained breathing apparatus. For escape from a contaminated area, wear a gas mask with an organic vapor canister or self-contained breathing apparatus.

ACROLEIN

Profile

CHEMICAL IDENTIFICATION

Alternative Names:

Acraldehyde
Acrylaldehyde
Acrylic aldehyde
Allyl aldehyde
Aqualin
Propenal
Prop-2-en-1-al
2-Propen-1-one
Slimicide

Chemical Abstract Services (CAS) Registry Number: 00107-02-8

Registry of Toxic Effects of Chemical Substances (RTECS) Number: AS 1050000

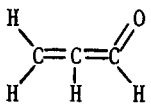
Hazardous Materials Table Identification Number: UN 1092

RCRA Identification Number: P 003

Molecular Weight: 56.07

Molecular Formula: C_3H_4O

Structure:



Classification: A member of the class of compounds called aldehydes. It is the simplest olefinic (unsaturated) aldehyde.

Description: A colorless or yellowish liquid with a disagreeable choking odor.

Uses: As a chemical intermediate, herbicide and as a tear gas.

Chemical/Physical Data

Boiling point: 52.5°C
Melting point: -86.95°C
Vapor pressure: 220 mm at 20°C; 269 mm at 25°C; 330 mm at 30°C
Vapor density: 1.94 (Relative to air = 1.0)
Solubility: in water: 220 g/l

HUMAN TOXICITY

Acrolein causes acute irritation of the eye and mucous membranes at low concentrations.

Effects associated with various exposure levels are listed below.

Effects	Exposure in air	Reference
Moderate irritation	0.25 ppm (0.6 mg/cu m) for 5 minutes	Verschueren, 1977

Effects (Continued)

Effects	Exposure in air	Reference
Intolerable irritation	5 ppm (12.5 mg/cu m) for 1 minute	Verschueren, 1977
Toxic effects on pulmonary system	0.3 ppm (0.76 mg/cu m) (child exposed) for 2 hours	RTECS, 1982
Irritation: physiological response detectable	1 ppm (2.5 mg/cu m)	ACGIH, 1980
Intense irritation	5.5 ppm (13.75 mg/cu m)	ACGIH, 1980
Lethal	153 ppm (383 mg/cu m) for 10 minutes	RTECS, 1982
Skin burns, dermatitis	Chronic exposure	Sittig, 1980

The maximum level at which one could escape within 30 minutes without any escape-impairing symptoms or irreversible effects is suggested to be 5 ppm (NIOSH/OSHA, 1978).

Carcinogenicity

U.S. EPA, CAG, 1980: Animal bioassay data for the carcinogenicity of acrolein are not adequate for making an assessment.

IARC, 1979: No carcinogenic effect was detected in hamsters exposed by inhalation to 4.0 ppm for 52 weeks. The absence of human data and the inadequacy of reported animal studies preclude evaluation of carcinogenicity of acrolein.

Mutagenicity

U.S. EPA, CAG, 1980: Evidence for mutagenicity exists, but acrolein has not been adequately tested. Acrolein has been reported to be a weak mutagen--active in bacteria, yeast, higher plants, and insects. Inhibition of cell division and of DNA, RNA, and protein synthesis have also been reported for bacteria, plants, and animals.

U.S. EPA, CHIP, 1978: It is mutagenic in yeast, algae, and fruitflies. Negative results were found in the bacteria E. coli, and in the mouse dominant lethal test.

NTP, 1980: Mutagenesis Salmonella typhimurium test result: Weakly positive.

Teratogenicity and Embryotoxity

No data were found to indicate that acrolein causes birth defects.

ANIMAL TOXICITY

Toxic effects of acrolein can be observed at relatively low concentrations. Oral-rat LD50 values fall in the range of moderately high toxicity (between 10 mg/kg and 100 mg/kg).

Acute Toxicity

Inhalation of 10 ppm for 3.5 hours caused respiratory irritation, salivation, lacrimation, and mild narcosis in cats (ACGIH, 1980). Results of lethal studies in several species as reported in the RTECS (1982) are listed below:

Route	Species	Lethal Dose or Lethal Concentration
Oral	Rat	46 mg/kg, LD50
	Mouse	40 mg/kg, LD50
	Rabbit	7 mg/kg, LD50
Inhalation	Rat	8 ppm (20 mg/cu m) for 4 hours, lowest LC
	Rabbit	10.5 ppm (24 mg/cu m) for 6 hours, lowest LC
	Guinea pig	10.5 ppm (24 mg/cu m) for 6 hours, lowest LC
	Mouse	66 ppm (165 mg/cu m) for 6 hours, LC50
	Cat	686 ppm (1570 mg/cu m) for 8 hours, lowest LC
Dermal	Rabbit	562 mg/kg, LD50

Chronic Toxicity

Inhalation by monkeys, dogs, and guinea pigs at 0.22 ppm for 90 days caused inflammation of the liver, lungs, kidney, and heart. Rats continuously exposed to acrolein at 0.55 ppm for 11-21 days showed significantly lower body weight, liver weight, and serum acid phosphatase levels than controls. Respiratory irritation, decreased macrophage number and susceptibility to infection were also observed. Squamous cell metaplasia and basal cell hyperplasia of the trachea were observed in monkeys after inhalation of 1.8 ppm (U.S. EPA, CHIP, 1980).

AQUATIC AND TERRESTRIAL TOXICITY

Aquatic Toxicity

Aquatic toxicity rating: TLm 96 is below 1 ppm (RTECS, 1982).

A summary of the U.S. EPA water quality criteria for protection of aquatic life is given below.

Acute toxicity to saltwater aquatic life occurs at concentrations as low as 55 µg/l. Sensitive species encounter toxicity at lower concentrations. Acute toxicity to freshwater aquatic life occurs at concentrations as low as 67 µg/l; chronic toxicity occurs at 21 µg/l (U.S. EPA, WQC, 1980).

Inhibition of cell division is reported in bacteria (Pseudomonas putida) at 210 µg/l and in algae (Microcysts aeroginos) at 0.04 µg/l. The 24-hour LC50 for goldfish is below 0.08 mg/l (Verschueren, 1977).

Bioaccumulation reported for bluegill is 344-fold (U.S.EPA, WQC, 1980).

Biodegradation in aquatic species is described as rapid (U.S. EPA, CHIP, 1980).

Phytotoxicity

Alfalfa sustained oxidant type damage when exposed to 0.1 ppm (0.25 mg/cu m) for 9 hours (Stahl, 1969).

Environmental Data

Air

Acrolein is formed as a product of combustion and has been measured in wood smoke and gasoline engine exhaust (Iarc, 1979). Acrolein is a component of urban smog with concentrations as high as 0.01 ppm (0.032 mg/cu m) measured in Log Angeles (U.S. EPA, WQC, 1980).

Acrolein is chemically reactive in the air, and degrades by oxidation and possibly photolysis. Its estimated atmospheric residence time is 0.2 days (Cupitt, 1980). Based on elevated concentrations in urban smog samples, moderate accumulation and dispersion in this medium can be inferred.

Water

No data on ambient acrolein levels were found. Acrolein is not expected to persist in water due to its short halflife (estimated at less than 1 day, Callahan, 1979). In water, acrolein degrades by hydration (reversible) to P-hydroxypropionaldehyde. Low concentrations are stable, however, and can be dispersed.

Soil

A low partition coefficient (-0.090, Callahan, 1979) and high solubility (320 g/l of water) suggest that acrolein will not accumulate significantly in this medium. Acrolein degrades in sludge, air and water, and adsorption in soil is probably poor (Callahan, 1979).

Biota

Acrolein occurs naturally in biota in small concentrations, and bioaccumulates in aquatic species. The half-life of acrolein in bluegill is estimated at 7 days (U.S. EPA, WQC, 1980). There is some evidence for degradation in this medium, and acrolein is not expected to biomagnify.

Acrolein is a common component of food in μg/g concentrations. It has been detected in potatoes, turkey, alcoholic beverages, wine and coffee roasting emissions (U.S. EPA, WQC, 1980).

INDUSTRIAL DATA

Production

No production in North Carolina reported in the Toxic Substances Control Act, (TSCA) Chemical Substances Inventory (U.S. EPA, TSCA Inventory, 1980).

Acrolein is produced only by Shell Chemical Company, Norco, Louisiana and Union Carbide Corporation, Chemicals and Plastics Division, Taft, Louisiana. Total production is estimated at 61 million pounds. An additional 100-150 million pounds was produced and consumed captively for production of acrylic acid and esters (U.S. EPA, CHIP, 1980).

Consumption and Use

Estimated U.S. Consumption in 1974:

Production of glycerin	50	percent
Production of synthetic methionine	25	percent
Other uses	25	percent

(U.S. EPA, CHIP, 1980)

Reported uses of acrolein and the corresponding SIC codes are listed below:

	SIC	Reference
Manufacture of glycerin	2869	U.S. EPA, CHIP, 1980
Manufacture of synthetic methionine	2831, 025	
1980 Manufacture of 1,2,6-hexanetriol	2869	
Manufacture of gluteraldehyde	2869	
Manufacture of colloidal metals	33	
Manufacture of herbicides	2879	
Manufacture of molluscicide	2879	
Manufacture of slimicide	2879	
Manufacture of algicide	2879	
Etherification of food starch	2099	
Manufacture of 2-hydroxyadipaldehyde	2869	IARC, 1979
Manufacture of quinoline	2869	
Manufacture of pentaerythitol	2869	

SIC Codes (Continued)

	SIC	Reference
Manufacture of cycloaliphatic epoxy resins	2869	
Manufacture of oil well additives	2869	
Manufacture of water-treatment chemicals	2869	
Manufacture of plastics	2821	Merck, 1976
Manufacture of perfumes	2844	
Warning agent in methyl chloride refrigerant.	-	
Poison gas mixtures for military use	-	

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air

Under evaluation for possible designation as a Hazardous Air Pollutant by the U.S. Environmental Protection Agency.

Workroom Air

The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 0.1 ppm (0.25 mg/cu m) as a time-weighted average.

The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygenists (ACGIH) for workroom air is 0.1 ppm (0.25 mg/cu m) as a time-weighted average. The recommended Short Term Exposure Limit (STEL) is 0.3 ppm (0.8 mg/cu m).

Water

Addressed by Ambient Water Quality Criteria set by the U.S. Environmental Protection Agency.

Designated a toxic pollutant by the U.S. Environmental Protection Agency. Code of Federal Regulations, Title 40, Part 401.

Designated a hazardous substance by the U.S. Environmental Protection Agency. Spills in escess of one pound must be reported.

Other

Regulated as a hazardous material by the U.S. Department of Transportation. Acrolein is classified as a Flammable Liquid, and shipments must carry a label which reads "Flammable Liquid and Poison."

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Agencies Concerned with this Chemical

Chemical Hazard Information Profile (CHIP) compiled by the Office of Testing and Evaluation, U.S. Environmental Protection Agency.

Subject of a monograph prepared by the International Agency for Research on Cancer (IARC).

Under toxicological evaluation through the National Toxicology Program to determine mutagenicity. Tested in the Fiscal Year 1980 using Salmonella mutagenicity assay. (National Toxicology Program, Fiscal Year 1980 Annual Plan (NTP-79-7, 1979).

Under toxicological evaluation through the National Toxicology Program to determine teratogenicity. Reproduction and fertility assays are reported to be in progress in Fiscal Year 1980. (National Toxicology Program, Fiscal Year 1980 Annual Plan (NTP-80-62, 1980).

REFERENCES

American Conference of Governmental Industrial Hygenists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Callahan, M.A., et al. Water-Related Fate of 129 Priority Pollutants. U.S. EPA Office of Water Planning and Standards, Washington, DC, EPA 440/4-79-029 (December, 1979).

Cupitt, L.T. Fate of Toxic and Hazardous Materials in the Air Environment. EPA-600/3-80-084, NTIS PB 80-221948 (September 1980).

International Agency for Research on Cancer (IARC). IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon, France, Volume 19. A World Health Organization Publication (WHO), Geneva (1979).

Merck Index: An Encyclopedia of Chemicals and Drugs, Ninth Edition, M. Windholz, Ed. Merck and Co., Rahway, NJ (1976).

National Institute for Occupational Safety and Health/Occupational Safety and Health Administration (NIOSH/OSHA). NIOSH/OSHA Pocket Guide to Chemical Hazards. DHEW (NIOSH) Publication No. 78-210 (September 1978).

National Toxicology Program, NTP Technical Bulletin, Department of Health and Human Services, Vol. 1, Issue 3 (December 1980).

Registry of Toxic Effects of Chemical Substances, Quarterly Microfiche Issue, R. J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville, MD, for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication (1982).

Sittig, M., Ed. Priority Toxic Pollutants. Noyes Data Corporation, Park Ridge, NJ (1980).

Stahl, Q. R. Preliminary Air Pollution Survey of Aldehydes. Prepared by Litton Systems, Inc., under Contract No. PH 22-68-25 for National Air Pollution Control Administration. Available from Clearinghouse for Federal Scientific and Technical Information, Springfield, VA APTD 69-24 (1969).

U.S. Environmental Protection Agency, Carcinogen Assessment Group (CAG). Carcinogen Assessment Group's Preliminary Risk Assessment on Acrolein. Washington, DC (February 11, 1980).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Chemical Hazard Information Profiles (CHIPs). EPA-560/11-80-011 (1980).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act, (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA PB-80-155-153 (1980).

U.S. Environmental Protection, Agency, Office of Water Planning and Standards. Ambient Water Quality Criteria for acrolein. EPA/440-5-80-016 (October, 1980).

Verschueren, Karel. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York, NY (1977).

ACRYLONITRILE

Executive Summary

CAS Number: 00107131

Acrylonitrile is an explosive, flammable liquid with an onion- or garlic-like odor. Approximately 1.5 billion pounds per year of acrylonitrile are manufactured in the United States by the reaction of propylene with ammonia and oxygen in the presence of a catalyst. Acrylonitrile is used in the manufacture of fibers, plastics, surface coatings and adhesives, as a pesticide and as a chemical intermediate. The toxic effects of acrylonitrile are similar to cyanide poisoning. Federal regulations require the reporting of all spills over 100 pounds (45.5 kg). North Carolina requires the reporting of all spills if they occur near water.

Health Effects

ACUTE. Acrylonitrile is highly toxic to humans when inhaled or absorbed through the skin. The TDLo (human) by inhalation is 16 ppm for 20 minutes. The probable lethal dose by ingestion is between 1 tsp. and 1 oz. for a 70 kg (150 lb) person. Symptoms of acute poisoning include headache, general irritability, liver and kidney irritation, vomiting and diarrhea. Acrylonitrile causes congestion in all organs of mice, rats and guinea pigs, as well as damage to the central nervous system, kidneys and liver. The LD50 for rats (oral administration) is 93 mg/kg.

CARCINOGENICITY. Both epidemiological and experimental data strongly suggest that acrylonitrile is a human carcinogen.

MUTAGENICITY. Acrylonitrile has been found to be mutagenic in a variety of bacterial strains, including Salmonella typhimurium.

TERATOGENICITY AND EMBRYOTOXICITY. Doses of 65 mg/kg (by gavage) to Sprague-Dawley rats on days 6-15 of gestation produced increased fetal malformations and embryotoxicity.

CHRONIC. Workers chronically exposed to acrylonitrile experienced changes in the heart, circulation and blood methemoglobin. Exposure to 520 ppm over long periods of time produced weakness, anemia, blood abnormalities and mild liver damage.

Occupational Health Regulations

ACGIH: Threshold Limit Value of 2 ppm (4.5 mg/cu m) as a time-weighted average. Recognized as a carcinogen.

NIOSH: Standard of 4 ppm (9 mg/cu m) as a time-weighted average and a ceiling limit of 10 ppm for 15 minutes.

OSHA: Standard for workroom air is 2 ppm (4.5 mg/cu m) as a time-weighted average. Recommended that acrylonitrile be handled as a potential human carcinogen.

Routes of Human Exposure

OCCUPATIONAL. Total emissions of acrylonitrile to the U.S. workplace in 1974 were estimated to be 14.1 million kg., with approximately 125,000 persons being exposed annually. Concentrations of acrylonitrile in workroom air range from 3-20 mg/cu m. Occupational exposure occurs in the production of plastics, fabrics, biological products, water treatment and pesticide/fumigant manufacture.

AMBIENT. It is estimated that 2.6 million persons are annually exposed to concentrations of 0.05-15 µg/cu m of acrylonitrile. These exposures are largely due to accidents such as spills during transport, fires or ingestion of contaminated food and water, or through the respiration of contaminated air from acrylonitrile or polyacrylonitrile plants.

CONSUMER. Consumer exposure occurs primarily through the use of products containing acrylonitrile such as dentures, clothing or food wrapping, and exposure to acrylonitrile vapors from polyacrylonitrile furniture and cigarettes.

Environmental Significance

Acrylonitrile is not known to occur naturally. It has an estimated atmospheric halflife of approximately 4 hours. There is little evidence of bioaccumulation and the aquatic toxicity rating (TLm 96) is 10-100 ppm.

Acute toxicity to freshwater aquatic life occurs at concentrations as low as 7.5 m µg/l. Acrylonitrile is not expected to be persistent in either ambient water or air.

Recommended Reviews

Hashimoto, K. and Kanai, R. Studies on the toxicology of acrylonitrile. Metabolism, mode of action and therapy. Ind. Health, 3:30-46, 1965.

Knobloch, K. et al. Experimental studies upon acute and subacute toxicity of acrylonitrile (Pol.). Med. Pracy, 22:257-269, 1971.

FIRST AID AND EMERGENCY RESPONSE INFORMATION

ACRYLONITRILE

First Aid

Eyes: Wash immediately with large amounts of water for at least 15 minutes, occasionally lifting upper and lower lids. Seek immediate medical attention. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH ACRYLONITRILE.

Skin: Remove chemically contaminated clothing. Wash affected area immediately with water for at least 15 minutes. Seek medical attention as required.

Inhalation: Get victim to fresh air. Give artificial respiration as required. Seek medical attention.

Ingestion: Give victim large amounts of water to drink, if conscious, then induce vomiting by having victim touch the back of his throat with his finger. Seek immediate medical attention.

Note to Physician: Treatment similar to cyanide poisoning and based on cyanomethemoglobin formation. Amyl nitrate (inh.), sodium nitrite (i.v.), sodium thiosulfate (i.v.) and oxygen may be required.

Procedures for Spills and Leaks (U.S. DOT Emergency Response Guidebook, 1980)

Isolate hazard area and restrict entry. Stay upwind and keep out of low areas. Wear positive pressure breathing apparatus and special protective clothing. Isolate for ½ mile in all directions if tank or tankcar is involved in fire. Evacuate in downwind direction as required by DOT. No flares, smoking or flames in hazard area. Do not touch spilled material. Stop leak if it can be done without risk. Use water spray to reduce vapors.

SMALL SPILLS: Flush area with flooding amounts of water. Do not get water inside containers.

LARGE SPILLS: Dike far ahead of spill for later disposal.

Fire and Explosion Information

GENERAL: Flammable, vapors may form explosive mixtures with air. Will ignite at 32°F (0°C).

EXPLOSIVE LIMITS: Upper - 17%, lower - 3%.

EXTINGUISHER: Carbon dioxide, dry chemical or foam.

Reactivity

MATERIALS TO AVOID: Reacts violently with strong acids, strong alkalies, strong oxidizers, especially bromine, and tetrahydrocarbazole. Copper, copper alloys, ammonia and amines may cause breakdown to poisonous products.

CONDITIONS TO AVOID: Oxygen, strong light and concentrated alkalies may cause violent spontaneous polymerization. Heat and flame may cause release of poisonous cyanide gas.

Protective Measures

STORAGE AND HANDLING: Store in a cool place away from materials listed above, and away from heat or sources of ignition.

ENGINEERING CONTROLS: Provide effective ventilation. Sinks, quick drench showers and eyewash stations should be available.

PROTECTIVE CLOTHING (Should not be substituted for proper handling and engineering controls): If direct contact is likely wear gloves, faceshields and protective coveralls. CONTACT LENSES SHOULD NOT BE WORN. Leather absorbs this chemical. Shoe protectors should be used and shoes discarded if they become soaked. Soiled clothing should be laundered at least once a week by trained personnel.

PROTECTIVE EQUIPMENT: At detectable levels use either a self-contained breathing apparatus with full facepiece in pressure-demand, positive pressure or continuous flow mode, a chemical cartridge respirator with an organic vapor cartridge, or a supplied-air respirator with a full facepiece and auxiliary self-contained breathing apparatus in pressure-demand, positive pressure or continous flow mode.

Profile

CHEMICAL IDENTIFICATION

Alternative Names:

Acrylon	Propenenitrile
Acrylonitrile monomer	2-Propenenitrile
Carbacryl	TL 314
Cyanoethylene	VCN ENT 54
Ventox Fumigrain	Vinyl Cyanide
Miller's Fumigrain	

Chemical Abstract Services (CAS) Registry Number: 00107-13-1

Registry of Toxic Effects of Chemical Substances (RTECS) Number: AT 5250000

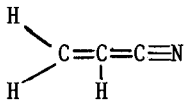
Hazardous Materials Table Identification Number: None

RCRA Identification Number: U003

Molecular Weight: 53.07

Molecular Formula: C_3H_3N

Structure:



Classification: vinyl cyanide

Description: Colorless, explosive flammable liquid with onion- or garlic-like odor.

Uses: In the manufacture of synthetic fibers, plastics, surface coatings and adhesives; as a pesticide and chemical intermediate

Chemical/Physical Data

Boiling point: 77.3°C at 760 mm Hg
Melting point: 82°C
Vapor pressure: 115 mm Hg at 26°C
Vapor density: 1.9 (Air = 1.0)
Solubility in water: 7.2 g/dL. at 0°C; 7.36 g/dl at 20°C; 7.9 g/dl at 40°C; 9.1 g/dl at 60°C (Verschueren, 1977)

HUMAN TOXICITY

Acrylonitrile is highly toxic to humans, especially when the route of administration is inhalation or absorption through the skin. Symptoms of acute poisoning include:

INHALATION: 16-100 ppm for 20-45 minutes causes headache, general irritability, liver and kidney irritation. Higher levels of exposure lead to vomiting, diarrhea, and liver changes.

SKIN CONTACT: Direct contact may cause blisters, redness and irritation. Absorption is significant and may lead to symptoms similar to those resulting from inhalation.

INGESTION: Ingestion of acrylonitrile results in irritation and chemical burns of the mouth, throat and stomach.

EYES: Can cause severe irritation and burns.

The TDLo (human) by inhalation is 16 ppm for 20 minutes. The probable lethal dose by ingestion is between 1 tsp. and 1 oz. for a 70 kg (150 lb.) person (TDB, 1982).

Workers chronically exposed to acrylonitrile experienced changes in the heart, circulation, and blood methemoglobin. Exposure to 520 ppm over long periods of time has produced weakness, anemia, blood abnormalities, and mild liver damage.

The maximum level at which one could escape within 30 minutes without any escape-impairing symptoms or irreversible effects is suggested to be 4,000 ppm (NIOSH, 1978).

Carcinogenicity

U.S. EPA, CAG, 1980: Epidemiological evidence, two positive drinking water animal bioassays, suggestive evidence in two inhalation animal bioassays, positive mutagenicity findings in Salmonella, the metabolic evidence of a probable directly carcinogenic metabolite of acrylonitrile, and the structural similarity to vinyl chloride all constitute substantial evidence that acrylonitrile is a human carcinogen.

IARC, 1979: Acrylonitrile is a suspected human carcinogen.

Mutagenicity

U.S. EPA, CAG, 1980: Acrylonitrile exhibited a positive mutagenic effect in bacterial systems tested.

NTP, 1980: Salmonella typhimurium mutagenesis test result: positive.

Teratogenicity and Embryotoxicity

Doses of 65 mg/kg (by gavage) to Sprague-Dawley rats on days 6-15 of gestation produced increased fetal malformations and embryotoxicity.

ANIMAL TOXICITY

Acrylonitrile causes congestion in all organs of mice, rats, and guinea pigs, as well as damage to the central nervous system, kidneys, and liver. Applied to the skin of rats at doses of 14 or 28 mg/kg for 2 months, acrylonitrile caused hemorrhaging and congestive plethora. Upon inhalation by rabbits at concentrations of 250 mg/cu m (114 ppm) for 6 months, functional disorders in the respiratory, cardiovascular, and renal systems were observed.

Acute Toxicity

Results of lethal studies in several species as reported in the TDB (1980) are listed below:

Route	Species	Lethal Dose or Lethal Concentration
Oral	Rat	93 mg/kg, LD50
	Rabbit	93 mg/kg, LD50
Inhalation	Rat	500 ppm for 4 hours, lowest LC
	Mice	784 ppm for 1 hour, LC100
	Dog	120 mg/kg, for 4 hours, lowest LC
	Cat	600 ppm for 4 hours, lowest LC
Dermal	Rabbit	280 mg/kg, LD50
	Guinea pig	250 mg/kg, LD50

Chronic Toxicity

Inhalation exposure of rats to 56 ppm for 4 hours, 5 days a week for 8 weeks resulted in irritation of the respiratory mucous membranes with hyperemia, lung edema, alveolar thickening and CNS disorders. Rats and rabbits breathing 50 mg/cu m for 6 months showed functional disorders in respiratory and cardiovascular systems.

Weight loss, liver and kidney damage have also been observed as a result of chronic exposure (U.S. EPA, WQC, 1980).

AQUATIC AND TERRESTRIAL TOXICITY

Aquatic Toxicity

The available data for acrylonitrile indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 7.5 mg/l. No definitive data are available concerning the chronic toxicity of acrylonitrile to sensitive freshwater aquatic life but mortality occurs at concentrations as low as 2.6 mg/l with a fish species exposed for 30 days (EPA, WQC, 1980).

Only one saltwater species has been tested with acrylonitrile, and no statement can be made concerning acute or chronic toxicity.

Aquatic toxicity rating: TLm 96 is 10-100 ppm. (RTECS, 1982).

Bioaccumulation: Little evidence of bioaccumulation on repeated exposure. Bluegills exposed for 28 days bio-concentrated acrylonitrile 48-fold.

Biodegradation in aquatic species: The half-life in bluegill tissue is 47 days.

ENVIRONMENTAL DATA

Air

There were no data found regarding the presence of acrylonitrile in ambient air. It is expected that this substance would photo-degrade to saturated derivatives upon entering the atmosphere. The total emissions of acrylonitrile to the U.S. workplace environment in 1974 were estimated to be 14.1 million kg (IARC, 1979). It has also been estimated that 125,000 persons are potentially exposed to acrylonitrile in U.S. workplaces (NIOSH, 1978). Concentrations of acrylonitrile in workroom air range from 3-20 mg/cu m (acrylic fiber plant). It has also been detected in acrylonitrile plants.

Water

Acrylonitrile has been detected at a concentration of 0.1 g/l in effluent discharged from a U.S. acrylic fiber manufacturing plant and in effluent discharged from chemical and latex manufacturing plants in Louisville, Kentucky (IARC, 1979). Acrylonitrile is not expected to be persistent in this medium.

Soil

Under hypohydrous conditions, acrylonitrile is strongly sorbed by clays. In aquatic systems, however, it is unlikely that sorption will function as a storage or transport mechanism for this substance (Callahan, 1979).

Biota

This substance is degraded by sewage sludge (Callahan, 1979).

Other

Acrylonitrile is not known to occur as a natural product. It has been detected in shelled walnuts, cigarette smoke, acrylic dentures, acrylic underwear, diapers and sanitary napkins (U.S. EPA, WQC, 1980). It is estimated that 2.6 million persons are annually exposed to concentrations of 0.05-15 µg/cu m of acrylonitrile (EPA, WQC, 1980). A summary of occupational and nonoccupational exposure sources are presented in the tables below (U.S. EPA, WQC, 1980).

EXPOSURE TO ACRYLONITRILE

Occupational	Non-occupational
1. Plastics	1. Accidental
Acrylonitrile Manufacturers	Exposure to liquid from transportation spill
Polymer Manufacturers	Combustion and fire (fireman and domestic personnel)
Polymer Molders	
Polymer Combustion Workers	Ingestion of contaminated water or food
Furniture Makers	Respirations of contaminated air (environmental exposure to acrylonitrile or polyacrylonitrile plants)
2. Fabrics	2. Nonaccidental
Fiber manufacturers	Cigarette smokers
Clothing Manufacturers	
3. Dental Polymer Manufacturers	Wearers of acrylic dentures
Contact Lens Fabricators	Wearers of acrylic underwear, diapers, and sanitary napkins.
Blood Filter Fabricators	Ingestion of food wrapped in polyacrylonitrile wrapping
4. Water Treatment and Manufacturers	
5. Pesticide and Fumigant Manufacturers, Sprayers, Farmers	Exposure to acrylonitrile vapors from polyacrylonitrile furniture

INDUSTRIAL DATA

Production

No production in North Carolina was reported in the Toxic Substance Control Act (TSCA) Chemical Substance Inventory (U.S. EPA, TSCA, 1980).

Estimated U.S. production for 1975 was 552 million kg (608,000 tons) with imports of 6.1 million kg (6,700 tons) and exports of 105.9 million kg (117,000 tons) (IARC, 1979).

Consumption and Use

Estimated U.S. Consumption:	
Manufacture of acrylic and modacrylic fibers	48 percent
Acrylonitrilebutadienestyrene and styrene acrylonitrile resins	21 percent
Adiponitrile	12 percent
Other	19 percent

(IARC, 1979)

Reported uses of acrylonitrile and the corresponding SIC codes are listed below:

Manufacture of copolymers for the production of acrylic and modacrylic fibers	282
Manufacture of apparel	23
Manufacture of carpeting	27
Manufacture of draperies and blankets	239
Manufacture of upholstery	25

(Sittig, 1980)

Copolymers with styrene and butadiene	282
Nitrile rubber	2822, 30
Synthetic soil blocks	-
Cyanoethylation of cotton	221
Bottles for soft drinks	3221
Grain fumigant	2879

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air

Under evaluation for possible designation as a Hazardous Air Pollutant by the U.S. Environmental Protection Agency.

Workroom Air

ACGIH — The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air is 2 ppm (4.5 mg/cu m) as a time-weighted average, with a 15 minutes ceiling limit of 10 ppm. Classified as a carcinogen

NIOSH — The National Institute of Occupational Safety and Health (NIOSH) recommends a standard of less than 4 ppm as a time-weighted average and a ceiling limit of 10 ppm for 15 minutes.

OSHA — The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 2 ppm as a time-weighted average. Handle as a potential human carcinogen.

Water

Addressed by Ambient Water Quality Criteria set by the U.S. Environmental Protection Agency.

Designated a toxic pollutant by the U.S. Environmental Protection Agency.

Designated a hazardous substance by the U.S. Environmental Protection Agency.

Other

Regulated as a hazardous material by the U.S. Department of Transportation. Acrylonitrile is classified as a flammable liquid and shipments must carry a label which reads "Flammable Liquid and Poison."

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Addressed by the Rebuttable Presumption Against Registration (RPAR) through the U.S. Environmental Protection Agency.

Agencies Concerned with this Chemical

Subject of a Risk Assessment Document prepared by the Carcinogen Assessment Group (CAG) of the U.S. Environmental Protection Agency.

Subject of a monograph prepared by the International Agency for Research on Cancer (IARC).

Addressed by a development plan prepared by the Interagency Regulatory Liaison Group (IRLG).

REFERENCES

American Conference of Governmental Industrial Hygenists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Callahan, M. A., et al. Water-Related Fate of 129 Priority Pollutants. U.S. EPA Office of Water Planning and Standards, Washington, DC, EPA 440/479029 (December 1979).

Cupitt, L. T. Fate of Toxic and Hazardous Materials in the Air Environment. EPA 600/380084, NTIS PB 80221948 (September 1980).

International Agency for Research on Cancer (IARC). IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon France, Volume 19. A World Health Orgnization Publication (WHO), Geneva (1979).

National Institute for Occupational Safety and Health/Occupational Safety and Health Administration (NIOSH/OSHA). NIOSH/OSHA Pocket Guide to Chemical Hazards. DHEW (NIOSH) Publication No. 78210 (September 1978).

National Institute for Occupational Safety and Health. National Occupational Hazard Survey. Available from Division of Technical Services. Cincinnati, OH, DHEW 74127, 77123, and 78114 (1980).

National Toxicology Program. Classification of 102 NTP Compounds for FY 81 by the Chemical Nomination and Selection Committee. U.S. Department of Health, Education, and Welfare, Jefferson, Arkansas (March 1980).

National Toxicology Program. Executive Summaries of Nine Compounds Nominated for FY 81 Testing. U.S. Department of Health, Education, and Welfare, Jefferson, AR (January, 1980).

Registry of Toxic Effects of Chemical Substances. Quarterly Microfiche Issue, R. J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication (1982).

Sittig. M., Ed. Priority Toxic Pollutants. Noyes Data Corporation, Park Ridge NJ (1980).

Toxicology Data Bank - The National Library of Medicine, Bethesda, Maryland (1982).

U.S. Environmental Protection Agency, Carcinogen Assessment Group (CAG). Carcinogen Assessment Group's Preliminary Risk Assessment on Acrylonitrile. Washington, DC (February 11, 1980).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory Available from the National Technical Information Service, Springfield, VA PB80155153 (1980).

U.S. Environmental Protection Agency, Office of Water Planning and Standards. Ambient Water Quality Criteria for Acrylonitrile. EPA 440/580-017 (October 1980).

Verschueren, Karel. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York, NY (1977).

ANILINE

Executive Summary

CAS NUMBER 00062-53-3

Aniline is a colorless oily liquid which darkens on exposure to air and light. U.S. production in 1978 was estimated at 500 million pounds. Aniline is used primarily as an intermediate in the production of isocyanates (40%), rubber chemicals (35%) and dyes (6%). Federal regulations require the reporting of spills which exceed 1,000 pounds (454 kilograms) or 118 gallons (447 liters). North Carolina requires the reporting of all spills if they occur near water.

Health Effects

ACUTE. Methemoglobinemia* is the most important result of aniline poisoning in man. Acute intoxication, cyanosis and death from asphyxiation may occur. Inhalation of 7-53 ppm causes only slight symptoms of methemoglobinemia but 100-160 ppm for over 1 hour can cause serious difficulty.

Single administration of oral doses of 5 or 15 mg of aniline per person to 20 adult humans had no apparent effect. Routes of exposure include inhalation, injection, and absorption through the skin.

CARCINOGENICITY. Epidemiological evidence suggests that aniline is not a human carcinogen. However, ingested aniline may be concentrated to aniline hydrochloride which has been shown to be carcinogenic in rats.

MUTAGENICITY. Aniline was negative in the Salmonella typhimurium test.

TERATOGENICITY & EMBRYOTOXICITY. There is no evidence that aniline causes birth defects or is embryotoxic.

CHRONIC. Chronic poisoning was reported to involve central nervous system symptoms and to cause liver cirrhosis and atrophy. No effects were found, other than a slight increase in methemoglobin, in several species of rats exposed to 5 ppm of aniline vapor daily for six months.

Occupational Health

The American Conference of Governmental Hygenists has established a Threshold Limit Value in air (time-weighted average concentration under which it is believed that all workers may be repeatedly exposed day after day without adverse effect) of 2 ppm (10 mg/cu m). The Short Term Exposure Limit (maximum concentration to which workers may be exposed for a period up to 15 minutes) is 5 ppm (20 mg/cu m).

*Methemoglobinemia, the presence of methemoglobin (a blood pigment) in the blood, which is unable to reversibly bind oxygen, resulting in the lack of oxygen transport.

Routes of Human Exposure

OCCUPATIONAL. Workers in industries producing isocyanates, dyes, herbicides, fungicides, rubber products and textiles are at risk of exposure to aniline.

AMBIENT. Aniline was detected in the atmosphere 2.5 miles from a chemical plant. It has been detected in river water in the U.S. (upper Catawba River in North Carolina) and in several European rivers (0.5 - 3.7 mg/l).

CONSUMER. Aniline has been reported in certain vegetables such as carrots, cauliflower, red radish, cabbage and rhubarb in concentrations ranging from 4.0 to 30.9 mg/kg.

Traces of aniline have been detected in cigarette smoke.

Environmental Significance

Aniline in the atmosphere reacts photochemically to form N-methylaniline, N,N-dimethylaniline, acetanilide, isomeric hydroxyanilines and phenols. There are no data on the atmospheric residence time of aniline.

The estimated half-life in water is probably less than 100 hours and less than one week in soil. Aniline is moderately toxic to nitrifying bacteria.

North Carolina Production and Users

Production: Raleigh Chemical, Raleigh, N.C. (No volume reported)

Users: No information available

Recommended Reviews

Chemical Hazard Information Profiles-Aniline, U.S. Environmental Protection Agency, EPA 560/11-80-011 (1980).

The Carcinogenic and Mutagenic Properties of N-hydroxyaminonaphthalenes, S. Belman et al., Cancer Research 28:535 (1968).

FIRST AID AND EMERGENCY RESPONSE INFORMATION

ANILINE

First Aid (NIOSH/OSHA Pocket Guide to Chemical Hazards)

Eyes: Immediately wash the eyes with large amounts of water, occasionally lifting upper and lower lids. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH ANILINE.

Skin: Promptly wash the skin with soap or mild detergent and water. Remove clothing if contaminated and wash skin. Get medical attention promptly.

Inhalation: Move the person to fresh air at once. Perform artificial respiration if necessary. Get medical attention as soon as possible.

Ingestion: Give large amounts of water then induce vomiting by having victim touch the back of his throat with his finger. Do not induce vomiting if victim is unconscious. Get medical attention immediately.

Note to Physician: Gastric lavage with water or potassium permanganate solution (1.5%). For severe cyanosis, give 0.1 ml/kg (1 mg/kg) of 1% methylene blue solution slowly intravenously. Blood methemoglobin and urine para-aminophenols are useful tests.

Procedures for Spills and Leaks (U.S. DOT Emergency Response Guidebook, 1980)

Isolate hazard area and restrict entry. Stay upwind and keep out of low areas. Wear positive pressure breathing apparatus and special protective clothing. No flares, smoking or flames in hazard area. Do not touch spilled material. Stop leak if it can be done without risk. Use water spray to reduce vapors.

SMALL SPILLS: Take up with sand, or other noncombustible absorbent material, then flush area with water.

SMALL DRY SPILLS: Shovel into dry containers and cover; move containers; then flush area with water.

LARGE SPILLS: Dike far ahead of spill for later disposal.

Fire and Explosion Information

GENERAL: Moderate fire hazard when exposed to heat or flames. Ignites at 76°C (158°F).

EXPLOSIVE LIMITS: Upper 25%, Lower 1.3%.

EXTINGUISHER: Carbon dioxide, dry chemical or alcohol foam.

Reactivity

CONDITIONS TO AVOID: Prolonged storage in open containers or exposure to light. When heated to decomposition, gives off highly toxic fumes.

MATERIALS TO AVOID: Reacts violently with ozone, strong oxidizers (permanganates, chlorine), acids and strong alkalies (sodium hydroxide).

Protective Measures

HANDLING AND STORAGE: Store in a cool, dry, dark location.

ENGINEERING CONTROLS: Provide adequate ventilation. Sinks, quick drench showers and eye wash stations should be available.

PROTECTIVE CLOTHING (Should not be substituted for proper handling and engineering controls): Safety goggles, apron and rubber gloves should be worn if contact with aniline is possible.

PROTECTIVE EQUIPMENT: For levels up to 100 ppm use a chemical cartridge respirator with organic vapor cartridge and full facepiece, gas mask with organic cartridge, or a supplied-air or self-contained breathing apparatus with full facepiece. For escape from a contaminated area use a gas mask with organic vapor cartridge or self-contained breathing apparatus.

ANILINE

Profile

CHEMICAL IDENTIFICATION

Alternative Names:

Aminobenzene	Blue Oil
Aminophen	C.I. 76000
Aniline Oil	C.I. Oxidation Base 1
Aniline Oil, liquid (DOT)	Cyanol
Benzenamine	Krystallin
Benzene, amino	Kyanol
Benzidam	Phenylamine

Chemical Abstract Services (CAS) Registry Number: 00062-53-3

Registry of Toxic Effects of Chemical Substances (RTECS) Number: BW 6650000

Hazardous Materials Table Identification Number: UN 1547

RCRA Identification Number: U 012

Molecular Weight: 93.14

Molecular Formula: C_6H_7N

Classification: Simplest aromatic amine

Description: Colorless oily liquid when freshly distilled; darkens on exposure to air and light. Characteristic aromatic odor and burning taste.

Uses: Chemical intermediate

Chemical/Physical Data

Boiling point: 184.13°C
Melting point: 6.3°C
Vapor pressure: 0.67 mm Hg at 25°C; 1 mm at 35°C; 10 mm at 69.4°C
Specific gravity: 1.022
Vapor density: 3.22 (Air = 1.0)
Solubility in water: 35 gm/l

HUMAN TOXICITY

Methemoglobinemia, formation of methemoglobin from hemoglobin, is a serious physiologic change resulting from aniline poisoning (U.S. EPA, CHIP, 1978). Man is more sensitive than the rat to this effect (IARC, 1974). (The symptoms of toxic methemoglobinemia result from lack of oxygen transport because of insufficient hemoglobin.) Acute intoxication, cyanosis, and possible death from asphyxiation may occur (ACGIH, 1980) due to methemoglobinemia. Inhalation of 7-53 ppm of aniline vapor causes only slight symptoms of methemoglobinia, while exposure to concentrations in excess of 100-160 ppm for over 1 hour can cause serious difficulty (U.S. EPA, CHIP, 1978). Single oral doses of 5 or 15 mg of aniline per person had no effect in 20 adult humans; doses ranging from 25 to 65 mg increased the blood level of methemoglobin (IARC, 1979). The lowest lethal dose reported for humans was 50 mg/kg (TDB, 1982).

Chronic poisoning is reported to involve central nervous system symptoms, and liver cirrhosis and atrophy have also been associated with aniline exposure (ACGIH, 1980).

Aniline is reported to be absorbed through the skin, and this route of exposure may be as important as inhalation (ACGIH, 1980).

The maximum level at which one could escape within 30 minutes without any escape-impairing symptoms or irreversible effects is suggested to be 100 ppm (380 mg/cu m) (NIOSH/OSHA, 1978).

Carcinogenicity

IARC, 1979 — There are no adequate data to indicate that aniline is carcinogenic in experimental animals; at the present time the weight of epidemiological evidence suggests that aniline is not a carcinogen for the human bladder.

The first observation of bladder cancers in industrial workers was made in men using aniline (probably impure) in the manufacture of dyes. Subsequent early observations of a similar nature and the comparison finding that hemorraghic cystitis was common in workers handling aniline lent support to the view that the bladder tumors were attributable to this amine. These tumors thus became known as "aniline bladder cancers." Later it became evident that 2-naphthylamine and benzidine were far more important in the causation of these bladder cancers than was aniline.

OSHA, 1980 — The evidence placing aniline on the Candidate List is derived from studies on its hydrochloride. In biologic systems containing chloride ions, the base and the hydrochloride salt would be in equilibrium. Thus, they would have qualitatively similar biological effects. Based on a brief scientific review, OSHA has concluded that aniline will be placed on the Candidate (Carcinogen) List.

Mutagenicity

NTP, 1980 — Mutagenesis Salmonella typhimurium test result: Negative

Teratogenicity and Embryotoxicity

No evidence was found to indicate that aniline causes birth defects or is embryotoxic.

ANIMAL TOXICITY

Aniline has been extensively tested in many species of animals. It is found to be absorbed rapidly through the skin. The primary effect is formation of methemoglobin. A single dose of 50 mg/kg produces methemoglobin in dogs (Hamblin, 1963).

Acute Toxicity

Results of lethal studies in several species as reported in the TDB 1982 are listed below:

Route	Species	Lethal Dose or Lethal Concentration
Oral	Rat	0.4 gm/kg, LD50
	Mouse	0.4 gm/kg, LD50
	Dog	0.2 gm/kg, LD50
	Cat	1.8 gm/kg; lowest lethal dose
	Rabbit	1.0 gm/kg; lowest lethal dose
	Guinea pig	1.8 gm/kg; lowest lethal dose
Inhalation	Rat	250 ppm (968 mg/cu m) for 4 hours, lowest LC
	Mouse	175 ppm (677 mg/cu m) for 7 hours, LC50
	Cat	190 ppm (697 mg/cu m) for 8 hours, lowest LC
Dermal	Rat	1.4 gm/kg, LD50
	Dog	1.5 gm/kg, LD50
	Cat	0.3 gm/kg, LD50
	Rabbit	0.8 gm/kg, LD50
	Guinea pig	1.3 gm/kg, LD50

Chronic Toxicity

No effects were found, other than a slight increase in methemoglobin in rats when several species were exposed to 5 ppm (20 mg/cu m) of aniline vapor daily for 6 months (ACGIH, 1980).

Aquatic Toxicity

Aquatic toxicity rating: TLm 96 is 10-100 ppm (RTECS, 1982)

Bioaccumulation: Mosquito fish retain small amounts of unchanged aniline and aniline metabolites in experimental ecosystems containing 0.01 to 0.1 µg/l aniline (U.S. EPA, CHIP, 1980).

Biodegradation: Rapidly and completely degraded by Daphnia and freshwater snails at concentrations of 0.01-0.1 µg/l (U.S. EPA, CHIP, 1980).

Phytotoxicity

Aniline has been implicated in the high mortality of loblolly and shortleaf pine over a 15,000 hectares area north of Raleigh, NC. Phytotoxic effects were noted first in 1971 (Cheeseman, et al., 1978). The following effects of aniline exposure were reported for the loblolly pine:

> 0.07 ppm--necrosis and abscission in some trees. 0.4 ppm--severe necrosis and abscission after chronic administration. 1-10 ppm--necrosis and abscission after 7 days.

ENVIRONMENTAL DATA

Air

Aniline was detected in the atmosphere 4,000 meters (2.5 miles) from a chemical plant (no amounts specified, IARC, 1974). It has an oxidative half-life in air of 12 hours (Radding, et al., 1977). Aniline undergoes photochemical degradation to form a variety of toxic products, including N-methylanaline, N,N-dimethylanaline, acetanilide, isomeric hydroxyanilines, and phenols. Transient accumulation to phytotoxic levels could occur near emissions sources (Cheeseman, et al., 1978). No quantitative data are available regarding the atmospheric residence time of aniline.

Water

Aniline has been found in the effluent of a chemical plant on the upper Catawba River, North Carolina (Shackelford and Keith, 1976). Concentrations ranging from 0.5 to 3.7 µg/l have been found in cerain European rivers (Neurath, 1977). Aniline has an estimated oxidative halflife in water of less than 100 hours. Although biologic degradation is expected, high solubility and toxicity to nitrifying bacteria make persistence and some accumulation likely (Radding, et al., 1977).

Soil

Aniline has a low estimated halflife in soil (less than one week) (U.S. EPA, CHIP, 1980). It is degraded by soil microbes (Verschueren, 1977) and no sorption is expected (Radding, 1977).

Biota

Aniline is metabolized in fish, crustacea and mammals but can accumulate (U.S. EPA, CHIP, 1980). Although possible in some species, biomagnification is not expected in most (U.S. EPA, CHIP, 1980).

Aniline has not been reported to occur as such in nature according to the IARC monograph (1973). It has been reported in certain vegetables, however. A review of the presence of primary and secondary amines (Neurath, et al., 1977) is included in the levels tabulated below.

Sample	Level of aniline reported (mg/kg)
Red cabbage	1.0
Cabbage	4.0
Cauliflower	22.0
Kale	0.7
White beet	1.2
Carrots	30.9
Red beet	0.6
Large radish	2.8
Red radish	4.6
Celery	0.7
Maize	0.6
Green salad	0.6
Rhubarb	5.0
Apple flesh	1.5
Apple peel	1.7
Broken beans	0.1
Bean salad	0.1
Rapeseed cake	120.0

INDUSTRIAL DATA

Production

Production in North Carolina was reported for one firm in the Toxic Substances Control Act (TSCA) Chemical Substances Inventory:

Raleigh Chemical, Raleigh, N.C.
Volume: No report (U.S. EPA, TSCA, 1980).

Annual production in the United States for 1978 was estimated at 500 million pounds (U.S. EPA, CHIP, 1980).

Consumption and Use

Estimated U.S. Consumption Pattern:

Isocyanates	40 percent
Rubber chemicals	35 percent
Dyes and intermediates	6 percent
Hydroquinone	4 percent
Drugs	4 percent
Miscellaneous	9 percent

(U.S. EPA, CHIP, 1980)

Reported uses of aniline and the corresponding SIC codes are listed below:

Chemical intermediates in the production of isocyanates and hydroquinones	2869
Chemical intermediate for rubber chemicals	2822, 30
Manufacture of dye	2865
Manufacture of drugs	283
Production of resins	282
Production of corrosion inhibitors and phenolics	2869
Production of explosives	2892
Production of herbicides and fungicides	2879
Production of surfactants	2843
Production of varnishes	2851

Consumption and Use (Continued)

Production of perfumes	2844
In textile industry	22
In paper industry	26
In petroleum refining	29
In metallurgy	34, 34

(U.S. EPA, CHIP, 1980; IARC, 1974)

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air
No guidelines for air have been established.

Workroom Air

ACGIH — The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygenists (ACGIH) for workroom air is 2 ppm (8 mg/cu m) as a time-weighted average. The recommended Short Term Exposure Limit (STEL) is 5 ppm (20 mg/cu m). The importance of avoiding skin exposure is noted.

OSHA — The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 5 ppm (19 mg/cu m) as a time-weighted average. The importance of avoiding skin exposure is noted.

Water
Designated a hazardous substance by the U.S. Environmental Protection Agency. Spills in excess of 1,000 pounds must be reported.

Other
Regulated as a hazardous material by the U.S. Department of Transportation.

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Agencies Concerned with this Chemical

Chemical Hazard Information Profile (CHIP) compiled by the Office of Testing and Evaluation, U.S. Environmental Protection Agency.

Appears on the 1976 Priority List of the Chemical Industry Institute of Toxicology (CIIT).

Designated a candidate carcinogenic substance by the Occupational Safety and Health Administration.

Subject of a monograph prepared by the International Agency for Research on Cancer (IARC).

Appears on the Priority List of the Interagency Testing Committee (ITC).

Tested through the National Toxicology Program to determine mutagenicity (National Toxicology Program, Fiscal Year 1981 Annual Plan, NTP8062, 1980).

REFERENCES

American Conference of Governmental Industrial Hygenists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Cheeseman, J. M., T. O. Perry, and W. W. Heck. Identification of Aniline as an Air Pollutant Through Biological Assay with Loblolly Pine. School of Forest Resources, North Carolina State University, Raleigh, NC (1978).

Hamblin, D. O. Aromatic Nitro and Amino Compounds. Industrial Hygiene and Toxicology, Second Revised Edition, Vol. 2, F. A. Patty, Ed. Interscience Publishers, New York, NY (1963).

International Agency for Research on Cancer (IARC). IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon France, Volume 19. A World Health Organization Publication (WHO), Geneva (1979).

National Institute for Occupational Safety and Health/Occupational Safety and Health Administration (NIOSH/OSHA). NIOSH/OSHA Pocket Guide to Chemical Hazards. DHEW (NIOSH) Publication No. 78-210 (September 1978).

National Toxicology Program. Fiscal Year 1981 Annual Plan. NTP 80-62 (1980).

Neurath, G. B., M. Dunger, F. G. Pein, D. Ambrosius, and O. Schreiber. Primary and Secondary Amines in the Human Environment. Food and Cosmetic Toxicology. Vol. 15, Pergamon Press, Great Britain (1977).

Occupational Safety and Health Administration (OSHA). Candidate Substance Data Summary Sheet. Chemical: Aniline. (1980).

Radding, S. B., et al. Review of the Environmental Fate of Selected Chemicals. U.S. Environmental Protection Agency. Available through the National Technical Information Service, Springfield, VA, PB 267 121 (May 1977).

Registry of Toxic Effects of Chemical Substances, 1982.

Shackelford, W. M., and L. H. Keith. Frequency of Organic Compounds Identified in Water. U.S. Environmental Protection Agency. EPA-600-4-76-062 (December 1976).

Toxicology Data Bank, National Library of Medicine, Bethesda, Maryland (1982).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Chemical Hazard Information Profiles (CHIPs). EPA-560/11-80-011 (1980).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA, PB-90-155-153 (1980).

Verschueren, Karel. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York, NY (1977).

ARSENIC

Executive Summary

CAS NUMBER: 07440-38-2

Arsenic is a silver-gray or tin-white, brittle element possessing both metallic and non-metallic (metalloid) properties. Arsenic exists in the +5, +3, 0, and -3 oxidation sites, and its compounds may be classified according to the oxidation state and according to whether arsenic is in the organic or inorganic form. Arsenic is prepared commercially by the reduction of arsenic trioxide or by direct smelting of the minerals arsenopyrite (FeAsS) and Ioelligite ($FeAs_2$). Arsenic trioxide is the most common form of commercially prepared arsenic, although there are about 50 arsenic compounds produced in the U.S. Most of the arsenic used in the U.S. is imported from Sweden, with 1978 imports estimated at 335,000 kg. Arsenic and its compounds are used in the manufacturing of glass, cloth and semiconductors, as fungicides and wood preservatives, in metal hardening and in various agricultural and veterinary applications. Federal regulations require the reporting of spills over 5,000 pounds for the following arsenic compounds: arsenic disulfide, arsenic pentoxide, arsenic trichloride, arsenic trioxide, and arsenic trisulfide. North Carolina requires the reporting of all spills of these compounds if they occur near water.

Health Effects

ACUTE. The acute toxic effects of arsenic usually follow the ingestion of inorganic arsenic compounds. Signs and symptoms may vary according to the amount and form involved, but the major characteristics of acute poisoning include profound gastrointestinal damage and cardiac abnormalities, shock and death.

CARCINOGENICITY. There is substantial evidence that atmospheric arsenic is a human carcinogen. Epidemiological studies have revealed a marked elevation in respiratory cancer rates for workers exposed to lead arsenate and calcium arsenate.

MUTAGENICITY. Existing data are inconclusive with regard to arsenic's ability to cause mutations, although arsenic compounds do induce chromosomal aberrations in mammalian cells.

TERATOGENICITY AND EMBRYOTOXICITY. Sodium arsenate has been found to cause birth defects in chicks and mice.

CHRONIC. Inhalation of inorganic arsenic compounds is the most common cause of chronic arsenic poisoning. Symptoms include weakness, loss of appetite, nausea and other gastrointestinal disturbances, most of which subside when exposure is halted.

Occupational Health Regulations (for elemental arsenic)

ACGIH: The Threshold Limit Value (TLV) for workroom air is 200 ug/cu m as a time-weighted average.

NIOSH: The standard for workroom air is 2 µg/cu m (inorganic arsenic) as a time-weighted average.

OSHA: The standard for workroom air is 500 µg/cu m as a time-weighted average.

Routes of Human Exposure

A partial list of occupations in which exposure may occur includes:

Alloy makers	Lead shot makers
Aniline color makers	Lead smelters
Arsenic workers	Leather workers
Babbitt metal workers	Painters
Brass makers	Paint makers
Bronze makers	Petroleum refinery workers
Ceramic enamel makers	Pigment makers
Ceramic smelters	Printing ink workers
Copper smelters	Rodenticide makers
Drug makers	Semiconductor compound Makers
Dye makers	Silver refiners
Enamels	Taxidermists
Fireworks makers	Textile printers
Gold refiners	Tree sprayers
Herbicide makers	Type metal workers
Hide preservers	Water weed controllers
Insecticide makers	Weed sprayers

AMBIENT. Arsenic is ubiquitous in the environment, usually in very low concentrations. Elevated levels occur as a result of runoff, drainage or contamination from arsenic-rich soils or rocks. Ambient exposure is not considered to be a significant health threat to humans.

CONSUMER. Arsenic can be present in small amounts in food as a result of contamination or as a residue of lead or calcium arsenate used as insecticides, particularly on potatoes and fruit. The estimated average daily consumption of arsenic from food is calculated to be 0.15-0.40 mg/person.

Environmental Significance

Arsenic accumulates in sediments, animals and plants at lower trophic levels. Marine organisms have the highest concentrations of arsenic found in living organisms. It is mobile in the aquatic environment to the extent that it is metabolized by a number of organisms to organic arsenicals. For freshwater aquatic life the concentration of total recoverable trivalent inorganic arsenic should not exceed 440 µg/cu m at any time.

Recommended Reviews

Committee on Medical and Biologic Effects of Environmental Pollutants, Arsenic, National Academy of Sciences, Washington, DC 1977

Technical and Microelectronic Analysis, Task III-Arsenic and Its Compounds, Final Report (1976), EPA 560/6-76-016.

FIRST AID AND EMERGENCY RESPONSE INFORMATION

ARSENIC

First Aid (U.S. DOT Emergency Response Guidebook, 1980)

	Arsine	Arsenic and Arsenic Compounds
Eyes:	Flush eyes with running water for at least 15 minutes, lifting upper and lower lids occasionally.	Flush with running water for 15 minutes, lifting upper and lower lids occasionally.
Inhalation	Seek immediate medical attention. Move victim to fresh air. Give artificial respiration if victim has stopped breathing. Give oxygen if breathing is difficult.	Same as for Arsine. Keep victim quiet and maintain normal body temperature.
Ingestion:		Give large amounts of water followed by milk. Do not induce vomiting. Seek immediate medical attention.
Skin:	Remove and isolate contaminated clothing and shoes. Wash exposed area with soap or mild detergent. If irritation persists, seek medical attention.	Same as for Arsine.

Spills and Leaks (U.S. DOT Emergency Response Guidebook, 1980)

Arsine	Arsenic and Arsenic Compounds
Isolate hazard area and deny entry. Evacuate area endangered by gas. Stay upwind and keep out of low areas. Wear positive pressure breathing apparatus and full protective clothing. Isolate for ½ mile in all directions if tankcar is involved in fire. No flares, smoking or flames in hazard area. Stop leak if it can be done without risk. Use water spray to reduce vapors but do not put water on leak area.	Isolate hazard area and deny entry. Stay upwind and keep out of low areas. Wear positive pressure breathing apparatus and special protective clothing. Do not touch spilled material. Stop leak if it can be done without risk. Use water spray to reduce vapors. SMALL SPILLS: Take up with sand or other non-combustible, absorbent material, then flush area with water. SMALL DRY SPILLS: Shovel into dry containers and cover; move containers; then flush area with water. LARGE SPILLS: Dike far ahead of spill for later disposal.

Spills and Leaks (Continued

Fire and Explosion Information

Arsine	Arsenic and Arsenic Compounds
Extremely flammable. May be ignited by heat, sparks and flames. Flammable vapor may spread away from spill. Container may explode in heat of fire. Vapor explosion hazard indoors, outdoors and in sewers. Let burn unless fire can be stopped immediately.	Some of these materials may burn but do not ignite readily. Cylinder may explode in heat of fire. Move container from fire area if it can be done without risk. Fight fire from maximum safe distance.
SMALL FIRES: Dry chemical or CO_2	Dry chemical, CO2, water spray or foam.
LARGE FIRES: Water spray, fog or foam	Water spray, fog or foam
Move container from fire area if it can be done without risk. Stay away from the ends of tanks and withdraw immediately in case of rising sound from venting safety device or discoloration of tank.	

Reactivity

MATERIAL TO AVOID (for Arsine): Strong oxidizers, chloride and nitric acid.

Protective Equipment

ARSINE: For levels up to 0.5 ppm, wear a supplied-air respirator or a self-contained breathing apparatus. For levels up to 2.5 ppm, wear the above with a full facepiece. For levels up to 6 ppm, wear a supplied-air respirator operating in the positive demand, positive pressure or continuous flow mode. For escape from a contaminated area, wear a gas mask or a self-contained breathing apparatus.

ARSENIC AND ARSENIC COMPOUNDS: At levels up to 50 mg/cu m, wear a supplied-air respirator or a self-contained breathing apparatus with full facepiece. For levels up to 100 mg/cu m, wear the above operating in positive demand, positive-pressure or continuous flow mode. For escape from a contaminated area, wear a self-contained breathing apparatus.

ARSENIC

Profile

Chemical Identification

Alternative Names:

Chemical Name	Oxidation States	Formula	CAS Number
Arsenic	0	As	07440-38-2
Arsenic-75			
Arsenic Black			
Arsenic Pentoxide	+5	As_2O_5	1303-28-3
Arsenic Trioxide	+3	As_2O_3	1327-53-2
Arsenic Sulfide	+3	As_2S_3	1303-33-9
Arsanilic Acid	Organometallic	$C_6H_4NH_2AsO(OH)_2$	98-50-0
Arsine	-3	AsH_3	7784-42-1
Calcium Arsenate	+5	$Ca_3(AsO_4)_2$	7778-44-1
Dimethylarsinic Acid	Organometallic	$(CH_3)_2AsO(OH)$	0075-60-5
Lead Arsenate	+5	$PbHAsO_4$	7645-25-2
Sodium Arsenate	+5	Na_3AsO_4	7631-89-2
Sodium Arsenite	+3	$NaAsO_2$	7784-46-5
Arsenic Trichloride	+3	$AsCl_3$	7784-34-1

Chemical Abstract Services (CAS) Registry Number: 07440-38-2

Registry of Toxic Effects of Chemical Substances (RTECS) Number: CG 0525000

Hazardous Materials Table Identification Number: UN 1561

Atomic Weight: 74.92

Atomic Symbol: As

Classification: An elemental metalloid

Description: A silver-gray or tin-white, brittle, crystalline, metallic-looking substance

Uses: Glass manufacturing, alloying agent, herbicide, insecticide, electronics and metallurgy

Chemical/Physical Data

Boiling point: 613°C
Melting point: 817°C
Density: 5.727 at 14°C
Solubility in water: insoluble in water, soluble in nitric acid

HUMAN TOXICITY

Arsenical compounds differ widely in their toxicity. Generally, the trivalent species of inorganic arsenic are substantially more toxic than pentavalent compounds. Inorganic compounds are much more toxic than organic species, some of which are essentially nontoxic. Most toxic of all species is arsine and its methyl derivatives. Because of its virtual insolubility in water, and hence in body fluids, elemental arsenic exhibits low toxicity in humans. All arsenicals, with the exception of arsine, disturb cell metabolism through the inhibition of sulfhydryl enzyme systems. Arsine combines with hemoglobin to form a powerful hemolytic poison.

The acute toxic effects of arsenic usually follow the ingestion of inorganic arsenical compounds, and are the result of severe inflammation of the mucous membranes and increased permeability of the blood capillaries. Although signs and symptoms vary in degree and timing according to the amount and form involved, the major characteristics of acute poisoning are profound gastrointestinal damage and cardiac abnormalities. With sufficiently high doses, shock may develop due to severe fluid losses, and death may follow within 24 hours. Survival of acute effects may be followed by an exfoliative dermatitis and peripheral neutritis.

Trivalent arsenic compounds are corrosive to the skin, and prolonged contact may result in a local erythema (redness) and blistering. Moist mucous membranes are most sensitive to the irritant action. Perforations of the nasal septum may occur as a result of exposure to arsenic dust. Arsenic trioxide and pentoxide are capable of producing skin sensitization and contact dermatitis.

Inhalation of inorganic arsenic compounds is the most common cause of chronic arsenic poisoning in the industrial setting. Symptoms include weakness, loss of appetite, nausea and other gastrointestinal disturbances, most of which subside when exposure is halted. Hyperpigmentation of the skin and peripheral neuropathy may ultimately occur (IARC, 1980, EPA, WQC, 1980).

The probable oral lethal dose for humans is 5-50 mg/kg, between seven drops and one teaspoonful for a 170 kg (150 lb.) man (TDB, 1982).

Arsine and its methyl derivatives are the most highly toxic of all arsenical compounds. Inhalation of arsine concentrations of 25 ppm for 30 minutes can be fatal. The maximum level of arsine at which one could escape within 30 minutes without any escape-impairing symptoms or irreversible effects is suggested to be 6 ppm (NIOSH, 1978).

Carcinogenicity

U.S. EPA, CAG, 1980	There is substantial evidence that atmospheric arsenic is a human carcinogen. Workers engaged in the production of insecticides

containing lead arsenate and calcium arsenate showed a marked elevation in respiratory cancer rates based upon a retrospective proportionate mortality study.

IARC, 1979 — Positive for humans.

Mutagenicity

U.S. EPA, CAG, 1980 — The evidence that arsenic compounds cause mutations and allied effects in bacteria is inconclusive. However, arsenic compounds induce chromosomal aberrations and morphological transformation in mammalian cells (IARC, 1980).

Teratogenicity and Embryotoxicity

Sodium arsenate has been found to cause birth defects in chicks and mice (CAG, 1980).

ANIMAL TOXICITY

Arsenic poisoning produces intense abdominal pain, a staggering gait, extreme weakness, trembling, salivation, vomiting, diarrhea, a normal to sub-normal temperature and collapse. It is a potent capillary poison, causing shock and circulatory failure (Waldron, 1980).

Acute Toxicity

Results of lethal studies in several species are listed below (TDB, 1982):

Route	Species	Lethal Dose or Lethal Concentration
Oral		
As_2O_5	Rat	8 mg/kg, LD50
	Mice	55 mg/kg, LD50
$C_2H_7AsO_2$	Rat	700 mg/kg, LD50
$As_8Ca_3O_2$	Rat	298 mg/kg, LD50
	Mice	794 mg/kg, LD50
$NaAsO_2$	Rat	41 mg/kg, LD50
$C_6H_8AsNO_3$	Rat	216 mg/kg, LD50
$PbHAsO_4$	Rat	100 mg/kg, LD50
Inhalation		
AsH_3	Rat	300 mg/cu m/15 min, LCLo
	Dog	400 mg/cu m/15 min, LCLo
	Monkey	70 mg/cu m/15 min, LCLo
$AsCl_3$	Mice	338 ppm/10 min. LCLo
	Cat	100 mg/cu m/1 hour, LCLo
Cutaneous		
$NaAsO_2$	Rat	150 mg/kg, LD50

Chronic Toxicity

Route	Species	Dose/Effect
Oral (As)	Mice	120 mg/kg (pregnancy); teratogenic effect

Growth depression, chronic hepatitis and cirrhosis of the liver were noticed in rats whose diets contained 300 ppm Arsenic (Luckey, 1978).

Aquatic Toxicity

For freshwater aquatic life the concentration of total recoverable trivalent inorganic arsenic should not exceed 400 µg/l at any time. Short-term effects on embryos and larvae of aquatic vertebrate species have been shown to occur at concentrations as low as 40 µg/l.

The available data for total recoverable trivalent inorganic arsenic indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 508 µg/l. No data are available concerning the chronic toxicity of trivalent inorganic arsenic to sensitive saltwater aquatic life.

ENVIRONMENTAL DATA

Air

Arsenic in trace amounts (ppb) may be present normally in the air at various times. In areas remove from man-related contamination, arsenic concentrations in the air are less than 0.02 µg/cu m, whereas in urban areas they vary from less than 0.01 µg/cu m to 0.16 µg/cu m. Physical removal from the atmosphere may occur as a result of rainfall; photolysis is not an important process in determining the fate of arsenic in the air (Waldron, 1980; Callahan, 1979).

Water

Almost all natural waters contain arsenic. Seawater has an average of 3-4 parts per billion; this concentration may be increased locally by industrial contamination or drainage from arsenic-rich soils or rocks. Levels of arsenic in fresh waters vary widely, with high concentrations usually resulting from natural thermal activity, runoff and drainage from arsenic-contaminated watersheds. Typical concentrations of arsenic in fresh water range from 0.5 ppb to 2.4 ppb. Most of the arsenic carried into water is precipated or absorbed on marine clays, phosphorites and hydrous oxides, resulting in sediment concentrations ranging from 7-29 ppm (freshwater sample) (Waldron, 1980).

Soil

Arsenic is ubiquitous in the earth's crust, occurring at general levels of 2-5 ppm. Exceptionally high concentrations occur in or over sulphide deposits where arsenic is present in relative abundance, averaging several hundred parts per million. Sedimentary rocks may have high concentrations of arsenic, especially if they contain manganese or iron oxides (Waldron, 1980). Arsenic entering the soil from the use of pesticides is on the decline because of the decreased use of sodium arsenate as a defoliant and replacement of lead arsenate with carbamates and organophosphates.

Biota

Arsenic is found in all living organisms. It is found in plants with concentrations ranging from 0.01 ppm to 5 ppm (dry weight), in earthworms at concentrations of 20 ppm, and in humans at 0.3 ppm (mostly in the hair and nails). Marine organisms have the highest concentrations of arsenic found in living organisms, with concentrations ranging from 0.5-50 ppm (lobsters). Bioaccumulation is most significant at lower trophic levels, with high toxicity lowering overall accumulation by marine organisms (Callahan, 1979). Arsenic is metabolized by a number of organisms to organic arsenicals, thereby increasing its mobility in the environment.

Other

Arsenic can be present in food as a contaminant or as a residue of lead or calcium arsenate used as insecticides, particularly on potatoes and fruit. Arsenic was found in 3.2% of food item samples examined in the U.S. during a market-basket survey, residues ranged from 0.1-4.7 mg/kg. Arsenic derived from insecticides has been detected in small quantities in tobacco smoke (IARC, 1973).

INDUSTRIAL DATA

Production

Production in North Carolina was reported for one arsenic compound in the U.S. EPA Toxic Substances Control Act (TSCA) Chemical Substances Inventory:

> Arsenic acid (07778-39-4) Mineral Research, Concord, N.C.
> No report of production volume was given. (U.S. EPA, TSCA Inventory, 1980).

Arsenic production in the U.S. is small with only one major U.S. producer. Almost all of the arsenic used in this country is imported from Sweden. Imports for 1978 were estimated at 335,000 kg (740,000 lbs) (IARC, 1980).

Estimated U.S. Consumption in 1978:

Alloying additive	90 percent
Electronic devices	7 percent
Veterinary medicines	3 percent

(IARC, 1980)

Reported uses of arsenic and the corresponding SIC codes are listed below:

In alloys, especially for hardening copper and lead.	
In semiconductors and other electronic components	
In veterinary medicines for producing arsenic compounds	
In special types of glass	
As, a radioactive isotope, is used in toxicological research	
Chemical synthesis, analytical reagent (Arsenic acid, pentoxide, trioxide, sodium arsenate, trichloride)	28
Pesticides, including herbicides, insecticides, fungicides, rodenticides and cotton defoliants: (trioxide, pentoxide, calcium arsenate and arsenite, sodium arsenate and arsenite, potassium arsenate, dimethyl arsonic acid, methane arsonic acid and its sodium salt, zinc metaarsenite)	2879
Pharmaceuticals (Arsenilic acid, arsonoacetic acid disodium salt, ethane arsonic acid, lead arsenate, potassium arsenate, sodium arsenite, diammonium arsenate, arsenic trioxide)	
Semiconductors (trisulfide, arsine gas, gallium arsenide, indium arsenide)	
Wood preservatives (pentoxide, sodium arsenate and arsenite)	
Corrosion inhibitor (sodium arsenite)	
Leather tanning (trisulfide, trioxide, potassium arsenate, sodium arsenite)	
Textile dyes, mordants (trioxide, sodium arsenite, potassium arsenate)	
Pigments (trisulfide, disulfide, pentasulfide, sodium arsenite)	
Glass, lenses, ceramics, mirrors (trisulfide, trioside, hemisolenide, pentoxide, trichloride potassium arsenite, cobaltous arsenate)	
Pyrotechnics (trisulfide)	
Adhesives (Pentoxide)	
Metallurgy (trioxide)	
Paper (potassium arsenate)	

(IARC, 1980, Merck, 1976)

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air

Under evaluation for possible designation as a Hazardous Air Pollutant by the U.S. Environmental Protection Agency.

Workroom Air

ACGIH — The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air is 200 µg/cu m as a time-weighted average.

NIOSH — The National Institute of Occupational Safety and Health (NIOSH) recommends a standard of 2 µg/cu m as a time-weighted average.

OSHA — The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 500 μg/cu m as a time-weighted average.

Water

Addressed by National Interim Primary Drinking Water Regulations set by the U.S. Environmental Protection Agency.

Addressed by Ambient Water Quality Criteria set by the U.S. Environmental Protection Agency.

Designated a toxic pollutant by the U.S. Environmental Protection Agency.

Other

Regulated as a hazardous material by the U.S. Department of Transportation.

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Addressed by Rebuttable Presumption Against Registration (RPAR) through the U.S. Environmental Protection Agency.

Agencies Concerned with this Chemical

Subject of a monograph prepared by the International Agency for Research on Cancer (IARC).

Addressed by a development plan prepared by the Interagency Regulatory Liaison Group (IRLG).

Addressed by a National Toxicology Program (NTP) Executive Summary and included in the list of 100 compounds nominated for NTP testing.

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Interagency Regulatory Liaison Group (IRLG). Excerpt on Arsenic. Regulator Reporter, Volume II, Issue 1.

International Agency for Research on Cancer. IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon, France, Volume 23. A World Health Organization Publication (WHO), Geneva (1981).

MEDLARS II Toxicology Data Bank (TDB) Record of Arsenic. National Library of Medicine (May 1981).

Michigan Department of Natural Resources, Environmental Protection Bureau. Michigan Critical Materials Register 1980. Hazard Assessment Sheet for Arsenic. Lansing, Michigan (1980).

National Institute of Occupational Safety and Health (NIOSH). Criteria for a Recommended Standard...Occupational Exposure to Arsenic. U.S. Depart ment of Health, Education, and Welfare. DHEW (NIOSH) Publication No. 76-129 (1975).

National Toxicology Program (NTP). Executive Summary for Arsenic. In Executive Summaries of Arsenic Compounds Nominated for FY 81 Testing. U.S. Department of Health, Education, and Welfare, Jefferson, Arkansas (1980).

Occupational Safety and Health Administration (OSHA). Candidate Substance Data Summary Sheet. Chemical: Arsenic Compounds.

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances . Chemical Hazard Information Profiles (CHIPs). EPA-560/11-80-011 (1980).

U.S. Environmental Protection Agency, Carcinogen Assessment Group (CAG). Carcinogen Assessment Group's Preliminary Risk Assessment on Arsenic Compounds, Washington, DC (February 11, 1980).

U.S. Environmental Protection Agency, Office of Water Planning and Standards. Ambient Water Quality Criteria for Arsenic. EPA/440-4-80-016 (October 1980).

Venugopal, and Luckey, 1978 Metal Toxicology in Mammals-2, Plenum Press, New York.

Waldron, H.A. 1980 Metals in the Environment, Academic Press, New York.

BENZENE

Executive Summary

CAS NUMBER: 00071-43-2

Benzene is a clear, colorless, highly flammable liquid. It is a nonpolar solvent with an odor characteristic of aromatic hydrocarbons. Produced commercially from coal since 1948 and from petroleum since 1941, benzene is currently produced in the U.S. by the catalytic reforming of petroleum. Fifty percent of all benzene produced is used in gasoline. The primary interest in benzene is its toxicity to man. Federal regulations require the reporting of all benzene spills exceeding 1000 pounds (454 kilograms) or 136 gallons (515 liters). North Carolina requires the reporting of all spills if they occur near water.

Health Effects

ACUTE. Benzene causes acute toxic effects on the central nervous system. The primary route of exposure is by inhalation. Single exposures to benzene in the air at 20,000 ppm have proven fatal within 50 to 10 minutes. Death is usually due to respiratory or cardiac failure. At lower levels, headaches, nausea, staggering gait, paralysis, convulsions, and unconsciousness are observed.

CARCINOGENICITY. There is substantial epidemiological evidence that benzene may cause leukemia in humans. However, no validated animal model has yet been developed for benzene as a carcinogen. Benzene has been designated an industrial substance suspect of carcinogenic potential by ACGIH.

MUTAGENICITY. Ample evidence exists that benzene exposure causes chromosomal aberrations in animals and humans which are probably heritable if they occur in the germinal cells. EPA (Cararcinogen Assessment Group) suggests that somatic mutations may occur at benzene concentrations as low as 1 ppm in air.

TERATOGENICITY. While some animal studies have reported a teratogenic effect, a Consumer Product Safety Commission review concluded that existing animal data do not show benzene to be a teratogen.

CHRONIC. The health effects of chronic exposure to benzene are by far the most serious of any of the common hydrocarbon solvents. Benzene has been shown to cause leukemia, destroy large red blood cells, reduce the white blood cell count and cause aplastic anemia. Most deaths have resulted from exposures to levels exceeding 200 ppm, though blood changes have been reported in workers exposed at levels below 100 ppm. Workers exposed to benzene concentrations between 300 and 700 ppm consistently show marked blood disorders.

Liquid benzene on the skin may cause erythema and blistering, and a dry scaly dermatitis may develop on prolonged or repeated exposure. If accidently ingested, benzene may cause ulceration of the gastrointestinal mucosa.

Occupational Health

The American Conference of Governmental Industrial Hygienists (ACGIH) has established a Threshold Limit Value for workroom air (time-weighted average concentration under which it is believed that all workers may be repeatedly exposed day after day without adverse effect) of 10 ppm (30 mg/cu m). This is the same as the current OSHA standard for a time-weighted average. However, OSHA issued a more stringent standard of 1 ppm in 1977, but this was revoked by court in 1981.

Routes of Human Exposure

OCCUPATIONAL. It has been estimated that 65% of all benzene used in the U.S. is in the production of ethylbenzene and phenol. Workers in these industries are at high risk of exposure. The National Institute for Occupational Safety and Health (NIOSH) requires that every worker subject to exposure to benzene must have urine sampling and analysis at quarterly intervals.

AMBIENT. EPA has assigned priorities to atmospheric sources of benzene emission:

High priority sources -
- Ethylbenzene/styrene manufacture
- Coke by-product plant
- Benzene storage vessels
- Maleic anhydride plants
- Chemical plants/petroleum refinery fugitive emissions

Low priority sources -
- Gasoline Marketing (service stations)
- Other chemical plants (ethylene, chlorobenzene, nitrobenzene, alkyl benzenes, etc.)
- Solvent users (rubber product manufacturing, adhesives, inks, paints).

CONSUMER. Along with ambient air exposures (self-service gasoline delivery), cigarettes (average 90 micrograms per cigarette) and food appear to constitute the major exposure routes to benzene for the general population. While data on benzene in food are limited, the chemical has been detected in nearly all major food categories. It has also been detected in municipal tap water at 0.1 to 0.3 mg/liter.

Environmental Significance

The half-life of benzene in air is estimated to be 7 days and between one hour and 1 week in environmental waters. A bioconcentration factor of 5.21 has been calculated on the basis of the octanol/water partition coefficient.

Acute toxicity to freshwater aquatic life occurs at concentrations as low as 5.3 mg/l and to saltwater aquatic life at concentrations as low as 5.1 mg/l. Sensitive species may suffer toxic effects at lower concentrations. Adverse effects can occur to fish species at concentrations as low as 0.7 mg/l exposed for 168 days. Aquatic algae are less sensitive to benzene than are most fish.

Soils serve as a major sink for atmospheric benzene but plant uptake is negligible. Releases of benzene to water and land are small (1% or less) compared with releases to air.

North Carolina Production and Users

Production: One North Carolina producer reported (TSCA Chemical Substances Inventory): Morganton Plastics, Morganton: 0.55.0 tons/year.

Users: No information available

Recommended Reviews

Carcinogen Assessment Group's Final Report on Population Risk to Ambient Benzene Exposures. U.S. EPA, Carcinogen Assessment Group (February, 1980).

NTP Technical Bulletin. Vol. 1, Issue 3. National Toxicology Program, Department of Health and Human Services (December, 1980).

EPA Information Paper on Benzene. U.S. EPA, Office of Research and Development (December 19, 1980).

First Aid (NIOSH/OSHA Pocket Guide to Chemical Hazards)

Eyes: Wash with large amounts of water immediately. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH BENZENE.

Skin: Wash the contaminated skin promptly with soap or mild detergent and water. Remove clothing if contaminated and wash skin.

Inhalation: Move to fresh air at once. Perform artificial respiration if necessary. Seek immediate medical attention.

Ingestion: Do not induce vomiting. Seek immediate medical attention.

Environmental Spills (U.S. Department of Transportation Emergency Response Guidebook, 1980)

Will burn: No flares, smoking or flames.

Fires: Water spray, fog or alcohol foam.

Use water spray to reduce vapors.

Small spills: Take up with sand or other noncombustible absorbent material, then flush area with water.

Large spills: Dike far ahead of spill for later disposal.

BENZENE

Profile

Chemical Identification

Alternative Names:

Benzin	Mineral Naphtha
Benzine	Motor Benzol
Benzol	NCI-C55276
Benzole	Nitration Benzene
Benzolene	Phene
Bicarburet of Hydrogen	Phenyl Hydride
Carbon Oil	Pyrobenzol
Coal Naphtha	Pyrobenzole
Cyclohexatriene	

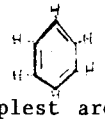
Chemical Abstract Services (CAS) Registry Number: 00071-43-2

Registry of Toxic Effects of Chemical Substances (RTECS) Number: CY140000

Hazardous Materials Table Identification Number: UN 1114

RCRA Identification Number: U 019

Molecular Weight: 78.12

Molecular Formula: C_6H_6 

Classification: The simplest aromatic compound

Description: A clear, colorless, highly flammable liquid. It is a nonpolar solvent with an odor characteristic of aromatic hydrocarbons.

Uses: In the manufacturing of detergents, organic chemicals, pesticides, synthetic rubber, aviation fuel, dyes, explosives and in the processing of nylon.

Chemical/Physical Data

Boiling point: 80.1°C
Melting point: 5.5°C
Vapor pressure: 92.5 mm at 25°C
Vapor density: 2.77 (air = 1.0)
Solubility in water: 800 mg/l at 20°C

HUMAN TOXICITY

The summary provided below is from an EPA Agency-wide Chemical Information paper (EPA, ORD, 1980).

Acute--Acute benzene poisoning is characterized by nausea, vomiting, ataxia (muscular incoordination) and excitement followed by depression and coma. Death is usually the result of respiratory or cardiac failure. Benzene exposure causes acute toxic effects on the central nervous system. Single exposures of benzene in the air at a concentration of 20,000 ppm have proved to be fatal within 5 to 10 minutes. Effects include headaches, nausea, staggering gait, paralysis, convulsions, and eventual unconsciousness and death, usually following cardiovascular collapse. Giddiness and euphoria have also been reported. Severe nonfatal cases have exhibited similar symptoms but recovered after a period of unconsciousness. Accidentally ingested benzene may result in ulceration of the gastrointestinal mucosa.

Chronic--Multiple exposures over time can cause leukemia. Benzene destroys red blood cells. It reduces the white blood cell count. A more severe result is known as aplastic anemia in which the blood producing cells of the bone marrow are severely reduced.

Additional information on toxic effects and concentrations have been noted by NIOSH and are summarized below.

The chronic exposure effects of benzene are by far the most serious disease caused by any of the common hydrocarbon solvents. Most deaths have resulted from exposures to levels exceeding 200 ppm. Blood changes are reported in workers exposed at levels below 100 ppm (ACGIH, 1980). Worker exposures to benzene concentrations between 300 and 700 ppm consistently showed marked blood dyscrasias (NIOSH, 1974).

Liquid benzene on the skin may cause erythema and blistering, and a dry, scaly dermatitis may develop on prolonged or repeated exposure. The rate of benzene absorption through the intact human skin is reported to be 0.4 $mg/cm^2/hr$. Skin absorption is not considered to be an important route of entry (NIOSH, 1974).

The maximum level at which one could escape within 30 minutes without any escape-impairing symptoms or irreversible effects is suggested to be 2,000 ppm (NIOSH/OSHA, 1978).

Carcinogenicity

U.S. EPA, CAG, 1980 CAG concluded that there is substantial epidemiological evidence that benzene is a human leukemogen. CAG estimates that the number of cases of leukemia per year in the general population due to ambient atmospheric benzene is about 90. (The 95 percent confidence interval is from 34 to 235.) This is between 0.23 and 1.62 percent of the total leukemia deaths in the U.S. based on statistics from 1973.

IARC, 1974 It is established that exposure to commercial benzene or benzene-containing mixtures may result in damage to the hematopoietic system. A relationship between such

exposure and the development of leukemia is suggested by many case reports, and this suggestion is strengthened by a case-control study from Japan. Benzene has been tested only in mice by subcutaneous injection and skin application. The data reported do not permit the conclusion that carcinogenic activity has been demonstrated.

Mutagenicity

U.S. EPA, CAG, 1979 CAG concluded that ample evidence exists that benzene causes chromosomal aberrations in animals and humans exposed. These chromosomal aberrations probably involve breaks in DNA and therefore are probable heritable events if they occur in the germinal cells, although the experiments have not been decisive. At the current time, quantitative estimates of heritable genetic damage due to benzene cannot be made from data on the frequency of somatic mutations, although this damage may be occurring at concentrations as low as 1 ppm in air.

Teratogenicity & Embryotoxicity

Shepard, 1980 Injections (3 ml/kg on the 13th day of gestation) resulted in increased incidence of cleft palate and mandible reduction in mice. Skeletal growth retardation and skeletal anomalies were observed in offspring of rats exposed to high concentrations (up to 2,000 ppm) during pregnancy. No developmental malformations were found when pregnant rats were exposed continuously to benzene vapors (1 to 670 mg/cu m). The number of fetuses was reduced with the higher concentrations.

ANIMAL TOXICITY

Many studies on the effects of benzene exposure on laboratory animals have been performed. Toxic effects have been observed in the bone marrow, blood (leukopenia), testes (degeneration of the seminiferous vesicles), central nervous system (decreased reflex activity, depression, sedation), behavior (decreased spontaneous behavior), and reduced resistence to infection (NIOSH, 1974).

Acute Toxicity

Results of lethal studies in several species as reported in the RTECS, 1980 are listed below:

Route	Species	Lethal Dose or Lethal Concentration
Oral	Rat	3,800 mg/kg, LD50
	Mouse	4,700 mg/kg, LD50
	Dog	2,000 mg/kg, lowest lethal dose
Inhalation	Rat	10,000 ppm (32,600 mg/cu m), for 7 hours, LC50
	Mouse	9,980 ppm (32,535 mg/cu m), LC50 (duration not given)
	Dog	4,526 ppm (14,600 mg/cu m), lowest lethal level (duration not given)

Chronic Toxicity

A rat inhalation study resulted in the development of a moderate degree of leukopenia after 5 to 8 weeks of 5 hr/day, 5 days/week exposure at 44 and 47 ppm. No effects were observed at exposures of 15 to 31 ppm. Rats displayed a decrease in the white blood cell counts following 756-hr. exposure at 50 ppm for 8 hr/day, 5 days/week. Observations included reduced amounts of DNA in the white cells, a depression in myelocytic activity and an increase in the red cell precursors in bone marrow (ACGIH, 1980).

Aquatic Toxicity

Aquatic toxicity rating: TLm is 10-100 (RTECS, 1980)

The EPA water quality criteria for protection of aquatic life are as follows:

Acute toxicity to freshwater aquatic life occurs at concentrations as low as 5.3 mg/l. Sensitive species encounter toxic effects at lower concentrations. Acute toxicity to saltwater aquatic life occurs at concentrations as low as 5.1 mg/l. Adverse effects occur at concentrations as low as .7 mg/l with a fish species exposed for 168 days (U.S. EPA, WQC, 1980).

Aquatic algae are less sensitive to benzene than are most fish (U.S. EPA, ORD, 1980).

No information was found regarding bioaccumulation or biodegradation in aquatic species. An average bioconcentration potential of 5.21 was estimated in developing the water quality criteria. This level is not considered significant (U.S. EPA, ORD, 1980).

ENVIRONMENTAL DATA

Air

The average ambient air level of benzene is estimated to be 3.26 ug/cu m or 10 ppb (U.S. EPA, WQC, 1980). Concentrations ranging from 50 ug/cu m to 200 ug/cu m (0.015-0.057 ppm) have been detected in Los Angeles air (IARC, 1975). Benzene has an estimated half-life in air of 20-50 hours calculated from smog chamber data (U.S. EPA, ORD, 1980), and degrades rather rapidly in this medium. Accumulation in air over urban areas can be significant, up to 100 times greater than normal background levels (U.S. EPA, WQC, 1980).

Water

Benzene has been detected in finished drinking water at 0.1 to 0.3 µg/l and in water and sediment samples from the lower Tennessee River in ppb concentrations (U.S. EPA, WQC, 1980). This compound has an estimated half-life in water of 1 hour to 1 week (U.S. EPA, ORD, 1980), and little accumulation in this medium is expected. Soluble benzene persists in water until slow biodegradation occurs.

Soil

There are limited data regarding the persistence of benzene in the soil. This compound probably volatizes before degradation can occur, but could also biodegrade slowly (Callahan, 1979). Soil may act as a "sink" for atmospheric benzene, resulting in some accumulation (U.S. EPA, ORD, 1980).

Biota

Although limited information is available regarding benzene's persistence in biota, degradation in this medium appears likely (Callahan, 1979). Slow bacterial degradation and a low octanol/water partition coefficient make accumulation unlikely. Biomagnification is not expected.

Benzene occurs in straight-run petroleum distillates and in coal-tar distillates. Motor gasolines are reported to contain small quantities of benzene, usually less than 5 percent, (IARC, 1974), although benzene content in leadfree gasolines may be much higher (up to 30%) (IARC, 1975). It has been detected in several foods including fruits, nuts, vegetables, dairy products, meats, fish, poultry and several beverages. Cigarettes are also estimated to contain benzene at 90 µg/cigarette (U.S. EPA, ORD, 1980).

INDUSTRIAL DATA

Production

Production in North Carolina was reported by 1 company in the Toxic Substances Control Act (TSCA) Chemical Substance Inventory:

Morganton Plastics, Morganton; 0.5-5.0 tons/year (U.S. EPA, TSCA Inventory, 1980).

Benzene production and importation was estimated at over 11 million metric tons in 1980 (U.S. EPA, ORD, 1980).

Consumption and Use

Estimated U.S. Consumption:

Chemical intermediate for ethylbenzene	42 percent
Chemical intermediate for phenol	23 percent
Chemical intermediate for cyclohexane	15 percent
Chemical intermediate for maleic anhydride	4 percent
Chemical intermediate for detergent aklylate	4 percent
Chemical intermediate for aniline	4 percent
Miscellaneous uses	8 percent

(MEDLARS, 1981)

Reported uses of benzene and the corresponding Standard Industrial Classification Codes are listed below:

	SIC	Reference
Chemical intermediate for ethyl benzene, phenol, cyclohexane, maleic anhydride, and aniline	2869	TDB, 1981
Chemical intermediate for detergent alkylate	284	
In manufacture of dichlorobenzenes, anthraquinone, benzene hexachloride, and biphenyl	2869	
In manufacture of chlorobenzene and DDT	287	
Manufacture of medicinal chemicals	283	
Manufacture of dyes	2865	
Manufacture of linoleum	3996	
Manufacture of varnish and laquers	2851	
Manufacture of oil cloth		
Manufacture of airplane dope		
As a solvent for waxes and resins		
Constituent for motor fuels		

Sources of high benzene emissions to the atmosphere have been assigned priorities by the U.S. Environmental Protection Agency.

High Priority Sources

Ethylbenzene/styrene manufacture
Coke by-product plants
Benzene storage vessels
Maleic anhydride plants
Chemical plants/petroleum refinery fugitive emissions

Low Priority Sources

Gasoline marketing
Other chemical plants (ethylene, chlorobenzene, nitrobenzene, alkyl benzenes, etc.)
Solvent users (Rubber product manufacturing, adhesives, inks, paints) (U.S. EPA, ORD, 1980).

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air

Designated a hazardous air pollutant by the U.S. Environmental Protection Agency.

Workroom Air

ACGIH — The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air is 10 ppm (30 mg/cu m) as a time-weighted average and the short term exposure limit is 25 ppm (75 mg/cu m). Benzene is designated an "Industrial Substance Suspect of Carcinogenic Potential for Man".

NIOSH — The National Institute of Occupational Safety and Health (NIOSH) recommends a standard of 1 ppm (3 mg/cu m) as a time-weighted average and a ceiling limit of 5 ppm (15 mg/cu m). NIOSH considers the evidence to be conclusive that benzene is leukemogenic and recommends that exposure to benzene be kept as low as possible.

OSHA — The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 10 ppm (30 mg/cu m) as a time-weighted average. The standards represent allowable concentrations of toxic or hazardous substances to which employees may be exposed without incurring adverse health effects. A more stringent standard reflecting the risk of leukemia from benzene was set at 1 ppm (3 mg/cu m) as a time-weighted average and a ceiling of 5 ppm (15 mg/cu m), but this standard was revoked by court action (Code of Federal Regulations, Title 24, Part 1910, Subpart Z).

Water

Addressed by Ambient Water Quality Criteria set by the U.S. Environmental Protection Agency.

Designated a toxic pollutant by the U.S. Environmental Protection Agency.

Designated a hazardous substance by the U.S. Environmental Protection Agency.

Other

Regulated as a hazardous material by the U.S. Department of Transportation. The regulations pertain to the identification and transportation of hazardous materials in commerce (Code of Federal Regulations, Title 49, Part 172.101). Benzene is classified as a flammable liquid and shipments must carry this label.

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency. The regulations address the proper management of hazardous wastes.

Institutions Concerned with this Chemical

Appears on the 1978 Priority List of the Chemical Industry Institute of Toxicology (CIIT).

Subject of a Risk Assessment Document prepared by the Carcinogen Assessment Group (CAG) of the U.S. Environmental Protection Agency.

Subject of a monograph prepared by the International Agency for Research on Cancer (IARC).

Addressed by a development plan prepared by the Interagency Regulatory Liaison Group (IRLG).

Tested by the National Cancer Institute (NCI) for carcinogenicity. (National Toxicology Program, Fiscal Year 1980 Annual Plan. NTP-79-7 (1979).

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Callahan, M.A., et al. Water-Related Fate of 129 Priority Pollutants. U.S. EPA Office of Water Planning and Standards, Washington, DC, EPA 440/4-79-029 (December 1979).

International Agency for Research on Cancer (IARC). IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon, France, Volume 7. A World Health Organization Publication (WHO), Geneva (1974).

Kingsbury, G. L., R. C. Sims, and J. B. White. Multimedia Environmental Goals for Environmental Assessment, Volumr IV. MEG Charts and Background Information Summaries (Categories 13-26), EPA-600/7-79-176b (NTIS PB 80-115116).

Merck Index: An Encyclopedia of Chemicals and Drugs, Ninth Edition, M. Wind-holz, ED. Merck and Co., Rahway, NJ (1976).

National Institute for Occupational Safety and Health/Occupational Safety and Health Administration (NIOSH/OSHA). NIOSH/OSHA Pocket Guide to Chemical Hazards. DHEW (NIOSH) Publication No. 78-210 (September 1978).

National Toxicology Program, NTP Technical Bulletin, Department of Health and Human Services, Vol. 1, Issue 3 (December 1980).

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfiche Issue, R. J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville, MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 80-111-4 (1980).

Shepard, T. H. Catalog of Teratogenic Agents. The John Hopkins University Press, Baltimore, MD (1980).

U.S. Environmental Protection Agency, Office of Research and Development (ORD). Agency-wide Chemical Information Paper on Benzene (December 1980).

U.S. Enviromental Protection Agency, Carcinogen Assessment Group (CAG). Carcinogen Assessment Group's Final Report on Population Risk to Ambient Benzene Exposures. Washington, DC (February 11, 1980).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA PB-80-155-153 (1980).

U.S. Environmental Protection Agency, Office of Water Planning and Standards. Ambient Water Quality Criteria for Benzene. EPA-440/5-80-018 (October 1980).

Verschueren, Karel. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York, NY (1977).

BENZIDINE

Executive Summary

CAS NUMBER: 00092-87-5

Benzidine is a grayish-yellow, white or reddish-gray crystalline powder which darkens on exposure to air and light. Benzidine is produced commercially in the U.S., primarily as a precursor of azo dyes. Estimated U.S. consumption of benzidine and benzidine congener dyes in 1978 was about 7 million lbs. Benzidine is highly toxic, and has been linked to bladder cancer in humans. Benzidine has been designated a toxic pollutant and a hazardous substance by the U.S. Environmental Protection Agency. No guidelines regarding the reporting of spills have been developed at the state or federal level.

Health Effects

ACUTE. Benzidine is toxic by all routes of administration, and is readily absorbed through the skin. Acute exposure is characterized by methemoglobinemia; ingestion causes nausea and vomiting which may be followed by kidney and liver damage.

When administered orally, benzidine is slightly toxic to rats with LD50 values reported in the range of 309 mg/kg. Acute toxic effects observed in rats following ingestion of a dose of 100 mg/kg in water included leukocytosis erythrocytopenia and thrombocytopenia.

CARCINOGENICITY. Epidemiological data clearly demonstrate that benzidine is a bladder carcinogen in humans, and experimental evidence indicates that it can induce cancer in a variety of organs in several species of animals. Benzidine is recognized as a carcinogen by the American Conference of Governmental Industrial Hygienists (ACGIH).

MUTAGENICITY. Benzidine and its three congeners all have been shown to be mutagenic in the Ames Salmonella assay.

TERATOGENICITY & EMBRYOTOXICITY. Benzidine has not been shown to be teratogenic or embryotoxic.

CHRONIC. Massive or prolonged exposure to benzidine may result in a secondary anemia consequent to hemolysis. Damage to the blood and bone marrow depression have also been reported.

Occupational Health

Case reports from several countries support the relationship between bladder cancer and occupational exposure to benzidine. No standards have been established for workroom air exposure.

Routes of Human Exposure

OCCUPATIONAL. Additional information on exposure, release and environmental fate is needed to complete a detailed risk assessment on benzidine. There is a major occupational risk to workers exposed to imported benzidine-based dyes that contain high concentrations of free benzidine.

AMBIENT. No measurements for benzidine in ambient air, surface or drinking water have been reported. The most important source of environmental release of benzidine and its congeners is probably the wastewaters from dye producer plants.

CONSUMER. The general public is exposed to benzidine, its congeners, and their derivative dyes and pigments mainly in certain paper, textiles, leather and other substrates; however, these dyes or pigments are generally regarded as "fast" (non-extractable).

Environmental Significance

Benzidine has an estimated half-life in air of less than one day. It is considered persistent in some soils, and can inhibit the anaerobic digestion of wastewater treatment processes. A TLm 96 of 1-10 ppm for aquatic life has been reported.

Recommended Reviews

Benzidine Revisited: A Review of the Literature and Problems Associated with the Use of Benzidine and Its Congeners, T,J, Haley, Clinical Toxicology, 8:13:42, 1975.

FIRST AID AND EMERGENCY RESPONSE INFORMATION

BENZIDINE

First aid (U.S. DOT Emergency Response Guidebook)

Benzidine is poisonous by inhalation, ingestion and contact with the skin. Move victim to fresh air; call emergency medical care. Remove and isolate contaminated clothing and shoes.

In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.

Note to Physician: If swallowed, remove by gastric lavage or emesis using activated charcoal. For severe methemoglobinemia, give methylene blue, 0.1 ml/kg in a 1% solution slowly IV. If methemoglobinemia does not respond to treatment, hemodialysis or exchange transfusion is useful.

Procedures for Spills and Leaks (U.S. DOT Emergency Response Guidebook 1980)

Isolate hazard area and deny entry. Stay upwind and keep out of low areas. Wear self-contained breathing apparatus and full protective clothing. Do not touch spilled material. Stop leak if it can be done without risk.

SMALL SPILLS:	Take up with sand, or other noncombustible absorbent material, then flush area with water.
SMALL DRY SPILLS:	Shovel into dry containers and cover, move containers, then flush area with water.
LARGE SPILLS:	Dike far ahead of spill for later disposal.

Fire and Explosion Information

May burn but does not ignite readily.

SMALL FIRES:	Dry chemical, CO_2, water spray or foam.
LARGE FIRES:	Water spray, fog or foam.

Move container from fire area if it can be done without risk.

Protective Measures

PROTECTIVE EQUIPMENT: For routine exposure, wear a powered air-purifying respirator equipped with high-efficiency filters. For escape from unknown concentrations, wear a self-contained, positive pressure breathing apparatus with a full facepiece.

BENZIDINE

Profile

CHEMICAL IDENTIFICATION

Alternative Names:

Biphenyl, 4,4'-diamino-	Fast Corinth Base B
4,4'-Biphenyldiamine	p-Diaminodiphenyl
C.I. Azoic Diazo Component 112	4,4'-Diaminodiphenyl
4,4'-Diaminobiphenyl	p,p'-bianiline
4,4'-Diphenylenediamine	4,4'-bianiline

Chemical Abstract Services (CAS) Registry Number: 00092-87-5

Registry of Toxic Effects of Chemical Substances (RTECS) Number: DC 9625000

Hazardous Materials Table Identification Number: UN 1885

RCRA Identification Number:

Molecular Weight: 184.23

Molecular Formula: $C_{12}H_{12}N_2$

Classification: A family of similar, synthetic aromatic amines

Description: Grayish-yellow, white, or reddish-gray crystalline powder which darkens on exposure to air and light

Uses: Dye manufacture

Chemical/Physical Data

Boiling point: 400°C
Melting point: 115-200° when heated slowly, 128°C when anhydrous and heated rapidly
Vapor density: 6.36 (air = 1.0)
Solubility in water: soluble in hot water, 9.3 g/l; slightly soluble in cold water (0.4 g/l).

HUMAN TOXICITY

Benzidine is toxic by all routes of administration. It is readily absorbed through the skin and emits highly toxic fumes when heated to decomposition. Benzidine can cause damage to the blood including nemolysis and bone marrow depression. On ingestion it causes nausea and vomiting which may be followed by liver and kidney damage. Acute exposure is characterized by methemoglobinemia. Massive or prolonged exposure may result in a secondary anemia consequent to hemolysis (VTSIR, 1979). Other effects observed in workmen suffering from acute benzidine poisoning include hematuria, acute hemorrhagic cystitis, acute hepatic disorders and dermatitis (VTSIR, 1979). A concentration of 18 mg/cu m over a 13 year period of intermittent exposures produced carcinogenc effects (NIOSH, 1977).

A significant increase in urinary b-glucuronidase activity was observed in workers exposed to benzidine. Elevated activity, although decreased by removal from exposure, does not return to normal levels (WQC, 1980). Dermatitis has been reported in workers in the benzidine dyestuff industry. Exposure to benzidine can produce cystitis and hematuria including early attack on urinary bladder (EPA, WQC, 1980).

Carcinogenicity

U.S. EPA CAG, 1980: Epidemiological data clearly demonstrates that benzidine is a bladder carcinogen in humans and experimental evidence indicates that it can induce cancer in a variety of organs in several species of animals.

IARC, 1979: Animal Data: Benzidine is carcinogenic in mice, rats, and hamsters, and possibly dogs. Given orally, it has produced bladder carcinoma in dogs after a long latent period and liver tumors in rats and hamsters.

Human Data: Epidemiological studies showed that occupational exposure to commercial benzidine alone was strongly associated with bladder cancer. In the same studies, exposure to 2-naphthylamine alone was similarly associated with bladder cancer. A number of case reports from several countries support the relationship between this neoplasm and occupational exposure to benzidine.

RTECS, 1980: Carcinogenic determination: Tumorigen

Mutagenicity

U.S. EPA, CAG, 1980: Benzidine and its three congeners all have been shown to be mutagenic in the Ames Salmonella assay.

NTP, 1980: Mutagenesis Salmonella typhimurium test result: Benzidine is scheduled for mutagenicity testing in FY 81.

Teratogenicity & Embryotoxicity

No evidence was found to indicate that benzidine causes birth defects.

Carcinogenic, mutagenic and teratogenic effects are summarized in the following tables (IARC, 1979).

Summary Information on Carcinogenic, Mutagenic, and Teratogenic Effects of Benzidine and Its Congeners

Compound	Carcinogen Human	Carcinogen Animal	Mutagen Strong	Mutagen Weak	Teratogen Human	Teratogen Animal
Benzidine	Yes (Bladder)	Yes (oral, 4 species)	+		n.r.*	n.r.*
Dichlorobenzidine	n.r.*	Yes (oral, 3 species	+		n.r.*	n.r.*
o-Tolidine	n.r.*	Yes (subcutaneous, 2 species)		+	n.r.*	n.r.*
Dianisidine	n.r.*	Yes (oral 1 species)		+	n.r.*	n.r.*

*n.r. -- Not recorded in the available literature

Summary Information on Carcinogenic, Mutagenic, and Teratogenic Effects and Metabolism of Benzidine-Related Dyes and Pigments

Base Compound	Carcinogen	Mutagen	Teratogen	Metabolized to base compounds
Benzidine	Direct Blue 6 Direct Black 38 Direct Brown 95	Direct Violet 1 Direct Red 28	n.r.*	Direct Black 4 Direct Black 38 Direct Blue 2 Direct Blue 6 Direct Brown 95 Direct Green 1 Direct Orange 8 Direct Red 28
Dichlorobenzidine	Negative results; Pigments Yellow 12, 13, 83	n.r.*	n.r.*	Negative Pigments Yellow 12, 13
o-Tolidine	Negative Pigment Yellow 16	Trypan	Trypan	n.r.*
Dianisidine	n.r.*	n.r.*	n.r.*	n.r.*

*n.r. -- Not recorded in the available literature
+Active ingredient is pure o-tolidine-based component of dye mixture

ANIMAL TOXICITY

Acute toxic effects observed in rats following ingestion of a dose of 100 mg/kg in water included leukocytosis, erythrocytopemia and thrombocytopemia (VTSIR, 1979).

Acute toxicity

Results of lethal studies in several species as reported in the RTECS, 1980 are listed below:

Route	Species	Lethal Dose or Lethal Concentration
Oral	Rat	309 mg/kg, LD50
	Mice	214 mg/kg, LD50
	Dog	200 mg/kg, LDLo 56 weeks, intermitt.
Inhalation	Rat	10 mg/cu m for 56 weeks, intermitt, lowest LC

Chronic Toxicity

Studies of the chronic toxic effects of benzidine in animals have revealed activity of blood phenolase enzyme in rabbits (EPA, WQC, 1980), and increased liver glutathione, in rats (NTIS, 1975).

Aquatic Toxicity

The available data for benzidine indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 2.5 mg/l. No data are available concerning the chronic toxicity of benzidine to sensitive freshwater aquatic life.

No saltwater organisms have been tested with benzidine and no statement can be made concerning acute or chronic toxicity.

Aquatic toxicity rating: TLm 96 is 1-10 ppm (RTECS, 1980).

Trout, bluegill, sunfish and larval lamprey died or showed signs of distress when exposed to 5 mg/l for 14 hours (NTIS, 1975).

Bioaccumulation: Benzidine is bioaccumulated in certain fish. It has been shown to bioaccumulate 44-135 fold in bluegill sunfish (EPA, TSCA CAS, 1980) at 21 days.

Biodegradation in aquatic species: Benzidine resists biological degradation (Radding, et al, 1975).

Phytotoxicity

Benzidine is not bioaccumulated by aquatic organisms (Callahan, 1979).

ENVIRONMENTAL DATA

Air

No measurements for benzidine in ambient air, surface or drinking water have been reported (EPA, 1976). It has an estimated half-life in air of less than one day (Radding, 1977), and oxidative degradation is expected.

Water

The most important source of environmental release of benzidine and its congeners is probably the wastewaters from dye-producer plants. The half-life of benzidine in water is estimated at 4 hours, but the hydrolysis rate is "not environmentally significant" (Callahan, 1979). Benzidine discharged into waters can be expected to adsorb onto clay particles and be dispersed via sediments. Low volatility is expected.

Soil

Benzidine is considered persistent in some soils, where it may be oxidized in the presence of metal cations. Sorption and subsequent transport on clay is significant.

Biota

Benzidine is degraded by a wide variety of organisms but is somewhat resistant to degradation by sludge (Callahan, 1979). Levels of benzidine exceeding 5 mg/l can inhibit anaerobic digestion wastewater treatment processes (EPA, NTIS, 1976). It has a short half-life in this medium, even in those organisms shown to accumulate this substance (bluegills, EPA, WQC, 1980). It has been suggested that benzidine may be produced from 1,2-diphenylhydrazine (hydrobenzene) by acidity in the stomach (IARC, 1979).

The general public is exposed to benzidine, its congeners, and their derivative dyes and pigments mainly in certain paper, textiles, leather and other substrates; however, these dyes or pigments are generally regarded as "fast" (non-extractable) (TSCA Risk Assessment, 1980).

INDUSTRIAL DATA

Production

No report of production in North Carolina is given in the EPA Toxic Substances Control Act (TSCA) Chemical Substances Inventory for benzidine, benzidine congeners, (3,3'-dichlorobenzidine, o-tolidine, and dianisidine) or the 85 derivative dyes reported to be produced in the United States in 1979 (U.S. EPA, TSCA, 1980).

	U.S. Production 1978	Production 1976
Benzidine	Small amounts	1,100,000 lbs
Dichlorobenzidine	Several million lbs	4,500,000 lbs
Dianidine	Small amounts	-
o-tolidine	200,000 lbs	200,000 lbs

Consumption and Use

Estimated U.S. Consumption

Type of dye	Quantity (10^6 lb) 1975	1976	1977	1978
Benzidinebased				
U.S. sales	4.2	6.6	4.6	1.9
Imports	0.9	0.6	1.3	1.6
o-Tolidine-based				
U.S. sales	2.1	2.3	1.9	2.8
Imports	0.1	0.1	0.1	0.1
Dianisidine-based				
U.S. sales	0.5	0.5	0.4	0.4
Imports	0.1	0.1	0.1	0.1
Dichlorobenzidine-based				
U.S. sales	8.4	11.6	12.8	--
Imports	0.1	0.1	0.05	0.03

Reference Powell, et al. 1979

Reported uses of benzidine and benzidine congener dyes and the corresponding SIC codes are listed below:

Coloring of textiles	22
Rubber	30
Plastics	282
Printing inks	
Paints and lacquers	285
Leather	
Paper products	

Small amount of benzidine are also used in analytical chemical techniques and security printing (U.S. EPA, 1980).

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air

No guidelines for ambient air have been established.

Workroom Air

ACGIH — Benzidine is recognized as a carcinogen by the American Conference of Governmental Industrial Hygienists (ACGIH). Limits for concentrations in workroom air have not been established. The importance of avoiding skin exposure is noted.

Water

Addressed by Ambient Water Quality Criteria set by the U.S. Environmental Protection Agency.

Designated a toxic pollutant by the U.S. Environmental Protection Agency.

Designated a hazardous substance by the U.S. Environmental Protection Agency.

Other
Regulated as a hazardous material by the U.S. Department of Transportation. Benzidine is classified as a poison and shipments must carry a label which reads "Poison".

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Agencies Concerned with this Chemical

Designated a candidate substance by the Occupational Safety and Health Administration.

Subject of a Risk Assessment Document prepared by the Carcinogen Assessment Group (CAG) of the U.S. Environmental Protection Agency.

Subject of a monograph prepared by the International Agency for Research on Cancer (IARC). Addressed by development plan prepared by the Interagency Regulatory Liaison Group (IRLG).

Under toxicological evaluation through the National Toxicology Program to determine mutagenicity (National Toxicology Program, Fiscal Year 1981 Annual Plan (NTP-80-62, 1980).

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Callahan, M. A., et al. Water-Related Fate of 129 Priority Pollutants. U.S. EPA Office of Water Planning and Standards, Washington, DC, EPA 440/4-79-029 (December 1979).

Cupitt, L. T. Fate of Toxic and Hazardous Materials in the Air Environment. EPA-600/3-80-084, NTIS PB 80-221948 (September 1980).

International Agency for Research on Cancer (IARC). IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon, France, Volume 19. A World Health Organization Publication (WHO) Geneva (1979).

Merck Index: An Encyclopedia of Chemical and Drugs, Ninth Edition, M. Windholz, Ed. Merck and Co., Rahway, NJ (1976).

National Institute for Occupational Safety and Health. National Occupational Hazard Survey. Available from Division of Technical Services. Cincinnati, OH, DHEW 74-127, 77-123, and 78-114 (1980).

National Toxicology Program. Classification of 102 NTP Compounds for FY 81 by the Chemical Nomination and Selection Committee. U.S. Department of Health, Education, and Welfare, Jefferson, Arkansas (March, 1980).

National Toxicology Program. Executive Summaries of Nine Compounds Nominated for FY 81 Testing. U.S. Department of Health, Education, and Welfare, Jefferson, Arkansas (January 1980).

National Toxicology Program. Fiscal Year 1981 Annual Plan. NTP 80-62 (1980).

National Toxicology Program. Executive Summaries of Twenty-Five Compounds Nominated for FY-80 Testing. U.S. Department of Health, Education, and Welfare, Jefferson, Arkansas (January 1980).

National Toxicology Program. Review of Current DHEW Research Related to Toxicology, Fiscal Year 1980. Department of Health, Education and Welfare, Public Health Service (1980).

National Toxicology Program. NTP Executive Summaries. Prepared by the National Center for Toxicological Research, Office of Scientific Intelligence, Jefferson, Arkansas (March 1979).

National Toxicology Program, NTP Technical Bulletin, Department of Health and Human Services, Vol. 1, Issue 3 (December 1980).

Powell, R., Murray M., Chen C., Lee A. 1979. Survey of the manufacture, import and uses for benzidine, related substances, and related dyes and pigments. Washington, DC: Office of Toxic Substances, US Environmental Protection Agency. EPA-560/13-79-005.

Radding SB, Holt BR, Jones JL, Liu DR, Mill T, Hendry DG. 1975. Review of the environmental fate of selected chemicals. Washington, DC: Office of Toxic Substances, U.S. Environmental Protection Agency. EPA 560/5-75-001.

Registry of Toxic Effects of Chemical Substances. October 1980 Quarterly Microfiche Issue, R. J. Lewis and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville, MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 80-111-4 (1980).

Shackelford, W. M., and L. H. Keith. Frequency of Organic Compounds Identified in Water. U.S. Environmental Protection Agency, EPA-600/4-76-062 (December 1980).

Shepard T. H. Catalog of Teratogenic Agents. The John Hopkins University Press, Baltimore, MD (1973).

Sittig, M., Ed. Priority Toxic Pollutants. Noyes Data Corporation, Park Ridge, N.J. (1980).

Stahl. Q. R. Preliminary Air Pollution Survey of Aldehydes. Prepared by Litton Systems, Inc., under Contract No. PH 22-68-25 for National Air Pollution Control Administration. Available from Clearinghouse for Federal Scientific and Technical Inforamtion, Springfield, VA APTD 69-24 (1969).

U.S. Environmental Protection Agency. Carcinogen Assessment Group (CAG). Carcinogen Assessment Group's Preliminary Risk Assessment on Benzidine. Washington, DC (February 11, 1980).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Chemical Hazard Information Profiles (CHIPs). EPA-560/11-80-011 (1980).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available form the National Technical Information Service, Springfield, VA PB-80-155-153 (1980).

U.S. Environmental Protection Agency, Office of Water Planning and Standards. Ambient Water Quality Criteria for Benzidine. EPA-440/5-80-023 (October 1980).

Verschueren, Karel. Handbook of Environmental Data on Organic Chemical. Van Nostrand Reinhold Co., New York, NY (1977).

CAS Number: 00100-44-7

Benzyl chloride is a highly refractive liquid with a pungent, irritating odor. It is used as a chemical intermediate in the manufacturing of dyes, plasticizers, lubricants, gasoline additives, pharmaceuticals, tanning agents and quaternary ammonium compounds. Benzyl chloride is produced commercially by the photochlorination of toulene, and is available both in technical and refined grades. Estimated total annual production in 1972 was 36 million kg (400,000 tons) of which 80% was used in the manufacture of benzyl butyl phthalate and benzyl butyl alcohol. Federal regulations require the reporting of spills of benzyl chloride if they exceed 100 lbs (45.5 kg). North Carolina requires the reporting of all spills if they occur near water.

Health Effects

ACUTE. Benzyl chloride is highly irritating to eyes, ears, nose and throat and can cause lung edema. It may also depress the central nervous system.

CARCINOGENICITY. Benzyl chloride produced local sarcomas when injected into rats and is considered a "suspect carcinogen" for humans.

MUTAGENICITY. Benzyl chloride is considered a weak mutagen.

TERATOGENICITY & EMBRYOTOXICITY. No evidence was found to indicate that benzyl chloride causes birth defects or is embryotoxic.

CHRONIC. No data were available.

Occupational Health Regulations

ACGIH — The Threshold Limit Value (TLV) for workroom air is 1 ppm (5 mg/ cu m) as a time-weighted average.

NIOSH — The recommended ceiling limit is 1 ppm (5 mg/cu m) in a 15 minute period.

OSHA — The standard for workroom air is 1 ppm (5 mg/cu m) as a time-weighted average.

Routes of Human Exposure

OCCUPATIONAL. Workers "at risk" include those in the following operations: production of disinfectants, bactericides, perfumes and pharmaceuticals, the making of synthetic tannins and penicillin, and in the production of benzyl acetate, benzyl cyanide, benzyl salicylate and benzyl cinnamate.

AMBIENT. No data were available regarding the occurrence of benzyl chloride in the ambient environment.

CONSUMER. No data available. Consumer exposure to toxic levels is unlikely.

Recommended Reviews

Van Oetting, W. F. (1955). The halogenated aliphatic, olefinic, cyclic, aromatic and aliphatic-aromatic hydrocarbons including the halogenated insecticides, their toxicity and potential dangers. U.S. Department of HEW, Public Health Service Publication #44, Washington, DC., pp 300-302.

FIRST AID AND EMERGENCY RESPONSE INFORMATION

BENZYL CHLORIDE

First Aid (NIOSH/OSHA Pocket Guide to Chemical Hazards, 1978)

Eyes: Wash eyes with large amounts of water, occasionally lifting upper and lower lids. Get medical attention immediately. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH BENZYL CHLORIDE.

Skin: Wash contaminated skin with soap and water. If chemical soaks through clothing, immediately remove the clothing and wash the skin with soap and water. Get medical attention promptly.

Inhalation: If large amounts are inhaled, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention immediately.

Ingestion: Have affected person vomit by touching the back of the throat with his finger or by giving him syrup of ipecac. Seek immediate medical attention.

Procedures for Spills and Leaks (U.S. DOT Emergency Response Guidebook, 1980)

Isolate hazard area and deny entry. Stay upwind and keep out of low areas. Wear positive pressure breathing apparatus and special protective clothing. Do not touch spilled material. Stop leak if it can be done without risk. Use waterspray to reduce vapors.

SMALL SPILLS: Take up with sand, or other noncombustible absorbent material, then flush area with water.

LARGE SPILLS: Dike far ahead of spill for later disposal.

Fire and Explosion Information

This substance may burn, but it does not ignite readily. Benzyl chloride is a dangerous disaster hazard since it will react with water or steam to produce toxic and corrosive fumes.

FLASH POINT: 140°F
SMALL FIRES: Dry chemical, CO_2
LARGE FIRES: Foam, CO_2

Move containers from fire area if it can be done without risk. Cool containers that are exposed to flames with water from the side until well after fire is out.

Reactivity

MATERIALS TO AVOID: Active metals: copper, aluminum, magnesium, iron, zinc, tin; strong oxidizers

Protective Measures

PROTECTIVE EQUIPMENT: At levels up to 10 ppm, wear a chemical cartridge respirator with an organic vapor cartridge and an acid gas cartridge with a full facepiece or a supplied-air respirator with a full facepiece or a self-contained breathing apparatus with a full facepiece. For escape from a contaminated area, wear a gas mask with an organic vapor cartridge and an acid gas cartridge with a full facepiece or a self-contained breathing apparatus with a full facepiece.

BENZYL CHLORIDE

Profile

Chemical Identification

Alternative Names:

Chloromethylbenzene
Chlorophenylmethane
alpha-Chlorotoluene
Toluene, alpha-Chloro-
Tolyl Chloride

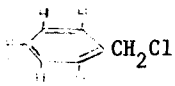
Chemical Abstract Services (CAS) Registry Number: 00100-44-7

Regsitry of Toxic Effects of Chemical Substances (RTECS) Number: XS 8925000

Hazardous Materials Table Identification Number: U 1738

Molecular Weight: 126.59

Molecular Formula: C_7H_7Cl

Structure: 

Classification: A chlorinated hydrocarbon

Description: A very refractive liquid with a rather unpleasant irritating odor

Use: Manufacturing of benzyl compounds, perfumes, pharmaceutical products, dyes, synthetic tannings and resins.

Chemical/Physical Data

Boiling point: 179°C
Melting point: -43°C
Vapor pressure: 1 mm Hg at 22°C
Solubility in water: 0.0033% at 20°C
Estimated half-life in water (Hydrolysis): 15 hours (NIOSH, 1978)
Log octanol/water partition coefficient: 2.30 (Radding, 1977)
Bioaccumulation in aquatic organisms: none
Odor threshold in air: 0.0016 mg/cu m

HUMAN TOXICITY

The human TCLo for inhalation of benzyl chloride has been found to be 16 ppm. This level of exposure was found to be intolerable within 1 minute. Benzyl chloride is highly irritating to eyes, ears, nose, and throat and can cause lung edema. It may depress the central nervous system (CHIP, 1978).

The maximum level at which one could escape within 30 minutes without any escape-impairing symptoms or irreversible effects is suggested to be 10 ppm (NIOSH, 1978).

Carcinogenicity

U.S. EPA, CAG, 1980: Benzyl chloride was tested in mice by intraperitoneal injection and in rats by subcutaneous injection. It was carcinogenic in rats, in which it produced local sarcomas.

IARC, 1979: Positive for animals

Mutagenicity

U.S. EPA, CAG, 1980: Benzyl chloride has been found to be mutagenic in four laboratories.

CHIP, 1978: Benzyl chloride has been found to be weakly mutagenic in Salmonella typhimurium (TA100) after treatment with 2 mg benzyl chloride per plate in the Salmonella/microsome test.

NTP, 1980: Mutagenesis Salmonella typhimurium test result: weak positive

Teratogenicity & Embryotoxicity

No evidence was found to indicate that benzyl chloride causes birth defects or is embryotoxic.

ANIMAL TOXICITY

Irritation of the mucous membranes and conjunctivitis were observed in rats exposed to 100-1000 mg/cu m for 2 hours. Benzyl chloride is a strong skin sensitizing agent for guinea pigs, and can cause leucopenia (IARC, 1976).

Acute Toxicity

Results of lethal studies in several species as reported in the RTECS, 1982 are listed below:

Route	Species	Lethal Dose or Lethal Concentration
Oral	Rat	1231 mg/kg, LD50
	Mice	1624 mg/kg, LD50
Inhalation	Rat	150 ppm for 2 hours, LC50
	Mice	80 ppm for 2 hours, LC50

Aquatic Toxicity

Aquatic toxicity rating: TLm 96 is 1-10 ppm (RTECS, 1982)

ENVIRONMENTAL DATA

Air

No data were available on the occurrence of benzyl chloride in the ambient atmosphere. Although benzyl chloride is reactive with the OH radical and probably degrades in the atmosphere,

estimates of its half-life in air vary considerably (Radding, 1977; Cuppitt, 1980).

Water
No data available regarding occurrence. Benzyl chloride hydrolizes in water and has an aquatic half-life of 15 hours (Radding, 1977). Accumulation is unlikely.

Soil
Because of its general reactivity and the likelihood of volatilization, benzyl chloride is not regarded as persistent in soils. There are insufficient data to assess accumulation.

Biota
Benzyl chloride is metabolized in higher animals (rats and mice). Its reactivity with water makes bioaccumulation and magnification unlikely.

Other
Benzyl chloride has been used as an irritant gas in chemical warfare (IARC, 1976).

INDUSTRIAL DATA

Production

No production in North Carolina reported in the Toxic Substance Control Act (TSCA) Chemical Substances Inventory (U.S. EPA, TSCA, 1980).

Total U.S. production was estimated to be 36 million kg (40,000 tons) in 1972 (IARC, 1976).

Consumption and Use

Estimated U.S. Consumption:

Benzyl butyl phthalate	67 percent
Benzyl butyl alcohol	13 percent
Quaternary amines	12 percent
Other uses	8 percent

(U.S. EPA, CHIP, 1980)

Reported uses of benzyl chloride and the corresponding SIC codes are listed below:

Production of organic chemicals	2869
Raw material for disinfectants, pharmaceuticals, and perfumes	283, 284
Gasoline additive	29

(U.S. EPA, CHIP, 1980)

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air

Under evaluation for possible designation as a Hazardous Air Pollutant by the U.S. Environmental Protection Agency.

Workroom Air

ACGIH — The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists ACGIH) for workroom air is 1 ppm (5 mg/cu m) as a time-weighted average.

NIOSH — The National Institute of Occupational Safety and Health (NIOSH) recommends a ceiling limit of 1 ppm (5 mg/cu m) in a 15 minute period.

OSHA — The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 1 ppm (5 mg/cu m) as a time-weighted average.

Water
Designated a hazardous substance by the U.S. Environmental Protection Agency.

Other
Regulated as a hazardous material by the U.S. Department of Transportation. The regulations pertain to the identification and transportation of hazardous materials in commerce (Code of Federal Regulations, Title 49, Part 172.101). Benzyl chloride is classified as a corrosive material, and shipments must carry a label which reads "Corrosive".

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Agencies Concerned with this Chemical

Chemical Hazard Information Profile (CHIP) compiled by the Office of Testing and Evaluation, U.S. Environmental Protection Agency.

Appears on the 1977 Priority List of the Chemical Industry Institute of Toxicology (CIIT).

Subject of a Risk Assessment Document prepared by the Carcinogen Assessment Group (CAG) of the U.S. Environmental Protection Agency.

Subject of a monograph prepared by the International Agency for Research on Cancer (IARC).

Subject to a proposed rule under the Toxic Substances Control Act that would require all chemical manufacturers to report production and exposure-related data to the U.S. Environmental Protection Agency (Federal Register, Vol. 45, No. 42, 1980).

Under toxicological evaluation through the National Toxicology Program to determine carcinogenicity (National Toxicology Program, Fiscal Year 1981 Annual Plan, NTP 80-62, 1980).

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Callahan, M. A., et al. Water-Related Fate of 129 Priority Pollutants. U.S. EPA Office of Water Planning and Standards, Washington, DC, EPA 440/4-79-029 (December 1979).

Cupitt, L. T. Fate of Toxic and Hazardous Materials in the Air Environment. EPA600/3-80-084, NTIS PB-221948 (September 1980).

International Agency for Research on Cancer (IARC). IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon, France, Volume 19. A World Health Organization Publication (WHO), Geneva (1979).

National Institute for Occupational Safety and Health/Occupational Safety and Health Administration (NIOSH/OSHA). NIOSH/OSHA Pocket Guide to Chemical Hazards. DHEW (NIOSH) Publication No. 78-210 (September 1978).

National Institute for Occupational Safety and Health. National Occupational Hazard Survey. Available from Division of Technical Services. Cincinnati, OH, DHEW 74-127, 77-123, and 78-114 (1980).

Radding, S., et al. Review of the Environmental Fate of Selected Chemicals. Prepared for the U.S. Environmental Protection Agency. Available from the National Technical Information Service, Springfield, VA, PB 267-121 (1977).

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfiche Issue, R. J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville, MD, for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 80-111-4 (1980).

U.S. Environmental Protection Agency, Carcinogen Assessment Group (CAG). Carcinogen Assessment Group's Preliminary Risk Assessment on Benzyl Chloride. Washington, DC (February 11, 1980).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Chemical Hazard Information Profiles (CHIPs). EPA-560/11-80-011 (1980).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA, PB-80-155-153 (1980).

Verschueren, Karel. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York, NY (1977).

BIPHENYL

Executive Summary

CAS NUMBER 00092-52-4

Biphenyl is a monosubstituted benzene hydrocarbon. It forms white or colorless crystals and has a pleasant odor. Biphenyl is produced by thermal dehydrogenation of benzene. North Carolina requires reporting of all spills of biphenyl if they occur near water.

Health Effects

ACUTE. Biphenyl is toxic to the central nervous system, the peripheral nervous system and the liver. Exposure at concentrations up to 123 mg/cu m and as low as 15 mg/cu m resulted in central and peripheral nerve damage and liver injury. One worker has died from acute yellow atrophy of the liver following heavy exposure to biphenyl for 11 years. Symptoms of poisoning include headache, diffuse gastrointestinal pain, nausea, indigestion, numbness and aching of limbs and general fatigue.

CARCINOGENICITY. Biphenyl is reported to produce neoplastic effects in mice when administered subcutaneously at 46 mg/kg. No other indication of carcinogenic potential has been reported.

MUTAGENICITY. Biphenyl was negative in the Salmonella typhimurium assay.

TERATOGENICITY & EMBRYOTOXICITY. No evidence was found to indicate that biphenyl causes birth defects or is embryotoxic.

CHRONIC. Symptoms of chronic exposure are rare, and include fatigue, headache, tremor, insomnia, sensory impairment and mood changes.

Occupational Health

The American Conference of Governmental Industrial Hygenists has established a Threshold Limit Value for workroom air (time-weighted average concentration under which it is believed that all workers may be repeatedly exposed day after day without adverse effect) of 0.2 ppm (1.5 mg/cu m). The recommended Short Term Exposure Limit (the maximum concentration to which workers may be exposed for a period up to 15 minutes) is 0.6 ppm (4 mg/cu m).

Routes of Human Exposure

OCCUPATIONAL. Because of its high thermal stability, biphenyl is used as a heat transfer agent. It is used in the manufacture of organic chemicals, including polychlorinated biphenyls, and as a fungistat in the shipping of citrus fruit. Production of biphenyl-impregnated fruit-wrapping paper under poor hygienic conditions has led to the poisoning of workers.

AMBIENT. An urban air concentration of 103 ug/1000 cu m was reported for one sample taken in Providence, RI. A rural air concentration of 11.3 ug/1000 cu m was reported for one sample taken in Kingston, RI.

Biphenyl has been detected in one sample from Chattanooga Creek at an estimated concentration of 2.0 ppb (2.0 ug/l). It has also been detected in combined water and sediment samples in the Tennessee River below a chemical plant complex at a concentration of 37 ug/l.

CONSUMER. Biphenyl has been detected in finished drinking water samples.

Environmental Significance

Estimated half-life in water is 7.52 hours based on evaporative loss from water at 25°C. A bioconcentration factor of 436 has been calculated based on the octanol/water coefficient.

North Carolina Production and Users

Production:	Chemol, Inc., Greensboro: 500-5,000 tons/year; Morganton Plastics, Morganton: 0.5-5.0 tons/year
Users:	No information available

Recommended Reviews

Occupational Health Guidelines for Diphenyl. NIOSH/OSHA Occupational Health Guidelines for Chemical Hazards, Volume I, Janaury 1981.

Diphenyl poisoning in fruit paper production, I. Hakkinen, et al., Archives of Environmental Health 26:70 (1973).

FIRST AID AND EMERGENCY RESPONSE INFORMATION

BIPHENYL

First Aid (NIOSH/OSHA Pocket Guide to Chemical Hazards)

Eyes: Wash with large amounts of water immediately, occasionally lifting upper and lower lids. Seek medical attention immediately. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH BIPHENYL.

Skin: Flush the contaminated skin immediately with water. Remove clothing if contaminated and flush skin.

Inhalation: Move to fresh air at once. Perform artificial respiration if necessary. Seek immediate medical attention.

Ingestion: Do not induce vomiting. Get medical attention immediately.

Procedures for Spills and Leaks (U.S. DOT Emergency Response Guidebook, 1980)

Isolate hazard area and restrict entry. Remove all ignition sources. Wear positive pressure breathing apparatus and special protective clothing. Do not touch spilled material. Stop leak if it can be done without risk.

SMALL SPILLS: Take up with sand or other noncombustible absorbent material.

LARGE SPILLS: Dike far ahead of spill for later disposal.

Fire and Explosion Information

FLASH POINT: 113°C (235°F) (closed cup)
AUTOIGNITION TEMPERATURE: 535°C (1004°F)
FLAMMABLE LIMITS: Lower - 0.6% at 111°C (212°F); upper 5.8% at 155°C (311°F)
EXTINGUISHER: Water, dry chemical, carbon dioxide, foam.

Reactivity

MATERIALS TO AVOID: Contact with oxidizers may cause fires and explosions.

Protective Measures

ENGINEERING CONTROLS: Provide adequate ventilation. Eye wash stations, sinks and shower should be available.

PROTECTIVE CLOTHING (Not to be substituted for proper engineering and handling controls): Wear rubber coated overalls, gloves and chemical goggles.

PROTECTIVE EQUIPMENT: At levels up to 10 mg/cu m, wear a chemical cartridge respirator with an organic vapor cartridge, or a dust and mist respirator; or a self-contained breathing apparatus with a supplied-air respirator. At levels up to 300 mg/cu m, wear a powered air-purifying respirator with an organic cartridge, a high-efficiency particulate filter and a full facepiece. For escape from a contaminated area, wear a gas mask with an organic vapor canister and particulate filter.

BIPHENYL

Profile

CHEMICAL IDENTIFICATION

Alternative Names:
Bibenzene
1,1'-Biphenyl
Diphenyl
1,1'-Diphenyl
Lemonene
Phenador-X
Phenylbenzene
PHPH
Xenene

Chemical Abstract Services (CAS) Registry Number: 00092-52-4

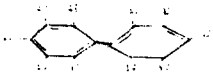
Registry of Toxic Effects of Chemical Substances (RTECS) Number: DU 8050000

Hazardous Materials Table Identification Number: Not applicable

RCRA Identification Number: None

Molecular Weight: 154.22

Molecular Formula: $C_{12}H_{10}$

Structure: 

Classification: Monosubstituted benzene hydrocarbon.

Description: White or colorless crystalline solid with a pleasant odor.

Uses: As a chemical intermediate and fungistat.

Chemical/Physical Data

Boiling point: 254-255°C
Melting point: 69-71°C
Vapor pressure: 1 mm at 71°C
Vapor density: 5.31 (Air = 1.0)
Solubility: Insoluble in water, soluble in organic solvents (Merck, 1976)

HUMAN TOXICITY

Poor hygienic conditions in a paper mill led to the death of one worker and poisoning of eight others. Concentrations in air averaged 15 to 35 mg/cu m and ranged as high as 128 mg/cu m over an 11 year period. Exposures resulted in central and peripheral nerve damage and liver injury. Cause of death was acute yellow atrophy of the liver. Neurological findings among other workers in the mill showed electroencephalographic and electromyographic abnormalities.

In another study transient nausea, vomiting and bronchitis were observed in workers exposed to biphenyl vapors.

Sittig (1979) has described symptoms of exposure.

Systemic -- In acute exposure, biphenyl exerts a toxic action on the central nervous system, on the peripheral nervous system, and on the liver. Symptoms of poisoning are headache, diffuse gastrointestinal pain, nausea, indigestion, numbness and aching of limbs, and general fatigue. Liver function tests may show abnormalities. Chronic exposure is characterized mostly by central nervous system symptoms including fatigue, headache, tremor, insomnia, sensory impairment, and mood changes. However, such symptoms are rare, however.

The maximum level at which one could escape within 30 minutes without any escape-impairing symptoms or irreversible effects is suggested to be 300 mg/cu m (NIOSH/OSHA, 1978). TCLO for humans (route of administration: inhalation), found by NIOSH (1976) is 4400 ug/cu m.

Carcinogenicity

No information on carcinogenic potential was found.

Mutagenicity

Mutagenesis Salmonella typhimurium test result: Negative (NTP, 1980).

Teratogenicity and Embryotoxicity

No evidence was found to indicate that biphenyl causes birth defects or is embryo toxic.

ANIMAL TOXICITY

Limited animal data for biphenyl are reported. Biphenyl is converted to hydroxy derivatives in rats following ingestion (ACGIH, 1980).

Acute Toxicity

Results of lethal studies are listed below:

Route	Species	Lethal Dose	Reference
Oral	Rat	3,280 mg/kg, LD50	NIOSH, 1976
	Rabbit	2,410 mg/kg, LD50	NIOSH, 1976
Dermal	Rabbit	2,500 mg/kg, LD50	ACGIH, 1980

Chronic Toxicity

Chronic inhalation studies have been conducted on rats, rabbits, and mice. Results are summarized below:

Inhalation by rats of biphenyl dust (impregnated on diatomaceous earth) at a concentration of 300 mg/cu m for 64 days, seven hours per day, caused irritation of

the nasal mucosa, labored breathing with bronchopulmonary lesions and slight toxic effects on liver and kidneys. Five rats died between the 29th and 49th days of exposure. Rabbits were unaffected, but mice exposed at only 5 mg/cu m for this period showed signs of respiratory difficulty. Rats at this concentration were not affected (ACGIH, 1980).

Aquatic Toxicity

Bioaccumulation: A bioconcentration factor of 436 has been calculated based on the octanol/water partition coefficient (Verschueren, 1977).

Biodegradation in aquatic species: No reports were found.

Phytotoxicity

Data on phytotoxicity from air pollution were not found.

Data on aquatic plants were not found.

ENVIRONMENTAL DATA

Air

Biphenyl has been reported at a concentration of 103 ug/cu m in an urban area (Providence, RI), and 11.3 mg/cu m in a rural area (Kinston, RI) (Krstolovic, 1977). There are no data available regarding the half-life or atmospheric residence time of this substance. Some accumulation can be inferred from elevated concentrations found in urban areas. Some dispersion is associated with the particulate phase of biphenyl in this medium.

Water

Biphenyl has been detected in finished drinking water samples (Shackelford and Keith, 1976) and in one sample from Chattanooga Creek at an estimated concentration of 2.0 ppb (2.0 ug/l) (Ewing et al., 1977). This substance has an estimated half-life in water of 7.52 hours calculated on evaporative loss, and is not considered persistent.

Soil

Biphenyl has been detected in combined water and sediment samples in the Tennessee River below a chemical plant complex at a concentration of 37 ug/l (Goodley and Gordon, 1976). This substance is degraded by soil microorganisms. Some dispersion by particulates, soils or sediments can be expected.

Biota

Degradation has been reported for rats and bacteria (Verschueren, 1977). Biphenyl also can be metabolized, reducing the likelihood of biomagnification. Based on its partition coefficient of 4.09 (Verschueren, 1977), some accumulation is expected in this medium.

INDUSTRIAL DATA

Production

Production in North Carolina was reported by two companies in the Toxic Substances Control Act (TSCA) Chemical Substance Inventory:

Chemol, Inc., Greensboro: 500-5,000 tons/year
Morganton Plastics, Morganton: 0.5-5.0 tons/year
(U.S. EPA, TSCA Inventory, 1980)

Estimated production in the U.S. in 1975 was 24,000 tons (TDB, 1982).

Consumption and Use

Specific U.S. consumption figures were not found.

Reported uses of biphenyl and the corresponding SIC codes are listed below:

	SIC	Reference
As a heat transfer agent		Merck, 1976
Fungistat in oranges (applied to shipping containers and wrapping paper)	2641	
Manufacture of organic chemicals	28	
Intermediate for polychlorinated biphenyls	2869	TDB, 1982

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air

No guidelines for air have been established.

Workroom Air

ACGIH — The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygenists (ACGIH) for workroom air is 0.2 (1.5 mg/cu m) as a time-weighted average. The recommended Short Term Exposure Limit (STEL) is 0.6 (4 mg/cu m).

OSHA — The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 0.2 ppm (1.5 mg/cu m) as a time-weighted average.

Water

No guidelines for water have been established.

Agencies Concerned with this Chemical

Under review by the Interagency Testing Committee for possible recommendation for priority consideration by the U.S. Environmental Protection Agency (Federal Register, Vol. 45, No. 196, 1980).

Subject to a proposed rule under the Toxic Substances Control Act. (Federal Register, Vol. 45, No. 42, 1980).

Under toxicological evaluation through the National Toxicology Program to determine microbial mutagenesis (National Toxicology Program, Fiscal Year 1980 Annual Plan, NTP-79-7, 1979).

REFERENCES

American Conference of Governmental Industrial Hygenists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Ewing, B. B., E. S. K, Chian, and J. C. Cook. Monitoring to Detect Previously Unrecognized Pollutants in Surface Waters: Organic Analysis Data. Prepared by Illinois University at Urbana-Champaign for Environmental Protection Agency. Available from National Technical Information Service, Springfield, VA. PB 273-349 (1977).

Goodley, P. C., and M. Gordon. Characterization of Industrial Organic Compounds in Water. Kentucky Academy of Science, 37(1-2), 11-15 (1976).

Krstulovic, A. M., D. M. Rosie, and P. R. Brown. Distribution of Some Polynuclear Aromatic Hydrocarbons. American Laboratory, 11-18 (1977).

Merck Index: An Encyclopedia of Chemicals and Drugs, Ninth Edition, M. Windholz, Ed. Merck and Co., Rahway, NJ (1976).

National Institute for Occupational Safety and Health/Occupational Safety and Health Administration (NIOSH/OSHA). NIOSH/OSHA Pocket Guide to Chemical Hazards. DHEW (NIOSH) Publication No. 78-210 (September 1978).

National Toxicology Program (NTP). Fiscal Year 1981 Annual Plan. NTP-80-62 (1980).

Shackelford, W. M., and L. H. Keith. Frequency of Organic Compounds Identified in Water. EPA-600/4-76-062 (December 1976).

Sittig, M., Ed. Hazard and Toxic Effects of Industrial Chemicals. Noyes Data Corporation, Park Ridge, NJ (1979).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA PB-80-155-153 (1980).

Verschueren, Karel. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York, NY (1977).

Executive Summary

CAS NUMBER: 00542-88-1

bis(Chloromethyl) ether (BCME) is a highly reactive, volatile, colorless liquid with a suffocating odor. BCME is not generally produced for resale, but is used mainly as a chemical intermediate. No federal regulations exist for the reporting of BCME spills. North Carolina requires the reporting of all spills near water.

Health Effects

ACUTE. BCME is a severely irritating chemical to the skin, eyes and mucous membranes. When inhaled at concentrations of 100 ppm, BCME has caused death. Inhalation at non-fatal levels can cause lung edema and secondary pneumonia.

CARCINOGENICITY. BCME is classified as a positive human carcinogen. There is strong suggestive evidence for BCME causing oatcelled carcinomas of the lung in a small population of lab workers.

BCME has been found to be carcinogenic in mice and rats via inhalation, dermal and subcutaneous routes. Oral exposure to BCME has not been studied.

MUTAGENICITY. BCME was found to be mutagenic in bacterial systems without metabolic activation, indicating that they are direct-acting mutagens.

TERATOGENICITY & EMBRYOTOXICITY. No evidence was found to indicate that BCME causes birth defects or is embryotoxic.

CHRONIC. All chronic studies have been concerned with BCME's cancer-causing potential.

Occupational Health

The American Conference of Governmental Industrial Hygienists has established a Threshold Limit Value for workroom air of 1 ppb (4.71 ug/cu m).

Routes of Human Exposure

OCCUPATIONAL. Occupations with potential for exposure to BCME include laboratory workers, ion-exchange resin makers and specific organic chemical plant workers. There is also potential exposure in workplaces where hydrochloric acid and formaldehyde may coexist. Trace amounts have been found in the textile industry, laboratories, and particle-board and paper manufacturing plants.

AMBIENT. BCME does not exist, as such, in nature. Exposure seems limited to occupational settings. However, it is reportedly stable in moist air and may be present in exhaust gases.

CONSUMER. BCME is a chemical intermediate and not a component of any final product. There should be little consumer exposure.

Environmental Significance

The estimated half-life of BCME in moist air is 25 minutes. The estimated half-life in water is 10-40 minutes. Bioaccumulation is unlikely.

Recommended Reviews

Ambient Water Quality Criteria for Chloroalkyl Ethers. Environmental Protection Agency, Washington, DC (October 1980).

IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals To Man: Some aromatic amines, hydrazine and related substances, n-nitroso compounds and miscellaneous alkylating agents, Vol. 4, p. 231238. International Agency for Research on Cancer (1979).

FIRST AID AND EMERGENCY RESPONSE INFORMATION

BIS (CHLOROMETHYL) ETHER

First Aid

Eyes: Irrigate immediately with large amounts of water, occasionally lifting upper and lower lids. Seek medical attention immediately. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH THIS CHEMICAL.

Skin: Wash contaminated skin with water. If the chemical soaks through the clothing, promptly remove the clothing and wash the skin with water. If irritation persists after washing, get medical attention.

Inhalation: Move the exposed person to fresh air immediately. If breathing has stopped, perform artificial respiration. Keep the person warm and at rest. Get medical attention as soon as possible.

Ingestion: Immediately get medical attention. If medical attention is not immediately available, induce vomiting by having him touch the back of this throat with his finger or by administering syrup of ipecac.

Procedures for Spills and Leaks

Isolate hazard area and restrict entry. Stay upwind and out of low-lying areas. Wear chemical cartridge respirator and protective clothing. Isolate for ½ mile in all directions if tank or tankcar is involved. No flares, smoking or flames in hazard area. Do not touch spilled material. Stop leak if it can be done without risk. Use water spray to reduce vapors.

SMALL SPILLS: Take up with sand or other non-combustible material, then flush area with water.

LARGE SPILLS: Dike far ahead of spill for later disposal.

Fire and Explosion Information

Details of fire and explosion hazard for BCME are unknown. Common ethers are easily ignited, have low flash points and are a dangerous explosion hazard when heated or exposed to flame or sparks. Also, ethers tend to form peroxides upon standing and when ethers containing peroxides are heated they can detonate.

EXTINGUISHER:

Small fires: dry chemical, CO_2, water spray or alcohol foam.

Large fires: water spray, fog or alcohol foam

Reactivity

MATERIALS TO AVOID: Reacts with acids or acid fumes to form highly toxic chloride fumes.

CONDITIONS TO AVOID: When heated decomposes to form highly toxic chloride fumes. Some organic chlorides decompose to form phosgene gas.

Protective Measures

Meticulous housekeeping and personal cleanliness are important. Annual physical examinations, including x-rays, should be required of all exposed personnel.

STORAGE AND HANDLING: Storage facilities should be cool and clean.

ENGINEERING CONTROLS: Adequate ventilation or an entirely enclosed system should be employed. Showers, sinks and eyewash stations should be available.

PROTECTIVE CLOTHING (Should not be substituted for proper handling and engineering controls): Wear appropriate clothing to prevent repeated or prolonged exposure. If there is a reasonable possibility of eye contact, goggles should be worn. Immediately remove any clothing that becomes wet to avoid flammability hazard.

PROTECTIVE EQUIPMENT: For levels above allowable, use a chemical cartridge respirator.

BIS (CHLOROMETHYL) ETHER

Profile

Chemical Identification

Alternative Names:

BCME	Dichlorinated methyl oxide
Bis-CME	1,1-Dichloro-dimethyl ether
Chloromethyl ether	Dichloromethyl Ether
Chloro(chloromethoxy) methane	Sym-dichloromethyl ether

Chemical Abstract Services (CAS) Registry Number: 00542-88-1

Registry of Toxic Effects of Chemical Substances (RTECS) Number: KN1575000

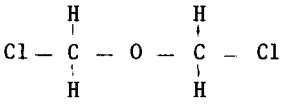
Hazardous Materials Table Identification Number: None

RCRA Identification Number: None

Molecular Weight: 114.96

Molecular Formula: $C_2H_4Cl_2O$

Structure:



Classification: Halogenated ether

Description: Highly reactive, colorless volatile liquid with a suffocating odor.

Uses: Chemical Intermediate

Chemical/Physical Data

Boiling point: 106°C
Melting point: -41.5°C
Vapor pressure: 30 torr at 22°C
Specific gravity: 1.315
Vapor density: 4.0 (air = 1.0)
Estimated half-life in air (moist): 25 minutes
Estimated half-life in water: 10-40 seconds
Hydrolysis: 38 seconds
Log octanol/water partition coefficient: -0.38 (EPA, WQC, 1980)
Bioaccumulation in aquatic organisms: not significant; unlikely food chain transfer

HUMAN TOXICITY

BIS(Chloromethyl)ether (BCME) is a severely irritating chemical to the skin, eyes and mucous membranes. When inhaled at a concentration of 100 ppm, BCME has caused death (TDB, 1982). Inhalation at non-fatal levels can cause lung edema and secondary peumonia (Radding, et.al., 1977). BCME may cause death or permanent injury after very short exposure to small quantities (TDB, 1982).

Carcinogenicity

IARC, 1979 — BCME is classified as a positive human carcinogen. BCME is carcinogenic to mice via inhalation, dermal, and subcutaneous routes. It is also carcinogenic in the rat via inhalation and subcutaneous routes. In humans there is strong suggestive evidence for BCME causing oat-celled carcinomas of the lung in a small population of lab workers.

WQC, 1980 — BCME has been shown to be carcinogenic in animals following inhalation or dermal exposure. In an inhalation study, BCME induced malignant tumors in the respiratory tract of male Sprague Dawley rats. Application of BCME to mouse skin induced skin tumors, while sub-cutaneous injection of BCME to newborn ICR Swiss random-bred mice induced pulmonary tumors. There were no cancer studies reported using oral administration of BCME.

Mutagenicity

WQC, 1980 — BCME was found to be mutagenic in bacterial systems without metabolic activation, indicating that they are direct-acting mutagens.

Teratogenicity & Embryotoxicity

No evidence was found to indicate that bis(chloromethyl)ether causes birth defects or is embryotoxic.

ANIMAL TOXICITY

Acute Toxicity

Results of lethal studies in several species as reported in TDB, 1982 are listed below:

Route	Species	Lethal Dose or Lethal Concentration
Oral	Rat	210 mg/kg, LD50
Inhalation	Rat	7 ppm for 7 hours, LC50
	Mouse	25 mg/cu m for 6 hours, LC50
	Hamster	7 ppm for 7 hours, LC50
Dermal	Rabbit	280 mg/kg, LD50

Death due to inhalation of vapors is often delayed, occurring several days to several weeks after exposure (Radding, et. al., 1977).

Chronic Toxicity

Results of chronic toxicity studies for several species as reported in TDB, 1982 are listed below:

Route	Species	Dose/Concentration	Effect
Inhalation	Rat	100 ppm/6 hr/4 wks - intermit	carcinogenesis
	Mouse	5 mg/cu m/82 days	neoplastic effects
Dermal	Mouse	5520 mg/kg/23 wks - intermit	neoplastic effects

Aquatic Toxicity

The U.S. EPA Water Quality Criteria (1980) for protection of aquatic life are given below:

> The available data for chloroalkyl ethers indicate that acute toxicity for freshwater aquatic life occurs at concentrations as low as 238 mg/l and would occur at lower concentrations among species that are more sensitive than those tested. No definitive data are available concerning the chronic toxicity of chloroalkyl ethers to sensitive freshwater aquatic life. No saltwater organism has been tested with any chloroalkyl ether and no statement can be made concerning acute or chronic toxicity.

The average bioconcentration factor for aquatic organisms of BCME is 0.63 (EPA, WQC, 1980).

Phytotoxicity

No data are available on the effects of any chloroalkyl or any aquatic plants (EPA, WQC, 1980).

ENVIRONMENTAL DATA

Air

There is no information available on the levels of chloroalkyl ethers in the ambient atmosphere. Exposure to BCME appears to be confined to occupational settings (EPA, WQC, 1980). BCME at 10 and 100 ppm was found to be stable in air with 70% relative humidity for at least 18 hours (IARC, 1979). Radding, et al (1977) noted no photochemical degradation for BCME. Due to its reported stability in moist air, it may be present in exhaust gases (TDB, 1982).

Water

bis(Chloromethyl)ether may not, under ordinary conditions, exist in water for periods of time longer than a few hours (EPA, WQC, 1980). BCME decomposes in the presence of water into hydrochloric acid and formaldehyde (IARC, 1979).

Soil

It is probable that the half-life of BCME in soil is comparatively short (Radding, et al, 1977).

Biota

BCME exhibits an average bioconcentration factor of 0.63 (EPA, WQC, 1980). It is probable that the half-life in organisms is compatatively short and that food chain transfer is unlikely (Radding, et al, 1977).

Other

BCME does not exist as such in nature (IARC, 1979), exposure appears confined to occupational settings. At-risk occupations include laboratory workers, ion-exchange resin makers and specific organic chemical plant workers. There is also potential exposure in workplaces where hydrochloric acid and formaldehyde may coexist. Trace amounts have been found in the textile industry, laboratories, and particle board and paper manufacturing plants. Technicians who conduct operations in which this reaction may occur should be protected by suitable ventilation (EPA, WQC, 1980).

INDUSTRIAL DATA

Production

No production in North Carolina is reported in the Toxic Substances Control Act (TSCA) Chemical Substances Inventory (U.S. EPA, TSCA, 1980).

bis(Chloromethyl)ether is a major component of chloromethylating reaction mixtures containing methanol, formaldehyde and hydrochloric acid. It is not generally produced for resale, but it is used as a chemical intermediate (IARC, 1979).

Consumption and Use

Estimated U.S. Consumption: No data available. Reported uses of bis(chloromethyl)ether and the corresponding SIC codes are listed below:

Monitoring indicator for chloromethyl ether	-
Intermediate in anionic exchange strong-base resins	282
(ACGIH, TLV, 1980)	
Intermediate in organic synthesis	28
Manufacture of polymers and insecticides	282, 2897
Treatment of textiles	22
(U.S. EPA, WQC, 1980)	

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air

No ambient air guidelines exist at the present time.

Workroom Air

ACGIH — The Threshold Limit Value (TLV) established by the American Conference of Governmental Hygienists for workroom air is 1 ppb (4.71 ug/cu m) as a time-weighted average. It is classified as a carcinogen by ACGIH (1980).

OSHA — BCME has been included on the Occupational Safety and Health Administration list of restricted chemicals as a carcinogen (U.S. Federal Register, 1974).

Water

Addressed by Ambient Water Quality Criteria, set by the U.S. Environmental Protection Agency. A maximum permissible concentration of BCME in ingested water has been set at 0.038 ng/l. This level should limit human lifetime risk of carcinogenesis from BCME in ambient water to not more than 10^{-5} (U.S. EPA, WQC, 1980).

Agencies Concerned with this Chemical

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Designated a carcinogen by the Occupational Safety and Health Administration (Federal Register, Vol. 39, 1974).

Subject of a monograph prepared by the International Agency for Research on Cancer (IARC).

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

International Agency for Research on Cancer (IARC). IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon France, Volume 19. A World Health Organization Publication (WHO) Geneva (1979).

Radding, S., et al. Review of the Environmental Fate of Selected Chemicals. Prepared for the U.S. Environmental Protection Agency. Available from the National Technical Information Service, Springfield, VA, PB 267 121 (1977).

Toxicology Data Bank - The National Library of Medicine, Bethesda, Maryland (1982).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA PB-80-155-153 (1980).

U.S. Environmental Protection Agency, Office of Water Planning and Standards. Ambient Water Quality Criteria for Chloroalkyl Ethers. EPA-440/5-80-016 (October, 1980).

U.S. Federal Register, Vol. 39, 1974.

CADMIUM

Executive Summary

CAS NUMBER: 07440-43-9

Cadmium is a metallic element in Group IIB of the periodic table. It is a soft, blue-white, malleable metal which occurs in very small amounts throughout the environment. Commercially, cadmium is used in electroplating other metals, in storage batteries, as a plastics stabilizer, and in pigments for dyes, textiles, printing and enamels. Estimated U.S. production of cadmium in 1975 was 1.99 million kg (4.4 million pounds) with an additional 2.30 million kg (5.2 million pounds) in imports. Cadmium is toxic to a variety of physiological systems in humans. Federal regulations require the reporting of spills of cadmium acetate, cadmium bromide and cadmium chloride if they exceed 100 pounds. North Carolina requires the reporting of all spills of these compounds if they occur near water.

Health Effects

ACUTE. Inhalation of cadmium is intensely irritating to the nose and throat, and produces delayed symptoms which includes coughing, chest pains, sweating, chills, shortness of breath and weakness. Ingestion of cadmium results in nausea, vomiting, diarrhea and abdominal pains. Acute intoxication may result in death.

CARCINOGENICITY. Cadmium has been shown to be carcinogenic in animals, producing tumors at the site of injection and a significant increase in the number of tumors at distant sites. Cadmium is suspected of causing prostate cancer in humans as a result of prolonged occupational exposure.

MUTAGENICITY. Cadmium salts increase the frequency of chromosomal mutations and induce in vitro mammalian cellular transformation. These mutagenic effects are correlated with cadmium's ability to induce carcinoogenic effects.

TERATOGENICITY AND EMBRYOTOXICITY. Cadmium has been found to be embryotoxic and teratogenic in experimental animals. The available data suggest that cadmium would not be a significant factor in human teratogenesis.

CHRONIC. Chronic cadmium exposure produced adverse effects in both the kidney and the lungs. The kidney is generally held to be the critical target organ. It is well accepted that chronic cadmium poisoning produces renal tubular damage with subsequent proteninuria and sometimes increased excretion of uric acid. Chronic excessive inhalation of cadmium results in loss of ventilatory capacity with a corresponding increase in residual volume, very similar to the cardinal features of emphysema.

Occupational Health Regulations

ACGIH — The Threshold Limit Value (TLV) for workroom air is 50 µg/cu m as a time-weighted average. The recommended Short Term Exposure Limit (STEL) is 200 µg/cu m.

NIOSH — The time-weighted average for workroom air is 40 µg/cu m and the recommended ceiling limit is 200 µg/cu m for 15 minutes.

OSHA — The recommended standard for workroom air is 200 µg/cu m as a time-weighted average. The ceiling limit is 600 µg/cu m for 15 minutes.

Routes of Human Exposure

OCCUPATIONAL. Workers at risk include those in battery manufacturing, electroplating, alloy production, and those involved in making ceramic and vapor lamps and in welding.

AMBIENT. Ambient exposure is limited to very small concentrations in the atmosphere and drinking water.

CONSUMER. The most significant route of exposure to cadmium for humans is through the ingestion of food; average daily intake for an adult human is 50-90 µg/day, of which 2.5 µg is actually assimilated.

Environmental Significance

The toxicity of cadmium to aquatic life is affected by water hardness. Concentrations below 10 µg/l are considered safe for most freshwater and saltwater life (as a 24 hour average). Cadmium is bioconcentrated by terrestrial and aquatic life.

Recommended Reviews

Fassett, D.W., Cadmium, Metallic Contaminants in Human Health, D.H.K. Lee, Ed., Chapter 4, p. 111, Academic Press, NY (1972).

FIRST AID AND EMERGENCY RESPONSE INFORMATION

CADMIUM

First Aid (NIOSH/OSHA)

	Cadmium Dust (Cd)	Cadmium Fume (CdO)
Eyes:	Wash eyes immediately with large amounts of water, lifting upper and lower lids occasionally. If irritation persists, seek medical attention. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH CADMIUM.	
Skin:	Wash contaminated skin with soap and water.	
Inhalation	Move exposed person to fresh air at air at once. If necessary, perform artificial respiration. Keep affected person warm and at rest. Seek medical attention.	Move exposed person to fresh air at air at once. If necessary perform artificial respiration. Keep affected person warm and at rest. Get medical attention as soon as possible.
Ingestion	If person is conscious, give large amounts of water. Induce vomiting by finger. Get medical attention immediately.	

Spills and Leaks (U.S. DOT Emergency Response Guidebook, 1980)

Isolate hazard area and deny entry. Stay upwind and keep out of low areas. Wear self-contained breathing apparatus and full protective clothing. Do not touch spilled material. Stop leak if it can be done without risk.

SMALL SPILLS: Take up with sand, or other noncombustible absorbent material, then flush area with water.

SMALL DRY SPILLS: Shovel into dry containers and cover; move containers, then flush area with water.

LARGE SPILLS: Dike far ahead of spill for later disposal.

Fire and Explosion Information

May burn, but does not ignite readily. Fire may produce irritating or poisonous gases.

SMALL FIRES: Dry chemical, CO2, water spray or foam.

LARGE FIRES: Water spray, fog or foam

Move containers if it can be done without risk.

Reactivity

MATERIALS TO AVOID: Strong oxidizers; elemental sulfur; selenium, tellurium.

Protective Measures

ENGINEERING CONTROLS: Process enclosure, local exhaust ventilation, personal protective equipment.

PROTECTIVE EQUIPMENT: (For cadmium dust). For levels up to 1 mg/cu m, use any dust respirator, except single-use. For levels up to 2 mg/cu m, use any dust respirator, except single-use or quarter-mask respirator, any high efficiency particulate filter respirator, any supplied-air respirator, or any self-contained breathing apparatus. For levels up to 10 mg/cu m, use a high efficiency particulate filter respirator with a full facepiece, or any supplied-air respirator with a full facepiece, helmet or hood, or any self-contained breathing apparatus with a full facepiece. For levels up to 40 mg/cu m use a powered air-purifying respirator with a high efficiency particulate filter, or a Type C supplied-air respirator operated in pressure-demand or other positive pressure or continuous-flow mode. For levels above 40 mg/cu m or entry and escape from unknown concentrations, use a self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode, or a combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode. (For cadmium fume). For levels up to 1 mg/cu m, use any fume respirator or high efficiency particulate respirator, any supplied-air respirator, or any self-contained breathing apparatus. For levels up to 5 mg/cu m use a high efficiency particulate filter respirator with a high efficiency particulate filter with a full facepiece. For levels up to 40 mg/cu m use a powered air-purifying respirator with a high efficiency particulate, or a Type C supplied-air respirator operated in pressure-demand or other positive pressure or continuous-flow mode. For levels above 40 mg/cu m or entry and escape from unknown concentrations, use a self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode, or a combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.

CADMIUM

Profile

Chemical Identification

Chemical Abstract Services (CAS) Registry Number: 07440-43-9

Registry of Toxic Effects of Chemical Substances (RTECS) Number: EU 98000

Hazardous Materials Table Identification Number: 2570

Molecular Weight: 112.40

Molecular Formula: Cd

Classification: A group IIb element.

Description: A silver-white, blue-tinged lustrous and malleable metal

Uses: In electroplating or machine parts, as a plastics stabilizer, in pigments and miscellaneous uses (batteries, alloys).

Chemical/Physical Data

Boiling point: 765°C
Melting point: 321°C
Vapor pressure: 1 mm Hg at 394°C
Density: 8.65 at 25°C
Solubility in water: insoluble in water, soluble in most acids
Valence state(s): +2

HUMAN TOXICITY

Cadmium exhibits a variety of dose-related toxic effects in all systems studies in humans. Its toxicologic potential is increased by poor or nonexistent homeostatic mechanisms. The degree of toxicity varies widely and is influenced by the route of administration and the compound involved. Cadmium intoxication causes problems in carbohydrate and mineral metabolism, in renal, hepatic, testicular and prostate functions, and disturbs the integrity of the central nervous system. In addition, it also causes poor lactation and lowered hematocrit values (Luckey, 1978).

Inhalation of cadmium dust may cause irritation of the nose and throat. Delayed symptoms include coughing, chest pains, sweating, chills, shortness of breath and weakness. Inhalation of cadmium fumes (CdO) results in similar symptoms. Ingestion of cadmium, particularly as a soluble salt, may cause nausea, vomiting, diarrhea and abdominal cramps. Acute intoxication may result in death (NIOSH, 1981).

Renal damage is the classic syndrome of chronic cadmium poisoning in humans. Clinical symptoms include proteinuria, serum proteins in the urine, and amyloid deposits in the kidney. Repeated or prolonged exposure to cadmium dust may cause loss of sense of smell, ulceration of the nose, emphysema, and mild anemia. Exposure to cadmium has been reported to cause an increase in the incidence of prostate cancer in men (Luckey, 1978).

Average concentrations responsible for fatalities have been estimated at 50 mg/cu m and 40 mg/cu m, both for exposures of one hour; no compound was identified (ACGIH, 1980).

The maximum level at which one could escape within 30 minutes without any escapeimpairing symptoms or irreversible effects is suggested to be 40 mg/cu m (NIOSH, 1978).

Carcinogenicity

U.S. EPA, CAG, 1980 — Injection of cadmium in experimental animals results in the development of malignant tumors (sarcomas) at the site of injection. Following subcutaneous injection of cadmium salts, a significant increase in the number of tumors at distant sites occurred. Orally administered cadmium has not been shown to be carcinogenic in animals, but existing studies are considered deficient and have not been accepted as negative studies.

IARC, 1979 — Cadmium has been classified as a positive animal carcinogen. No excess of any form of cancer was detected in 3 studies of men occupationally exposed to cadmium, but each of these studies was of very small sample size or of insufficient time from onset of exposure to permit statistical evaluation of the carcinogenicity of cadmium.

Mutagenicity

U.S. EPA, CAG, 1980 — "Cadmium salts increase the frequency of point and chromosomal mutations. They induce in vitro mammalian cellular transformation and enhance transformation of virus-infected mammalian cells". These mutagenic effects are correlated with cadmium's ability to induce carcinogenic effects.

Teratogenicity and Embryotoxicity

Cadmium embryotoxicity occurs in experimental rats, mice and hamsters. Cadmium was teratogenic to mice at 10 ppm in the drinking water. In rats, oral doses of 40 mg Cd/kg body weight per day at $CdCl_2$ given on days 6-19 of gestation increased fetal resorption and caused skeletal, kidney and heart abnormalities in fetuses, and stillborn offspring. The dosage and route of

administration in these experiments and the poor dietary absorption suggest that cadmium should not be a significant factor in human teratogenesis (Luckey, 1978).

ANIMAL TOXICITY

Cadmium is toxic to all systems studied in animals, and exhibits a variety of toxic effects which are dose related. Acute toxicity resulting from oral ingestion of cadmium salts produces the following symptoms: excessive salivation, persistent vomiting, abdominal pains, diarrhea, vertigo, loss of consciousness, ulcerative gastroenteritis and subdural hemorrhages. Cadmium has a high toxicologic potential which is enhanced by accumulation in animal tissues (Luckey, 1978).

Acute toxicity

Results of lethal sutdies in several species are listed below:

Route	Species	Lethal Dose or Lethal Concentration (compound wt.)
Oral		
($CdCl_2$)	Rat	88 mg/kg, LD50 (TDB, 1982)
	Rabbit	70 mg/kg, LD100 (TDB, 1982)
(CdF_2)	Guinea Pig	150 mg/kg, LD50
Inhalation		
(CdO)	Monkey	1100 mg/cu m for 4 hours, LD100
($Cd_3(PO_4)_2$)	Mouse	650 mg/cu m for 4 hours, LD100

Chronic Toxicity

Symptoms of chronic cadmium toxicity include growth retardation, impaired kidney function, impaired reproductive function, hypertension, tumor formation, and teratogenic effects. Chronic feeding of cadmium at low levels to rats, lambs and poultry resulted in diminished growth and feed consumption (Luckey, 1978).

Aquatic Toxicity

"For total recoverable cadmium the criterion (in µg/l) to protect freshwater aquatic life is the numerical value given by (1.05(ln(hardness))-8.53) as a 24-hour average, and the concentration (in µg/l) should not exceed the numerical value given by $e^{(1.05(\ln(\text{hardness}))-3.73)}$ at any time. For example, at hardnesses of 50, 100 and 200 mg/l as $CaCO_3$ the criteria are 0.012, 0.025, and 0.051 µg/l, respectively, and the concentration of total recoverable cadmium should not exceed 1.5, 3.0 and 6.3 µg/l, respectively, at any time.

For total recoverable cadmium the criterion to protect saltwater aquatic life is 4.5 µg/l as a 24-hour average, and the concentration should not exceed 59 µg/l at any time.

Bioconcentration factors for fish and crustaceans were generally less than 400, whereas those for bivalve molluscs were above 2,500 in long exposures, with no indication that steady-state was reached. Cadmium mortality is cumulative for exposure periods beyond four days. Chronic cadmium exposure resulted in significant effects on the growth of bay scallops at 78 µg/l and on reproduction of a copepod at 44 µg/l." (EPA, WQC, 1980)

ENVIRONMENTAL DATA

Air

Cadmium is present as a particulate in the ambient atmosphere in very low concentrations. Rural sites report mean concentrations of 0.003 µg/cu m, with 0.014-0.023 µg/cu m mean concentrations found in urban sites. Principal manmade sources of cadmium in the atmosphere are smelter emissions, reprocessing of cadmium-containing metals and the burning of plastics and coal. The importance of atmosphereic cadmium in relation to potential effects on humans lies in its possible contribution to soil, water and vegetation, and not inhalation (Waldron, 1980). The daily assimilation of cadmium from ambient air is estimated to be 0.02 µg/day for humans. Cigarette smoking may increase this amount by up to 2.0 µg/day (Waldron, 1980).

Water

The presence of cadmium in water is extremely low. Seawater levels range from 0.05 ppb to 0.2 ppb with an average concentration of 0.10 ppb. Cadmium was found in only 2.5% of 1,500 raw fresh water samples; the mean concentration in these samples was 9.5 µg/l. Of the 380 finished water samples tested, only one was found to contain cadmium - the concentration in this sample was 12 µg/l (Waldron, 1980). Sewage and industrial water represent important routes of entry into the aquatic environment for cadmium. Human absorption of cadmium from drinking water is estimated at 2.1 µg/day. Photolysis and volatilization are not important processes with regard to the environmental fate of cadmium.

Soil

Cadmium is a rare but widely dispersed metal in the earth's crust, with an average concentration of 0.2 ppm. Levels in soil range from 0.06 ppm in virgin soil to several hundred ppm in the vicinity of some smelters (Waldron, 1980). Sorption to organic materials and clay minerals is significant in reducing the aquatic load and transport velocity of cadmium (Callahan, 1979).

Biota

Cadmium steadily accumulates in the body with normal exposure, reaching a peak level at age 50 of about 30 mg. Approximately 50% of this burden is born by the kidneys and the liver(CAG, 1978). Certain marine plankton and brown algae bioconcentrate cadmium 900-fold; the concentration

factor for freshwater plants is about 1600. Plants generally show increased tissue cadmium levels in response to increases in the environment from normal sources or from soil, water or air contamination. Average dry-weight cadmium content of terrestrial plants was found to be 0.6 ppm (Waldron, 1980). There is little evidence of bioconcentration in food chains.

Other

Cadmium is ubiquitious in the environment, usually in very small amounts. Average daily intake of cadmium for humans from food is estimated to be 50-90 µg/day, of which 2.5 µg is actually assimilated (Waldron, 1980).

Workers are exposed to cadmium dusts and aerosols in battery manufacturing, electroplating, in making alloys and solders, ceramic and vapor lamps and in welding. Approximately 100,000 workers in the U.S. risk potential occupational exposure to cadmium in the workplace (EPA, WQC, 1980).

INDUSTRIAL DATA

Production

No production in North Carolina reported in the Toxic Substance Control Act (TSCA) Chemical Substance Inventory (U.S. EPA, TSCA Inventory, 1980).

Estimated U.S. production of cadmium in 1975 was 1.99 million kg (4.4 million pounds) with an additional 2.38 million kg (5.2 million pounds) in imports. (MEDLARS, DCT, 1981).

Consumption and Use

Estimated U.S. Consumption in 1975:

Metal plating	49 percent
Plastics stabilizers	18 percent
Pigments	14 percent
Miscellaneous	19 percent

(IARC, 1976)

Reported uses of cadmium and the corresponding SIC codes are listed below:

Electroplating metal, primarily steel, for corrosion resistance	347
Production of cadmium salts of big chain fatty acids for use as plastic stabilizers	282
Production of cadmium compounds for use as pigments	2816
Alloys for storage batteries	369
Production of alloys for high speed bearings, easily fused alloys, aluminum solder, Cd-Hg amalgum	34
Deoxidizer in nickel plating, in cadmium vapor lamps, photoelectric cells, photometers	347, 36

Reported uses of cadmium compounds and their corresponding SIC codes are given below:

Pigments and phosphors; chloride, iodide, carbonate, sulfide, sulfate, selenide, telluride, tongstate	2816
Pesticides including nematocides and fungicides (iodide, oxide, succinate, carbonate, nitrate)	2879
Storage batteries and electrodes (hydroxide, oxide)	369
Electrical components, e.g., seminconductors (chloride, oxide iodide, selenide, telluride)	367
Electroplating (acetate, cyanide, iodide, oxide, fluoroborate)	347
Textile dying and printing (acetate, chloride)	223, 226
Photography (bromide, chloride, iodide)	3861
Porcelain and ceramics (acetate, oxide)	326
Mirrors and glass (chloride, oxide, fluoride)	32
Chemical catalyst, reagent (acetate, chloride, iodide, nitrate, oxide, selenide, sulfate, tungstate)	28
Lubricant (chloride)	29
Pharmaceuticals (oxide, salicylate)	283
Xray screens and research equipment (tungstate)	38
Alloys (oxide)	33

(IARC, 1976, Merck, 1976)

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air

No guidelines for ambient air have been established.

Workroom Air

ACGIH — The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air is 50 µg/cu m as a time-weighted average. The recommended Short Term Exposure Limit (STEL) is 200 µg/cu m.

NIOSH — The National Institute of Occupational Safety and Health (NIOSH) recommends a standard of 40 µg/cu m as a time-weighted average and a ceiling limit of 200 µg/cu m for 15 minutes.

OSHA — The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 200 µg/cu m as a time-weighted average. The recommended

Short Term Exposure Limit (STEL) is 600 ug/cu m for 15 minutes.

Water

Addressed by National Interim Primary Drinking Water Regulations set by the U.S. Environmental Protection Agency.

Addressed by Ambient Water Quality Criteria set by the U.S. Environmental Protection Agency.

Designated a toxic pollutant by the U.S. Environmental Protection Agency.

Designated a hazardous substance by the U.S. Environmental Protection Agency.

Other

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Agencies Concerned with this Chemical

Subject of a Risk Assessment Document prepared by the Carcinogen Assessment Group (CAG) of the U.S. Environmental Protection Agency.

Subject of a monograph prepared by the International Agency for Research on Cancer (IARC).

Addressed by a development plan prepared by the Interagency Regulatory Liaison Grup (IRLG).

Addressed by a National Toxicology Program (NTP) Executive Summary and included in the list of 100 compounds nominated for NTP testing.

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Interagency Regulatory Liaison Group (IRLG). Excerpt on Cadmium. Regulator Reporter, Volume II, Issue 1.

International Agency for Research on Cancer. IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon, France, Volume 23. A World Health Organization Publication (WHO), Geneva (1981).

MEDLARS II Toxicology Data Bank (TDB) Record of Cadmium. National Library of Medicine (May 1981).

Michigan Department of Natural Resources, Environmental Protection Bureau. Michigan Critical Materials Register 1980. Hazard Assessment Sheet for Cadmium. Lansing, Michigan (1980).

National Institute of Occupational Safety and Health (NIOSH). Criteria for a Recommended Standard...Occupational Exposure to Cadmium. U.S. Depart ment of Health, Education, and Welfare. DHEW (NIOSH) Publication No. 76-129 (1975).

National Toxicology Program (NTP). Executive Summary for Cadmium. In Executive Summaries of Cadmium Compounds Nominated for FY 81 Testing. U.S. Department of Health, Education, and Welfare, Jefferson, Arkansas (1980).

Occupational Safety and Health Administration (OSHA). Candidate Substance Data Summary Sheet. Chemical: Cadmium Compounds.

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances . Chemical Hazard Information Profiles (CHIPs). EPA-560/11-80-011 (1980).

U.S. Environmental Protection Agency, Carcinogen Assessment Group (CAG). Carcinogen Assessment Group's Preliminary Risk Assessment on Cadmium Compounds, Washington, DC (February 11, 1980).

U.S. Environmental Protection Agency, Office of Water Planning and Standards. Ambient Water Quality Criteria for Cadmium. EPA/440-4-80-016 (October 1980).

Venugopal, and Luckey, 1978 Metal Toxicology in Mammals-2, Plenum Press, New York.

Waldron, H.A. 1980 Metals in the Environment, Academic Press, New York.

CARBON TETRACHLORIDE

Executive Summary

CAS Number: 00056235

Carbon tetrachloride is a colorless liquid with an ether-like odor which has been produced in quantity for many years and used widely for many purposes. Estimated U.S. production in 1976 was 388,000 metric tons. Recent concern about toxicity and potential carcinogenicity has limited the uses of carbon tetrachloride. Federal regulations require the reporting of spills greater than 1000 pounds (454.5 kilograms). North Carolina requires the reporting of all spills if they occur near water.

Health Effects

ACUTE. The most common effects of both acute and chronic carbon tetrachloride poisoning are liver and kidney damage, which in severe cases can be fatal. Exposure may be by ingestion, inhalation, or dermal routes. Alcohol appears to enhance the hepatotoxic effects of carbon tetrachloride.

Restricted visual fields and other eye abnormalities have occurred with average time-weighted exposures of 7 to 24 ppm. Exposure levels of 33 to 124 ppm for 2 hours have caused fatigue. Headache and giddiness are associated with exposures to 45 to 97 ppm carbon tetrachloride.

Carbon tetrachloride is irritating to the skin and can be absorbed by this route. Topical exposure of both hands for 30 minutes is estimated to be equivalent to vapor exposure at 10 ppm for 3 hours.

CARCINOGENICITY. Carbon tetrachloride is an animal carcinogen and there are suggestive case reports of liver cancer in humans. In the absence of adequate data for humans, carbon tetrachloride should be regarded as a potential human carcinogen.

MUTAGENICITY. Little information is available concerning mutagenicity of carbon tetrachloride. It was found not to be mutagenic in the Salmonella typhimurium or Escherichia coli reversion tests.

TERATOGENICITY & EMBRYOTOXICITY. Increased fetal mortality was observed after oral and subcutaneous administration of 150 mg carbon tetrachloride to pregnant animals. Retarded development was observed in the fetuses of rats exposed to 300 ppm and 1,000 ppm for 7 hours per day on days 6-15 of gestation.

CHRONIC. Exposure of animals to 10 ppm of carbon tetrachloride for several weeks or months produced detectable accumulation of fat in the liver.

Carbon tetrachloride, like many other chlorinated hydrocarbons, acts as a central nervous system depressant.

Occupational Health

The American Conference of Governmental Industrial Hygienists has established a Threshold Limit Value for workroom air (time-weighted average concentration under which it is believed that all workers may be repeatedly exposed day after day without adverse effect) of 10 ppm (65 mg/cu m), and a Short Term Exposure Limit (the maximum concentration to which workers may be exposed for a period up to 15 minutes) of 20 ppm (130 mg/cu m). The ACGIH (130 mg/cu m) has published (1979) a notice of intended change in the TLV to 5 ppm (30 mg/cu m) as a time-weighted average with a designation of "industrial substance suspect of carcinogenic potential for man."

Routes of Human Exposure

OCCUPATIONAL. The primary use of carbon tetrachloride is in the manufacture of fluorocarbon propellants (estimated 95 percent or more of U.S. consumption). Other uses, such as grain fumigant, industrial solvent, dry cleaning agent, and other applications were once widespread but are now declining because of the chemical's toxicity.

AMBIENT. Background tropospheric concentration ranges from 0.120-0.140 ppm (0.75 to 0.88 mg/cu m); concentrations are generally higher over urban areas. Air samples taken at 42 locations in the U.S. (1974) contained an average concentration of 1.4 mg/cu m (0.22 ppb) carbon tetrachloride.

Carbon tetrachloride was measured in seawater at 0.72 µg/l in Scripps Institution of Oceanography pier water (excluding rainy season). A level of 2.8 µg/l was measured in rain in La Jolla, CA. Concentrations between 0.3 and 2.8 µg/l are reported in snow in North America. Untreated water reservoir levels average 1.4 µg/l ± 0.009.

CONSUMER. Limited information indicates that carbon tetrachloride is widely distributed in edible fish and various food; typical ranges are 1 to 30 ppb.

Environmental Significance

Estimated oxidative half-life of carbon tetrachloride in air is greater than 2.7 years. Based on decomposition, the estimated half-life in water is 70,000 years.

Bluegills concentrated carbon tetrachloride 30 fold within 21 days. The biological half-life in their tissues was less than 1 day. A bioconcentration factor of 17 is estimated for rainbow trout. Tissue residues are not expected to pose an environmental hazard.

Acute toxicity occurs at concentrations as low as 35 gm/l for freshwater aquatic life and as low as 50 gm/l for saltwater aquatic life. No data are available concerning the chronic toxicity of carbon tetrachloride to sensitive freshwater or saltwater aquatic life.

North Carolina Production and Users

Production: No known producers
Users: No information available

Recommended Reviews

Chloroform, Carbon Tetrachloride and Other Halomethanes, National Academy of Sciences, National Research Council (1978).

FIRST AID AND EMERGENCY RESPONSE INFORMATION

CARBON TETRACHLORIDE

First Aid (NIOSH/OSHA Pocket Guide to Chemical Hazards)

Eyes:	Wash with large amounts of water immediately. CONTACT LENSES SHOUD NOT BE WORN WHEN WORKING WITH CARBON TETRACHLORIDE.
Skin:	Immediately wash the contaminated skin with soap or mild detergent and water. Remove clothing immediately if contaminated and wash skin.
Inhalation:	Move to fresh air at once. Perform artificial respiration if necessary. Seek immediate medical attention.
Ingestion:	Induce vomiting by finger or by giving syrup of ipecac. Seek medical attention.

Procedures for Spills and Leaks (U.S. DOT Emergency Response Guidebook, 1980)

Isolate hazard area and restrict entry. Stay upwind and keep out of low areas. Wear positive pressure breathing apparatus and special protective clothing. Do not touch spilled material; stop leak if you can do it without risk. Use water spray to reduce vapors.

SMALL SPILLS:	Take up with sand, or other noncombustible absorbent material, then flush area with water.
LARGE SPILLS:	Dike far ahead of spill for later disposal.

Fire and Explosion Information

GENERAL: Nonflammable.

Reactivity

CONDITIONS TO AVOID: High temperature. Decomposes to form the highly poisonous and corrosive gases phosgene, hydrochloric acid and chlorine.

MATERIALS TO AVOID: Severe reactions occur with metals such as sodium, potassium and magnesium, oxidizing agents such as permanganates and dichromates, allyl alcohol, and silanes.

Protective Measures

STORAGE AND HANDLING: Protect from physical damage. Store in a cool, dry location away from fire hazards.

ENGINEERING CONTROLS: Provide adequate ventilation, eyewash stations, showers and sinks.

PROTECTIVE CLOTHING (Should not be substituted for proper handling and engineering controls): Splash proof goggles, rubber gloves and boots, and non-absorbent clothing should be worn if contact with carbon tetrachloride is likely.

PROTECTIVE EQUIPMENT: For exposures up to 100 ppm use a supplied-air or self-contained breathing apparatus. For up to 300 ppm use the above with full facepiece. For escape from contaminated area, use self-contained breathing apparatus or gas mask with organic vapor cartridge.

Profile

CHEMICAL IDENTIFICATION

Alternative Names:

Benzinoform	Necatorina
Carbona	Necatorine
Carbon Chloride	Perchloromethane
Carbon Tet	RIO
ENT 4,705	Tetrachlorocarbon
Fasciolin	Tetrachloromethane
Flukoids	Tetrafinol
Freon 10	Tetraform
Halon 104	Tetrasol
Methane Tetrachloride	Univerm
Methane, tetrachloro-	Vermoestricid

Chemical Abstract Services (CAS) Registry Number: 0056-23-5

Registry of Toxic Effects of Chemical Substances (RTECS) Number: FG 4900000

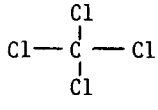
Hazardous Materials Table Identification Number: UN 1846

RCRA Identification Number: U 211, F 001

Molecular Weight: 153.82

Molecular Formula: CCl_4

Structure:



Classification: Alkyl halide; chlorinated hydrocarbon

Description: A colorless, clear, nonflammable liquid with an ethereal odor

Uses: Industrial solvent and extractant, spot remover, dry cleaning agent, pesticide and others.

Chemical/Physical Data

Boiling point: 76.54°C
Melting point: -22.99°C
Vapor pressure: 55.65 mm Hg at 10°C; 89.5 mm Hg at 20°C
Vapor density: 5.5 at 29°C (Air = 1.0)
Solubility in water: 800 mg/l at 20°C

HUMAN TOXICITY

Studies indicate that carbon tetrachloride exhibits a wide range of toxic effects. Industrial and accidental exposures by ingestion, inhalation, and dermal routes have produced acute, subacute, and chronic poisoning, some of which were fatal (U.S. EPA, WQC, 1980).

The 1975 occupational standard is based on reports of liver and eye changes found in workers chronically exposed to carbon tetrachloride. There are some indications of liver effects after prolonged exposures at 5-10 ppm or higher. Alcohol appears to enhance the hapatotoxic effects of carbon tetrachloride. Restricted visual fields and other eye abnormalities have occurred with average time-weighted exposures at 7 to 24 ppm. Carbon tetrachloride is irritating to skin and can be absorbed by this route. Topical exposure of both hands for 30 minutes is estimated to be equivalent to vapor exposure at 10 ppm for 3 hours (NIOSH, 1975).

The evidence linking carbon tetrachloride to liver cancer in workers prompted NIOSH to revise the recommended standard in 1976.

Carbon tetrachloride, like many other chlorinated hydrocarbons, acts as a central nervous system depressant. Exposure at 33 to 124 ppm for 2 hours has caused fatigue. Headaches and giddiness have been associated with 45 to 97 ppm levels. Many reports exist of acute and chronic exposures resulting in kidney and/or liver effects (ACGIH, 1980).

The maximum level at which one could escape within 30 minutes without any escape-impairing symptoms or irreversible effects is suggested to be 300 ppm (NIOSH/OSHA, 1978).

Carcinogenicity

IARC, 1979 — There is sufficient evidence that carbon tetrachloride is carcinogenic in experimental animals. There are case reports that suggest that carbon tetrachloride may cause liver cancer in humans. In the absence of adequate data in humans, it is prudent to regard carbon tetrachloride as if it presented a carcinogenic risk to humans.

OSHA, 1981 — Statistically significant increases in tumors of the liver and of the adrenal glands in rats are noted.

U.S. EPA, WQC, 1980 — The U.S. EPA Carcinogen Assessment Group (CAG) has determined that carbon tetrachloride is an animal carcinogen. Water quality criteria are based on the incremental increase of cancer risk with increasing exposures. Non-threshold behavior is assumed.

Mutagenicity

U.S. EPA, WQC, 1980 — Little information is available concerning mutagenicity of carbon tetrachloride. It was found not to be mutagenic in the Salmonella typhimurium or Escherichia coli reversion tests.

Teratogenicity & Embryotoxicity

Increased fetal mortality was observed after oral and subcutaneous administration of 150 mg carbon tetrachloride to pregnant animals. Retarded development was observed in the fetuses of rats exposed to 300 ppm and 1,000 ppm for 7 hours per day on days 6-15 of gestation (IARC, 1979).

ANIMAL TOXICITY

Carbon tetrachloride has been extensively tested in many animals and by many routes. Metabolites in mammals include chloroform, hexachloroethane, and carbon dioxide. Liver injury is the most prominent effect, and a correlation is believed to exist between the degree of liver necrosis and the incidence of hepatomas (U.S. EPA, WQC, 1980).

Results of lethal studies in several species as reported in the (RTECS, 1982) are listed below:

Route	Species	Lethal Dose or Lethal Concentration
Oral	Rat	2,800 mg/kg, LD50
	Mouse	12,800 mg/kg, LD50
	Dog	1,000 mg/kg, lowest lethal dose
	Rabbit	6,380 mg/kg, LD50
Inhalation	Rat	4,000 ppm (24,867 mg/cu m) for 4 hours, lowest LC
	Mouse	9,526 ppm (59,220 mg/cu m) for 8 hours, LC50
	Dog	14,620 ppm (90,889 mg/cu m) for 8 hours, lowest LC
	Cat	38,110 ppm (236,920 mg/cu m) for 2 hours, lowest LC
	Guinea pig	20,000 ppm (124,335 mg/cu m) for 2 hours, lowest LC
Dermal	Rat	5,070 mg/kg, LD50

Chronic Toxicity

Exposure of guinea pigs, rats, dogs, and monkeys to 10 ppm for several weeks or months produced detectable accumulation of fat in the liver. No effects were observed at 1 ppm (ACGIH, 1980). Chronic exposure to 5 ppm resulted in a slight increase in liver weight in guinea pigs (Verschueren, 1977).

Studies indicate that highest carbon tetrachloride concentrations occur in the bone marrow of dogs after oral administration; with inhalation exposure, concentration is highest in the brain. Organ distribution of carbon tetrachloride varies with route of administration, concentration, and exposure duration (U.S. EPA, WQC, 1980).

AQUATIC AND TERRESTRIAL TOXICITY

Aquatic Toxicity

Aquatic toxicity rating: TLm 96 is 10-100 ppm (RTECS, 1982).

The U.S. EPA Water Quality Criteria (1980) for protection of aquatic life are given below:

> The available data for carbon tetrachloride indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 35.2 mg/l.
>
> The available data for carbon tetrachloride indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 50 mg/l.

Bioconcentration

Bluegill bioconcentrated carbon tetrachloride 30 fold within 21 days. The biological half-life in these fish was less than 1 day. A bioconcentration factor of 17 is estimated for rainbow trout. (U.S. EPA, WQC, 1980).

Phytotoxicity

No phytotoxicity data are reported (U.S. EPA, WQC, 1980).

ENVIRONMENTAL DATA

Air

Tropospheric concentration ranges from 0.120 - 0.140 ppm (0.75 - 0.88 µg/cu m) (NAS, 1978). Over urban areas, carbon tetrachloride concentrations are generally higher than those found over marine or non-urban areas. Carbon tetrachloride has an estimated atmospheric residence time of 18 to 100 years (NAS, 1978). Most of the carbon tetrachloride produced in the past 60 years is still in the atmosphere (Radding, 1977). This compound is highly persistent in air, and degradation is observed only after migration to the upper atmosphere.

Water

Carbon tetrachloride was measured in seawater at 0.72 µg/l in Scripps Institution of Oceanography pier water (excluding rainy season). A level of 2.8 µg/l was measured in rain in la Jolla, CA. Concentrations between 0.3 and 2 µg/l are reported in snow in North America. Untreated reservoir levels average 1.4 µg/l ± 0.009 (NAS, 1978).

Although carbon tetrachloride has a short half-life based on volatility (29 minutes from a 1 ppm solution at 25°C; Verschueren, 1977), the soluble portion may be quite stable resulting in some dispersion. This compound is resistant to degradation in water (U.S. EPA, WQC, 1980) and would

accumulate to significant levels if it were not removed via volatilization.

Soil
The persistence of carbon tetrachloride in ambient soil cannot be objectively determined due to insufficient data.

Biota
The accumulation of carbon tetrachloride in biota does not appear to be significant, due largely to its relatively short half-life (less than 1 day in tissues of bluegill; U.S. EPA, WQC, 1980). There is no evidence of biomagnification (Callahan, 1979).

Limited information indicates that carbon tetrachloride is widely distributed in edible fish and various foods; the typical range is 1 to 30 ppb. The use of fumigant mixtures containing carbon tetrachloride to treat food generally results in negligible residuals if properly handled (NAS, 1978).

INDUSTRIAL DATA

Production

No production in North Carolina is reported in the Toxic Substances Control Act (TSCA) Chemical Substance Inventory (U.S. EPA, TSCA, 1980).

Estimated U.S. production in 1976 was 388,000 metric tons (NAS, 1978).

Consumption and Use

It is estimated that greater than 95 percent of U.S. consumption is as a chemical intermediate in the production of fluorocarbons. Other uses such as industrial solvent, dry-cleaning agent, and other applications are declining because of the chemical's toxicity (NAS, 1978).

Reported uses of carbon tetrachloride and the corresponding SIC codes are listed below:

Production of dichlorofluoromethane and trichlorofluoromethane	2869, 385
Industrial solvent	-
Grain fumigant, pesticide	011, 2879
Petroleum additives	29
Spot remover (home use banned by FDA in 1970)	22, 721

(IARC, 1979)

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air
Under evaluation for possible designation as a Hazardous Air Pollutant by the U.S. Environmental Protection Agency.

Workroom Air

ACGIH — The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air is 5 ppm (30 mg/cu m) as a time-weighted average with a designation of "Industrial Substance Suspect of Carcinogenic Potential for Man." The recommended Short Term Exposure Limit (STEL) is 20 ppm (130 mg/cu m). The importance of skin exposure is noted.

NIOSH — The National Institute of Occupational Safety and Health (NIOSH) recommends a 1 hour ceiling limit of 2 ppm (13 mg/cu m).

OSHA — The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 10 ppm (65 mg/cu m) as a time-weighted average. The acceptable ceiling limit is 25 ppm. Maximum ceiling (5 minutes in 4 hours) is 200 ppm.

Water
Addressed by Ambient Water Quality Criteria set by the U.S. Environmental Protection Agency.

Designated a toxic pollutant by the U.S. Environmental Protection Agency.

Designated a hazardous substance by the U.S. Environmental Protection Agency. Spills in excess of 1,000 pounds must be reported.

Other
Regulated as a hazardous material by the U.S. Department of Transportation.

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Addressed by the Rebuttable Presumption Against Registration (RPAR) through the U.S. Environmental Protection Agency.

Agencies Concerned with this Chemical

Designated a candidate substance by the Occupational Safety and Health Administration.

Subject of a monograph prepared by the International Agency for Research on Cancer (IARC).

Subject of a Risk Assessment prepared for U.S. EPA's Carcinogen Assessment Group (CAG) for the Office of Water Planning and Standards.

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Callahan, M.A., et al. Water-Related Fate of 129 Priority Pollutants. U.S. EPA Office of Water Planning and Standards, Washington, DC, EPA 440/4-79-029 (December, 1979).

International Agency for Research on Cancer (IARC). IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon, France, Volume 20. A World Health Organization Publication (WHO), Geneva (1979).

National Academy of Sciences, National Research Council. Chloroform, Carbon Tetrachloride, and Other Halomethanes. National Academy of Sciences, Washington, DC (1978).

National Institute for Occupational Safety and Health (NIOSH). Criteria for a Recommended Standard...Occupational Exposure to Carbon Tetrachloride. U.S. Department of Health, Education, and Welfare, DHEW (NIOSH) Publication No. 76-133 (1975, 1976).

National Institute for Occupational Safety and Health/Occupational Safety and Health Administration (NIOSH/OSHA). NIOSH/OSHA Pocket Guide to Chemical Hazards. DHEW (NIOSH) Publication No. 78-210 (September, 1978).

Occupational Safety and Health Administration (OSHA). Candidate Sustance Summary Sheet. Chemical: Carbon Tetrachloride (1980).

Radding, S.B., et al. Review of the Environmental Fate of Selected Chemicals. U.S. Environmental Protection Agency. Available through the National Technical Information Service, Springfield, VA, PB 267 121 (May, 1977).

Registry of Toxic Effects of Chemical Substances, Quarterly Microfiche Issue, R. J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville, MD, for National Institute for Occupational Safety and Health. DHHS, (NIOSH) Publication (1982).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA, PB-90-155-153 (1980).

U.S. Environmental Protection Agency, Office of Water Planning and Standards. Ambient Water Quality Criteria for Carbon Tetrachloride. EPA-440/5-80-026, PB 81-117376 (October, 1980).

Verschueren, Karel. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York, NY (1977).

CHROMIUM

Executive Summary

CAS NUMBER: 07440-47-3

Chromium is a steel-gray or blue-white lustrous, brittle metal. It is naturally occurring, present in air, soil and water, and is an essential trace element found in almost all living organisms. The most important mineral occurrence of chromium is in the form of chromite ore, which is mined commercially, crushed and concentrated for industrial use. Chromium metal is produced from the ore and is used in electroplating and in the formation of stainless steel and other metals. Chromium forms compounds in two chemical states - a trivalent "chromic" form (+3) and the hexavalent "chromate" form (+6). The known harmful effects of chromium are generally the result of industrial exposure to the hexavalent (chromate) form. Federal regulations require the reporting of all spills of chromic acid, chromic acetate and chromic sulfate if the spill exceeds 1,000 pounds. North Carolina requires the reporting of all spills (for these three substances) if they occur near water.

Health Effects

ACUTE. Chromium compounds are irritating and corrosive and can enter the body by ingestion, inhalation and through the skin. Acute exposures to chromium dust or mist may cause coughing and wheezing, headache, dyspnea, fever and loss of weight. Hexavalent chromium compounds may be irritants and cause allergic contact dermatitis and eczema. Chromate or chromium salts are poorly absorbed from the human gastrointestinal tract, although accidental swallowing of dichromate can cause GI ulcerations and CNS depression.

CARCINOGENICITY. Chromate is considered a primary carcinogen, inducing cancer at the site of administration in both animals and humans. There is sufficient evidence of respiratory cancer in workers occupationally exposed during chromate production.

MUTAGENICITY. Hexavalent chromium compounds cause mutations and allied effects in a very wide variety of systems. There is good evidence that chromium (III) is not mutagenic. An increased frequency of chromosomal aberrations has been observed in workers exposed to chromium (VI) compounds.

TERATOGENICITY AND EMBRYOTOXICITY. Embryotoxic and teratogenic effects occurred in hamsters following exposure to chromium (VI) trioxide. Chromium (III) compounds apparently cross the placenta to only a small extent.

CHRONIC. Electroplaters exposed to acidic mist of hexavalent chromium compounds developed perforated or ulcerated nasal septa and skin ulcers.

Occupational Health

It is estimated that 175,000 persons in 104 occupations are exposed to hexavalent chromium compounds. The American Conference of Governmental Industrial Hygienists has established a Threshold Limit Value for workroom air (time-weighted average concentration under which it is believed that all workers may be repeatedly exposed day after day without adverse effect) of 0.05 mg Cr/cu m.

Routes of Human Exposure

OCCUPATIONAL. Principal occupational exposure to chromium compounds occurs during chromium extraction and ferroalloy production, electroplating and pigment production. Airborne concentrations of Cr(VI) during electroplating range from 0.71 to 9.12 µg/cu m.

AMBIENT. Background air concentrations range from 0.01 to 0.03 µg/cu m in large industrial areas of the U.S. to 0.01 µg/cu m in rural areas. There are no current ambient air quality standards established for chromium by either federal or state governments.

CONSUMER. The major consumer exposure to chromium occurs as a consequence of chromium in food (average daily intake for humans is 280 µg/day); this exposure has not been shown to produce any adverse effects in humans.

Environmental Significance

Soluble forms of chromium (VI) can be stable and transported long distances in water. Weak adsorption onto sediments occurs for both species (+3 and +6). Biomagnification is not expected in higher organisms.

Recommended Reviews

Hartford, W. H., 1979; Chromium compounds. In: Kirk, R.E. et al, eds. Encyclopedia of Chemical Technology, 3rd edition. vol 6, New York, NY, John Wiley and Sons, pp. 82-86, 97-98, 101, 105-110, 113, 1115.

Waldron, H.A., ed. Metals in the Environment, London, Academic Press, 1980.

FIRST AID AND EMERGENCY RESPONSE INFORMATION

CHROMIUM

First Aid (NIOSH/OSHA Pocket Guide to Chemical Hazards)

Chromic Acid and Chromates	Chromium Metal and Insol. Cr Salts
Eyes: Wash immediately with large amounts of water and seek medical attention. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH THESE COMPOUNDS.	Wash immediately with large amounts of water and seek medical attention. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH THESE COMPOUNDS.
Skin: Flush contaminated skin with soap and water. Remove clothing if contaminated and wash skin. Seek medical attention if irritation persists after washing.	Flush contaminated skin with soap and water. Remove clothing if contaminated and wash skin. Seek medical attention if irritation persists after washing.
Inhalation: Move exposed person to fresh air at once. Perform artificial respiration if necessary. Get medical attention as soon as possible.	Move exposed person to fresh air at once. Perform artificial respiration if necessary. Get medical attention as soon as possible.
Ingestion: Give large amounts of water immediately. Induce vomiting by finger. Get immediate medical attention.	Give large amounts of water immediately. Induce vomiting by finger. Get immediate medical attention.

Procedures for Spills and Leaks (U.S. DOT Emergency Response Guidebook)

Isolate hazard area and deny entry. Stay upwind and keep out of low areas. Wear self-contained breathing apparatus and full protective clothing. Do not touch spilled material. Stop leak if it can be done without risk. Keep combustibles away from spilled material.

Chromic acid sol. & Chromic fluoride	Chromic acid, chromic anhydride and chromium trioxide
SMALL SPILLS: Take up with sand or other non-combustible, absorbent material, then flush area with water.	
SMALL DRY SPILLS: Shovel into dry containers and cover; move containers then flush area with water.	Shovel into dry containers and cover; move containers; then flush area with water.
LARGE SPILLS: Dike far ahead of spill for later disposal.	Dike far ahead of spill for later disposal.

Fire and Explosion Information

Some of these materials will burn rapidly and may ignite combustibles such as wood, paper, oil, etc. Explosive concentrations may accumulate in tanks. Reaction with fuels may be violent. Move container from fire area if it can be done without risk. Cool containers that are exposed to flames with water from the side until well after fire is out.

SMALL FIRES: Dry chemical, CO_2, water spray or foam

LARGE FIRES: Water spray, fog or foam.

Reactivity

MATERIALS TO AVOID: Combustibles, strong oxidizers and water (soluble chromic and chromous salts only)

Protective Measures

ENGINEERING CONTROLS: Local exhaust ventilation, general dilution ventilation and personal protective equipment.

PROTECTIVE CLOTHING (Should not be substituted for proper handling and engineering controls): Impervious clothing, gloves and faceshields.

PROTECTIVE EQUIPMENT: For chromium metal and insoluble chromium salts: For levels up to 5 mg/cu m use any dust and mist respirator. For levels up to 10 mg/cu m use any dust and mist respirator, except single-use or quarter mask respirator, any fume respirator or high efficiency particulate respirator, any supplied-air respirator, or any self-contained breathing apparatus. For levels up to 50 mg/cu m use a high efficiency particulate filter respirator with a full facepiece, any supplied-air respirator with a full facepiece, helmet, or hood, or any self-contained breathing apparatus with a full facepiece. For levels up to 500 mg/cu m use a powered air-purifying respirator with a high efficiency particulate filter, or a Type C supplied-air respirator operated in pressure-demand or other positive pressure or continuous-flow mode. For levels greater than 500 mg/cu m or entry and escape from unknown concentrations use a self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode, or a combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode. For chromic acid and chromates: For levels up to 5 mg/cu m use a high

efficiency particulate filter respirator with a full facepiece. Any supplied-air respirator with a full facepiece, helmet or hood, or any self-contained breathing apparatus with a full facepiece. For levels up to 30 mg/cu m use a powered air-purifying respirator with a full facepiece and a high efficiency particulate filter, or a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure mode or with a full facepiece, hlemet or hood operated in continuous-flow mode. For levels greater than 30 mg/cu m or entry and escape from unknown concentrations, use a self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode, or a combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.

The North Carolina Toxic Substances Management Guide

CHROMIUM

Profile

CHEMICAL IDENTIFICATION

Alternative Names:

Chromium	Chromic Oxide	Chromium trioxide
Chrome	Chrome Oxide	Chrome acid
	Chromic oxide	Chromic anhydride
	Chromium sequioxide	
	Chromium(+3) trioxide	
	C. I. 77288	
	C. I. Pigment Green 17	

Chemical Abstract Services (CAS) Registry Number:
7440-47-3 1333-82-0

Registry of Toxic Effects of Chemical Substances (RTECS) Number:
GB 4200000 GB 6475000 GB 6500000

Hazardous Materials Table Identification No:
NA 1463

RCRA Identification No:

Atomic Weight:		
52.00	152.00	100.00
Molecular Formula:		
Cr	Cr_2O_3 (+3)	CrO_3 (+6)

Classification: A subgroup of VI B metal.

Description: A steel-gray or blue-white lustrous, brittle metal (crystals).

Uses:		
Metal plating	pigment	metal plating
Boiling Point:		
2672°C	4000°C	Decomposes
Melting Point:		
1857° ± 20°C	2435°C	196°C

Vapor pressure:
1 mm Hg at 1616°C

Density:		
7.20 at 28°C	5.21	2.70
Solubility in water:		
Insoluble	Insoluble	625.3 g/l at 20°C

Valence states: -2 to +6

HUMAN TOXICITY

Chromium (III) is considered to be an essential element in nutrition and for the maintenance of normal glucose tolerance of experimental animals and humans. When discussing the biological effects of chromium and its compounds, it is important to distinguish between the different oxidation states, because of their greatly different abilities to penetrate cellular membranes and associated differences in distribution and effects in biological systems. Evaluation of experimental studies in animals and in "in vitro" test systems for carcinogenicity and mutagenicity is sometimes difficult because of lack of information about the purity of the chemical compounds used and in particular about the oxidation state of chromium salts (IARC, 1980).

Chromium compounds are irritants and corrosive and can enter the body by ingestion, inhalation and through the skin. Acute exposures to chromium dust or mist may cause coughing and wheezing, headache, dyspnea, pain on deep inspiration, fever and loss of weight (Sittig, 1979). Electroplaters exposed to acidic mist of chromium compounds encountered perforated or ulcerated nasal septa and skin ulcers (ACGIH, 1980). The larynx is also affected by inhalation of chromium (VI) compounds (Luckey, 1978).

Hexavalent chromium compounds may cause irritant and allergic contact dermatitis. Dermatitis from exposure to soluble hexavalent chromium has been reported in lithographers, diesel repair shop workers and leather workers (ACGIH, 1980). Chromate-contact dermatitis varies from a dry erythematous condition to eczema on the exposed limbs; the eczema is due to the direct necrotizing effect of chromate (Luckey, 1978). In the past, treatment of warts by local application of chromic acid caused Cr(VI) poisoning in humans, leading to nephritis, anuria, and extensive lesions in the kidneys (ACGIH, 1980).

Chromium is poorly absorbed from the human gastrointestinal tract (IARC, 1973). Accidental swallowing of dichromate causes ulcerations and CNS depression (Luckey, 1978).

Carcinogenicity

There is sufficient evidence for the carcinogenicity of calcium chromate and some relatively insoluble chromium (VI) compounds (sintered calcium chromate, lead chromate, strontium chromate, sintered chromium trioxide) in rats (IARC, 1980). Calcium chromate (VI) is carcinogenic by several routes producing tumors at the sites of administration. There is limited evidence for the carcinogenicity of lead chromate (VI) oxide and cobalt-chromium alloy in rats (IARC, 1980). Current data are inadequate for the evaluation of the carcinogenicity of other chromium (VI) compounds and of chromium (III) compounds. Chromium is considered a primary carcinogen, and does not induce cancer in areas of the human body other than at the site of administration.

There is sufficient evidence of respiratory carcinogenicity in men occupationally exposed during chromate production. Data on lung cancer risk in other chromium-associated occupations and for cancer at other sites are insufficient. The epidemiological data do not allow an evaluation

of the relative contributions to carcinogenic risk of metallic chromium, chromium (III) compounds and chromium (VI) or of soluble versus insoluble chromium compounds (IARC, 1980).

Although the available epidemiological evidence does not permit a clear distinction between the relative carcinogenicity of chromium compounds of different oxidation states or solubilities, it appears that exposure to a mixture of chromium (VI) compounds of different solubilities (as found in the chromate production industry) carries the greatest risk to humans.

Mutagenicity

Chromium (VI) compounds cause mutations and allied effects in a very wide range of prokaryotic and eukaryotic systems, both in in vitro and in vivo (IARC, 1980). Hexavalent chromium interacts with bacterial DNA by causing frameshift mutations and basepair substitutions. There is good evidence that chromium (III) compounds are not mutagenic: the few positive results in assays for chromosomal aberrations were obtained only with extremely high doses and could be explained by nonspecific toxic effects.

An increased frequency of chromosomal aberrations has been observed in workers exposed to chromium (VI) compounds.

Teratogenicity & Embryotoxicity

Chromium (III) compounds apparently cross the placenta to only a small extent when administered parenterally to laboratory animals. Some teratogenic effects have been reported with extremely high doses. It is uncertain whether the effects reported represent a direct effect on the embryo or are the result of maternal toxicity. Embryotoxic and teratogenic effects occurred in hamsters following exposure to chromium (VI) trioxide (IARC, 1980).

ANIMAL TOXICITY

Trivalent chromium is one of the least toxic of the trace metals (Luckey, 1978). Hexavalent chromium is topically corrosive, and large oral doses caused albuminuria and fatty degeneration/necrosis of the kidneys in rabbits. Potassium dichromate, administered intratracheally to guinea pigs, is rapidly absorbed and is found in the spleen and in increased concentrations in red blood cells. Chromite dust is easily translocated from the lungs of rabbits or dogs to other organs, and chromium appears in increased amounts in the urine (IARC, 1973).

Acute Toxicity

Results of lethal studies in several species as reported in the RTECS, 1980 are listed below:

Route	Species	Lethal Dose or Lethal Concentration
Oral		
Chromic Acid (H_2CrO_4)	Rat	350 mg/kg, LD 100
Chromic trichloride ($CrCl_3$)	Rat	1,870 mg/kg, LD 50
Lead Chromate ($PbCrO_4$)	Guinea Pig	400 mg/kg, LD50
Dermal		
Chromium trioxide (CrO_3)	Dog	330 mg/kg MLD
Sodium Chromate (Na_2CrO_4)	Rabbit	243 mg/kg, LD 100
Chromic Trichloride ($CrCl_3$)	Mouse	140 mg/kg, LD 50

Chronic Toxicity

Route	Species	Lethal Dose or Lethal Concentration
Intravenous	Rat	2 mg/kg; 6 wks intermittent, TDLo, neoplastic effects
Implant	Rats	1 mg/kg; 6 wks intermittent, TDLo, neoplastic effects

AQUATIC LIFE AND WILDLIFE TOXICITY

WQC 1980 For total recoverable hexavalent chromium the concentration to protect freshwater aquatic life is 0.29 µg/l as a 24-hour average and the concentration should not exceed 21 ug/l at any time.

The available data indicate that chronic toxicity to freshwater aquatic life occurs at concentrations as low as 44 µg/l.

For total recoverable hexavalent chromium the concentration to protect saltwater aquatic life is 18 µg/l as a 24 hour average and the concentration should not exceed 1,260 µg/l at any time.

Algae are sensitive to hexavalent chromium, showing reduced growth at 10 µg/l.

Bioaccumulation in aquatic species: A concentration of 1.0 is estimated for the rainbow trout (U.S. EPA, WQC, 1980). Concentration factors as high as 2300 have been reported for phytoplankton. Excretion in higher species accounts for the apparent lack of biomagnification.

Phytotoxicity

Data on phytotoxicity through air pollution were not available. Concentrations of 0.5 mg/l in water solution and 10 mg/kg in soil cultures reduced soybean yields.

ENVIRONMENTAL DATA

Chromium can exist in valence states of -2 to +6, but only the hexavalent (+6) and trivalent (+3) species are of environmental significance.

Hexavalent Chromium

Hexavalent chromium is a strong oxidizing agent which reacts readily with reducing agents e.g. SO_2, organic matter to form CrIII (U.S. EPA, WQC, 1980). Hexavalent chromium can be found in solution combined with oxygen to form three anionic species:

Hydrochromate $(HCrO_4)^-$

Hydrochromate is the predominate species at lower pH (63% at pH 6-6.2) (U.S. EPA, WQC, 1980). It may also be the predominate species accounting for the weak adsorption of Cr(VI) to sediments (Callahan, 1979).

Chromate $(CrO_4)^{-2}$

Predominate at alkaline and neutral pH (95% at pH 7.8-8.5) (U.S. EPA, WQC, 1980).

Dichromate $(Cr_2O_7)^{-2}$

Predominate at very low pH, dichromate is expected to make up only a low proportion of Cr(VI) in normal pH ranges (U.S. EPA, WQC, 1980).

Trivalent Chromium

Trivalent chromium is the principal valence state in nature, found in geologic deposits and chromium ores (chromite). Cr(III) will quickly precipitate out of solution due to formation of the insoluble hydroxide or oxide. Although it is only weakly absorbed to sediments, adsorption is greater than for Cr(VI). Cr(III) is the most stable form of chromium under normal redox conditions (U.S. EPA, WQC, 1980). Reduction to Cr procedes slowly and is influenced by water hardness.

Ambient Air

The Cr(III) valence state predominates in this medium. General concentrations range from 0.002 to 0.02 ug/cu m. Levels in nonurban areas usually fall below the limit of detection and may be as low as 5 pg/cu m (5×10^{-9} mg/cu m) (U.S. EPA, WQC, 1980). Urban levels are higher, exceeding 0.010 ug/cu m in 59 of 186 samples (U.S. EPA, WQC, 1980). Some accumulation and subsequent dispersion can be expected near industrial sources.

Water

Concentrations in water are generally low. Chromium was not detected in 75% of 1,577 samples taken in a surface water survey. An average level of 9.5 ug/l was found for the remaining samples, with levels as high as 50 ug/l reported (U.S. EPA, WQC, 1980). The range of concentrations found in U.S. rivers was 0.7-84 ug/l. Seawater contains less than 1 ug/kg. It is estimated that 6.7 x 106 kg of chromium are added to the oceans annually.

Cr(VI) is predominant in water. Soluble Cr(VI) can be stable and transported long distances. Cr(VI) is soluble, but reduces to Cr(III) which precipitates out of a solution at a pH less than 5 (Callahan, 1979). Weak adsorption to sediments occurs for both species (+3 and +6). Some accumulation as a soluble anion is expected for Cr(VI).

Soil

As a compound, chromium is present in small quantities in all soils (IARC, 1980). As chromic oxide, it is present at levels ranging from trace to 250 mg/kg (IARC, 1980). As the predominate species in soil, Cr(III) is removed from this medium as a solute in runoff. It also replaces Fe(III) or Al(III) in geologic deposits. Some accumulation of Cr(III) is expected to occur in soil.

Biota

Cr is ubiquitous in plant tissue at concentrations ranging from 10-1000 ug/kg (IARC, 1980). It was found in samples of 119 fish caught in Austria at levels of 0.02-0.21 mg/kg (IARC, 1980). Normal concentrations in human tissue range from 0.020 to several hundred ug/kg. This level of concentration falls throughout life in every organ except the lung, where it increases with age. Cr(III) has been found in all examined sources of ribonucleic acid (RNA) (IARC, 1980). Chromium is an essential nutrient and widely dispersed in nature. Biomagnification is not expected. Lower plants and bacteria can accumulate chromium, but higher organisms seem capable of excretion (Callahan, 1979).

Major environmental exposure to chromium occurs as a consequence of chromium in food (brown sugar and animal fats). The average daily intake for humans is estimated at 280 ug/day (NRC, 1977). The occurrence of chromium in food has not been shown to produce any significant adverse effects in man or experimental animals.

It is estimated that 175,000 persons in 104 occupations are exposed to hexavalent chromium compounds (IARC, 1980). Potential occupational exposures in the manufacture of chromium products to chromium compounds are summarized in the following table (IARC, 1980):

Occupation	Chromium Compounds
Chromium extraction and ferro-alloy production	Chromite (III) ore, sodium chromate (VI), sodium dichromate (VI), chromium (VI) trioxide
Electroplating	Chromium (VI) trioxide, sodium and potassium dichromates (VI)
Refractory materials	Chromic (III) oxide, chrome-magnesium alloys
Pigment production	Sodium dichromate (VI), potassium chromate (VI), chromates (VI) of ammonium, barium, calcium, lead, molybdenum and zinc

In industrial workroom areas where chromium-plating is occurring, airborne concentrations of Cr(VI) ranged from 0.71 to 9.12 µg/cu m (mean 3.24 µg/cu m) (NIOSH, 1975).

INDUSTRIAL DATA

Production

Production of chromium and chromium compounds in North Carolina was reported in the Toxic Substances Control Act (TSCA) Chemical Substances Inventory by the following companies:

	Chemical	Volume in Tons
Wilmington Machine, Wilmington	Chromium	0.25-0.5
Diamond Shamroack, Castle Hayne	Dichromic acid, dichromium salt	50,000 100,000
	Chromium oxide	5,000 25,000
	Chromium acid	
The Mogul Corp., Charlotte	Chromic acid, zinc salt	0.5 5

Consumption and Use

Estimated U.S. Consumption of chromic ore in 1976:

Metallurgical	59.3 percent
Refractory	20.1 percent
Chemical	20.6 percent (IARC, 1980)

Estimated U.S. Consumption of chromium metal in 1976:

High-carbon ferrochromium	60 percent
Low-carbon ferrochromium	25 percent
Ferrochromium-silicon	16 percent
Other alloys and chromium metal	1 percent (IARC, 1980)

Reported uses of metallic chromium and the corresponding SIC codes are given below:

High and low-carbon ferrochromium	33, 34
Ferrochromium silicon	33, 34
Electroplating	347

Reported uses of chromium compounds and the corresponding SIC's are given below:

Pigments for corrosion inhibiting paints, linoleum, vinyl, rubber, artists colors varnishes, prints, wood, paper, automobile finishing, glass and ceramics, (chromic oxide, chromic phosphate, lead chromate, lead chromate oxide, potassium dichromate, sodium chromate, sodium dichromate, zinc chromate hydroxide, zinc potassium chromate)	2816, 2851 3996, 282 30, 3952 2641, 2491, 32
Printing dyes (chromic acetate, lead chromate)	27
In the textile industry as dyes, mordants, preservatives (chromic acetate, chromic chloride, chromium potassium sulphate, potassium chromate, potassium dichromate, sodium chromate, and sodium dichromate)	27 223, 22, 6
Leather tanning (chromium sulphate, sodium chromate, sodium dichromate)	3111
As a coating to impart corrosion resistance in electroplating primers, washes and polishes in meallurgy (calcium chromate, chromium chloride, chromic oxide, chromium trioxide, sodium chromate, zinc chromate, zinc potassium chromate)	34, 3471, 3479
Batteries (Barium chromate, calcium chromate)	3691, 3892
Catalysts (Chromic oxide, chromium trioxide, sodium dichromate)	28
Chemical intermediate in the production of other chromium salts (chromic chloride, chromic oxide, chromium potassium sulphate, sodium chromate, sodium dichromate)	281

Refractory brick (chromic oxide)	3255
Pyrotechnics (Barrium chromate)	2892 (IARC, 1980)

Anticorrosive agent in cooling waters (U.S. EPA, WQC, 1980)

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air
Designated a hazardous air pollutant by the U.S. Environmental Protection Agency.

Workroom Air

ACGIH — The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for Workroom air is 0.05 mg Cr/cu m as a time-weighted average. The TLVs are intended for use in the practice of industrial hygiene.

NIOSH — The National Institute of Occupational Safety and Health (NIOSH) recommends a standard of 0.025 Cr(VI) mg/cu m as a time-weighted average and a ceiling limit of 0.05 Cr(VI) mg/cu m. NIOSH is responsible for developing criteria for setting occupational standards designed to protect the health and safety of workers for a 40-hour week over a working lifetime.

OSHA — The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 0.5 mg/cu m for soluble chromic or chromous salts; 1 mg/cu m for chromium metal or insoluble salts as a time-weighted average. The standards represent allowable concentrations of toxic or hazardous substances to which employees may be exposed without adverse health effects (Code of Federal Regulations, Title 24, Part 1910, Subpart Z).

Water
Addressed by National Interim Primary Drinking Water Regulations set by the U.S. Environmental Protection Agency. The maximum contaminant for chromium in drinking water is 0.05 mg/l (U.S. EPA, 1978).

Designated a toxic pollutant by the U.S. Environmental Protection Agency.

Designated a hazardous substance by the U.S. Environmental Protection Agency.

Other
Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Agencies Concerned with this Chemical

Subject of a monograph prepared by the International Agency for Research on Cancer (IARC). IARC monographs contain in-depth evaluations of carcinogenic risks of chemicals to man.

Addressed by development plan prepared by the Interagency Regulatory Liaison Group (IRLG).

Under toxicological evaluation through the National Toxicology Program to determine mutagenicity. (National Toxicology Program, Fiscal Year 1981 Annual Plan (NTP-80-62, 1980).

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Interagency Regulatory Liaison Group (IRLG). Excerpt on Chromates. Regulator Reporter, Volume II, Issue 1.

International Agency for Research on Cancer. IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon, France, Volume 23. A World Health Organization Publication (WHO), Geneva (1981).

MEDLARS II Toxicology Data Bank (TDB) Record of Chromium. National Library of Medicine (May 1981).

Michigan Department of Natural Resources, Environmental Protection Bureau. Michigan Critical Materials Register 1980. Hazard Assessment Sheet for Chromium. Lansing, Michigan (1980).

National Institute of Occupational Safety and Health (NIOSH). Criteria for a Recommended Standard...Occupational Exposure to Chromium VI. U.S. Department of Health, Education, and Welfare. DHEW (NIOSH) Publication No. 76-129 (1975).

National Toxicology Program (NTP). Executive Summary for Chromium. In Executive Summaries of Chromium Compounds Nominated for FY 81 Testing. U.S. Department of Health, Education, and Welfare, Jefferson, Arkansas (1980).

Occupational Safety and Health Administration (OSHA). Candidate Substance Data Summary Sheet. Chemical: Chromium VI Compounds.

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Chemical Hazard Information Profiles (CHIPs). EPA-560/11-80-011 (1980).

U.S. Environmental Protection Agency, Carcinogen Assessment Group (CAG). Carcinogen Assessment Group's Preliminary Risk Assessment on Chromium VI Compounds, Washington, DC (February 11, 1980).

U.S. Environmental Protection Agency, Office of Water Planning and Standards. Ambient Water Quality Criteria for Chromium. EPA/440-4-80-016 (October 1980).

Venugopal, and Luckey, 1978 Metal Toxicology in Mammals-2, Plenum Press, New York.

Waldron, H.A. 1980 Metals in the Environment, Academic Press, New York.

Executive Summary

CAS NUMBER: 00067-66-3

Chloroform is a clear, colorless, non-flammable liquid with an ether-like odor. In the past it was used as an anesthetic agent and as a cleaning solvent in the dry cleaning industry. Today chloroform is used widely as a solvent and as an intermediate in the production of refrigerants, plastics and pharmaceuticals. Current annual production of chloroform approaches 120,000 metric tons. Federal regulations require the reporting of all chloroform spills exceeding 1000 lbs. North Carolina requires the reporting of all spills near water.

Health Effects

ACUTE. The sites of biological effects of chloroform include: 1) central nervous system; 2) heart; 3) liver; 4) kidney; and 5) offspring.

Inhalation of 10,000 ppm of chloroform vapor produces clinical anesthesia. Higher concentrations are associated with cardiovascular depression. Death from chloroform overdosage is attributed to ventricular fibrillation. Delayed death, resulting from chloroform anesthesia (on the second day or later), is associated with liver necrosis.

CARCINOGENICITY. There is sufficient evidence that chloroform is carcinogenic in mice and rats. In the absence of adequate data on humans, it is reasonable to regard chloroform as if it presented a carcinogenic risk to humans.

MUTAGENICITY. In assays with Salmonella typhimurium and with Escherichia coli, chloroform was not mutagenic in the presence of microsomal preparations from mouse, rabbit, or rat liver.

TERATOGENICITY AND EMBRYOTOXICITY. Chloroform is not highly teratogenic in rats, but is highly embryotoxic. When pregnant rats were exposed to 30, 100 or 300 ppm on days 6-15 of gestation, a significant increase of fetal abnormalities was observed. At 300 ppm there was a high incidence of fetal resorption.

CHRONIC. Liver injury is typical of chronic or repeated exposure. Kidney effects, though less common, may also be observed. Two epidemiologic studies of occupational exposure to chloroform found episodes of lassitude, dry mouth, depression, irritability, and painful urination. Local irritation has been reported when chloroform is applied to the skin.

Occupational Health

The American Conference of Governmental Industrial Hygenists has established a Threshold Limit Value for workroom air (time-weighted average concentration under which it is believed that all workers may be repeatedly exposed day after day without adverse effect) of 10 ppm (50 mg/cu m).

The Occupational Safety and Health Administration standard for workroom air is 50 ppm (240 mg/cu m) as a timeweighted average. The National Institute for Occupational Safety and Health recommends a 1-hour ceiling limit of 2 ppm and classifies chloroform as a "Cancer-Suspect" Agent.

Routes of Human Exposure

OCCUPATIONAL. Very few reports of occupational poisoning from chloroform are recorded, due in part to the limited industrial use of this solvent.

AMBIENT. Chloroform appears to be ubiquitous in the environment in trace amounts. It is formed in municipal water supply systems and in municipal and industrial wastewater effluents as a result of the chemical interaction of applied chlorine and certain organic precursors. Concentrations measured in rain and snow, respectively, are 17 ug/l ± 13 and 3 to 90 ug/l. Over urban areas, concentrations of chloroform are generally higher than those found elsewhere.

CONSUMER. Fluid intake is generally the most important route of exposure to chloroform. In April 1976, the U.S. Food and Drug Administration listed approximately 1900 human drug products that contained chloroform. These included cough syrups, expectorants, antihistamines, linaments, and decongestants. The FDA banned the use of chloroform as an ingredient in human drug and cosmetic products as of July 29, 1976. However, any drug product containing chloroform in residual amounts from its use as a processing solvent in manufcture or as a by-product from the synthesis of an ingredient is not considered to contain chloroform as an ingredient.

In 1971, farmers in the U.S. used approximately 51,000 kg of chloroform as an insecticidal fumigant on stored grain. A notice of rebuttable presumption against continued registration of pesticide products containing chloroform was issued by the Environmental Protection Agency in 1976. The future use of chloroform in agriculture in the U.S. depends largely on the outcome of these actions.

Chloroform is widely distributed in edible fish, marine organisms, water birds, and other foods with typical ranges of 1-30 ppb.

Environmental Significance

Estimated half-life in water is 18-25 minutes (based on evaporation from a 1 ppm solution at 25°C). Estimated atmospheric residence time is 0.2 to 0.3 years.

The available data for chloroform indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 28.9 mg/l. Twenty-seven day LC50 values indicate that chronic toxicity occurs at concentrations as low as 1.25 mg/l.

The data base for saltwater species is limited to one test and no statement can be made concerning acute or chronic toxicity.

An average bioconcentration factor of 9.5 (3.75 for the edible portion of fish) has been calculated based on the octanol/water partition coefficient. This level is not considered to be a significant environmental problem.

Concentrations of chloroform in 5 species of fish and 3 species of mollusks collected from seawater ranged from 56-1,040 ug/kg (dry-weight basis) in the various organs of mollusks and from 7-851 ug/kg (dry-weight basis) in fish. Relative concentrations in the organs of fish were found to be: brain gill liver muscle.

Phytotoxicity from chloroform in air has not been reported. Inhibition of cell multiplication in freshwater algae starts at 185 mg/l.

Chloroform has the potential to react with, and thereby deplete, the atmospheric ozone layer.

Recommended Reviews

Ambient Water Quality for Chloroform, U.S. Environmental Protection Agency. EPA/440580033 (October, 1980).

Drinking Water and Health, Volume 3, National Research Council, National Academy of Sciences, pages 5-7, 203-204 (1980).

Chloroform, Carbon Tetrachloride and Other Halomethanes, National Academy of Sciences (1978).

First Aid (NIOSH/OSHA Pocket Guide to Chemical Hazards)

Eyes:	Wash with large amounts of water immediately, occasionally lifting upper and lower lids. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH CHLOROFORM. Get medical attention immediately.
Skin:	Wash the contaminated skin promptly with soap and water. Remove clothing if contaminated and wash skin with soap and water.
Inhalation:	Move to fresh air at once. Perform artificial respiration if necessary. Seek immediate medical attention.
Ingestion:	Induce vomiting by having victim touch the back of his throat with his finger or by giving syrup of ipecac. Seek medical attention.

Procedures for Spills and Leaks

SMALL SPILLS:	Take up with sand, or other noncombustible absorbent material, then flush area with water.
SMALL DRY SPILLS:	Shovel into dry container and cover; move containers then flush area with water.
LARGE SPILLS:	Dike far ahead of spill for later disposal.

Fire and Explosion Information

GENERAL: Chloroform is non-flammable and non-explosive.

Reactivity

CONDITIONS TO AVOID: Sunlight will decompose chloroform to highly toxic fumes.

MATERIALS TO AVOID: Strong alkalies like lye and potassium hydroxide decompose chloroform to chloride salts and formates. Incompatible with chemically active metals.

Protective Measures

STORAGE AND HANDLING: Store in dark bottles or cans in a cool place. Do not wear jewelry or contact lenses when using chloroform.

ENGINEERING CONTROLS: Provide adequate ventilation, eye wash stations and showers.

PROTECTIVE CLOTHING: (Should not be substituted for proper ventilation and engineering controls): Impervious gloves, splashproof goggles and apron should be worn if contact is likely.

PROTECTIVE EQUIPMENT: For levels up to 500 ppm, use a supplied-air respirator or selfcontained breathing apparatus. For levels up to 1,000 ppm use a suppliedair respirator with full facepiece or self-contained breathing apparatus with full facepiece. For escape use a gas mask with an organic vapor canister or a self-contained breathing apparatus.

CHLOROFORM

Profile

CHEMICAL IDENTIFICATION

Alternative Names:

Formyl Trichloride	Methyl Trichloride
Freon 20	R 20
Methane Trichloride	R 20 (Refrigerant)
Methane, trichloro	Trichloroform
Methenyl Trichloride	Trichloromethane

Chemical Abstract Services (CAS) Registry Number: 00067-66-4

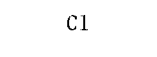
Registry of Toxic Effects of Chemical Substances (RTECS) Number: FS 9100000

Hazardous Materials Table Identification Number: UN 1888

RCRA Identification Number: U 044 Molecular Weight: 119.39

Molecular Formula: $CHCl_3$

Structure:



Classification: Saturated alkyl halide; chlorinated hydrocarbon

Description: A clear, colorless, nonflammable liquid with an ether-like odor

Uses: Chemical intermediate

Chemical/Physical Data

Boiling point: 61.7°C
Melting point: -63.5°C
Vapor pressure: 160 mm Hg at 20°C; 245 mm at 30°C
Vapor density: 4.12 (Air = 1.0)
Solubility in water: 8,000 mg/l at 20°C
Specific gravity: 1.489

HUMAN TOXICITY

The acute toxic symptoms of chloroform have been summarized in the Martindale Pharmacopoeia as follows:

> Chloroform is hepatotoxic and nephrotoxic. It depresses respiration and produces hypotension. Cardiac output is reduced and arrhythmias may develop. Poisoning leads to respiratory depression and cardiac arrest. It may take 6 to 24 hours after exposure before the appearance of symptoms which include abdominal pain, vomiting, and at a later stage, jaundice. Liquid chloroform is an irritant to the skin and mucous membranes and may cause burns if spilled on them (Martindale, 1977).

The narcotic effects of chloroform on the central nervous system have been well-documented. Toxic hepatitis has been reported among chemical workers exposed to chloroform. Cardiac irregularities during anesthesia and local irritation when applied to skin have also been reported. Two epidemiologic studies of occupational exposure to chloroform found episodes of lassitude, dry mouth, depression, irritability, and painful urination. To date, there have been no published reports of any association between chloroform and cancer in humans (NIOSH, 1978).

Liver injury is typical in chronic or repeated exposure. Kidney effects, though less common, may also be observed, (Irish, 1963). The table below indicating human response to various chloroform levels is adapted from Irish (1963).

PHYSIOLOGICAL RESPONSE TO VARIOUS CONCENTRATIONS OF CHLOROFORM IN MAN

Concentration, ppm	Response
205-307	Lowest amount that can be detected by smell
389	Endured for 30 minutes without complaint
1,024	Definite after-effects; fatigue and headache still felt hours later
1,024	Dizziness, increased intercranial pressure, and nausea after 77 minutes
1,475	Dizziness and salivation after a few minutes
4,096	Vomiting, sensation of fainting
14,336-16,384	Narcotic limiting concentration

The most serious effect to be considered is the cancer-causing potential of chloroform (U.S. EPA, WQC, 1980).

The maximum level at which one could escape within 30 minutes without any escape-impairing symptoms or irreversible effects is suggested to be 1,000 ppm (NIOSH/OSHA, 1978).

Carcinogenicity

U.S. EPA, EPA, WQC, 1980	The U.S. EPA Carcinogen Assessment Assessment Group (CAG) has determined that chloroform is an animal carcinogen. Water quality criteria are based on the incremental increase of cancer risk with increasing exposures. Nonthreshold behavior is assumed.

IARC, 1979 — There is sufficient evidence that chloroform is carcinogenic in mice and rats. In the absence of adequate data in humans, it is reasonable, for practical purposes, to regard chloroform as if it presented a carcinogenic risk to humans.

NIOSH, 1978 — In the recent National Cancer Institute study, male rats were fed chloroform in corn oil (at 90 and 180 mg/kg body weight) for 111 weeks. A significant increase in epithelial tumors of the kidney was observed.

Mutagenicity

IARC, 1979 — In assays with Salmonella typhimurium and with Escherichia coli, chloroform was not mutagenic in the presence of microsomal preparations from mouse, rabbit, or rat liver.

Teratogenicity & Embryotoxicity

ACGIH, 1980 — Chloroform is not highly teratogenic in rats but is highly embryotoxic. When pregnant rats were exposed to 30, 100 or 300 ppm on days 6-15 of gestation, a significant incidence of fetal abnormalities was observed. At 300 ppm, there was a high incidence of fetal resorption. Retarded fetal development was observed at 30, 100, and 300 ppm exposures.

ANIMAL TOXICITY

The acute and chronic effects of chloroform in animals have been summarized by NIOSH. The 1978 Current Intelligence Bulletin described effects as follows:

> Depression of the central nervous system has been seen in a number of animal studies on the effects of chloroform inhalation. Inhalation of chloroform also produces dilation of pupils of the eyes, reduced reaction to light, and reduced intraocular pressure. Fatty degeneration and necrosis of the liver as well as kidney impairment have been seen in experimental animals after ingestion, inhalation, and intravenous administration (NIOSH, 1978).

Acute Toxicity

Results of lethal studies in several species as reported in the TDB (1982) are listed below:

Route	Species	Lethal Dose or Lethal Concentration
Oral	Rat	0.8 gm/kg, LD50
	Mouse	1.1 gm/kg, LD50
	Dog	1.0 gm/kg, Lowest lethal dose
	Rabbit	0.5 gm/kg, Lowest lethal dose
Inhalation	Rat	8,000 ppm (40 gm/cu m) for 4 hours, Lowest lethal concentration
	Mouse	5,600 ppm (28 gm/cu m), LC50
	Dog	20,000 ppm (100 gm/cu m) LC50
	Cat	7,000 ppm (35 gm/cu m) for 4 hours, lowest lethal concentration
	Rabbit	11,800 ppm (59 gm/cu m), LC50
	Guinea pig	20,000 ppm (92 gm/cu m) for 2 hours, lowest lethal concentration

Aquatic Toxicity

Aquatic toxicity rating: TLm 96 is 10-100 ppm (RTECS, 1982).

The U.S. EPA Water Quality Criteria (1980) for protection of aquatic life are given below:

> The available data for chloroform indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 28.9 mg/l. Twenty-seven day LC50 values indicate that chronic toxicity occurs at concentrations as low as 1.24 mg/l.
>
> The data base for saltwater species is limited to one test and no statement can be made concerning acute or chronic toxicity.

Bioaccumulation: There is some evidence for weak to moderate bioaccumulation by marine organisms. Although chloroform is found at higher concentrations in fatty tissues, there is no evidence for biomagnification in aquatic food chains (Callahan, 1979).

Bioconcentration: An average bioconcentration factor of 9.5 (3.75 for the edible portion of fish) is calculated based on the octanol/water partition coefficient. This level is not considered to be a significant environmental problem (U.S. EPA, WQC, 1980).

Phytotoxicity

Phytotoxicity from chloroform in air is not reported.

Inhibition of cell multiplication in freshwater algae starts at 185 mg/l (Verschueren, 1977).

ENVIRONMENTAL DATA

Air

Background concentrations range from 0.020-0.080 ppb (0.10 - 0.4 ug/cu m) (NAS, 1978). Chloroform has an estimated atmospheric residence time of 0.2 to 0.3 years (Callahan, 1979). Chloroform degrades rapidly in the atmosphere through photolytic attack by hydroxyl radicals (Callahan, 1979). No significant accumulation is expected.

Water

Chloroform was measured in seawater at 0.01-48 ug/l in the east Pacific open ocean (mixed layers 1000 meters). Concentrations measured in rain and snow, respectively, are 17 ug/l $\pm$ 13 and 3 to 90 ug/l. A level of 11 ug/l $\pm$ 4 was measured in water from an untreated reservoir (NAS, 1978). Chloroform formation is known to occur during the chlorination of drinking water. Chloroform has an estimated half-life in water of 18-25 minutes based on evaporation (Verschueren, 1977). Chloroform undergoes rapid loss to the atmosphere via volatilization (Callahan, 1979); it does not degrade in water.

Soil

There is no clear evidence of selective concentration of chloroform in soil or sediments (Callahan, 1979). Removal by volatilization is a likely fate.

Biota

Chloroform has a low calculated bioaccumulation factor; biodegradation is very slow. No biomagnification is expected, but marine organisms may be a significant source of chloroform (NAS, 1978).

Chloroform is widely distributed in edible fish, marine organisms, water birds, and other foods with typical range of 1-30 ppb (ug/kg) (NAS, 1978).

Concentrations of chloroform in 5 species of fish and 3 species of mollusks collected from seawater ranged from 56-1,040 ug/kg (dry-weight basis) in the various organs of mollusks and from 7-851 ug/kg (dry-weight basis) in fish. Relative concentrations in the organs of fish were found to be: brain gill liver muscle (IARC, 1979).

Chloroform has been detected in postmortem human tissues at 168 ug/kg (wet tissue) (IARC, 1979).

INDUSTRIAL DATA

Production

No production in North Carolina has been reported in the Toxic Substances Control Act (TSCA) Chemical Substance Inventory (U.S. EPA, TSCA, 1980).

Estimated U.S. production in 1976 was 133,000 metric tons (NAS, 1978).

Current annual production approaches 120,000 metric tons (U.S. EPA, WQC, 1980).

Consumption and Use

Estimated U.S. Consumption:

Synthesis of chlorofluorodiethane for use in refrigerants and propellants	51.3	percent
Synthesis of chlorodifluoromethane for use in plastics	24	percent
Miscellaneous uses	24.7	percent

Reported uses of chloroform and the corresponding SIC codes are listed below:

Synthesis of chlorodifluoromethane	2869, 385
Drugs, cosmetics, toothpaste, vitamins, and artificial flavors	283
In grain fumigants and pesticides	011, 2879
Industrial solvent	-

(IARC, 1979)

Although banned by the FDA in 1976 for use in human drug products, chloroform may appear in residual amounts from its use as a solvent in processing or as a byproduct (IARC, 1979).

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air

Under evaluation for possible designation as a Hazardous Air Pollutant by the U.S. Environmental Protection Agency.

Workroom Air

ACGIH The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygenists (ACGIH) for workroom air is 10 ppm (50 mg/cu m) as a time-weighted average. Chloroform is designated an "Industrial Substance Suspect of Carcinogenic Potential for Man".

NIOSH The National Institute of Occupational Safety and Health (NIOSH) recommends a 1-hour ceiling limit of 2 ppm. The chemical is classified as a "Cancer Suspect Agent".

OSHA The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 50 ppm (240 mg/cu m) as a time-weighted average.

Water

Addressed by Ambient Water Quality Criteria set by the U.S. Environmental Protection Agency.

Designated a toxic pollutant by the U.S. Environmental Protection Agency.

Designated a hazardous substance by the U.S. Environmental Protection Agency. Spills in excess of 1000 pounds must be reported.

Other
Regulated as a hazardous material by the U.S. Department of Transportation.

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Addressed by the Rebuttable Presumption Against Registration (RPAR) through the U.S. Environmental Protection Agency.

Agencies Concerned with this Chemical

Designated a candidate substance by the Occupational Safety and Health Administration.

Subject of a monograph prepared by the International Agency for Research on Cancer (IARC).

Addressed by development plan prepared by the Interagency Regulatory Liaison Group (IRLG).

REFERENCES

American Conference of Governmental Industrial Hygenists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Callahan, M. A., et al. Water-Related Fate of 129 Priority Pollutants. U.S. EPA, Office of Water Planning and Standards, Washington, DC, EPA 44/4-79-029 (December, 1979).

International Agency for Research on Cancer, (IARC). IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon, France, Volume 20. A World Health Organization Publication (WHO), Geneva (1979).

Irish, D. D. Aliphatic Halogenated Hydrocarbons. Industrial Hygiene and Toxicology, Second Revised Edition, Vol. 2, F. A. Patty, Ed. Interscience Publisher, New York, NY (1963).

Martindale. The Extra Pharmacopoeia. Twenty-seventh Edition. Ainsley Wade, Ed. The Pharmaceutical Press, London (1977).

National Academy of Sciences, National Research Council. Chloroform, Carbon Tetrachloride, and Other Halomethanes. National Academy of Sciences, Washington, DC (1978).

National Institute for Occupational Safety and Health (NIOSH), 1978. Current Intelligence Bulletin.

National Institute for Occupational Safety and Health/Occupational Safety and Health Administration (NIOSH/OSHA). NIOSH/OSHA Pocket Guide to Chemical Hazards. DHEW (NIOSH) Publication No. 78-210 (September 1978).

Registry of Toxic Effects of Chemical Substances, Quarterly Microfiche Issue, R. J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville Md for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication (1982).

Toxicology Data Bank (TDB). The National Library of Medicine - Bethesda, Maryland (1982).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA PB-80-155-153 (1980).

U.S. Environmental Protection Agency, Office of Water Planning and Standards. Ambient Water Quality Criteria for Chloroform. EPA-440/5-80-033 (October 1980).

Verschueren, Karel. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York, NY (1977).

DICHLOROBENZENES

Executive Summary

ISOMER	CAS NUMBER
Dichlorobenzenes (ortho primarily)	25321-22-6
o-Dichlorobenzene	00095-50-1
m-Dichlorobenzene	00541-73-1
p-Dichlorobenzene	00106-46-7

The ortho and meta isomers are colorless liquids while the para isomer is a volatile monoclinic crystal. Approximately 25,000 tons of o-dichlorobenzene and 18,500 tons of p-dichlorobenzene are produced annually in the U.S. Production data for the m-isomer were not reported.

The o-isomer is used primarily in the production of pesticides and organic chemicals (53%) and solvents (35%). The p-isomer is used to produce room deodorants (50%) and moth control chemicals (40%).

Federal regulations require the reporting of all dichlorobenzene spills if they exceed 100 pounds (45.4 kg) or 9.2 gallons (34.8 liters). North Carolina requires the reporting of all spills if they occur near water.

Health Effects

ACUTE. The dichlorobenzenes may be absorbed through the lungs, gastrointestinal tract and intact skin. Their relatively low water and high lipid solubility favor the penetration of most biological membranes.

Human exposure to dichlorobenzene (primarily 1,4-dichlorobenzene; p-isomer) has resulted in a wide variety of acute effects including eye and upper respiratory tract irritations, vomiting, loss of strength, dizziness, headache, anemia, profuse rhinitis, jaundice, methemoglobinemia and other blood pathologies. The oral lethal dosage for rats is 4.2 gm/kg (LCLo) for the o-isomer and 0.5 gm/kg (LD50) for the p-isomer.

CARCINOGENICITY. Five cases of leukemia in humans exposed to chlorobenzenes have been reported. However, five studies in animals indicate that chlorobenzenes are not carcinogenic. These studies were too short and the number of animals was too small to adequately assess carcinogenicity. The EPA Carcinogen Assessment Group concluded that there is insufficient data to evaluate the carcinogenicity potential of chlorobenzenes.

MUTAGENICITY. Monochlorobenzene and p-dichlorobenzene have been reported to be mutagenic, however all three dichlorobenzene isomers were negative in the Ames Salmonella typhimurium test.

TERATOGENICITY AND EMBRYOTOXICITY. No data on the teratogenicity and embryotoxicity of dichlorobenzenes have been reported. The ability of chlorinated benzenes to pass membrane barriers would suggest a potential for transplacental toxicosis.

CHRONIC. Numerous chronic health effects in humans exposed to dichlorobenzene have been reported. These have included weight loss, anemia, decreased appetite, chronic lymphoid leukemia, exhaustion, erythema, edema, acute myeloblastic leukemia, splenomegaly, cirrhosis of the liver, jaundice, hypogranulocytosis, chronic progressive cough, blood cells in the urine and acute glomerulonephritis.

Occupational Health

The American Conference of Governmental Industrial Hygenists has established Threshold Limit Values in air (time-weighted concentrations under which it is believed that all workers may be repeatedly exposed day after day without adverse effect) for both p-dichlorobenzene (75 ppm - 450 mg/cu m) and o-dichlorobenzene (50 ppm - 300 mg/cu m). The recommended Short Term Exposure Limit (maximum concentration to which workers may be exposed for a period of 15 minutes) for p-dichlorobenzene is 110 ppm (675 mg/cu m). The importance of exposure of the skin to o-dichlorobenzene is noted. The ortho form is more toxic than the para form.

Routes of Human Exposure

OCCUPATIONAL. Workers involved in the production of toluene diisocyanate, dyestuffs, herbicides, insecticides and air deodorants are at risk of exposure to the 1,2- and 1,4-isomers or both. No information is available on the production and use of the 1,3-isomer.

AMBIENT. There is very little data on the atmospheric concentrations of dichlorobenzene but o-dichlorobenzene was detected in aerial fallout and high volume air samples taken in California at concentrations ranging from 8 to 53 ng/cu m.

All three isomers have been detected in groundwater, drinking water (1-3 ppb), sewage treatment plant effluents and industrial discharges.

Dichlorobenzenes may be formed in the chlorination of drinking water.

CONSUMER. It has been estimated that as many as 500,000 people may be exposed to para-dichlorobenzene used as a room deodorant or for moth control.

The Food and Drug Administration allows the use of 1,4-dichlorobenzene (0.8 mg/kg) in the manufacture of resins for food coating products.

Indoor air concentrations measured in Tokyo ranged from 105 to 1,700 ug/cu m.

Environmental Significance

The acute and chronic toxicity of dichlorobenzenes to freshwater aquatic life occurs at concentrations as low as 1.1 and 0.8 mg/l, respectively. A concentration as low as 2.0 mg/l is toxic to saltwater aquatic life.

All three isomers of dichlorobenzene bioaccumulate. The concentration factors in the bluegill exposed for 14 days were 89 for the o-isomer, 66 for the m-isomer and 60 for the p-isomer.

The half-life of dichlorobenzenes has been estimated at 3 days in air and 8-12 hours in water. The ortho and para isomers have been detected in soils as products of lindane degradation.

North Carolina Production and Users

Production: None reported

Users: No information available

Recommended Reviews

Ambient Water Quality Criteria for Dichlorobenzenes, U.S. Environmental Protection Agency, EPA/440-5-80-039 (1980).

FIRST AID AND EMERGENCY RESPONSE INFORMATION

DICHLOROBENZENES

First Aid (NIOSH/OSHA Pocket Guide to Chemical Hazards)

o-Dichlorobenzene (1,2-DCB)

Eyes: Immediately wash the eyes with large amounts of water, occasionally lifting upper and lower lids. Seek medical attention immediately. CONTACT LENS SHOULD NOT BE WORN WHEN WORKING WITH 1,2-DICHLOROBENZENE.

Skin: Promptly wash the skin with soap or mild detergent and water. Remove the clothing if contaminated and wash the skin. Get medical attention immediately.

Inhalation: Move the exposed person to fresh air at once. Perform artificial respiration if necessary. Get medical attention as soon as possible.

Ingestion: Induce victim to vomit by touching the back of his throat with his finger or by giving syrup of ipecac. Seek medical attention immediately.

p-Dichlorobenzene (1,4-DCB)

Eyes: Same as for 1,2-dichlorobenzene

Skin: Wash the skin with soap or mild detergent and water.

Inhalation: Same as for 1,2-dichlorobenzene.

Ingestion: Give the person large quantities of water, then try to induce vomiting. Seek medical attention immediately.

Procedures for Spills and Leaks (U.S. DOT Emergency Response Guidebook, 1980)

Isolate hazard area and restrict entry. Remove all ignition sources. Stay upwind and keep out of low areas. Wear positive pressure breathing apparatus and special protective clothing. Do not touch spilled material. Stop leak if it can be done without risk.

SMALL SPILLS: Take up with sand, or other noncombustible absorbent material, then flush area with water.

LARGE SPILLS: Dike far ahead of spill for later disposal.

Fire and Explosion Information

GENERAL: Flammable when exposed to a source of ignition. Gives off poisonous gases when burning. Ignites at 66°C (150°F)

EXPLOSIVE LIMITS: Lower 1.7%.

EXTINGUISHER: Carbon dioxide, dry chemical or foam.

Reactivity

MATERIALS TO AVOID: Strong oxidizers such as permanganate and chlorine and contact with acids or acid fumes gives rise to poisonous gases. Contact with strong oxidizers or with hot aluminum or aluminum alloys may cause fires and explosions.

CONDITIONS TO AVOID: Heat may contribute to chemical decomposition yielding toxic products.

Protective Measures

STORAGE AND HANDLING: Store in a cool, well ventilated building away from any source of ignition.

ENGINEERING CONTROLS: Adequate ventilation with emergency shower and eye wash stations should be provided.

PROTECTIVE CLOTHING (Should not be substituted for proper handling and engineering controls): Wear rubber gloves and apron along with eye goggles if contact with fumes or particles is likely. Liquid o- and p-dichlorobenzenes will attack some forms of plastics, rubber, and coatings.

PROTECTIVE EQUIPMENT: For levels up to 1,000 ppm, wear one of the following respirators: chemical cartridge respirator with organic vapor cartridge with full facepiece and dust filter; gas mask with organic vapor canister and dust filter; supplied-air with full facepiece; self-contained breathing apparatus with full facepiece. For escape wear either a self-contained breathing apparatus or a gas mask with an organic vapor canister and particulate filter.

DICHLOROBENZENES

Profile

CHEMICAL IDENTIFICATION

Name: Dichlorobenzenes (mixed isomers)

Alternative Names:

Benzene, Dichloro- (Mixed isomers)
Dichloricide
Paramoth

Chemical Abstract Services (CAS) Registry Number: 25321-22-6

Registry of Toxic Effects of Chemical Substances (RTECS) Number: CZ 4430000

Molecular Weight: 147.01

Molecular Formula: $C_6H_4Cl_2$

Classification: Halogenated aromatic compound.

Form: Liquid, predominantly the orthoisomer

Name: m-Dichlorobenzene

Alternative Names:

Meta-Dichlorobenzene
1,3-Dichlorobenzene
Benzene, 1,3-Dichloro

Chemical Abstract Services (CAS) Registry Number: 00541-73-1

Registry of Toxic Effects of Chemical Substances (RTECS) Number: Not listed

RCRA Identification Number: U 070

Molecular Weight: 147.01

Molecular Formula: $C_6H_4Cl_2$

1,3-Dichlorobenzene

Classification: Halogenated aromatic compound

Description: A colorless liquid

Chemical/Physical Data

Boiling point: 173°C
Melting point: -24.7°C
Vapor pressure: 5 mm Hg at 39°C
Solubility in water: 123 mg/l at 25°C
Specific gravity: 1.282

Name: o-Dichlorobenzene

Alternative Names:

Benzene, o-Dichloro
Benzene, 1,2-Dichloro
Chloroben
DCB
Dilantin DB
Dizene
Dowtherm E
NCI-C54944
o-Dichlorobenzol
1,2-Dichlorobenzene
Dichlorobenzene, Ortho, Liquid
ODB
ODCB
Orthodichlorobenzene
Orthodichlorobenzol
Special Termite Fluid
Termitkil

Chemical Abstract Services (CAS) Registry Number: 00095-50-1

Registry of Toxic Effects of Chemical Substances (RTECS) Number: CZ 4500000

Hazardous Materials Table Identification Number: UN 1591

RCRA Identification Number: U 071

Molecular Weight: 147.00

Molecular Formula: $C_6H_4Cl_2$

Classification: Halogenated aromatic compound

Description: A colorless liquid

Uses: Pesticide

Chemical/Physical Data

Boiling point: 180.5°C
Melting point: -17.0°C
Vapor pressure: 1.15 mm Hg at 20°C; 1.5 mm at 25°C; 1.9 mm at 30°C
Vapor density: 5.07 (Air = 1.0)
Solubility in water: 100 mg/l at 20°C; 145 mg/l at 25°C
Specific gravity: 1.30
Flash point (closed cup): 48°C

Name: p-Dichlorobenzene

Alternative Names:

Benzene, p-Dichloro-
Dichloride
p-Dichlorobenzol
1,4-Dichlorobenzene
Dichlorobenzene, Para Solid
NCI-C54955
Paracide
Para Crystals
Paradi
para-Dichlorobenzene
Para dichlorobenzene
Paradichlorobenzol
Paradow
Paramoth
Paranuggets
Parazene
PDB
PDCB
Santochlor

Chemical Abstract Services (CAS) Registry Number: 00106-46-7

Registry of Toxic Effects of Chemical Substances (RTECS) Number: CZ 4550000

Hazardous Materials Table Identification Number: UN 1592

Molecular Weight: 147.01

Molecular Formula: $C_6H_4Cl_2$

Classification: Halogenated aromatic compounds

Description: Volatile monoclinic crystals with characteristic, penetrating odor.

Uses: Room deodorants and moth control chemicals.

Chemical/Physical Data

Boiling point: 174°C
Melting point: +53.1°C
Vapor pressure: 0.64 mm Hg at 20°C; 1.0 mm at 25°C; 1.8 mm at 30°C
Vapor density: 5.07 (Air = 1.0)
Solubility in water: 79 mg/l at 25°C
Flash point (closed cup): 66°C
Specific gravity: 1.248

HUMAN TOXICITY

The dichlorobenzenes may be absorbed through the lungs, gastrointestinal (GI) tract, and intact skin. Relatively low water solubility and high lipid solubility of halobenzenes favor their penetration of most membranes by diffusion, including pulmonary and GI epithelia, the brain, hepatic parenchyma, renal tubules, and the placenta (U.S. EPA, WQC, 1980).

Exposure of male production workers to 1,4-dichlorobenzene for 1-7 months resulted in loss of weight, exhaustion and blood dyscrasia. Five cases of blood disorders (including 2 cases of chronic lymphoid leukemia, 2 cases of acute myeloblastic leukemia and 1 case of myeloproliferative syndrome) were found in subjects exposed to ortho or para dichlorobenzenes as a solvent for other chemicals or in chlorinated benzene mixtures (NTP, 1979).

Effects of human poisoning from dichlorobenzenes are summarized in Table 1. This table is excerpted from the U.S. EPA Water Quality Criteria Document (1980).

TABLE 1. HUMAN POISONING BY DICHLOROBENZENE

Compound	Subject and Exposure	Effects	Reference
1,2-DCB mixtures (o-DCB)	Male; 40 yrs; chronic occupational exposure through inhalation and perhaps dermal absorption.	Weakness, fatigue, chronic lymphoid leukemia.	Girard, et al. 1969
1,2-DCB (o-DCB)	Female; 18 yrs.; chronic occupational exposure via inhalation as pressing/ ironing worker.	Severe acute hemolytic anemia; fatigue; nausea, headache, bone marrow hyperplasia.	Gadrat, et al. 1962
1,4-DCB (p-DCB)	Male; 20 yrs; and workmates; 1 to 7 months occupational exposure during manufacture of 1,4-DCB; inhalation (presumably)	Weight loss; exhaustion; decreased appetite; methemoglobinemia and other blood pathologies.	Ware and West 1977

The maximum level at which one could escape within 30 minutes without any escape-impairing symptoms or irreversible effects is suggested to be 1,000 ppm for p-dichlorobenzene and for 1,700 ppm for o-dichlorobenzene (NIOSH, 1978).

Carcinogenicity

IARC, 1979 — No adequate animal studies on which to base an evaluation of carcinogenicity were available to the Working Group. For human data, one report has suggested an association between leukemia and exposure to dichlorobenzenes, but this is insufficient evidence from which to assess the carcinogenic risk of this compound.

U.S. EPA, CAG, 1979 — Five reports indicate that chlorochlorobenzenes are not carcinogenic in animals, but all of these reports are inadequate in design to assess carcinogenicity.

Mutagenicity

U.S. EPA, WQC, 1980 — o-Dichlorobenzene gave a negative mutagenic response in Aspergillus, but its genotoxic effect in other systems could not be evaluated due to its toxicity or because of volatilization. p-Dichlorobenzene was reported to be mutagenic in one study.

U.S. EPA, WQC, 1980 — Chromosomal and other nuclear derangements in roots of Allium exposed for 4 hours to o-dichlorobenzene vapor are reported. Chromosome fragmentation in root tip cells and effects in meiotic cells of flower buds resulted from exposure to saturated aqueous solution.

NTP, 1980 — Mutagenesis Salmonella typhimurium test result: Negative for each of the three isomers.

Teratogenicity & Embryotoxicity

Embryotoxicity and teratogenicity of dichlorobenzenes apparently have not been studied and reported. The potential for transplacental

toxicosis or developmental effects may be inferred from evidence that lower chlorinated benzenes pass membrane barriers (including egg and placenta) and affect hormone-metabolizing systems (U.S. EPA, WQC, 1980).

ANIMAL TOXICITY

Results of acute and longterm toxicity studies in animals for the predominant dichlorobenzene isomers are summarized in the following tables. These tables are adapted from the U.S. EPA Water Quality Criteria Document (1980).

Acute Toxicity of 1,2-Dichlorobenzene

Route	Species	Lethal Dose or Lethal Concentration
Inhalation	Guinea Pig	4,808 mg/cu m for 24 hours, LCLo
	Rat	4,249 mg/cu m for 7 hours, LCLo
Oral	Rabbit	1,875 mg/kg, LD50

Chronic Toxicity of 1,2-Dichlorobenzene

Route	Species	Dose/Effect or Concentration
Inhalation	Rat	455 mg/cu m daily for 15 days; hepatic porphyria
Oral	Rat	376 mg/kg (tube); 4 d/wk, 130 doses; liver and kidney weight increase, cloudy swelling in liver

Acute Toxicity of 1,4-Dichlorobenzene

Route	Species	Dose/Concentration and Effect
Oral	Mouse	2,950 mg/kg; LD50
	Rat	500 mg/kg; LD50
	Rabbit	2,812 mg/kg; LD50

Chronic Toxicity of 1,4-Dichlorobenzene

Route	Species	Dose/Concentration and Effect
Inhalation	Rat, Guinea pig and rabbit	4,800 mg/cu m; 8 hours/day, 5 day/week, up to 69 exposures. Severe irritation, CNS depression and collapse, liver, kidney and lung pathology; death
Inhalation	Rat, Guinea pig and rabbit	576 mg/cu m; 7 hours/day; 5 day/week; up to 67 exposures; no adverse effects in several parameters.
Oral	Rat	1,000 mg/kg per dose (tube); 92 doses in 219 days; CNS depression; weight loss; liver degeneration and necrosis; deaths
Oral	Rat	18.8 mg/kg/day; 5 day/week, 138 doses in 192 days; No adverse effects

Aquatic Toxicity

The aquatic toxicity rating for dichlorobenzenes is from less than 1 ppm - 10 ppm (TLm, 96 hours) (RTECS, 1982).

The U.S. EPA Water Quality Criteria for the protection of aquatic life are given below:

> The available data for dichlorobenzenes indicate that acute and chronic toxicity to freshwater aquatic life occur at concentrations as low as 1.1 and 0.8 mg/l, respectively, and would occur at lower concentrations among species that are more sensitive than those tested.
>
> The available data for dichlorobenzenes indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 2.0 mg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of dichlorobenzenes to sensitive saltwater aquatic life (U.S. EPA, WQC, 1980).

Bioaccumulation: The following concentration factors were observed in the bluegill exposed for 14 days.

o-isomer 89
m-isomer 66
p-isomer 60
(U.S. EPA, WQC, 1980)

Biodegradation in aquatic species: A half-life of less than one day was observed in the bluegill for each of the three isomers (U.S. EPA, WQC, 1980).

Phytotoxicity

The toxic effects of dichlorobenzenes on algae were measured for Skeletonema costatus and Selenastrum capriconium. Effects on Chlorophylla were observed at concentrations as low as 44 mg/l (U.S. EPA, WQC, 1980).

ENVIRONMENTAL DATA

Air

o-Dichlorobenzene was detected in aerial fallout and high volume air samples taken in California at concentrationa from 8 to 53 mg/cu m. It was concluded that aerial fallout of chlorinated benzenes is less significant than that of DDT and PCB's because of the higher volatility. Gas phase concentrations were not reported. Samples taken in surburban Tokyo ranged from 1.5 to 4.2 ng/cu m. Indoor levels measured in Tokyo ranged from 105 to 1,700 ug/cu m (U.S. EPA, WQC, 1980). Dichlorobenzenes have an estimated half-life in air of about 3 days (Callahan, 1979). They are reactive to atmospheric OH-radical, but the m-isomer is reported resistant to autooxidation by ozone. Dispersion by air is likely.

Water

All three isomers have been detected in groundwater, drinking water, sewage treatment plant effluents and industrial discharges. Dichlorobenzenes may be formed as a result of the chlorination of drinking water (U.S. EPA, WQC, 1980). Estimated half-life in water for these substances is about 10 hours (Callahan, 1979). Volatilization is the major pathway for removal from this medium, and significant accumulation is unlikely.

Soil

Ortho and paraisomers have been detected in soils as products of lindane degradation. These substances are resistant to sewage organisms, and a partition coefficient of 3-39 (Callahan, 1979) indicates that some adsorption is likely. Volatilization may prevent accumulation.

Biota

Dichlorobenzenes have been detected in the blood of residents of New Orleans and in human adipose tissue from Japanese subjects (U.S. EPA, WQC, 1980). They accumulate 60-80 fold at equilibrium, and are slow to degrade (U.S. EPA, WQC, 1980). Biomagnification has not been studied.

Dichlorobenzenes are not known to occur in nature (IARC, 1974).

Production

No production of dichlorobenzenes in North Carolina was reported in the Toxic Substances Control Act (TSCA) Chemical Substances Inventory (U.S. EPA, TSCA, 1980).

The estimated U.S. production of o-dichlorobenzene in the last few years has been about 50 million pounds (25,000 tons). In 1976, U.S. production of p-dichlorobenzene was 37 million pounds (18,500 tons) (U.S. EPA, CAG, 1979).

No data on the commercial production of m-dichlorobenzene were found.

Consumption and Use

Estimated U.S. Consumption Patterns:

o-isomer	
Pesticides and organic chemicals	53 percent
Solvent for toluene diisocyanate	20 percent
Solvent for miscellaneous uses	15 percent
Manufacture of dyes	8 percent
p-isomer	
Room deodorant	50 percent
Moth control	40 percent

(IARC, 1974)

Reported uses and the corresponding SIC codes are listed below:

o-isomer	
Solvent for waxes, gums, resins, tars, asphalt, oils, engine parts	22, 28, 2861 295 30, 31, 25, 37
Dye intermediate	2865
Sulfur absorbent (from gas)	2818
Herbicide, insecticide, fumigant	2879
Heat transfer agent	2879
Degreasing agent for metals, leather, wool	34, 31, 224, 225, 226
Component of rustproofing	
p-isomer	
Insecticide (for the control of clothing moths)	2879
Space deodorant	
Manufacture of polyphenylene sulfide resins	2821
Dye intermediate (2,5-dichloroaniline dyes)	2865
In pharamceuticals	2834
In fumigants	3879
Fumigant to control mildew and molds on leather and fabrics	

(IARC, 1974; Merck 1976; ACGIH, 1980)

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air

1,4-Dichlorobenzene is under evaluation for possible designation as a Hazardous Air Pollutant by the U.S. Environmental Protection Agency.

Workroom Air

ACGIH The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air for p-dichlorobenzene is 75 ppm (450 mg/cu m) and for o-dichlorobenzene is 50 ppm (300 mg/cu m) as a time-weighted average. The importance of skin exposure is noted.

OSHA — The Occupational Safety and Health Administration's (OSHA) standard for workroom air for p-dichlorobenzene is 75 ppm (450 mg/cu m) and the standard for o-dichlorobenzene is 50 ppm (300 mg/cu m) as a time-weighted average.

Water

Addressed by Ambient Water Quality Criteria set by the U.S. Environmental Protection Agency.

Designated a toxic pollutant by the U.S. Environmental Protection Agency.

Designated a hazardous substance by the U.S. Environmental Protection Agency. Spills in excess of 100 pounds must be reported.

Other

Regulated as a hazardous material (o- and p-isomers) by the U.S. Department of Transportation.

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Agencies Concerned with this Chemical

Subject of a Risk Assessment Document prepared by the Carcinogen Assessment Group (CAG) of the U.S. Environmental Protection Agency.

1,2-Dichlorobenzene and 1,4-dichlorobenzene are the subject of a monograph prepared by the International Agency for Research on Cancer (IARC).

Under review by the Interagency Testing Committee for possible recommendation for priority consideration by the U.S. Environmental Protection Agency (Federal Register, Vol. 45, No. 196, 1980).

Subject to a proposed rule under the Toxic Substances Control Act. (Federal Register, Vol. 45, No. 42, 1980).

Under toxicological evaluation through the National Toxicology Program to determine mutagenicity (all isomers) and carcinogenicity (o- and p- isomers). (National Toxicology Program, Fiscal Year 1981 Annual Plan, NTP-80-62, 1980).

Addressed by a National Toxicology Program (NTP) Executive Summary and included in the list of 100 compounds nominated for NTP testing.

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Callahan, M. A., et al. Water-Related Fate of 129 Priority Pollutants. U.S. EPA Office of Water Planning and Standards, Washington, DC, EPA 440/4-79-029 (December 1979).

International Agency for Research on Cancer (IARC). IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon France, Volume 7. A World Health Organization Publication (WHO), Geneva, (1974).

Merck Index: An Encyclopedia of Chemicals and Drugs, Ninth Edition, M. Windholz, Ed. Merck and Co., Rahway, NJ (1976).

National Institute for Occupational Safety and Health/Occupational Safety and Health Administration (NIOSH/OSHA). NIOSH/OSHA Pocket Guide to Chemical Hazards. DHEW (NIOSH) Publication No. 78-210 (September 1978).

National Toxicology Program. Fiscal Year 1981 Annual Plan. NTP 80-62 (1980).

National Toxicology Program. NTP Executive Summaries. Prepared by the National Center for Toxicological Research, Office of Scientific Intelligence, Jefferson, AR (March 1979).

U.S. Environmental Protection Agency, Carcinogen Assessment Group (CAG). Carcinogen Assessment Group's Preliminary Risk Assessment on Chlorobenzene, o-Dichlorobenzene, and p-dichlorobenzene. Washington, DC (1979).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA PB-90-155-153 (1980).

U.S. Environmental Protection Agency, Office of Water Planning and Standards. Ambient Water Quality Criteria for Dichlorobenzenes. EPA-440/5-80-039 (October 1980).

Verschueren, Karel. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York, NY (1977).

Executive Summary

CAS NUMBER 00107-06-2

1,2-Dichloroethane is a colorless, oily, flammable liquid with a chloroform-like odor. It is currently produced primarily by catalytic chlorination of ethylene, but an increasing percentage is being produced by oxychlorination. 1,2-Dichloroethane is not known to occur as a natural product. It was estimated that 163 million pounds of 1,2-dichloroethane were released to the environment in 1974. Emissions during the manufacture of end products, principally vinyl chloride, were identified as the major source. Federal regulations require the reporting of all 1,2-dichloroethane spills exceeding 1,000 pounds (455 kilograms) or 95 gallons (360 liters) and North Carolina requires the reporting of all spills (regardless of quantity) near water.

Health Effects

ACUTE. 1,2-Dichlorobenzene may affect a variety of human organs or systems. The primary effects are central nervous system depression and gastrointestinal upset. Liver, kidney and adrenal injuries occur in a dose-related fasion. Specific adverse neurological effects include headache, dizziness, unconsciousness, vertigo, hand tremors, generalized weakness, sleepiness, nervousness, and mental confusion. Hepatic effects include liver function abnormalities, cellular damage, toxic chemical hepatitis, jaundice and liver enlargement.

Most reported fatalities have occurred following acute accidental or industrial exposures.

CARCINOGENICITY. There is sufficient evidence that 1,2-dichloroethane is carcinogenic in mice and rats. In the absence of adequate data in humans. it is reasonable, for practical purposes, to regard 1,2-dichloroethane as if it presented a carcinogenic risk to humans.

MUTAGENICITY. 1,2-Dichloroethane is mutagenic in Salmonella typhimurium, Drosophila melanogaster and Hordeum vulgare. A metabolite, chloroacetaldehyde, is hundreds of times more active in S. typhimurium. 1,2-Dichloroethane can form a reactive chloroethyl sulfide intermediate in the presence of rat liver enzymes.

TERATOGENICITY & EMBRYOTOXICITY. No evidence was found to indicate that 1,2-dichloroethane causes birth defects. 1,2-Dichloroethane is reported to be an embryotoxin in the rat.

CHRONIC. Exposure for up to 5 years at concentrations not exceeding 25 ppm caused no apparent changes in blood or internal organs but various complaints and nervous system effects were noted.

Occupational Health

The American Conference of Governmental Industrial Hygienists has established a Threshold Limit Value for workroom air (time-weighted average concentration under which it is believed that all workers may be repeatedly exposed day after day without adverse effect) of 10 ppm (40 mg/cu m). The recommended Short Term Exposure Limit (the maximum concentration to which workers may be exposed for a period up to 15 minutes) is 15 ppm (60 mg/cu m).

The Occupational Safety and Health Administration's standard for workroom air is 50 ppm (200 mg/cu m) as a time-weighted average with a ceiling of 100 ppm. The National Institute of Occupational Safety and Health recommends that occupational exposure be limited to 1 ppm (4 mg/cu m), with a 15-minute ceiling concentration of 2 ppm (8 mg/cu m).

Routes of Human Exposure

OCCUPATIONAL. The great majority of all 1,2-dichloroethane produced in the U.S. is used as the starting material in the manufacture of vinyl chloride. 1,2-Dichloroethane serves as an intermediate in the production of several chlorinated hydrocarbon solvents, as well as vinylidene chloride and ethyleneamines. Formulations of tetraethyl lead, the gasoline antiknock additive, incorporate dichloroethane as a lead scavenger. The NIOSH National Occupational Hazards Survey estimated that 1.9 million U.S. workers were potentially exposed. It is estimated that workers primarily exposed were those in hospitals, blast furnaces, steel mills and air transportation industries.

AMBIENT. In 1974, total annual U.S. emissions of 1,2-dichloroethane to the ambient air were estimated to have been 74 million kg. The individual sources of these emissions were : (1) manufacture of end products, primarily vinyl chloride; (2) manufacture of 1,2-dichloroethane; (3) use as a solvent; (4) storage and distribution. 1,2-Dichloroethane is a constituent of vinyl chloride reactor bottoms which are disposed of via landfill or incineration. In surveys of water supplies, 1,2-dichloroethane was detected in more than 30 percent of samples at concentrations ranging from 0.2 to 8.0 ug/l. Levels as high as 90 ug/l have been detected in raw water samples from sites near industrialized areas.

CONSUMER. Residues from use of the chemical as a grain fumigant may contaminate food items, though the volatility of 1,2-dichloroethane would tend to reduce this problem. Concentrations ranging from 2-23 ug/g were detected in spices that were prepared using dichloroethane as an extractant. It has been reported in the milk of nursing mothers who were occupationally exposed by inhalation and skin absorption.

Environmental Significance

Estimated half-life in air is 34 months or longer, based on reaction with hydroxyl radicals. Estimated oxidative half-life in air is 234 hours (9.75 days). Estimated half-life in water is 29 minutes, based on evaporation from a 1 ppm solution at 25°C (rates varied substantially with stirring speed), and 50,000 years, based on hydrolysis only. A concentration factor of 2 was observed in bluegills exposed for 14 days.

The available freshwater data for 1,2-dichloroethane indicate that acute toxicity

occurs at concentrations as low as 118 mg/l, and chronic toxicity occurs at concentrations as low as 20 mg/l. Saltwater data indicate that acute toxicity to fish and invertebrate species occurs at concentrations as low as 113 µg/l. Acute and chronic toxicity would occur at lower concentrations among species that are more sensitive than those tested.

Limited evidence for biodegradation was found. Oysters and fish exposed to radioactive labelled 1,2-dichloroethane showed lower dichloroethane levels than expected from the amount of C^{14} accumulation.

No data on phytotoxicity from air pollution were available.

An increase in mutation frequency has been observed in barley when kernels were treated for 24 hours at 20°C with 1,2-dichloroethane.

Data on aquatic plants or algae were not found.

Recommended Reviews

Carcinogen Assessment Group's Preliminary Report on Ethylene Dichloride, U.S. Environmental Protection Agency (June 15, 1980).

Chemical Hazard Information Profiles (CHIPs), U.S. Environmental Protection Agency, EPA-560/11-80-011, September 1, 1977.

Ambient Water Quality Criteria for Chlorinated Ethanes, U.S. Environmental Protection Agency, EPA/440-5-80-029 (October, 1980).

First Aid (NIOSH/OSHA Pocket Guide to Chemical Hazards)

Eyes: Wash with large amounts of water immediately, occasionally lifting upper and lower lids. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH 1,2-DICHLOROETHANE.

Skin: Wash the contaminated skin promptly with soap and water. Remove clothing if contaminated and wash skin with soap and water.

Inhalation: Move to fresh air at once. Perform artificial respiration if necessary. Seek immediate medical attention.

Ingestion: Induce vomiting by having victim touch the back of his throat with his finger or by giving syrup of ipecac. Seek medical attention.

Procedures for Spills and Leaks (U.S. DOT Emergency Response Guidebook, 1980)

Isolate hazard area and deny entry. Stay upwind and keep out of low areas. Wear self-contained breathing apparatus and full protective clothing. Isolate for ½ mile in all directions if tank or tankcar is involved in fire. No flares, smoking or flames in hazard area. Stop leak if it can be done without risk. Use water spray to reduce vapors.

SMALL SPILLS: Take up with sand, or other noncombustible absorbent material, then flush area with water.

LARGE SPILLS: Dike far ahead of spill for later disposal.

Fire and Explosion Information

This substance will burn. It may be ignited by heat, sparks and flames. Flammable vapor may spread away from spill and flashback. Container may explode in heat of fire. Vapor explosion hazard indoors, outdoors or in sewers. Runoff to sewer may create fire or explosion hazard.

SMALL FIRES: Dry chemical, CO_2, water spray or foam.

LARGE FIRES: Water spray, fog or foam.

Move containers from fire area if it can be done without risk. Stay away from ends of tanks. Cool containers that are exposed to flames with water from the side until well after fire is out. For massive fire in cargo area, use unmanned hose holder and monitor nozzles. Withdraw immediately in case of rising sound from venting safety device or discoloration of tank.

Reactivity

MATERIALS TO AVOID. Strong oxidizers, strong caustics, chemically active metals such as aluminum or magnesium powder, sodium, potassium.

Protective Measures

ENGINEERING CONTROLS: Sinks, showers and eye wash stations should be available.

PROTECTIVE EQUIPMENT: For levels up to 1,000 ppm, use any chemical cartridge with an organic vapor cartridge(s), any supplied-air respirator, or any self-contained breathing apparatus. For levels up to 4,000 ppm use a gas mask with a chin-style or a front- or back-mounted organic vapor canister, any supplied-air respirator with a full facpiece, helmet, or hood, any self-contained breathing apparatus with a full facepiece, or a Type C supplied-air respirator operated in pressure-demand or other positive pressure or continuous-flow mode. For levels greater than 4,000 ppm or entry and escape from unknown concentrations, use a self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode, or a combination respirator which includes a Type C suppliedair respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.

1,2-DICHLOROETHANE

Profile

Chemical Identification

Alternative Names:

1,2-Bichloroethane	Di-Chlor-Mulsion
Borer Sol	Ethylene Chloride
Brocide	Ethylene Dichloride
Destruxol Borer-Sol	Freon 150
	Glycol Dichloride

Chemical Abstract Services (CAS) Registry Number: 000107-06-2

Registry of Toxic Effects of Chemical Substances (RTECS) Number: KI 0525000

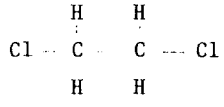
Hazardous Materials Table Identification Number: UN 1184

RCRA Identification Number: U 077

Molecular Weight: 98.96

Molecular Formula: $C_2H_4Cl_2$

Structure:



Classification: Saturated alkyl halide; chlorinated hydrocarbon

Description: A colorless, oily, flammable liquid with a chlorform-like odor

Uses: Chemical intermediate in production of vinyl-chloride

Chemical/Physical Data

Boiling point: 83.47°C
Melting point: -35.36°C
Vapor pressure: 61 mm Hg at 20°C; 105 mm at 30°C
Vapor density: 3.4 (Air = 1.0)
Solubility in water: 8,690 mg/l at 20°C (Verschueren, 1977)
Specific gravity: 1.25

HUMAN TOXICITY

1,2-Dichloroethane may affect a variety of human organs or systems including hematological, carciovascular, pulmonary, renal/urologic, gastrointestinal, hepatic biliary, musculoskeletal, neurological, dermatological, and others. Adverse neurological effects include headache, dizziness, unconsciousness, vertigo, hand tremors, generalized weakness, sleepiness, nervousness, and mental confusion. Hepatic effects include liver function abnormalities, cellular damage, toxic chemical hepatitis, jaundice, and liver enlargement (NIOSH, 1978).

Exposure for up to 5 years at concentrations not exceeding 25 ppm caused no changes in blood or internal organs, but various complaints and nervous system effects were noted (ACGIH, 1980).

The primary effects are central nervous system depression and gastrointestinal upset. Liver, kidney, and adernal injuries occur in a dose-related fashion (U.S. EPA, CHIP, 1980).

Most of the reported fatalities have occurred following acute accidental or industrial exposures.

The maximum level at which one could escape within 30 minutes without any escape-impairing symptoms or irreversible effects is suggested to be 1,000 ppm (NIOSH/OSHA, 1978).

Carcinogenicity

U.S. EPA, CAG, 1978 — There is evidence than exposure to 1,2-dichloroethyene poses a carcinogenic risk to man. This is based on the National Cancer Institute bioassay study of 1,2-dichloroethylene which showed a statistically significant increase of tumors in both Osborne-Mental rats and B6C3F1 mice after long-term oral intubation. A quantitative risk, assuming a lifetime continuous exposure to 1 ug/cu m of 1,2-dichloroethylene showed an individual lifetime risk of approximately 1.2 per 100,000.

NIOSH, 1978 — NIOSH recommends handling of 1,2-dichloroethylene as if it were a human carcinogen based on National Cancer Institute data for male and female rats and mice. Evidence associating the chemical with human cancer has not been presented.

IARC, 1979 — There is sufficient evidence that 1,2-dichloroethylene is carcinogenic in mice and rats. In the absence of adequate data in humans, it is reasonable, for practical purposes, to regard 1,2-dichloroethylene as if it presented a carcinogenic risk to humans.

U.S. EPA, WQC, 1980 — Water Quality Criteria are based on incremental increase of cancer risk with increasing exposures. Nonthreshold behavior is assumed.

Mutagenicity

U.S. EPA, CAG, 1978 — 1,2-Dichloroethane and its metabolite, chloroacetaldehyde, have been shown to be mutagenic in

Salmonella typhimurium. Chloroacetaldehyde was hundreds of times more active.

IARC, 1979 — 1,2-Dichloroethane is mutagenic in Salmonella typhimurium, Drosophila melanogaster, and Hordeum vulgare. It can form a reactive chloroethyl sulfide intermediate in the presence of rat liver enzymes.

Teratogenicity and Embryotoxicity

No evidence was found to indicate that 1,2-dichloroethane causes birth defects. 1,2-Dichloroethane is reported to be an embryotoxin in the rat (NIOSH, 1978).

ANIMAL TOXICITY

All of the chloroethane compounds are known to cause central nervous system depression, usually expressed as abnormal weakness, intoxication, restlessness, irregular respiration, muscle incoordination, and unconsciousness. Chloroethanes are irritating to the eyes and skin (NIOSH, 1978).

Acute Toxicity

Results of lethal studies involving 1,2-dichloroethane in several species as reported in the RTECS, 1980 are listed below:

Route	Species	Lethal Dose or Lethal Concentration
Oral	Rat	680 mg/kg, LD50
	Mouse	600 mg/kg, lowest lethal dose
	Dog	2,000 mg/kg, lowest lethal dose
	Rabbit	860 mg/kg, LD50
Inhalation	Rat	1,000 ppm (4,000 mg/cu m) for 4 hours, lowest LC
	Mouse	1,250 ppm (5,000 mg/cu m) for 2 hours, lowest LC
	Rabbit	3,000 ppm (12,000 mg/cu m) for 7 hours, lowest LC
	Pig	3,000 ppm (12,000 mg/cu m) for 7 hours, lowest LC
	Guinea pig	1,500 ppm (6,000 mg/cu m) for 7 hours, lowest LC

Administration to the eyes of dogs and foxes resulted in opacity of the cornea (ACGIH, 1980).

Chronic Toxicity

Damage to the liver has been demonstrated in six species tested (NIOSH, 1978). Increased mortality was observed in five species exposed for 7 hours per day, 5 days per week at 200 ppm; weight loss, pulmonary congestion, and liver changes were noted (ACGIH, 1980). There were no abnormal findings in rats exposed at 100 ppm, but effects were reported in cats and guinea pigs exposed at this level (ACGIH, 1980).

Aquatic Toxicity

Aquatic toxicity rating: TLm 96 is 100-1,000 ppm (RTECS, 1980).

The U.S. EPA Water Quality Criteria (1980) for protection of aquatic life are given below:

> The available freshwater data for chlorinated ethanes indicate that toxicity increases greatly with increasing chlorination and that acute toxicity occurs at concentrations as low as 118 mg/l for 1,2-dichloroethane. Chronic toxicity occurs at concentrations as low as 20 mg/l for 1,2-dichloroethane. Acute and chronic toxicity would occur at lower concentrations among species that are more sensitive than those tested.
>
> The available saltwater data for chlorinated ethanes indicate that toxicity increases greatly with increasing chlorination and that acute toxicity to fish and invertebrate species occurs at concentrations as low as 113 mg/l for 1,2-dichloroethane.

Bioaccumulation: A concentration factor of 2 was reported for the bluegill exposed (U.S. EPA, WQC, 1980).

Biodegradation in aquatic species: Limited evidence for biodegradation was found. Oysters and fish exposed to radio-labeled 1,2-dichloroethane showed lower dichloroethane levels than expected from the amount of C14 accumulation (Callahan, 1979).

Phytotoxicity

No data on the phytoxocity from air pollution were available.

An increase in mutation frequency has been observed in barley when kernels were treated for 24 hours at 20°C with 1,2-dichloroethane (IARC, 1979).

Data on aquatic plants or algae were not found.

ENVIRONMENTAL DATA

Air

Concentrations of 1,2-dichloroethane in rural air samples were below the limit of detection (Grimsrud, 1975). 1,2-Dichloroethane has an estimated half-life in air of several months (Callahan, 1979). High rates of discharge into the atmosphere, combined with relatively slow degradation, can result in significant accumulation (U.S. EPA, CHIP, 1980).

Water

In surveys of water supplies, 1,2-dichloroethane was detected in more than 30 percent of samples at concentrations ranging from 0.2 to 8.0 ug/l (U.S. EPA, WQC, 1980). Levels as high as 90 ug/l have been detected in raw water samples from sites near industrialized areas (U.S. EPA, CHIP, 1980). 1,2-Dichloroethane has a relatively short half-life in water (estimated at 29 minutes by evaporation; Callahan, 1979). Although highly volatile, it is resistant to hydrolysis and chemical degradation. Significant accumulation is not expected.

Soil

1,2-Dichloroethane is slightly soluble, and is probably removed to air and water rather than degrading in this medium. This substance has a low partition coefficient (1.48; Radding, 1977), implying low adsorption and accumulation.

Biota

A concentration factor of 2 was observed in bluegills exposed for 14 days (U.S. EPA, WQC, 1980). Low rates of bioaccumulation and a low octanol/water partition coefficient suggest that accumulation in this medium is probably not significant. Biomagnification is also unlikely.

Other

1,2-Dichloroethane is not known to occur as a natural product. Residues from the use of the chemical as a grain fumigant may cause contamination of food items, but treated grain products may contain little 1,2-dichloroethane because of its volatility. Concentrations ranging from 2-23 ug/g were detected in spices that were prepared using dichloroethane as an extractant (U.S. EPA, WQC, 1980).

In an EPA-sponsored report, it was estimated that 163 million pounds of 1,2-dichloroethane were released to the environment in 1974. Emissions during the manufacture of end products were identified as the major source (U.S. EPA, CHIP, 1980).

Production

No production in North Carolina has been reported in the Toxic Substances Control Act (TSCA) Chemical Substance Inventory (U.S. EPA, TSCA, 1980).

The estimated U.S. production was 3,600 million kg (4 million tons). Since some 1,2-dichloroethane is produced but not separated (and therefore not reported), this is likely to be an underestimate (IARC, 1979). In 1975, it was the 16th highest volume chemical produced in the United States (U.S. EPA, CHIP, 1980).

Consumption and Use

Estimated U.S. Consumption for 1976:

Production of vinyl chloride	81.6 percent
Production of 1,1,1-trichloroethane, tetrachloroethylene, trichloroethylene and vinylidene chloride	9.4 percent
Production of ethylene amines	2.8 percent
Lead scavenger	1.9 percent
Miscellaneous uses	0.1 percent
Export	4.2 percent

(IARC, 1979)

Reported uses of 1,2-dichloroethane and the corresponding SIC codes are listed below:

Production of vinyl chloride, trichloroethane, tetrachloroethylene, trichloroethylene, vinylidene chloride, and ethylene amines	2869
Lead scavenger	29
Industrial solvent	-
Fumigant for grains	011
Fumigant for carpets and upholstery	721
Manufacture of polysulfide elastomers and ethyleneimine	2811, 1869

(IARC, 1979)

RESEARCH AND REGULATORY DATA

Ambient Air

Under evaluation for possible designation as a Hazardous Air Pollutant by the U.S. Environmental Protection Agency.

Workroom Air

ACGIH — The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air is 10 ppm (40 mg/cu m) as a time-weighted average. The recommended Short Term Exposure Limit (STEL) is 15 ppm (60 mg/cu m).

NIOSH — The National Institute of Occupational Safety and Health (NIOSH) recommends that occupational exposure be limited to 1 ppm (4 mg/cu m). A ceiling concentration of 2 ppm (8 mg/cu m) as determined over a 15-minute sampling period is also recommended.

OSHA — The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 50 ppm (200 mg/cu m) as a time-weighted average with a ceiling of 100 ppm and a 5 minute maximum in any 3 hour period fo 200 ppm.

Water

Addressed by Ambient Water Quality Criteria set by the U.S. Environmental Protection Agency.

Designated a toxic pollutant by the U.S. Environmental Protection Agency.

Designated a hazardous substance by the U.S. Environmental Protection Agency. Discharges in excess of 1,000 pounds must be reported.

Other

Regulated as a hazardous material by the U.S. Department of Transportation. The regulations pertain to the identification and transportation of hazardous materials in commerce (Code of Federal Regulations, Title 49, Part 172.101). 1,2-Dichloroethane is classified as a "Flammable Liquid", and shipments must carry this label.

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Agencies Concerned with this Chemical

Chemical Hazard Information Profile (CHIP) compiled by the Office of Testing and Evaluation, U.S. Environmental Protection Agency.

Appears on the 1977 Priority List of the Chemical Industry Institute of Toxicology (CIIT).

Designated a candidate substance by the Occupational Safety and Health Administration.

Subject of a Preliminary Report prepared by the Carcinogen Assessment Group (CAG) of the U.S. Environmental Protection Agency.

Subject of a monograph prepared by the International Agency for Research on Cancer (IARC).

Chlorinated paraffins are included on the Priority List of the Interagency Testing Committee (ITC).

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Callahan, M.A., et al. Water-Related Fate of 129 Priority Pollutants. U.S. EPA Office of Water Planning and Standards, Washington, DC, EPA 440/4-79-029 (December 1979).

Grimsrud, E.P., and R. A. Rasmussen. Survey and Analysis of Halocarbons in the Atmosphere by Gas Chromatography-Mass Spectrometry. Atmospheric Environment, 9, 1014-17 (1975).

International Agency for Research on Cancer (IARC). IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon France, Volume 20. A World Health Organization Publication (WHO), Geneva (1979).

National Institute for Occupational Safety and Health (NIOSH). Current Intelligence Bulletin No. 27. Chloroethanes: A Review of Toxicity. U.S. Department of Health, Education and Welfare, DHEW(NIOSH) Publication No. 78-81 (1978).

National Institute for Occupational Safety and Health/Occupational Safety and Health Administration (NIOSH/OSHA). NIOSH/OSHA Pocket Guide to Chemical Hazards. DHEW (NIOSH) Publication No. 78-210 (September 1978).

Radding, S., et al. Review of the Environmental Fate of Selected Chemicals. Prepared for the U.S. Environmental Protection Agency. Available from the National Technical Information Service, Springfield, VA, PB 267-121 (May 1977).

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfiche Issue, R. J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville, MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 80-111-4 (1980).

U.S. Environmental Protection Agency, Carcinogen Assessment Group (CAG). Carcinogen Assessment Group's Preliminary Report on Ethylene Dichloride. Washington, DC (June 15, 1978).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Chemical Hazard Information Profiles (CHIPs). EPA-560/11-80-011 (1980).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA PB-80-155-153 (1980).

1,2-DICHLOROPROPANE

Executive Summary

CAS Number 00078-87-5

1,2-Dichloropropane is a colorless, flammable liquid with a chloroform-like odor. It is prepared from propyl chloride and antimony chloride, and is soluble in water (2.7 g/l at 20°C). The principal use of 1,2-dichloropropane is that of a soil fumigant for controlling nematodes. It is regulated as a hazardous material by USDOT and as a hazardous waste under RCRA. Federal regulations require the reporting of spills which exceed 5000 pounds (2270 kg) or 522 gallons (1976 liters). North Carolina requires the reporting of all spills if they occur near water.

Health Effects

ACUTE. 1,2-Dichloropropane is only mildly irritating to the skin and moderately irritating to the eye and does not cause serious or permanent injury. Acute lethal concentrations (LD50 or LC50) include:

Oral Route (LD)	Rat	1,900 mg/kg
Inhalation Route (LC)	Rat	2,000 ppm (9244 mg/cu m) for 4 hours
Dermal Route (LD)	Rabbit	8,750 mg/kg

In animals exposed to lethal doses, there were liver abnormalities, renal tubular necrosis, pneumonia and fat degeneration within the heart.

CARCINOGENICITY. Evidence of carcinogenicity has not been presented; however, inhalation of 380 ppm (1,760 mg/cu m) in air was reported to induce hepatomas in mice.

MUTAGENICITY. 1,2-Dichloropropane is reported to be mutagenic in two Salmonella typhimurium strains, with or without metabolic conversion.

TERATOGENICITY & EMBRYOTOXICITY. No evidence was found to indicate that this chemical causes birth defects.

CHRONIC. Daily dosing of rats (14.4 and 360 mg/kg) for up to 30 days caused inhibition of serum chloinesterase and alanine transaminase. Rats exposed continuously to 216 ppm (1,000 mg/cu m) in air for 7 days showed significant liver effects.

Occupational Health

The American Conference of Governmental Industrial Hygienists has established a Threshold Limit Value (time-weighted average concentration under which it is believed that all workers may be repeatedly exposed day after day without adverse effect) of 75 ppm (350 mg/cu m) and a Short Term Exposure Limit (the maximum concentration to which workers may be exposed for a period up to 15 minutes) of 110 ppm (510 mg/cu m).

Routes of Human Exposure

OCCUPATIONAL. Agricultural workers who apply soil fumigants and workers in dry cleaning industries and degreasing operations are likely to be exposed.

AMBIENT. No data on atmospheric levels were found. Dichloropropanes have been reported in chemical plant effluents. An ambient water criterion cannot presently be derived. However, by extrapolation, a water concentration of 483 ug/l can be calculated.

CONSUMER: 1,2-Dichloropropane has been detected in municipal drinking water (1.0 µg/l) and in well water. Its use as a soil fumigant may result in contamination of tubers and other food crops but no quantitative data are available.

Environmental Significance

The available data for dichloropropane indicate that acute and chronic toxicity to freshwater aquatic life occur at concentrations as low as 23 mg/l and 5.7 mg/l, respectively, and to saltwater aquatic life at 10.3 gm/l and 3.0 mg/l. A bioaccumulation potential of 10.4 has been computed.

Dichloropropane appears to undergo minimal degradation in the soil with the major route of dissipation appearing to be volatilization.

North Carolina Production and Users

PRODUCTION: None reported under TSCA USERS: No information

Recommended Reviews

Ambient Water Quality Criteria for Dichloropropanes, (Dichloropropanes), EPA-440/5-80-043, U.S. Environmental Protection Agency, (1980).

Halogenated hydrocarbons in New Orleans drinking water and blood plasma, B. Dowty, et al. Science 87-75 (1975).

FIRST AID AND EMERGENCY RESPONSE INFORMATION

1,2-DICHLOROPROPANE

First Aid (NIOSH/OSHA Pocket Guide to Chemical Hazards)

Eyes:	Wash with large amounts of water immediately. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH 1,2-DICHLOROPROPANE.
Skin:	Wash contaminated skin promptly with soap and water. Remove clothing if contaminated and wash skin with soap and water.
Inhalation:	Move to fresh air at once. Perform artificial respiration if necessary. Seek immediate medical attention.
Ingestion:	Induce vomiting by finger or by giving syrup of ipecac. Seek medical attention.

Procedures for Spills and Leaks (U.S. DOT Emergency Response Guidebook, 1980)

Isolate hazard area and deny entry. Stay upwind and keep out of low areas. Wear self-contained breathing apparatus and full protective clothing. Isolate for ½ mile in all directions if tank or tankcar is involved in fire. No flares, smoking or flames in hazard area. Stop leak if it can be done without risk. Use water spray to reduce vapors.

SMALL SPILLS:	Take up with sand, or other noncombustible absorbent material, then flush area with water.
LARGE SPILLS:	Dike far ahead of spill for later disposal.

Fire and Explosion Information

Will burn. May be ignited by heat, sparks and flames. Flammable vapor may spread away from spill. Container may explode in heat of fire. Vapor explosion hazard indoors, outdoors or in sewers. Runoff to sewer may create fire or explosion hazard.

FLASH POINT:	$60^{\circ}F$
SMALL FIRES:	Dry chemical, CO_2, water spray or foam.
LARGE FIRES:	Water spray, fog or foam.

Move containers from fire area is you can do it without risk. Stay away from ends of tanks. Cool containers that are exposed to flames with water from the side until well after fire is out. For massive fire in cargo area, use unmanned hose holder or monitor nozzles. Withdraw immediately in case of rising sound from venting safety device or discoloration of tank.

Reactivity

MATERIALS TO AVOID: Strong oxidizers, strong acids

Protective Measures

PROTECTIVE EQUIPMENT: At levels up to 400 ppm, wear a chemical cartridge respirator with an organic vapor canister, or a supplied-air respirator, or a self-contained breathing apparatus. At levels up to 2000 ppm, wear a gas mask with an organic vapor canister, or a supplied-air respirator with a full facepiece, or a self-contained breathing apparatus with a full facepiece. For escape from a contaminated area, wear a gas mask with an organic vapor canister or a self-contained breathing apparatus.

1,2-DICHLOROPROPANE

Profile

Chemical Identification

Alternative Names:

alpha, beta-dichloropropane
ENT 15,406
Propylene chloride
Propylene dichloride

Chemical Abstract Services (CAS) Registry Number: 00078-87-5

Registry of Toxic Effects of Chemical Substances (RTECS) Number: TX 9625000

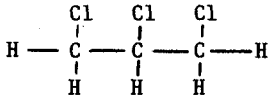
Hazardous Materials Table Identification Number: UN 1279

RCRA Identification Number: U 083

Molecular Weight: 112.99

Molecular Formula: $C_3H_6Cl_2$

Structure:



Classification: Saturated alkyl halide; chlorinated hydrocarbon

Description: A colorless, flammable, mobile liquid with a chloroformlike odor.

Uses: Soil fumigant

Chemical/Physical Properties

Boiling point: 95-96°C
Melting point: -100.44°C
Vapor pressure: 50 mm at 25°C
Vapor density: 3.9
Solubility in water: 2.7 gm/l at 20°C
Density: 1.159 at 25°C
Flash point: 21°C (open cup)

HUMAN TOXICITY

Limited human data are available relative to the toxicity of 1,2-dichloropropane. It is mildly irritating to the skin and moderately irritating to the eye, but does not cause serious or permanent injury (ACGIH, 1980).

Recent concern for the hepatotoxic potential (demonstrated in animals) may prompt reconsideration of the current and rather high occupational exposure recommendation of 75 ppm (ACGIH, 1980).

Carcinogenicity

U.S. EPA, WQC, 1980: Evidence of carcinogenicity has not been presented in the studies reported. Although inhalation of 380 ppm (1.7 gm/cu m) in air is reported to induce hepatomas, too few mice survived the exposures to make a valid evaluation.

NTP, 1980: Carcinogenesis bioassay testing was performed in FY 1980 in rats and mice. Administration was by gavage (direct introduction into the stomach).

Mutagenicity

U.S. EPA, WQC, 1980: 1,2-Dichloropropane is reported to be mutagenic in two Salmonella typhimurium strains, with or without metabolic conversion. The chemical is also reported to cause chromosomal aberrations in rat bone marrow.

NTP, 1980: Mutagenesis Salmonella typhimurium test result: equivocal.

Teratogenicity and Embryotoxicity

No evidence was found to indicate that 1,2-Dichloropropane causes birth defects.

ANIMAL TOXICITY

1,2-Dichloropropane has been studied in several animal species and by several routes of administration.

Acute Toxicity

Results of lethal studies as reported in the RTECS, 1980 are listed below:

Route	Species	Lethal Dose or Lethal Concentration
Oral	Rat	1,900 mg/kg, LD50
	Mouse	860 mg/kg, LD50
	Dog	5,000 mg/kg, lowest lethal dose
	Guinea pig	2,000 mg/kg, LD50
Inhalation	Rat	9,244 mg/cu m (2,000 ppm) for 4 hours, lowest LC
Dermal	Rabbit	8,750 mg/kg, LD50

Gross effects in animals exposed to lethal concentrations (repeated exposures) included weight loss, central nervous system depression, abnormal respiratory noises, and neuromuscular weakness. Also observed were liver abnormalities, including fatty degeneration and necrosis, as well as renal tubular necrosis, pneumonia, fatty degeneration in the heart and other effects (U.S. EPA, WQC, 1980).

Chronic Toxicity

Daily dosing of rats (14.4 and 360 mg/kg) for up to 30 days caused inhibition of serum cholinesterase and alanine transaminase. Rats

exposed continuously to 216 ppm (1,000 mg/cu m) in air for 7 days showed significant liver effects. Rats, guinea pigs, and dogs exposed to 400 ppm for 128 to 140 daily 7-hour periods showed no effect except a decreased weight gain by rats. In a similar study with mice "slight fatty degeneration of the liver" was observed (U.S. EPA, WQC, 1980).

Aquatic Toxicity

Aquatic toxicity rating: TLm 96 is 10-100 ppm (RTECS, 1980).

The U.S. EPA Water Quality Criteria (1980) for protection of aquatic life are given below:

> The available data for dichloropropane indicate that acute chronic toxicity to freshwater aquatic life occur at concentrations as low as 23 and 5.7 mg/l, respectively.
>
> The available data for dichloropropane indicate that acute and chronic toxicity to saltwater aquatic life occur at concentrations as low as 10.3 and 3 mg/l, respectively.

Bioaccumulation: an average aquatic bioconcentration factor of 4.11 for the edible portion of fish (calculated on the basis of the estimated octanol/ water partition coefficient) is used in deriving the water quality criterion for protection of human health. A bioaccumulation potential of 10.4 was computed (U.S. EPA, WQC, 1980).

Phytotoxicity

No data are available on phytotoxicity from air pollution. Data on aquatic plants or alga are not reported.

ENVIRONMENTAL DATA

Air
No data on atmospheric levles of 1,2-dichloropropane was found. The substance degrades via tropospheric photo-oxidation (Callahan, 1979). Volatilization and dispersion by air are likely.

Water
1,2-Dichloropropane has been detected in municipal drinking water at 1.0 µg/l (U.S. EPA, WQC, 1980). Dichloropropanes have been reported in well water and in chemical plant effluents; the isomers were not specified (Shackelford, 1977). This substance has an estimated half-life in water of approximately 50 minutes based on volatility (Callahan, 1979). It is slowly degraded by hydrolosis, and in spite of its volatility, may return to this medium by precipitation.

Soil
1,2-Dichloropropane is expected to volatilize quickly in this medium, however small amounts absorbed on soil are likely to persist for long periods (U.S. EPA, WQc, 1980). Some dispersion is likely in this medium.

Biota
1,2-Dichloropropane is metabolized in rats. It has a moderate bioaccumulation factor of 10.4 (U.S. EPA, WQC, 1980).

Use of 1,2-dichloropropane as a soil fumigant may result in contamination of tubers and other food crops, but no quantitative data are available to indicate residue levels in commercial foodstuffs (U.S. EPA, WQC, 1980). The chemical is not known to occur naturally.

Production

No production in North Carolina has been reported in the Toxic Substance Control Act (TSCA) Chemical Substance Inventory (U.S. EPA, TSCA, 1980).

Production of 1,3-dichloropropane/1,2-dichloropropane mixture was estimated at 60 million pounds (30,000 tons) for 1975. 1,2-Dichloropropane makes up 3-5 percent of this mixture (U.S. EPA, WQC, 1980).

Consumption and Use

Estimated U.S. consumption:

The principal use of 1,2-dichloropropane is that of soil fumigant. No quantitative data were found (U.S. EPA, WQC, 1980).

Reported uses of 1,2-dichloropropane and the corresponding SIC codes are listed below:

Soil fumigant for controlling nematodes	01
Dry cleaning processes	721
Degreasing processes	
(U.S. EPA, WQC, 1980)	
Oil and fat solvent	207
(Merck, 1976)	
Scavenging agent for gasoline	29
Intermediate in chemical synthesis	28
(ACGIH, 1980)	

RESEARCH AND REGULATORY DATA

Ambient Air
No guidelines for dichloropropanes in air have been established.

Workroom Air
ACGIH The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists for workroom air is 75 ppm (350 mg/cu m) as

a time-weighted average. The recommended Short Term Exposure Limit (STEL) is 110 ppm (510 mg/cu m).

OSHA — The Occupational Safety and Health Administration's standard for workroom air is 75 ppm (350 mg/cu m) as a time-weighted average.

Water

Addressed by Ambient Water Quality Criteria set by the U.S. Environmental Protection Agency.

Dichloropropane is designated a toxic pollutant by the U.S. Environmental Protection Agency.

Dichloropropane is designated a hazardous substance by the U.S. Environmental Protection Agency. Spills in excess of 5,000 pounds must be reported.

Other

Regulated as a hazardous material by the U.S. Department of Transportation. The regulations pertain to the identification and transportation of hazardous materials in commerce (Code of Federal Regulations, Title 49, Part 172.101). 1,2-Dichloropropane is classified as a "Flammable Liquid" and shipments must carry this label.

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Agencies Concerned with this Chemical

Appears on the Priority List of the Interagency Testing Committee (ITC).

Subject to a proposed rule under the Toxic Substances Control Act that would require all chemical manufacturers to report production and exposure-related data to the U.S. Environmental Protection Agency (Federal Register, Vol. 45, No. 42, 1980).

Under toxicological evaluation through the National Toxicology Program to determine carcinogenicity. (National Toxicology Program, Fiscal Year 1981 Annual Plan, NTP-80-62, 1980).

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Callahan, M. A., et al. Water-Related Fate of 129 Priority Pollutants. U.S. EPA Office of Water Planning and Standards, Washington, DC, EPA 440/4-79-029 (December 1979).

Merck Index: An Encyclopedia of Chemicals and Drugs, Ninth Edition, M. Windholz, Ed. Merck and Co., Rahway, NJ (1976).

National Toxicology Program. Fiscal Year 1981 Annual Plan. Department of Health and Human Services, NTP-80-62 (December 1980).

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfiche Issue, R. J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville, MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 80-111-4 (1980).

Schackelford, W. M., and L. H. Keith. Frequency of Organic Compounds Identified in Water. EPA Publication No. 600/4-76-062 (December 1976).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA PB-80-155-153 (1980).

U.S. Environmental Protection Agency, Office of Water Planning and Standards. Ambient Water Quality Criteria for Dichloropropanes/Dichloropropenes. EPA-440/ 5-80-043, PB 81-117541 (October 1980).

Verschueren, Karel. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York, NY (1977).

DIMETHYLAMINE

Executive Summary

CAS NUMBER: 00124-40-3

Dimethylamine is a gas with a strong, ammoniacal odor. It is used as a solvent, in the manufacture of dimethylacetamide and dimethylformamide, as a rubber polymerization accelerator, in pharmaceutical preparations and in textile chemicals. Dimethylamine is produced by reacting ammonia and methanol over a dehydrating catalyst. One hundred million lbs of dimethylamine were produced in the U.S. in 1977. One of the primary health concerns with dimethylamine is in its role as a nitrosamine precursor. Regulations regarding spills have not been developed at either the state or federal level.

Health Effects

ACUTE. Dimethylamine is moderately toxic to humans, irritating the lungs, eyes, and upper respiratory tract at concentrations of 20-100 ppm. Oral exposure in animals has resulted in irritation of the gastrointestinal mucosa and at higher levels of exposure, extensive hemorrhages in the stomach wall. The LD50 for mice and rats is 316 mg/kg and 698 mg/kg, respectively.

CARCINOGENICITY. Although it is a nitrosamine precursor, dimethylamine has not been shown to be carcinogenic.

MUTAGENICITY. Studies regarding the mutagenicity of dimethylamine have been inconclusive. Mutagenesis Salmonella typhimurium test results were negative; however, rats exposed to DMA at concentrations of 0.5 and 1 mg/cu m for 3 months had significant increases in the number of cells with abnormal numbers of chromosomes.

TERATOGENICITY AND EMBRYOTOXICITY. No evidence was found to indicate that dimethylamine causes birth defects or is embryotoxic.

CHRONIC. Chronic exposure generally results in relatively minor toxicological changes. Fatty degeneration and necrosis of the liver were observed in rats, guinea pigs, rabbits and mice after prolonged exposure.

Occupational Health Regulations

ACGIH: Threshold Limit Value for workroom air is 10 ppm (18 mg/cu m).

OSHA: Standard for workroom air (time-weighted average) is 10 ppm (18 mg/cu m).

Routes of Human Exposure

OCCUPATIONAL. Exposure to dimethylamine may occur during the following operations: preparation of textile spinning solvents, pharmaceuticals, detergents and soaps, rubber maufacture and fuel production.

AMBIENT. It is estimated that 20.6 million pounds of dimethylamine are released annually to the environment. It is therefore widely dispersed in nature.

CONSUMER: Dimethylamine has been found in commercial fish.

Environmental Significance

Although widely dispersed, dimethylamine is not considered persistent in the environment. It has an aquatic toxicity rating (TLm 96) of 10-100 ppm.

Recommended Reviews

Patty, F. A. 1963. Industrial Hygiene and Toxicology, 2nd edition. New York, Interscience Publishers.

FIRST AID AND EMERGENCY RESPONSE INFORMATION

DIMETHYLAMINE

First Aid (NIOSH/OSHA)

Eyes: Wash eyes immediately with large amounts of water, lifting the lower and upper lid occasionally. Get medical attention immediately. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH DIMETHYLAMINE.

Skin: Immediately flush the contaminated skin with water. Remove contaminated clothing immediately and wash the skin with water. If irritation persists, seek medical attention.

Inhalation: Move exposed person to fresh air at once. Perform artificial respiration if necessary. Keep exposed person warm and at rest. Get medical attention as soon as possible.

Ingestion: If victim is conscious, give large amounts of water immediately. After giving water, induce vomiting by finger. Do not make an unconscious person vomit. Get medical attention immediately.

Procedures for Spills and Leaks (U.S. DOT Emergency Response Guidebook, 1980)

Isolate hazard area and deny entry. Stay upwind, and keep out of low areas. Wear self-contained breathing apparatus and full protective clothing. Isolate for ½ mile in all directions if tank or tankcar is involved in fire. No flares, smoking or flames in hazard area. Stop leak if it can be done without risk. Use water spray to reduce vapors, but do not put water on leak area.

Fire and Explosion Information

This substance is extremely flammable, it may be ignited by heat, sparks and flames. The flammable vapor may spread away from spill. Containers may explode in the heat of fire. There can be vapor explosion hazards indoors, outdoors and in sewers. Let fire burn unless leak can be stopped immediately.

SMALL FIRES: Dry chemical or CO_2

LARGE FIRES: Water spray, fog or foam

Move container from fire area if it can be done without risk. Stay away from ends of tanks. Cool containers that are exposed to flames with water from the side until well after fire it out. Withdraw immediately in case of rising sound from venting safety device or discoloration of tank.

Reactivity

CONDITIONS TO AVOID: Heat sources

MATERIALS TO AVOID: Strong oxidizers, chlorine and mercury. Liquid dimethylamine will attack some forms of plastics, rubber and coatings.

Protective Measures

ENGINEERING CONTROLS: General dilution ventilation, local exhaust ventilation, personal protective equipment.

PROTECTIVE CLOTHING (Should not be substituted for proper engineering controls): Impervious clothing, gloves and faceshields.

PROTECTIVE EQUIPMENT: For levels up to 500 ppm use a chemical cartridge respirator with a full facepiece and cartridge(s) which provides protection against dimethylamine, a gas mask with a chin-style or a front- or back-mounted canister which provides protection against dimethylamine, any supplied-air respirator with a full facepiece, helmet or hood, or any self-contained breathing apparatus with a full facepiece. For levels up to 2,000 ppm use a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure mode or with a full facepiece, helmet, or hood operated in continuous-flow mode. For levels greater than 2,000 ppm or entry and escape from unknown concentrations, use a self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode, or a combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.

DIMETHYLAMINE

Profile

Chemical Identification

Alternative Names:

DMA
N-Methylmethanamine
Methanamine, N-Methyl-

Chemical Abstract Servides (CAS) Registry Number: 00124-40-3

Registry of Toxic Effects of Chemical Substances (RTECS) Number: IP 8750000

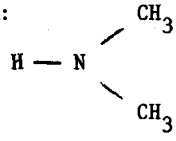
Hazardous Materials Table Identification Number: UN 1032

RCRA Identification Number: U 092

Molecular Weight: 45.08

Molecular Formula: C_2H_7N

Structure:



Classification: Secondary aliphatic amine

Description: A gas at ordinary temperatures with a pungent, ammoniacal odor

Uses: As an acid gas absorbent, solvent and chemical intermediate

Chemical/Physical Data

Boiling point: 7.4°C
Melting point: -93°C
Vapor pressure: 1,290 mm at 25°C
Vapor density: 1.55 (air = 1.0)
Solubility in water: Infinitely soluble
Log octanol/water partition coefficient: -0.38 (U.S. EPA, 1981)
Odor threshold in air: 23.2-47 ppb (117-237 ug/cu m) (U.S. EPA, CHIP, 1978); 600 ppb (3,024 ug/cu m) (ACGIH, 1980)

HUMAN TOXICITY

Dimethylamine is moderately toxic to humans by ingestion and inhalation. At concentrations of 20-100 ppm, methylamines are irritating to the lungs, eyes and upper respiratory tract (U.S. EPA CHIP, 1978). Dermatitis and conjunctivitis are occasionally observed in chemical workers after prolonged exposure to the gas. No systemic effects from industrial exposure have been reported.

The maximum level at which one could escape within 30 minutes without any escape-impairing symptoms or irreversible effects is suggested to be 2,000 ppm (NIOSH, 1978).

Carcinogenicity

CHIP, 1978 — A number of studies have been attempted to determine whether nitrosamines are formed after concurrent administration of dimethylamine and nitrite and, if so, whether the nitrosamine formed is carcinogenic. Tumors observed in the exposed animals were found not to be carcinogenic.

Mutagenicity

CHIP, 1978 — Rats exposed to 0.5 or 1 mg/cu m DMA for 3 months had significant increases at both concentrations in the number of cells having an abnormal number of chromosomes. There was a normal incidence, however, of structural chromosome breakage.

NTP, 1980 — Mutagenesis Salmonella typhimurium test result: negative.

Teratogenicity and Embryotoxicity

No evidence was found to indicate that dimethylamine causes birth defects, or is embryotoxic.

ANIMAL TOXICITY

Dimethylamine gas is a severe respiratory, eye, and mucous membrane irritant in animals. Repeated exposures to levels between 100-200 ppm for 18-20 weeks resulted in marked irritation of the respiratory tract with pulmonary edema, as well as hepatic injury. Both the liquid and the vapor are highly irritating to the eyes, and exposure may result in the loss of visual acuity.

Acute Toxicity

Results of lethal studies in several species as reported in the TDB, 1982 are listed below:

Route	Species	Lethal Dose or Lethal Concentration
Oral	Mice	316 mg/kg, LD50
	Rat	698 mg/kg LD50
	Rabbit	240 mg/kg, LD50

Chronic Toxicity

Route	Species	Dosage/Effects
Oral	Guinea pig	3.5 mg/kg; increase in liver weight (U.S. EPA, CHIP, 1978)
Inhalation	Rats, Guinea pig, Rabbit, Dogs & Monkeys	9 mg/cu m for 90 days; no toxic effects

Aquatic Toxicity

Aquatic toxicity rating: TLm 96 is 10-100 ppm (TDB, 1982).

Data on accumulation and biodegradation of dimethylamine were not available.

Phytotoxicity

Data on phytotoxicity from air pollution were not available.

ENVIRONMENTAL DATA

Air
Dimethylamine has been detected above feed lots at levels of 632 µg/cu m. This substance decomposes rapidly in ultraviolet light; its half-life in sunlight is 30 minutes, so there is little likelihood that it is a daytime air pollutant (U.S. EPA, CHIP, 1978). Transient accumulation may occur near industrial sources (U.S. EPA, STAR, 1976). In the presence of nitrogen, dimethylamine forms n-nitrosodimethylamine, a suspected carcinogen.

Water
Dimethylamine and other simple aliphatic amines can be found as natural constituents of water. Concentrations are generally low due to bacteria degradation (U.S. EPA, WQC, 1980).Dimethylamine was detected at levels of 1.2 µg/l (average) for the river Waal, Netherlands (Verschueren, 1977). It was also detected in the effluents of a sewage treatment plant, latex plant, and chemical plant (Shackelford and Keith, 1976).

Although dimethylamine undergoes bacterial and oxidative degradation, some persistance and dispersion may be expected due to its high solubility and numerous sources of origin.

Soil
Dimethylamine occurs naturally in soils, where it undergoes biological and microbial degradation. Removal occurs by solubilization in water and volatilization in air. Because it is a natural product of microbial degradation (as well as a component), this substance is widely dispersed. Traces of dimethylamine have been found after the application of the pesticide dimethyldithiocarbamate, which degrades to dimethylamine (U.S. EPA, CHIP, 1978).

Biota
Dimethylamine is a normal product of bacterial decay of organic matter. It has been detected in feces and urine (U.S. EPA, STAR, 1976). This substance is widely dispersed in nature, where it degrades to metabolites and forms nitrosomines.

Other
High levels of dimethylamine have been found in fish.

INDUSTRIAL DATA

Production

No production in North Carolina reported in the Toxic Substances Control Act (TSCA) Chemical Substance Inventory (U.S. EPA, TSCA, 1980).

The estimated U.S. production in 1972 was 4.75×10^4 tons (U.S. EPA CHIP, 1978). Production in 1978 was estimated at 71.8 million pounds (3.59×10^4 tons).

Consumption and Use

Estimated U.S. Consumption for 1978:

Dimethyl formamide and acetamide	50 percent
Lauryl dimethyl oxide	15 percent
Rubber chemical accelerators	15 percent
Pesticides and dimethyl hydrazine	20 percent

Reported uses of dimethylamine and the corresponding SIC codes are listed below:

Production of dimethyl formamide, dimethyl acetamide, spinning solvent for acrylic fibers	2824, 22
Production of lauryl dimethyloxide, a surfactant	2843
Production of thiuram derivatives used for rubber accelators	2822, 30
Production of 1,1-dimethyl hydrazine for rocket fuel	2869
Sulfate salt used in tanning (U.S. EPA, CHIP, 1978)	31
Pesticides	2879
Pharmaceuticals (ACGIH, 1980)	283

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air
No guidelines for air have been established.

Workroom Air
ACGIH — The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air is 10 ppm (18 mg/cu m) as a time-weighted average.

OSHA — The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 10 ppm (18 mg/cu m) as a time-weighted average.

Water
Designated a hazardous substance by the U.S. Environmental Protection Agency.

Other
Regulated as a hazardous material by the U.S. Department of Transportation. Dimethylamine is

classified as a flammable gas, and shipments must carry a label which reads "flammable gas".

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Agencies Concerned with this Chemical

Chemical Hazard Information Profile (CHIP) compiled by the Office of Testing and Evaluation, U.S. Environmental Protection Agency.

Appears on the 1977 Priority List of the Chemical Industry Institute of Toxicology (CIIT).

Subject to a proposed rule under the Toxic Substances Control Act that would require all chemical manufacturers to report production and exposure-related data to the U.S. Environmental Protection Agency (Federal Register, Vol. 45, No. 42, 1980).

Under toxicological evaluation through the National Toxicology Program to determine mutagenicity (National Toxicology Program, Fiscal Year 1981 Annual Plan, NTP-80-62, 1980).

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

National Institute for Occupational Safety and Health/Occupational Safety and Health Administration (NIOSH/OSHA). NIOSH/OSHA Pocket Guide to Chemical Hazards. DHEW (NIOSH) Publication No. 78-210 (September 1978).

National Toxicology Program (NTP). Executive Summary for Dimethylamine. In Executive Summaries of dimethylamine nominated for FY 81 Testing. U.S. Department of Health, Education, and Welfare, Jefferson, Arkansas (1980).

Toxicology Data Bank - The National Library of Medicine, Bethesda, Maryland (1982).

U.S. Environmental Protection Agency, Office of Water Planning and Standards. Ambient Water Quality Criteria for Nitrosamines. EPA/440-5-80-016 (October, 1980).

U.S. Environmental Protection Agency, Office of Research and Development. A Scientific and Technical Assessment Report on Nitrosamines. U.S. Environmental Protection Agency, Washington, DC, EPA-600/6-77-001 (1976).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Chemical Hazard Information Profiles (CHIPs). EPA-560/11-80-011 (1978).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA PB-80-155-153 (1980).

Verschueren, Karel. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York, NY (1977).

1,4-DIOXANE

Executive Summary

CAS NUMBER 00123-91-1

1,4-Dioxane is a colorless, flammable liquid ether. U.S. production in 1972 was estimated to be 8,200 tons. It is used mainly as a stabilizer in chlorinated solvents in the chemical, cosmetic, pharmaceutical, rubber and textile processing industries. North Carolina requires the reporting of all spills if they occur near water.

Health Affects

ACUTE. Experimental inhalation exposures to 1,4-dioxane in humans indicated that 300 ppm for 15 minutes caused irritation of the eye, nose and throat and 5,500 ppm for 1 minute caused the same symptoms plus vertigo. Liver and kidney damage and death can result from one week exposure to concentrations ranging from 208 to 650 ppm.

Oral toxicity for 1,4-dioxane is relatively low (oral LD50 in the rat is 4.2 g/kg.

CARCINOGENICITY. Experimental toxicologic studies in mice, rats and guinea pigs have indicated that 1,4-dioxane can cause malignant tumors by oral administration. There are no human data.

MUTAGENICITY. 1,4-Dioxane was negative in the Ames Salmonella typhimurium test.

TERATOGENICITY AND EMBRYOTOXICITY. There is no evidence that 1,4-dioxane causes birth defects.

CHRONIC. No adverse effects of any kind were observed in rats, rabbits and dogs receiving 130 to 136 seven-hour exposures over 180 to 195 days at 50 ppm of 1,4-dioxane.

Occupational Health

The American Conference of Governmental Industrial Hygienists has established a Threshold Limit Value in air (time-averaged concentration under which it is believed that all workers may be repeatedly exposed day after day without adverse effect) of 25 ppm (90 mg/cu m). The Short Term Exposure Limit (maximum concentration to which workers may be exposed for a period up to 15 minutes) is 100 ppm (360 mg/cu m).

Routes of Human Exposure

OCCUPATIONAL. Workers using chlorinated solvents are at high risk of exposure.

AMBIENT. No data have been reported on the levels of 1,4-dioxane in air. It has been detected in finished drinking water at Gastonia, N.C. and in river water (Upper Catawba River, N.C.).

CONSUMER. No information available.

Environmental Significance

1,4-Dioxane is stable to light but forms an explosive peroxide in air. The estimated residence time in the atmosphere is 3.9 days. No information is available on its half-life in water.

The aquatic toxicity rating (TLm 96) is 100 to 1000 ppm. Inhibition of cell multiplication for the aquatic algae, Microcytis aeruginosa, starts at 575 mg/l.

North Carolina Production and Users

Production: Hercofina, Wilmington (no volume reported).

Users: No information available.

Recommended Reviews

Criteria for a Recommended Standard: Occupational Exposure to Dioxane, National Institute of Occupational Safety and Health, Publication No. 77-226 (1977).

FIRST AID AND EMERGENCY RESPONSE INFORMATION

1,4-DIOXANE

First aid (NIOSH/OSHA Pocket Guide to Chemical Hazards)

Eyes:	Immediately wash the eyes with large amounts of water, occasionally lifting upper and lower lids. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH 1,4-DIOXANE.
Skin:	Promptly wash the skin with water. Remove clothing if contaminated and wash skin.
Inhalation:	Move the exposed person to fresh air at once. Perform artificial respiration if necessary. Get medical attention as soon as possible.
Ingestion:	Induce vomiting by giving syrup of ipecac. Seek medical attention immediately.

Procedures for Spills and Leaks (U.S. DOT Emergency Response Guidebook, 1980)

Isolate hazard area and deny entry. Stay upwind and keep out of low areas. Wear self-contained breathing apparatus and full protective clothing. Isolate for ½ mile in all directions if tank or tankcar is involved in fire. No flares, smoking or flames in hazard area. Stop leak if it can be done without risk. Use water spray to reduce vapors.

SMALL SPILLS:	Take up with sand, or other noncombustible absorbent material, then flush area with water.
LARGE SPILLS:	Dike far ahead of spill for later disposal.

Fire and Explosion Information

Will burn. May be ignited by heat, sparks and flames. Flammable vapor may spread away from spill and flash back. Container may explode in heat of fire. Vapor explosion hazard indoors, outdoors or in sewers. Runoff to sewer may create fire or explosion hazard.

FLASH POINT:	$54^{o}F$
SMALL FIRES:	Dry chemical, CO_2, water spray or alcohol foam.
LARGE FIRES:	Water spray, fog or alcohol foam.

Move container from fire area if it can be done without risk. Stay away from ends of tanks. Cool containers that are exposed to flames with water from the side until well after fire is out. For massive fire in cargo area, use unmanned hose holder or monitor nozzles. Withdraw immediately in case of rising sound from venting safety device or discoloration of tank.

Reactivity

MATERIALS TO AVOID: Strong oxidizers.

Protective Measures

ENGINEERING CONTROLS: Sinks, showers and eyewash stations should be available.

PROTECTIVE EQUIPMENT: At levels up to 200 ppm, wear a supplied-air respirator with a facepiece, or a self-contained breathing apparatus with a facepiece. For escape from a contaminated area, wear a gas mask with an organic vapor canister or a self-contained breathing apparatus.

1,4-DIOXANE

Profile

Chemical Identification

Alternative Names:

Diethylene Dioxide	1,4-Dioxan
1,4-Diethylene Dioxide	Dioxane-1,4
Diethylene Ether	Dioxane (DOT)
Diethylene Oxide	p-Dioxin, Tetrahydro
1,4-Dioxacyclohexane	Dioxyethylene Ether
Diokan	Glycol Ethylene Ether
Dioxan	Tetrahydro-p-Dioxane
p-Dioxane	Tetrahydro-1,4-Dioxane

Chemical Abstract Services (CAS) Registry Number: 00123-91-1

Registry of Toxic Effects of Chemical Substances (RTECS) Number: JG 8225000

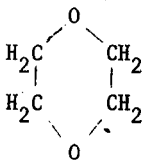
Hazardous Materials Table Identification Number: UN 1165

RCRA Identification Number: U 108

Molecular Weight: 88.12

Molecular Formula: $C_4H_8O_2$

Structure:



Classification: A symmetrical cyclic ether

Description: Colorless, flammable liquid with an ether-like odor

Uses: As a chemical stabilizer.

Chemical/Physical Data

Boiling point: 101.1°C
Melting point: 11.8°C
Vapor pressure: 29 mm Hg at 20°C; 37 mm at 25°C; 50 mm at 30°C
Vapor density: 3.03 (Air = 1.0)
Solubility in water: Miscible with water
Closed cup flash point: 12°C
Autoignition temperature: 180°C

HUMAN TOXICITY

Human death has occurred following heavy exposure to 1,4-dioxane vapors; severe kidney damage and liver necrosis were the cause of death. Other effects noted in exposed workers include nausea, vomiting, and irritation of eyes and respiratory passages (ACGIH, 1980).

Although classified by the ACGIH as an animal tumorigen, the Committee does not consider 1,4-dioxane of practical significance as an occupational carcinogen (ACGIH, 1980).

Summaries of effects in humans exposed via inhalation are given in Tables 1 and 2. These tables are reproduced from the NIOSH Criteria Document (1977). References indicated in the tables are listed with the Criteria Document excerpt in Section III of this dossier.

The maximum level at which one could escape within 30 minutes without any escape-impairing symptoms or irreversible effects is suggested to be 200 ppm (720 mg/cu m) (NIOSH/OSHA, 1978).

TABLE 1. CASE SUMMARIES OF OCCUPATIONAL EXPOSURE TO 1,4-DIOXANE IN HUMANS

Ref.	Exposure No. Concentration (ppm)	Time	Effects
31	208-650	1 wk.	Liver and kidney damage, death
20	Unknown	5 d	Liver and kidney damage, lung edema, death
"	"	4-6 wk	Anuria, death
"	"	"	Liver and kidney damage, death
"	"	"	Liver and kidney damage, coma, death
"	"	7-8 wk	Liver and kidney damage, lung congestion
32	-	-	Skin erythema, no death

TABLE 2. EXPERIMENTAL INHALATION EXPOSURES IN HUMANS

Ref. No.	Exposure Concentration (ppm)	Time (min)	Effects
19	5,500	1	Irritation of eye, nose, throat, vertigo
21	2,000	3	Strong odor, tolerance
19	1,600	10	Mucous membranes, burning
21	1,000	5	Odor
22	300	15	Irritation of eye, nose, throat
22	200	480	Safe concentration for sensory tests
27	170, 270		170 ppm -- odor threshold 270 ppm - pronounced odor
26	2.8, 5.6		2.8 ppm - detection threshold 5.6 ppm - recognition threshold

Carcinogenicity

NIOSH, 1977 Experimental toxicologic studies in mice, rats, and guinea pigs have indicated that dioxane can cause malignant tumors. These studies involved administration of the compound in drinking water. There is also equivocal evidence of carcinogenesis from dioxane when applied dermally, but this evidence has not been judged persuasive.

IARC, 1979 Animal data: 1,4-Dioxane is carcinogenic in rats and guinea pigs by oral administration. It produced malignant tumors of the nasal cavity and liver in rats and tumors of the liver and gall bladder in guinea pigs. It was also active as a promoter in a two-stage skin carcinogenesis study in mice. No carcinogenic effect was observed in one inhalation study in rats.

Human data: No case reports or epidemiological studies were available to the Working Group.

OSHA, 1981 There was a statistically significant increase in the incidence of squamous-cell carcinoma of the nasal turbinate in male and female Osborne-Mendel rats receiving p-dioxane at 0.5 percent and 1 percent in their drinking water. In females only, the incidence of hepatocellular adenoma was significantly increased.

Mutagenicity

NTP, 1980 Mutagenesis Salmonella typhimurium test result: Negative

Teratogenicity and Embryotoxicity

No evidence was found to indicate that 1,4-dioxane causes birth defects.

ANIMAL TOXICITY

Oral toxicity for 1,4-dioxane is relatively low. Inhalation studies show effects ranging from eye, nose, and lung irritation to severe or fatal liver and kidney damage (ACGIH, 1980).

Acute Toxicity

Results of lethal studies in several species as reported in the RTECS, 1980 are listed below:

Route	Species	Lethal Dose
Oral	Rat	4.2 g/kg, LD50
	Mouse	5.7 g/kg, LD50
	Cat	2.0 g/kg, LD50
	Rabbit	2.0 g/kg, LD50
	Guinea pig	3.2 g/kg, LD50
Dermal	Rabbit	7.6 g/kg, LD50

Results of inhalation studies are summarized in Table 3. This table is reproduced from the NIOSH Criteria Document (1977).

Chronic Toxicity

No adverse effects of any kind were observed in rats, rabbits, and dogs receiving 130 to 136 7-hr exposures during 180 to 195 days at 50 ppm of dioxane vapor; guinea pigs receiving 82 exposures at 50 ppm also showed no effects. No adverse effects were observed in rats and rabbits exposed at 100 ppm for 7 hours/day, 5 days/week for 2 years (ACGIH, 1980).

TABLE 3. ANIMAL INHALATION EXPERIMENTS

Ref. No.	Species	Exposure Concentration, ppm; Duration	Effects
24	Guinea pig, rabbit, rat, mouse	37,500; 3 hr	50% mortality; lung, liver and kidney damage
26	Mouse	1,400-39,000;	Death above 8,300 ppm single doses
"	Cat	12,000-31,000; until irritation noted, in min	Narcosis
24	Guinea pig, rat, rabbit mouse	4,000-11,000; 8 hr.	Liver and kidney damage
19	Guinea pig	1,000-30,000; maximum 480 min	Mucous membrane irritation; congestion, edema of lungs
55	Rat	1,500-6,000; Avoidance to buzzer, shock, in min	Behavioral changes above 3,000 ppm
21	Guinea pig, rat	1,000-10,000; twice/5 d, once/ 6th and 0/7th d	Liver and kidney damage increased with doses; death at 10,000 ppm after 2 exposures
24	Cat, mouse, rabbit, guinea pig	1,350-2,700; 8 hr/34-45d	Liver and kidney damage
26	Cat	1,400; 6.5 hr/ 14 d	Increased blood
68	Rat	111; 7 hr/d, 5 d/wk, for 2 yr.	Various tumors in both control and dioxane-treated

Aquatic Toxicity

Aquatic toxicity rating: TLm 96 is 100-1000 ppm (RTECS, 1980).

No information is available regarding bioaccumulation or biodegradation in aquatic species.

Phytotoxicity

No data are available on the effects of vapor phase dioxane on plants.

Inhibition of cell multiplication for the aquatic algae (Microcystis aeruginosa starts at 575 mg/l (Verschueren, 1977).

ENVIRONMENTAL DATA

Air

No data were found on the levels of 1,4-dioxane in air. 1,4-Dioxane has an estimated atmospheric residence time of 3.9 days (Cupitt, 1980). It is stable to light, but forms explosive peroxide in air (IARC, 1980). The persistence of the substance in air has not been objectively determined.

Water

1,4-Dioxane has been detected in finished drinking water in the United States including that of Gastonia, N.C. It has also been detected in the landfill leachate, raw sewage, and the effluents of sewage treatment plants and chemical plants. One of these chemical plants was located in the Upper Catawba River, North Carolina (Shackelford, 1977). Quantitative data regarding degradation in water were not found. Because of its miscibility and presence in a variety of water samples, some accumulation can be expected.

Soil

1,4-Dioxane is removed from the soil via water and oxidation (IARC, 1976). The likelihood of accumulation has not been determined.

Biota

1,4-Dioxane degraded quickly in humans exposed to small concentrations (NIOSH, 1977). It is miscible, and not expected to accumulate in fatty tissues. Similarly, no biomagnification is expected.

INDUSTRIAL DATA

Production

Production at Hercofina, Wilmington, North Carolina has been reported in the Toxic Substances Control Act (TSCA) Chemical Substances Inventory (U.S. EPA, TSCA, 1980).

U.S. production in 1973 was estimated to be 7.4 million kg (8,200 tons) (IARC, 1976).

Name: 1,4-Dioxane
CAS Number: 00123-91-1

Consumption and Use

Estimated U.S. Consumption:

No quantitative data were found on consumption patterns. It is "used mainly as a stabilizer in chlorinated solvents" (IARC, 1976).

Reported uses of 1,4-dioxane and the corresponding SIC codes are listed below:

Stabilizer in chlorinated solvents	
Solvent for cellulose acetate, ethyl cellulose, benzyl cellulose, resins, oils, waxes, and some dyes	282,2821 2823,2865
Solvent for electrical, agricultural, and biochemical intermediates	36, 287, 283
Solvent for adhesives and sealants	2891
Solvent for cosmetics and pharmaceuticals	2844, 2834
Solvent for rubber chemicals and surface coatings	2822, 30

(IARC, 1976)

Wetting and dispersing agent in textile processing, dyebaths, stain, and printing compositions	22, 226
Cleaning and detergent preparations	2841, 2842

(MEDLARS, 1981)

Used as a perservative, fumigant, and deodorant Nonaqueous solvent with lead-ion selective electrodes Formerly used for preparing tissue sections in histology
(NIOSH, 1977)

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air

Under evaluation for possible designation as a Hazardous Air Pollutant by the U.S. Environmental Protection Agency.

Workroom Air

ACGIH — The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air is 25 ppm (90 mg/cu m) as a time-weighted average. The importance of skin exposure is noted for technical grade 1,4-dioxane.

NIOSH — The National Institute of Occupational Safety and Health (NIOSH) recommends a standard of 1 ppm (3.6 mg/cu m).

OSHA — The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 100 ppm (360 mg/cu m) as a time-weighted average.

Water

No guidelines for water have been established.

Other

Regulated as a hazardous material by the U.S. Department of Transportation. The regulations pertain to the identification and transportation of hazardous materials in commerce (Code of Federal Regulations, Title 49, Part 172.101). 1,4-Dioxane is classified as a flammable liquid and shipments must carry a label which reads "Flammable Liquid".

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Agencies Concerned with this Chemical

Designated a candidate substance by the Occupational Safety and Health Administration.

Subject of a monograph prepared by the International Agency for Research on Cancer (IARC).

Subject to a proposed rule under the Toxic Substances Control Act that would require all chemical manufacturers to report production and exposure-related data to the U.S. Environmental Protection Agency (Federal Register, Vol. 45, No. 42, 1980).

Under toxicological evaluation through the National Toxicology Program to determine mutagenicity. (National Toxicology Program, Fiscal Year 1981 Annual Plan, NTP-80-62, 1980).

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Cupitt, L. T. Fate of Toxic and Hazardous Materials in the Air Environment. EPA600/380084, NTIS PB 80221948 (September 1980).

International Agency for Research on Cancer (IARC). IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon France, Volume 11. A World Health Organization Publication (WHO), Geneva (1976).

MEDLARS II. Toxicology Data Bank (TDB) Record of 1,4-Dioxane. National Library of Medicine (May 1981).

Merck Index: An Encyclopedia of Chemicals and Drugs, Ninth Edition, M. Windholz, Ed. Merck and Co., Rahway, NJ (1976).

National Institute for Occupational Safety and Health (NIOSH). Criteria for a Recommended Standard...Occupational Exposure to Dioxane. U.S. Department of Health, Education and Welfare. DHEW (NIOSH) Publication No. 77226 (September, 1977).

National Institute for Occupational Safety and Health/Occupational Safety and Health Administration (NIOSH/OSHA). NIOSH/OSHA Pocket Guide to Chemical Hazards. DHEW (NIOSH) Publication No. 78210 (September 1978).

National Toxicology Program. Fiscal Year 1981 Annual Plan. NTP 8062 (1980).

Occupational Safety and Health Administration (OSHA). Candidate Substance Data Summary Sheet. Chemical: p-Dioxane (1981).

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfiche Issue, R. J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville, MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 801114 (1980).

Shackelford, W. M., and L. H. Keith. Frequency of Organic Compounds Identified in Water. U.S. Environmental Protection Agency, EPA600/476062 (December 1976).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA PB-80-155-153 (1980).

Verschueren, Karel. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York, NY (1977).

EPICHLOROHYDRIN

Executive Summary

CAS NUMBER 00106-89-8

Epichlorohydrin is a colorless liquid with a characteristic chloroform-like irritating odor. Major commercial uses include the manufacturing of glycerin, unmodified epoxyresins, and epichlorhydrin elastomers. U.S. Production capacity in 1978 was 470 million pounds (213 million kg). Epichlorohydrin is regulated as a hazardous material by USDOT and as a hazardous waste under RCRA. Federal regulations require reporting of all spills in excess of 1,000 pounds (454 kg) or 102 gallons (386 liters). North Carolina requires the reporting of all spills if they occur near water.

Health Effects

ACUTE. Epichlorohydrin is a highly toxic substance which is easily absorbed through the skin. Skin contact can cause severe chemical burns usually following a latent period of several minutes or hours. Systemic poisoning may result from dermal absorption.

In acute inhalation exposures, workers have experienced irritation of the eyes and throat, facial swelling, nausea, vomiting, headache, and dypsnea. Frequent infections of the upper respiratory tract have also followed acute exposure. Transient burning of the eyes and nasal passages was reported at concentrations as low as 20 ppm.

CARCINOGENICITY. There is substantial evidence that epichlorohydrin is a human carcinogen. A statistically significant increase in deaths due to respiratory cancer was observed in an epidemiological study of 864 workers occupationally exposed to epichlorohydrin.

MUTAGENICITY. Increased chromosomal aberrations have been observed in exposed workers. Epichlorohydrin has been shown to be mutagenic to a wide variety of species, including bacteria, plants, Drosophila, and mice.

TERATOGENICITY & EMBRYOTOXICITY. Exposure to epichlorohydrin has been shown to induce reversible sterility in rats. A fertility study in male workers, however, did not show decreases in sperm count or effects in hormonal activity.

CHRONIC. A cumulative toxic action observed in experimental animals was believed to be due to nephrotoxicity. Acute exposures in animals have demonstrated renal insufficiency and alterations in blood hemoglobin and white cell counts.

Routes of Human Exposure

OCCUPATIONAL. Epichlorohydrin is used in the manufacture of epoxy resins, surface active agents, pharmaceuticals, insecticides, agricultural chemicals, textile chemicals, coatings, adhesives, ion-exchange resins, solvents, plasticizers, glycidyl esters, ethynyl-ethylenic alcohol and fatty acid derivatives. According to the National Occupational Health Survey (1978) an estimated 85,000 workers are potentially exposed to epichlorhydrin in the workplace.

AMBIENT. In air samples taken 100-200 meters from a factory discharging epichlorohydrin, levels of 0.5 - 1.2 mg/cu m were reported. Lower levels were found 400 meters from the factory and no epichlorhydrin was detected at a distance of 500-600 meters.

Epichlorohydrin has been detected in seawater.

CONSUMER. Epichlorohydrin has been used to crosslink starch in food. It has also been used as a solvent in paints, varnishes, nail enamel, and lacquers.

Environmental Significance

Epichlorohydrin is highly volatile and reactive, however it degrades quickly and significant accumulation is not expected. Estimated half-life in water at pH 7 is 36.3 hours, and the biological half-life in aquatic organisms is estimated to be less than than value. Estimated oxidative half-life in air is estimated to be 23 hours for aliphatic epoxides. Adsorption in soils is unlikely.

The aquatic toxicity factor (TLm 96) is 10-100 ppm and the 24 hour LC50 for goldfish was reported as 23 mg/l. Cell division is inhibited in aquatic algae at 6 mg/l.

FIRST AID AND EMERGENCY RESPONSE INFORMATION

EPICHLOROHYDRIN

First Aid (NIOSH/OSHA Pocket Guide to Chemical Hazards)

Eyes: Wash with large amounts of water immediately occassionally lifting upper and lower lids. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH EPICHLOROHYDRIN.

Skin: Wash with soap or mild detergent and water immediately. Remove clothing if contaminated and wash skin immediately.

Inhalation: Move to fresh air at once. Perform artificial respiration if necessary. Seek medical attention.

Ingestion: Induce vomiting by having the victim touch the back of his throat with his finger or by giving large amounts (one pint or more) of warm salt water (2 tablespoons of salt per pint of water). Seek medical attention.

Procedures for Spills and Leaks (U.S. DOT Emergency Response Guidebook, 1980)

Isolate hazard area and deny entry. Stay upwind and keep out of low areas. Wear positive pressure breathing apparatus and special protective clothing. Isolate for ½ mile in all directions if tank or tankcar is involved in fire. No flares, smoking or flames in hazard area. Do not touch spilled material. Stop leak if it can be done without risk. Use water spray to reduce vapors.

SMALL SPILLS: Flush area with flooding amounts of water. Do not get water inside of containers.

LARGE SPILLS: Dike far ahead of spill for later disposal.

Fire and Explosion Information

Will burn. May be ignited by heat, sparks and flames. Flammable vapor may spread away from spill and flash back. Container may explode in heat of fire. Vapor explosion and poison hazard indoors, outdoors or in sewers. Runoff to sewer may create fire or explosion hazard.

GENERAL: Flammable; ignites at 33°C (92°F).
EXPLOSIVE LIMITS: Upper - 14.5%, lower - 3.3%.
EXTINGUISHER: Use CO_2, dry chemical or alcohol foam, while wearing a self-contained breathing apparatus.

Reactivity

CONDITIONS TO AVOID: High temperatures can cause epichlorohydrin to break down and give off poisonous fumes of chlorides and phosgene.

MATERIALS TO AVOID: Can react violently with nitric acid, sulfuric acid, 2-aminoethanol, chlorosulfonic acid, ethylene diamine and potassium tert-butoxide.

Protective Measures

STORAGE AND HANDLING: Store in a cool place away from heat, sources of ignition and materials listed above.

ENGINEERING CONTROLS: Use in an enclosed process, with local exhaust ventilation or with automated equipment operated by personnel in a closed control booth or room. Sinks, showers and eyewash stations should be available.

PROTECTIVE CLOTHING (Should not be substituted for proper handling and engineering controls): If contact is likely, wear safety goggles, faceshield and apron, suit, boots and gloves made of impervious material (for example polyethylene). Do not use neoprene, rubber or leather.

PROTECTIVE EQUIPMENT: For levels up to 25 ppm use a gas mask with organic vapor canister or a Type C supplied-air respirator operated in the pressure-demand (positive pressure) or continous-flow mode. For levels up to 100 ppm use a gas mask (full facepiece) with chin-style or front-mounted organic vapor canister with impervious plastic cover for head and neck or a Type C supplied-air respirator operated in the pressure-demand (positive pressure) or continuous-flow mode with a full facepiece and impervious plastic cover for head and neck. For up to 1,000 ppm use a self-contained breathing apparatus with full facepiece operated either in the demand mode or in the pressure-demand (positive pressure) mode worn under an impervious plastic suit with headpiece or a combination Type C supplied-air respirator with full facepiece operated in the pressure-demand (positive pressure) mode and an auxiliary self-contained air supply worn under an impervious plastic suit with headpiece. For escape from a contaminated area use a gas mask (full facepiece) with chin- or front-mounted organic vapor canaister or a self-contained breathing apparatus with full facepiece operated either in the demand (negative pressure) mode or in the pressure-demand (positive pressure) mode.

EPICHLOROHYDRIN

Profile

Chemical Identification

Alternative Names:

1-Chloro-2,3-epoxypropane
3-Chloro-1,2-epoxypropane
3-Chloro-1,2-propylene oxide
(Chloromethyl)ethylene oxide
(Chloromethyl)oxirane
2-Chloromethyl oxirane
3-Chloropropylene-1,2-oxide
Chloropropylene oxide
gamma-Chloropropylene Oxide
ECH
ECHH
alpha-Epichlorohydrin
1,2-Epoxy-3-chloropropane
2,3-Epoxypropyl chloride
Glycerol epichlorohydrin
Glycidyl chloride
Oxirane, (chloromethyl)-
Oxirane, 2-(chloromethyl)-
Propane, 1-chloro-2,3-epoxy-
SKEKhG

Chemical Abstract Services (CAS) Registry Number: 00106-89-8

Registry of Toxic Effects of Chemical Substances (RTECS) Number: TX 4900000

Hazardous Materials Table Identification Number: UN 2023

RCRA Identification Number: U 041

Molecular Weight: 92.53

Molecular Formula: C_3H_5ClO

Classification: Chlorinated epoxide

Description: Colorless, mobile liquid with a characteristic chloroform-like irritating odor.

Uses: Chemical intermediate in manufacturing of resins, insecticides and adhesives.

Chemical/Physical Data

Boiling point: 116.5°C
Melting point: -48°C
Vapor pressure: 12 mm Hg at 20°C
Vapor density: 3.21 (Air = 1)
Solubility in water: 60,000 mg/l at 20°C
Specific gravity: 1.1812

HUMAN TOXICITY

Epichlorohydrin is a highly toxic substance which is easily absorbed through the skin. Skin contact can cause severe chemical burns usually following a latent period of several minutes or hours. Systemic poisoning may result from dermal absorption (NIOSH, 1976).

In acute inhalation exposures, workers have experienced irritation of the eyes and throat, facial swelling, nausea, vomiting, headache, and dypsnea. Frequent infections of the upper respiratory tract have also followed acute exposure (NIOSH, 1976). Transient burning of the eyes and nasal passages is reported at concentrations as low as 20 ppm (NIOSH, 1978).

Human effects associated with specific exposures (NIOSH, 1976) are tabulated below:

Exposure level	Effect
0.05 ppm	Odor threshold.
0.08 ppm	Changes in electroencephalogram recordings
20 ppm	Temporary burning of the eye and nasal passages
40 ppm	Eye and throat irritation lasting 48 hours
100 ppm	Intolerable
100 ppm (Brief exposure)	Lung edema and kidney lesions

Carcinogenicity

U.S. EPA, CAG, 1980 — The Carcinogen Assessment Group concluded that there is substantial evidence that epichlorohydrin is a human carcinogen. The unit risk calculated (the lifetime cancer risk associated with lifetime exposure at 1 ug/cu m) is 2.9×10^{-5}.

IARC, 1979 — Epichlorohydrin administered by subcutaneous injection was found to be carcinogenic in mice, producing local sarcomas. In a two-stage initiation-promotion experiment, an increased incidence of skin papilomas and carcinomas was also observed in mice receiving 2 mg epichlorohydrin applied to the skin as an initiator.

NIOSH, 1978 — An epidemiological study of 864 workers occupationally exposed to epichlorohydrin suggests that epichlorohydrin may be a human

carcinogen. A statistically significant increase in deaths due to respiratory cancer was observed in these workers.

Mutagenicity

U.S. EPA, CAG, 1980 — Increased chromosomal aberrations have been observed in workers exposed to epichlorohydrin. Epichlorohydrin has been shown to be mutagenic to a wide variety of species including bacteria, plants, Drosophila, and mice.

NIOSH, 1978 — Cytogenic analyses were conducted on 35 workers before and after occupational exposure to epichlorohydrin. After one year's exposure, a significant increase was detected in lymphocyte chromosome aberrations.

IARC, 1976 — Epichlorohydrin produced reverse mutations in Escherichia coli and in Neurospora crassa. Recessive lethal mutations have been obtained in Drosophila melanogaster. Dominant lethal mutations were not produced in Swiss mice receiving 150 mg/kg.

Teratogenicity and Embryotoxicity

Exposure to epichlorohydrin has been shown to induce reversible sterility in rats (IARC, 1976). A fertility study in male workers, however, did not show decreases in sperm count or effects in hormonal activity (ACGIH, 1980).

ANIMAL TOXICITY

Epichlorohydrin can cause central nervous depression and irritation of the respiratory tract. Death is generally due to depression of the respiratory center. The cumulative toxic action is believed to be due to nephrotoxicity (Hine, 1981). Acute exposures in experimental animals have also demonstrated renal insufficiency, alterations in blood hemoglobin and white cell counts, and reversible sterility.

NIOSH (1976) has summarized and tabulated the effects of epichlorohydrin in animals.

Toxic Effects of Epichlorohydrin

Route	Species	Dose/Concentration and Effect
Inhalation	Rat	91.0 ppm; 4 hr; kidney damage, liver function disrupted
	Mice	8.300 ppm for 30 min; 100% Mortality
Subcutaneous	Rat	150 mg/kg, LD50
	Mice	0.23 ml/kg/d for 4 days; 100% Mortality
Oral	Mice	0.23 ml/kg; LD50

Aquatic Toxicity

Aquatic toxicity rating: TLm 96 is 10-100 ppm (RTECS, 1980). The 24-hour LC50 for goldfish is reported as 23 mg/l (Verschueren, 1977).

Biodegradation in aquatic species: Epichlorohydrin reacts readily with biological molecules; the expected biological half-life is estimated to be less than the half-life in water (36.3 hours at pH 7) (NIOSH, 1976).

Phototoxicity

No data are available on the effects to plants from epichlorohydrin in air.

Aquatic algae are affected (inhibition of cell division) at 6 mg/l (Verschueren, 1977).

ENVIRONMENTAL DATA

Air

In samples taken 100-200 meters from a factory discharging epichlorohydrin, levels of 0.5-1.2 mg/cu m were reported. Lower levels were found 400 meters from the factory and no epichlorohydrin was detected as a distance of 500-600 meters (NIOSH, 1976). Epichlorohydrin has an estimated atmospheric residence time of 5.8 days (Cupitt, 1980), and an estimated oxidative half-life in air of 23 hours (Radding, 1977). It is not expected to be persistent in this medium.

Water

Epichlorohydrin has been detected in seawater (Shackelford, 1976). It is highly volatile in this medium, and has an oxidative half-life of 8.2 days (Radding, 1977). Epichlorohydrin degrades quickly in water, and accumulation is not expected to be significant.

Soil

No data on the occurrence of epichlorohydrin in ambient soils were found. It has a low partition coefficient of 0.30 (Radding, 1977). Epichlorohydrin degrades quickly in water, and accumulation is not expected to be significant.

Biota

The biological half-life of epichlorohydrin is estimated to be shorter than the half-life in water (NIOSH, 1976). It reacts readily with biological molecules and degrades quickly. Biomagnification is unlikely.

INDUSTRIAL DATA

Production

No production in North Carolina has been reported in the Toxic Substances Control Act (TSCA) Chemical Substance Inventory (U.S. EPA, TSCA, 1980).

Reported U.S. production capacity in 1978 was 470 million pounds (213 million kilograms) (NIOSH, 1978).

Consumption and Use

Estimated U.S. Consumption:

Manufacture of glycerin	46.6	percent
Unmodified epoxy resins	38.8	percent
Epichlorohydrin elastomers	1.7	percent
Exports	3.8	percent

(IARC, 1976)

Reported uses of epichlorohydrin and the corresponding SIC codes are listed below:

Production of glycerin, unmodified epoxy resins, and epichlorohydrin elastomers	2869, 282
As a cross link starch in food	20

(IARC, 1976)

Solvent for natural resins, synthetic resins	2821, 1823
Solvent for gums	2861
Solvent for cellulose ester and ethers	2861, 2823
Solvent for paints, varnishes, nail enamel, and lacquers	2851
In celluloid	2821

(Merck, 1976)

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air

Under evaluation for possible designation as a Hazardous Air Pollutant by the U.S. Environmental Protection Agency. Emission Standards for Hazardous Air Pollutants (NESHAPs) may be established for designated pollutants which increase the risk of cancer or irreversible health effects to the general population when emitted to the ambient air from specific sources (Code of Federal Regulations, Title 40, Part 61).

Workroom Air

ACGIH — The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air is 2 ppm (10 mg/cu m) as a time-weighted average. The recommended Short Term Exposure Limit (STEL) is 5 ppm (19 mg/cu m).

NIOSH — The National Institute of Occupational Safety and Health (NIOSH) has recommended a standard of 5 ppm (19 mg/cu m) for 15 minutes. In an October 1981 Current Intelligence Bulletin, NIOSH summarized recent evidence of carcinogenicity and recommended that epichlorohydrin be handled as a potential occupational carcinogen, with exposures being limited to as few employees as possible at the lowest levels attainable.

OSHA — The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 5 ppm (19 mg/cu m) as a time-weighted average.

Water

Designated a hazardous substance by the U.S. Environmental Protection Agency. Spills in excess of 1,000 pounds must be reported.

Other

Regulated as a hazardous material by the U.S. Department of Transportation. The regulations pertain to the identification and transportation of hazardous materials in commerce. Epichlorohydrin is classified as a "Flammable Liquid" and shipments must carry this label (Code of Federal Regulations, Title 49, Part 172.101).

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Agencies Concerned With This Chemical

Designated a candidate substance by the Occupational Safety and Health Administration.

Subject of a Risk Assessment Document prepared by the Carcinogen Assessment Group (CAG) of the U.S. Environmental Protection Agency.

Subject of a monograph prepared by the International Agency for Research on Cancer (IARC).

Appears on the Priority List of the Interagency Testing Committee (ITC).

Under review by the Interagency Testing Committee for possible recommendation for priority consideration by the U.S. Environmental Protection Agency (Federal Register, Vol. 45, No. 196, 1980).

Subject to a proposed rule under the Toxic Substances Control Act that would require all chemical manufacturers to report production and exposure-related data to the U.S. Environmental Protection Agency (Federal Register, Vol. 45, No. 42, 1980).

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Cupitt, L. T. Fate of Toxic and Hazardous Materials in the Air Environment. EPA-600/3-80-084, NTIS PB 80-221948 (September 1980).

Hine, C. et al. Epoxy Compounds. Patty's Industrial Hygiene and Toxicology, Vol. IIA, 3rd Revised Edition, G. D. Clayton and F. E. Clayton, Eds., John Wiley and Sons, NY (1981).

International Agency for Research on Cancer (IARC). IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon, France, Volume II. A World Health Organization Publication (WHO), Geneva (1976).

Merck Index: An Encyclopedia of Chemicals and Drugs, Ninth Edition, M. Windholz, Ed. Merck and Co., Rahway, NJ (1976).

National Institute for Occupational Safety and Health (NIOSH). Criteria for a Recommended Standard...Occupational Exposure to Epichlorohydrin. U.S. Department of Health, Education, and Welfare. DHEW (NIOSH) Publication No. 76-206 (1976).

National Institute for Occupational Safety and Health (NIOSH). Current Intelligence Bulletin No. 30. Epichlorohydrin. U.S. Department of Health, Education, and Welfare. DHEW (NIOSH) Publication No. 79-105 (1978).

National Institute for Occupational Safety and Health/Occupational Safety and Health Administration (NIOSH/OSHA). NIOSH/OSHA Pocket Guide to Chemical Hazards. DHEW (NIOSH) Publication No. 78-210 (September 1978).

Radding, S., et al. Review of the Environmental Fate of Selected Chemicals. Prepared for the U.S. Environmental Protection Agency. Available from the National Technical Information Service, Springfield, VA, PB 267 121 (May 1977).

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfiche Issue, R. J. Lewis and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville, MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 80-111-4 (1980).

Shackelford, W. M. and L. H. Keith. Frequency of Organic Compounds Identified in Water. Environmental Protection Agency, EPA-600/4-76-062 (December 1976).

U.S. Environmental Protection Agency, Carcinogen Assessment Group (CAG). Carcinogen Assessment Group's Preliminary Risk Assessment on Epichlorohydrin. Washington, DC (February 20, 1980).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA, PB-80-155-153 (1980).

Verschueren, Karel. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York, NY (1977).

ETHYLENEIMINE

Executive Summary

CAS NUMBER: 00151-56-4

Ethylenimine is a clear, colorless, flammable liquid with an ammoniacal odor (detectable at 2 ppm). It is produced on a commercial basis by the reaction of ammonia and ethylene dichloride. There is currently only one U.S. manufacturer, with an estimated annual production of less than 2.2 million lbs. Ethylenimine is used as a chemical intermediate, in water treatment and in paper processing. Ethylenimine is highly toxic by inhalation, skin contact and ingestion. There are no current regulations for reporting spills at either the federal or state level, but extreme caution should be exercised in preventing skin contact, inhalation or contamination of water sources.

Health Effects

ACUTE. Dermal exposure to ethylenimine has resulted in skin sensitization and dermatitis. Inhalation causes irritation of the throat, eye and nose, followed by vomiting. The probable oral lethal dose for humans is estimated to be 5-50 mg/kg for a 70 kg (150 lb) person.

CARCINOGENICITY. Ethylenimine has been found to be carcinogenic in animals. No case reports or epidemiological studies were available regarding humans.

MUTAGENICITY. Ethylenimine has been found to be mutagenic in S. typhimurium plate assays and in mammalian germinal cell lines by dominant-lethal assays in rats.

TERATOGENICITY AND EMBRYOTOXICITY. No evidence was found to indicate that ethylenimine was teratogenic. Some evidence of embryotropic effects were found, including depression in body weight gain of pregnant rats exposed by inhalation for 20 days (10 mg/cu m).

CHRONIC. Inhalation of ethylenimine has resulted in delayed lung injury with congestion, edema and hemorrhage, kidney damage and blood changes.

Occupational Health Regulations

OSHA: Time-weighted average for workroom air is 0.5 ppm (1 mg/cu m). The importance of skin exposure is noted.

ACGIH: Threshold Limit Value for workroom air is 500 ppb (1 mg/cu m).

Routes of Human Exposure

OCCUPATIONAL. Ethylenimine is a highly reactive compound and is used in many organic syntheses. A list of occupations in which exposure may occur includes: effluent treaters, paper makers, synthetic organic chemicals and textile workers.

AMBIENT. There are no data available regarding ambient exposure levels.

CONSUMER. Ethylenimine is present in some drugs and cosmetics.

Environmental Significance

Ethylenimine is generally not persistent in ambient media, with elevated levels being confined to occupational settings. Toxic effects were reported for aquatic life at concentrations of 0.11 mg/l, and for bacteria at concentrations of 5.5 µg/l.

Recommended Reviews

Dow Chemical Company 1966 Ethylenimine: Chemistry, Handling and Uses, Midland, Michigan.

FIRST AID AND EMERGENCY RESPONSE INFORMATION

ETHYLENEIMINE

First Aid

1. Terminate exposure immediately.
2. Enforce complete rest, keep victim comfortably warm.
3. Administer several hundred milligrams Vitamin E by mouth (if patient is conscious).
4. If oxygen therapy is necessary, give pure oxygen at high inspiratory concentrations.
5. Perform artificial respiration if necessary; remove frothy exudate.

Procedures for Spills and Leaks (U.S. DOT Emergency Response Guidebook, 1980)

Isolate hazard area and deny entry. Stay upwind and keep out of low areas. Wear positive pressure breathing apparatus and special protective clothing. Isolate for ½ mile in all directions if tank or tankcar is involved in fire. No flares, smoking or flames in hazard area. Do not touch spilled material. Stop leak if it can be done without risk. Use water spray to reduce vapors.

SMALL SPILLS: Flush area with flooding amounts of water. Do not get water inside containers.

LARGE SPILLS: Dike far ahead of spill for later disposal.

Fire and Explosion Information

This substance will burn. May be ignited by heat, sparks and flames. Flammable vapor may spread away from spill. Container may explode in heat of fire. Vapor explosion and poison hazard indoors, outdoors or in sewers. Runoff to sewer may create fire or explosion hazard.

EXPLOSIVE LIMITS: Lower - 3.6%, Upper - 4.6%.
SMALL FIRES: Dry chemical, CO_2, water spray or foam.
LARGE FIRES: Water spray, fog or foam.

Stay away from ends of tanks. Because of its high reactivity, do not get water inside of container. Cool containers that are exposed to flames with water from the side until well after fire is out. Withdraw immediately in case of rising sound from venting safety device or discoloration of tank.

Reactivity

CONDITIONS TO AVOID: Heat sources
MATERIALS TO AVOID: Catalytically active metals or chloride ions

ETHYLENEIMINE

Profile

CHEMICAL IDENTIFICATION

Alternative Names:

Aminoethylene	Di-hydro-1H-azirine
Azacyclopropane	Dimethyleneimine
Aziridine	EI
Azirane	Ethylimine
Dihydroazirine	TL 337

Chemical Abstract Services (CAS) Registry Number: 00151-56-4

Registry of Toxic Effects of Chemical Substances (RTECS) Number: KX 5075000

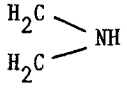
Hazardous Materials Table Identification Number: UN 1185

RCRA Identification Number: P 054

Molecular Weight: 43.08

Molecular Formula: C_2H_5N

Structure:



Classification:

Description: Liquid with intense odor of ammonia

Uses: Chemical intermediate

Chemical/Physical Data

Boiling point: 55-56°C
Melting point: -74°C
Vapor pressure: 160 mm Hg at 20°C
Vapor density: 1.5 (Air = 1.0) (Verschueren, 1977)
Solubility in water: Soluble
Estimated oxidative half-life in water: 56 hours.
Estimated half-life in water, hydrolysis rate: 15.4 days
Log octanol/water partition coefficient: -1.12
Odor threshold in air: 1.96 ppm (3.5 mg/cu m) (Verschueren, 1977).

HUMAN TOXICITY

Ethylenimine is highly toxic by inhalation, skin contact and ingestion. The free amine is a potent skin irritant and vesicant (ACGIH, 1980).

> Two workers developed skin sensitization and a case of slowly healing dermatitis during small-scale production. Two or three cases of nose and throat irritation with conjunctivitis resulted from exposure to unknown concentrations. It was determined experimentally that eye and nose irritation in humans becomes evident at about 100 ppm. A 2 to 3 minute exposure to ethylenimine vapors in the laboratory did not produce any symptoms until 3 hours later when vomiting occurred followed by irritation of the mouth, throat and eyes, which subsided in 1 to 2 days. Severe eye burns have resulted from direct contact but no systemic injury or fatalities have been reported.

The probable oral lethal dose for humans has been estimated to be 5-50 mg/kg for a 70 kg (150 lb.) person (RTECS, 1980).

Carcinogenicity

IARC, 1979 — Ethylenimine is carcinogenic in two strains of mice following its oral administration, producing an increased incidence of liver-cell and pulmonary tumors. Subcutaneous injection of single doses in suckling mice produced an increased incidence of tumors at the injection site following its subcutaneous injection in oil. No case reports or epidemiological studies were available to the working group regarding humans.

Mutagenicity

ACGIH, 1980 — Ethylenimine does not have appreciable cytotoxicity, however, it does have a mutagenic effect in the fruit fly. Mutagenicity has been confirmed in S. typhimurium plate assay and in mammalian germinal cell lines by dominant-lethal assay in rats.

NTP, 1980 — Mutagenesis S. typhimurium test result: Positive.

Teratogenicity and Embryotoxicity

No evidence was found to indicate that ethylenimine causes birth defects. An embryotoxic effect of ethylenimine has been demonstrated in rats at the 10 mg/cu m level; a very significant depression in body weight gain of pregnant rats during 20 days inhalation, a decrease in the relative number of pregnant rats, and fetuses with hematomas.

ANIMAL TOXICITY

Acute Toxicity

Results in lethal studies in several species as reported in the RTECS, 1980 are listed below:

Route	Species	Lethal Dose or Lethal Concentration
Oral	Rat	15 mg/kg, LD50
	Mice	235 mg/kg cumulative dose, 76 week contin: TDLo

Lethal Studies (Continued)

Inha-	Rat	25 ppm for 8 hours, lowest LC
	Mice	1,800 mg/cu m for 10 minutes; LCLo
	Guinea pig	25 ppm for 10 minutes LC50
	Mice	2236 ppm for 10 minutes LC50
Dermal	Guinea pig	14 mg/kg, LD50

Chronic Toxicity

Inhalation of ethylenimine has resulted in delayed lung injury with congestion, edema and hemorrhage, kidney damage and blood changes (ACGIH, 1980).

Aquatic Toxicity

Toxic effects were reported for the alga, Microystis aeruginosa, at 0.11 mg/l and for the bacteria, Pseudomonas putida, at 5.5 µg/l (Verschueren, 1977).

Phytotoxicity

No data available.

ENVIRONMENTAL DATA

Air

No data were found on the occurrence of ethylenimine in ambient air. This substance is highly reactive with a low oxidative half-life, and high levels are expected to occur only in occupational settings.

Water

No data were found on the occurrence of this substance in water. Its high solubility would prevent volatilization, but degradation is expected to be significant in natural waters (Radding, 1977). Ethylenimine has an estimated half-life in water of 15.4 days based on hydrolysis, which is relatively slowed under basic pH conditions.

Soil

Ethylenimine has a partition coefficient of -1.12, and adsorption onto organic sediments is not expected. Degradation is possible, but removal via volatilization or runoff is more likely.

Biota

Ethylenimine is biologically reactive, metabolism having been observed in several species (IARC, 1975). There seems to be little propensity for accumulation in lipids (Radding, 1977).

Other

Ethylenimine is a highly reactive compound and is used in many organic syntheses. The polymerization products, polyethyleneimines, are used as auxiliaries in the paper industry and as flocculation aids in the clarification of effluents. It is also used in the textile industry for increasing wet strength, flameproofing, shrinkproofing, stiffening, and waterproofing. A partial list of occupations in which exposure may occur includes:

Effluent treaters	Organic chemists
Paper makers	Textile makers
Polyethyleneimine makers	

INDUSTRIAL DATA

Production

No production in North Carolina reported in the Toxic Substances Control Act (TSCA) Chemical Substances Inventory (U.S. EPA, TSCA, 1980).

The estimated U.S. production was 2.2 million pounds (1,000 tons) in 1970 (IARC, 1975).

Consumption and Use

Estimated U.S. Consumption in 1966:

Polymerized to polyethyleneimine	50 percent (TDB, 1982)

Reported uses of ethylenimine and the corresponding SIC codes are listed below:

Production of polyethylenimine used as a flocculant in water treatment and in the textile and paper industries as a wet strength additive (IARC, 1975)	26, 22
Used in textile industry for flameproofing, shrinkproofing, stiffening, and waterproofing (Sittig, 1979)	
Production of chemicals including 2-aziridinyl ethanol, triethylenamine, and dyes (IARC, 1975)	2865, 2869
Oil additives	2911
In exchange resins, coating resins	282
Intermediate in drug and cosmetic manufacture	283
(Sittig, 1979)	

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air

No guidelines for ambient air have been established.

Workroom Air

ACGIH — The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air 0.5 ppm as a time-weighted average.

OSHA — The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 0.5 ppm (1 mg/cu m) as a time-weighted average. The importance of skin exposure is noted.

Water

No guidelines for water have been established.

Other

Regulated as a hazardous material by the U.S. Department of Transportation. Ethylenimine is classified as a flammable liquid, and shipments must carry a label which reads "flammable liquid and poison".

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Agencies Concerned with this Chemical

Subject of a monograph prepared by the International Agency for Research on Cancer (IARC).

Subject of a proposed rule under the Toxic Substances Control Act that would require all chemical manufacturers to report production and exposure-related data to the U.S. Environmental Protection Agency (Federal Register, Vol. 45, No. 42, 1980).

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Callahan, M.A. et al. Water-Related Fate of 129 Priority Pollutants. U.S. EPA Office of Water Planning and Standards, Washington, DC, EPA 440/4-79-029 (December 1979).

Cupitt, L. T. Fate of Toxic and Hazardous Materials in the Air Environment. EPA-600/3-80-084, NTIS PB 80-221948 (September 1980).

International Agency for Research on Cancer (IARC). IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon, France, Volume 19. A World Health Organization Publication (WHO), Geneva (1979).

Merck Index: An Encyclopedia of Chemicals and Drugs, Ninth Edition, M. Windholz, Ed. Merck and Co., Rahway, NJ (1976).

National Institute for Occupational Safety and Health/Occupational Safety and Health Administration (NIOSH/OSHA). NIOSH/OSHA Pocket Guide to Chemical Hazards. DHEW (NIOSH) Publication No. 78-210 (September 1978).

National Institute for Occupational Safety and Health. National Occupational Hazard Survey. Available from Division of Technical Services. Cincinnati, OH, DHEW 74-127, 77-123, and 78-114 (1980).

National Toxicology Program. Executive Summaries of Twenty-Five Compounds Nominated for FY- 80 Testing. U.S. Department of Health, Education, and Welfare, Jefferson, Arkansas (January 1980).

Radding. S., et al. Review of the Environmental Fate of Selected Chemicals. Prepared for the U.S. Environmental Protection Agency. Available from the National Technical Information Service, Springfield, VA, PB 267 121 (May 1977).

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfiche Issue, R. J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville, MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 80-111-4 (1980).

Shackelford, W. M., and L. H. Keith. Frequency of Organic Compounds Identified in Water. U.S. Environmental Protection Agency. EPA-600/4-76-062 (1976).

Shepard, T. H. Catalog of Teratogenic Agents. The John Hopkins University Press, Baltimore, MD (1973).

Sittig, M., Ed. Priority Toxic Pollutants. Noyes Data Corporation, Park Ridge, NJ (1980).

Stahl, Q. R. Preliminary Air Pollution Survey of Aldehydes. Prepared by Litton Systems, Inc., under Contract No. PH 22-68-25 for National Air Pollution Control Administration. Available from Clearinghouse for Federal Scientific and Technical Information, Springfield, VA APTD 69-24 (1969).

U.S. Environmental Protection Agency, Carcinogen Assessment Group (CAG). Carcinogen Assessment Group's Preliminary Risk Assessment on Ethylenimine. Washington, DC (February 11, 1980).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Chemical Hazard Information Profiles (CHIPs). EPA-560/11-80-011 (1980).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA PB-80-155-153 (1980).

Verschueren, Karel. Handbook of Environmental Data on Organic Compounds. Nostrand Reinhold Co., New York, NY (1977).

ETHYLENEDIAMINE

Executive Summary

CAS Number: 00107-15-3

Ethylenediamine is a colorless, clear, thick liquid with an ammonialike odor. It is formed through a reaction of ethylenedichloride with ammonia. Estimated U.S. production in 1978 was 93 million pounds (46,500 tons). It is estimated that 25% of U.S. production is exported. About 25% is used in carbamate fungicides. The remainder is used in numerous other production processes. There is limited toxicity information on ethylenediamine although it is a high volume, high exposure chemical. North Carolina requires the reporting of all ethylenediamine spills if they occur near water.

Health Effects

ACUTE. Ethylenediamine is a well-established contact allergen. The lowest concentration shown to produce toxic effects in humans is 200 ppm. Ethylenediamine produces irritation to eyes, nasal mucosa and respiratory tract (with asthematic symptoms) and causes skin corrosion and corneal injury.

The manufacturer estimates that a lethal dose for a 100 lb person may be 1-2 fluid ounces, extrapolated from a rat LD50 of 1200 mg/kg by oral route. Studies of ethylenediamine oral exposure of rats report LD50's ranging from 76 mg/kg to 1400 mg/kg.

CARCINOGENICITY. No carcinogenic effects of aliphatic amines have been described, however, amines can react with nitrites, either during use or following absorption, to form potentially carcinogenic or mutagenic nitrosomines (see the Nitrosamine Profile).

MUTAGENICITY. No data exist on mutagenicity due to ethylenediamine exposure.

TERATOGENICITY & EMBRYOTOXICITY. No data exist on teratogenicity or embryotoxicity of ethylenediamine.

CHRONIC. Repeated daily exposures of humans to 484 ppm ethylenediamine produced depilation and lung and kidney damage. Little, if any, experimentation has been done on the effects of chronic exposure on test animals.

Occupational Health

The American Conference of Governmental Industrial Hygienists (ACGIH) has established a Threshold Limit Value for workroom air (time-weighted average concentration under which it is believed that all workers may be repeatedly exposed day after day without adverse effect) of 10 ppm (25 mg/cu m).

Routes of Human Exposure

OCCUPATIONAL. No specific data exists on the number or occupations of at-risk persons exposed to ethylenediamine. The OSHA standard has a limit of 10 ppm (25 mg/cu m). A 10 ppm TLV may be too high for sensitive individuals.

AMBIENT. No data exists concerning ambient concentrations of ethylenediamine.

CONSUMER. Ethylenediamine may be ingested in the form of food additives or on food contaminated by the use of pesticides containing ethylenediamine.

Exposure via skin absorption can occur during use of cosmetics containing ethylenediamine. These cosmetic preparations include hair set and cold wave lotions, as well as nail polish which can cause allergic reactions in beauty operations and patrons and their spouses.

Environmental Significance

An aquatic 96 hour TLm of 10-100 ppm is reported for ethylenediamine. Inhibition of cell multiplication is reported at 0.4 and 0.5 mg/l for a tested species of algae and bacteria, respectively. Creek chub (fish) demonstrated a critical range of 30-60 mg/k for 24 hours.

No data was available on bioaccumulation of ethylenediamine in the environment. It is reactive with atmospheric oxidants and has been degraded by acclimated activated sludge.

Recommended Reviews

Documentation of The Threshold Limit Values, Fourth Edition, 1980. American Conference of Governmental Industrial Hygienists, Inc.

Chemical Hazard Information Profiles (CHIPs) U.S. Environmental Protection Agency, Washington, DC (1978).

FIRST AID AND EMERGENCY RESPONSE INFORMATION

ETHYLENEDIAMINE

First Aid (NIOSH/OSHA Pocket Guide to Chemical Hazards)

Eyes: Irrigate immediately with large amounts of water, occasionally lifting lower and upper lids. Get medical attention immediately. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH THIS CHEMICAL.

Skin: Immediately flush contaminated skin with water. Remove contaminated clothing and flush skin with water. Get medical attention immediately.

Inhalation: Move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the person warm and at rest. Get medical attention as soon as possible.

Ingestion: Immediately give large amounts of water, then induce vomiting by having person touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

Procedures for Spills and Leaks (U.S. DOT Emergeny Response Guidebook)

Isolate hazard area and restrict entry. Stay upwind; keep out of low areas. Wear self-contained breathing apparatus and full protective clothing. Isolate for ½ mile in all directions if tank or tankcar is involved in fire. No flares, smoking or flames in hazard area. Do not touch spilled material. Stop leak if you can do it without risk. Use water spray to reduce vapors. Do not get water inside containers. Do not allow chemical to enter a confined space, such as a sewer, as an explosion may result.

SMALL SPILLS: Take up with sand, or other noncombustible absorbent material, then flush area with water.

LARGE SPILLS: Dike far ahead of spill for later disposal.

Fire and Explosion Information

GENERAL: The flash point of ethylenediamine is 93°F (closed cup); the autoignition point is 379.4°C (715°F). It poses a moderate fire hazard when exposed to heat or flame.

FLAMMABLE LIMITS: Upper - 14.4%, lower - 4.2%.

EXTINGUISHER: Dry chemical, carbon dioxide, alcohol foam.

Move container from fire area if you can do it without risk. Stay away from ends of tanks. Do not get water inside container. Cool containers that are exposed to flames with water from the side until well after fire is out. Withdraw immediately in case of rising sound from venting safety device or discoloratoin of tank.

Reactivity

MATERIALS TO AVOID: Ethylenediamine is incompatible with strong acids, strong oxidizers and chlorinated organic compounds.

CONDITIONS TO AVOID: Any contact with sources of ignition or extreme high temperatures can cause fire or explosion.

Protective Measures

STORAGE AND HANDLING: Eating, drinking, and smoking should not be permitted when ethylenediamine is handled, processed, or stored. Ethylenediamine should be stored in a cool, well-ventilated place, out of the direct rays of the sun and away from areas of high fire hazard. Storage containers should be 55 gallon tin-lined drums. Storage facilities should be periodically inspected. Incompatible materials should be isolated.

ENGINEERING CONTROLS: Adequate ventilation should be employed. Shower, sinks, and eyewash station should be available.

PROTECTIVE CLOTHING (Should not be substituted for proper handling and engineering controls): Employees should be provided with and required to use impervious clothing, gloves, face shields (eighth-inch minimum), and other appropriate protective clothing necessary to prevent any possibility of skin contact with solid or liquid ethylenediamine. Dust- and splash-proof goggles should be provided for and required to be used by employees when any possibility exists of solid or liquid ethylenediamine or solutions containing ethylenediamine contacting the eyes.

PROTECTIVE EQUIPMENT: For levels up to 500 ppm, use a chemical cartridge respirator with a full facepiece and a cartridge(s) providing protection against ethylenediamine, a gas mask with a chin-style or a front- or back-mounted canister providing protection against ethylenediamine, any supplied-air respirator with a full facepiece, helmet, or hood, or any self-contained breathing apparatus with a full facepiece. For levels up to 1200 ppm use a Type C supplied-air respirator with a full face-piece operated in pressure-demand or other positive pressure mode or with a full facepiece, helmet, or hood operated in continuous-flow mode. For levels greater than 2000 ppm or entry and escape from unknown concentrations, use self-contained breathing

apparatus with a full facepiece operated in pressure-demand or other positive pressure mode, or a combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.

ETHYLENEDIAMINE

Profile

CHEMICAL IDENTIFICATION

Alternative Names:

beta-Aminoethylamine
1,2-Diaminoethane
Dimethylenediamine
1,2-Ethanediamine
1,2-Ethylenediamine

Chemical Abstracts Services (CAS) Number: 00107-15-3

Registry of Toxic Effects of Chemical Substances (RTECS) Number: KH8575000

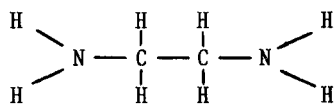
Hazardous Materials Table Identification Number: UN1604

RCRA Identification Number: P053

Molecular Formula: $C_2H_8N_2$

Molecular Weight: 60.12

Structure:



Classification: Primary alphatic diamine

Description: Colorless, clear, thick liquid with ammonia-like odor.

Use: Chemical intermediate

Chemical/Physical Data

Boiling point: 116-117°C
Melting point: 8.5°C
Vapor Pressure: 10.7 mm at 20°C
Vapor density: 2.07 (air = 1.0)
Solubility in water: very soluble
Density: 0.898
Flash point: 93°F (closed cup)
Odor threshold in air: 1.0 ppm

HUMAN TOXICITY

Ethylenediamine is a well established contact allergen which is irritating to the eyes and the respiratory tract and causes skin corrosion and corneal injury (NTP, 1980). Ethylenediamine is moderately toxic, by oral, dermal, and inhalation routes. Effects may involve both reversible and irreversible changes which are not severe enough to cause death or permanent injury. Occupational exposures of 100 ppm for a few seconds were found to be inoffensive but higher concentrations of 200 and 400 ppm produced noticeable irritation to the nasal mucosa and respiratory irritation with asthematic symptoms. The lowest concentration shown to produce toxic effects in humans is 200 ppm. Repeated daily exposures of 484 ppm ethylenediamine produced depilation and lung, kidney, and liver damage (ACGIH, 1980; TDB, 1982). Extrapolating from a rat LD50 of 1200 mg/kg, a manufacturer of ethylenediamine estimates that a lethal dose for a 100 lb. person may be 1-2 fluid ounces (TDB, 1982).

The maximum level at which one could escape within 30 minutes without any escape impairing symptoms or irreversible effects is suggested to be 2000 ppm (NIOSH, 1980).

Carcinogenicity

NTP, 1980 — No carcinogenic effects of aliphatic amines have been described.

TDB, 1982 — Amines can react with nitrite, either during use or following absorption, to form potentially carcinogenic or mutagenic nitrosomines.

Mutagenicity

No data exist on mutagenicity of ethylenediamine.

Teratogenicity & Embryotoxicity

No data exist on teratogenicity or embryotoxicity of ethylenediamine.

ANIMAL TOXICITY

Acute effects of oral, dermal, and inhalation exposure to ethylenediamine range from irritation to lethality. Little, if any, testing has been done on chronic effects of ethylenediamine exposure (TDB, 1982).

Acute Toxicity

Results of acute toxicity studies as reported by TDB (1982) are listed below:

Route	Species	Dose	Effect
Oral	Rat	76 mg/kg	LD50
	Guinea Pig	470 mg/kg	LD50
	Rat - female	1200 mg/kg	LD50
Inhalation	Rat	4000 mg/kg	LC50
Skin	Rabbit	730 mg/kg	LD50

Chronic Toxicity

Route	Species	Dose	Effect
Skin	Rabbit	450 mg	moderate skin irritation
Skin	Rabbit	10 mg/24 hrs.	severe skin irritation
Eye	Rabbit	675 ug	severe eye irritation

Aquatic Toxicity

Aquatic toxicity rating: TLm 96 is 10-100 ppm (TDB, 1982).

Results of aquatic toxicity studies, as reported by Verschueren, 1977, are listed below:

Species	Dose	Effect
Bacteria: E. coli	200 mg/l	no lethal effects
Pseudomonas pudita	0.5 mg/l	inhibition of cell multiplication
	(0.85 mg/l for a neutralized solution)	
Algae: Microcystis aeruginosa	0.04 mg/l	inhibition of cell multiplication
	(0.08 mg/l for a neutralized solution)	
Crustacean: Daphnia	8 mg/l	no lethal effects
Fish: Creek Chub	30-60 mg/k; 24 hrs.	critical range

Phytotoxicity

See aquatic toxicity. No data exists on the effects of ethylenediamine on vascular plants.

ENVIRONMENTAL DATA

The estimated release rate of ethylenediamine into the environment is 22.5 million pounds per year (U.S. EPA, CHIP, 1978).

Air
The release rate of ethylenediamine into ambient air is unknown. Ethylenediamine is reactive towards atmospheric oxidants (U.S. EPA, CHIP, 1978).

Water
No data exists on the presence or behavior of ethylenediamine in the aquatic environment.

Soil
Ethylenediamine is a natural degradation product of the fungicide Maneb. Fourteen days after maneb application, ethylenediamine was found at levels of 0.09 and 0.05 ppm in beans and tomatoes, respectively (U.S. EPA, CHIP, 1978).

Biota
No data exists on the presence or bioaccumulation of ethylenediamine in biota. It has been degraded by acclimated activated sludge (Verschueren, 1977).

Other
The large production volume and numerous products containing ethylenediamine suggests that the exposed population is potentially large. Besides occupational exposure, the use of the chemical in cosmetics (such as hair set and cold wave lotions and nail polish), and foods (as a food additive), and the contamination of foods from pesticides containing ethylenediamine, indicates potential widespread exposure by oral and dermal routes (NTP, 1980; TDB, 1982).

INDUSTRIAL DATA

Production

No production in North Carolina was reported in the Toxic Substances Control Act (TSCA) Chemical Substance Inventory (U.S. EPA, TSCA Inventory, 1980).

Estimated U.S. production in 1978 was 93 million pounds (46,500 tons) (U.S. EPA, CHIP, 1980).

Consumption and Use

Estimated U.S. consumption in 1972 (TDB, 1982):

Carbamate fungicides	25 percent
Export	25 percent
Chelating agents	13 percent
Dimethylolethylene urea resins	8 percent
Amino ethyl ethanolamine	8 percent
Miscellaneous applications	21 percent

Reported uses of ethylenediamine and the corresponding SIC codes are listed below:

Stabilizer in synthetic fiber manufacturing for caprolactan polymers	2824, 22
Stabilizer in pharmaceuticals	283
Stabilizer in solvents	-
Neutralizer in rubber products	2822, 30
In dyes, waxes, dimethylo-ethylene-urea resins	2865, 2821
In fungicides and insecticides	2879
In manufacture of EDTA	2865
In asphalt wetting agents	295

(U.S. EPA, CHIP, 1980)

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air
No standards for ambient air exist at this time.

Workroom Air
The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 10 ppm (25 mg/cu m) as a time-weighted average. The standards represent allowable concentrations of toxic or hazardous substances to which employees may be exposed without incurring adverse health effects (Code of Federal Regulations, Title 24, Part 1910, Subpart Z).

The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air is 10 ppm (25 mg/cu m) as a time-weighted average.

Water
Designated a hazardous substance by the U.S. Environmental Protection Agency. The hazardous substance designation and the proposed reporting regulations are to limit the discharge of toxic and hazardous substances to the nation's water (Code of Federal Regulations, Title 40, Part 116).

Other
Regulated as a hazardous material by the U.S. Department of Transportation. The regulations pertain to the identification and transportation of hazardous materials in commerce (Code of Federal Regulations, Title 49, Part 172.101). Ethylenediamine is classified as a flammable liquid, and shipments must carry a label which reads "Flammable Liquid".

Agencies Concerned with this Chemical

Chemical Hazard Information Profile (CHIP) compiled by the Office of Testing and Evaluation, U.S. Environmental Protection Agency.

Appears on the 1977 Priority List of the Chemical Industry Institute of Toxicology (CIIT). CIIT performs in-depth, extensive toxicity testing of commodity chemicals of high priority to the chemical industry (Chemical Industry Institute of Toxicology. 1979 Annual Report and Scientific Review: Science in the Public Interest, Research Triangle Park, N.C., 1980).

Under toxicological evaluation through the National Toxicology Program to determine teratogenicity, mutagenicity and carcinogenicity. (National Toxicology Program, Fiscal Year 1980 Annual Plan (NTP-80-62, 1980).

Addressed by a National Toxicology Program (NTP) Executive Summary and included in the list of 100 compounds nominated for NTP testing.

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Chemical Industry Institute of Toxicology (CIIT). 1979 Annual Report and Scientific Review: Science in the Public Interest. Research Triangle Park, N.C., (1980).

National Institute for Occupational Safety and Health/Occupational Safety and Health Administration (NIOSH/OSHA). NIOSH/OSHA Pocket Guide to Chemical Hazards. DHEW (NIOSH) Publication No. 78-210 (September, 1978).

National Toxicology Program (NTP). Fiscal Year 1981 Annual Plan. Department of Health and Human Services, NTP-80-62 (December, 1980).

National Toxicology Program. NTP Executive Summaries. Prepared for the National Center for Toxicological Research, Office of Scientific Intelligence, Jefferson, Arkansas (March, 1979).

Toxicology Data Bank (TDB). National Library of Medicine, Bethesda, MD (1982).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Chemical Hazards Information Profiles (CHIPs). Washington, DC (1978).

Verschueren, Karel. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., (New York, NY (1977).

ETHYLENE OXIDE

Executive Summary

CAS Number: 00075-21-8

Ethylene oxide (ETO) is a colorless, flammable gas with a sweetish odor. It is used as a fumigant, sterilant, rocket propellant, petroleum demulsifier, and is an intermediate in the manufacture of ethylene and other glycols, surfactants and ethanolamines. Production in the U.S. occurs by the direct catalytic oxidation of ethylene with air or oxygen. In March 1973, total production was estimated at 1,892 million kg. Ethylene oxide is regulated as a hazardous material by the U.S. Department of Transportation (classified as "flammable liquid") and as a hazardous waste by the U.S. Environmental Protection Agency.

Health Affects

ACUTE. Ethylene oxide is a central nervous system depressant, an irritant and a protoplasmic poison. Contact with dilute solutions causes irritation and necrosis of the eyes as well as blistering, edema and necrosis of the skin. Exposure to the vapor results in respiratory tract and lung irritation and CNS depression.

CARCINOGENICITY. Laboratory tests for carcinogenicity have produced indefinite results. The best evidence for carcinogenicity of ethylene oxide is the report of leukemia in exposed workers.

MUTAGENICITY. Ethylene oxide is a classical chemical mutagen. It induces base pair substitutions in the Ames test, gene mutations in plants and animals, breaks chromosomes of plants, animals and humans, and causes DNA damage in the spermatids of mice.

TERATOGENICITY AND EMBRYOTOXICITY. Ethylene oxide was found to be teratogenic in mice at doses of 150 mg/kg.

CHRONIC. Long term exposure to low concentrations of ethylene oxide may cause respiratory tract irritation, loss of sense of smell, nausea and vomiting. Repeated skin exposure results in scaling, cracking and redness. Blood changes have also been observed as a result of exposures lasting 11-15 years.

Occupational Health Regulations

ACGIH: The Threshold Limit Value (TLV) for workroom air is 10 ppm (20 mg/cu m).

NIOSH: The standard (time-weighted average) for workroom air is 50 ppm (90 mg/cu m) and the ceiling limit is 75 ppm for 15 minutes.

OSHA: The standard for workroom air is 50 ppm (90 mg/cu m) as a time-weighted average.

Routes of Human Exposure

OCCUPATIONAL. Workers at risk include hospital workers, medical products makers and sterilizers, fumigators of spices, foods, books and textiles, and producers of chemicals such as ethylene glycol and acrylonitrile.

AMBIENT. No data available.

CONSUMER. Ethylene oxide is found in cigarette smoke, walnut meats, copra and whole spices.

Environmental Significance

Ethylene oxide has an aquatic toxicity rating (TLm 96) of 10-100 ppm. The LD50 (24 hours) for goldfish is 90 mg/l. The critical concentration for general fish toxicity is within the range of 100-1000 mg/l.

Recommended Reviews

Embree, J. W. & Hine, C. H. (1975) Mutagenicity of ethylene oxide. Toxicol. appl. Pharmacol., 33, 172-173.

Hollingsworth, R. L. et al. Toxicity of ethylene oxide determined on experimental animals. Arch. Industrial Health., 13 217-227.

FIRST AID AND EMERGENCY RESPONSE INFORMATION

ETHYLENE OXIDE

First Aid (NIOSH/OSHA Pocket Guide)

Inhalation: Move victim to fresh air. Give artificial respiration or oxygen as required. Seek medical attention.

Skin: Remove soaked clothing. Immediately flush contaminated area with water. Seek medical attention.

Eyes: Immediately wash eyes with large amounts of water, occasionally lifting upper and lower lids. Seek medical attention immediately. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH THIS CHEMICAL.

Ingestion: When this chemical has been swallowed and the person is conscious, immediately give the person large quantities of water. After the water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Get medical attention immediately.

Note to Physician: May require supportive measures for pulmonary edema when inhaled at high concentrations.

Procedures for Spills and Leaks (U.S. DOT Emergency Response Guidebook)

Isolate hazard area and deny entry. Stay upwind and keep out of low areas. Wear positive pressure breathing apparatus and special protective clothing. No flares, smoking or flames in hazard area. Do not touch spilled material. Stop leak if it can be done without risk. Use water spray to reduce vapors.

SMALL SPILL OR LEAK (from drum, smaller container or small leak from tank): Isolate 550 feet in all directions. Flush area with flooding amounts of water. Do not get water inside containers.

LARGE SPILL OR LEAK FROM A TANK (or from many containers, drums, etc.): First, isolate 1140 feet in all directions, then evacuate in a downwind direction a width of 3.0 miles and a length of 4.7 miles.

Fire and Explosion Information

GENERAL: Extremely flammable and explosive. Will burn at $-0.4^{\circ}F$ ($-18^{\circ}C$).

EXPLOSIVE LIMIT: Upper - 100%, lower - 3%.

EXTINGUISHER: Alcohol foam, carbon dioxide or dry chemical.

Reactivity

MATERIALS TO AVOID: Oxidizing agents such as dichromate, permanganate and chlorine; strong acids, strong alkalies, iron chloride, tin chloride, aluminum chloride, iron oxide and aluminum oxide.

CONDITIONS TO AVOID: Direct sunlight, heat and sources of ignition.

Protective Measures

STORAGE AND HANDLING: Store in an outdoor tank or container or indoors in a standard fire proof room or cabinet. Store in a cool, ventilated place out of direct sun, away from fire hazards and the above materials.

ENGINEERING CONTROLS: Use with adequate ventilation. Eye wash stations, sinks and showers should be readily available.

PROTECTIVE CLOTHING (should not be substituted for proper handling and engineering controls): Wear neoprene gloves, safety glasses and plastic protective clothing if contact is likely. ETO gas will soak into leather and rubber causing prolonged contact with skin. If shoes or clothing become contaminated, they should be discarded.

PROTECTIVE EQUIPMENT: For levels up to 500 ppm, use a supplied-air respirator or a self-contained breathing apparatus. For up to 800 ppm use the above with full facepiece. For escape from a contaminated area, use a gas mask with an organic vapor canister or a self-contained breathing apparatus.

EHTYLENE OXIDE

Profile

Chemical Identification

Alternative Names:

Alpha, beta-oxidoethane	ETO
Anprolene	Oxacyclopropane
Dihydrooxirene	Oxane
Dimethylene oxide	Oxidoethane
EO	Oxiran
1,2-epoxyethane	

Chemical Abstract Services (CAS) Registry Number: 00075-21-8

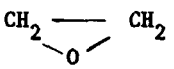
Registry of Toxic Effects of Chemical Substances (RTECS) Number: KX 2450000

Hazardous Materials Table Identification Number: UN 1040

Molecular Weight: 44.06

Molecular Formula: C_2H_4O

Structure:



Classification: An alkyl epoxide

Description: Colorless, flammable gas with sweetish odor

Use: Chemical intermediate & fumigant, and sterilant

Chemical/Physical Data

Boiling point: 10.7°C at 760 mm Hg
Melting point: -112.5°C
Vapor pressure: 1.49 mm Hg at 40°C; 20 mm Hg at 1095°C
Vapor density: 1.49 (40°C) (air = 1.0)
Solubility in water: soluble in water
Estimated atmospheric residence time: 5.8 days
Estimated half-life in water: 76 hours at 37°C and 6 months at 4°C
Hydrolysis rate: half-life (hydrolysis: 23 hours)
Bioaccumulation in aquatic organisms: spreads to all organs rapidly, excreted rapidly; biological half-life - 9 minutes.
Odor Threshold in air: 700 ppm (1260 mg/cu m)

HUMAN TOXICITY

Ethylene oxide is a central nervous system depressant, an irritant, and a protoplasmic poison. Contact with dilute solutions may cause irritation and necrosis of the eyes, as well as edema, blistering and necrosis of the skin. Exposure to the vapor results in irritation of the eyes, respiratory tract, lungs and depression of the central nervous system. Delayed responses to prolonged exposure include nausea and vomiting, which may be followed by convulsive seizures, profound weakness of the extremities and secondary infection of the lungs (Patty, 1963).

Systemic poisoning due to exposure to ethylene oxide is rare, but three cases have been reported in which headache, vomiting, dyspnea, diarrhea, and lymphocytosis occurred (IARC, 1979). The main toxic problems encountered in industry result from cutaneous contact with ethylene oxide, and include primary irritation and sensitization of the skin. Chronic intoxication of humans by ethylene oxide has not been reported (ACGIH, 1980). Skin burns have been reported after prolonged contact with a 1% solution of ethylene oxide in water (IARC, 1979).

The maximum level at which one could escape within 30 minutes without any escape-impairing symptoms or irreversible effects is suggested to be 800 ppm (NIOSH, 1978).

ANIMAL TOXICITY

When single doses of ethylene oxide were given gastrically as a 10% solution in olive oil to groups of rats, all animals survived a 0.1 g/kg dose, while 0.2 g/kg killed all animals. A 1% aqueous solution had an intragastric LD50 of 0.33 g/kg for rats and 0.27 g/kg for guinea pigs (see table below). High concentrations of ethylene oxide gas are both irritating to the mucous membranes and depressing to the central nervous system.

Acute Toxicity

Results of lethal studies in several species as reported in the TDB, 1980 are listed below:

Route	Species	Lethal Dose or Lethal Concentration
Oral	Rat	330 mg/kg, LD50
	Guinea pig	270 mg/kg, LD50
Inhalation	Rat	1,462 ppm for 4 hours, LC50
	Mice	836 ppm for 4 hours, LC50
	Dogs	960 ppm for 4 hours, LC50
	Guinea Pig	7000 ppm for 150 minutes, LCLo

Chronic Toxicity

Results of repeated exposure of animals to vapors of ethylene oxide are summarized in the following table (Patty, 1963):

Name: Ethylene Oxide
CAS Number: 00075-21-8

ppm	Hrs.	Exposure No.	Mortality ratio	Species	Pathological findings
841	7	6	10/10	Rat	Gross irritation of the respiratory tract; mice seemed most susceptible
		8	8/8	Guinea pig	
		4	1/1	Rabbit	
		1	5/5	Mouse	
		7	1/1	Monkey	
357	7	7	2/20	Rat	Moderate loss of body weight; severe lung injury
			4/10	Mouse	
		33	10/10	Mouse	Secondary respiratory infection the primary cause of death; impaired nervous function at lumbar and sacrel level, reversible, no blood changes
		38	10/10	Rat, F	
		38	8/10	Rat,M	
		148	1/2	Rabbit	
		38-94	0/4	Monkey	
		123	0/16	Guinea pig, M&F	Growth depression, increased lung weight in males and degeneration of testicular tubules; no nervous signs
290	6	6 wk.	0/3	Dog	Vomiting, occasional tremors, transient paraplegia, anemia
204	7	122-157	22/40	Rat	Appreciable number of rats died of secondary respiratory infection; growth depression in rat; Posterior paresis in monkey and rabbit; increased lung weight in rat and guinea pig
			1/16	Guinea pig	
			0/4	Rabbit	
			2/10	Mouse	
			0/2	Monkey	
113	7	122-157	0/40	Rat	No findings except growth depression in male rats
			0/16	Guinea	
			0/4	Rabbit	
			0/2	Monkey	
100	6	130	3/20	Rat	No clinical signs, no significant findings except anemia in dog
			8/30	Mouse	
			0/3	Dog	

Exposure Table (Continued)

Carcinogenicity

U.S. EPA, CAG, 1980: Ethylene oxide has been tested in mice by skin application and in rats by subcutaneous injection. Although no carcinogenic effect was observed, the data do not allow an evaluation. The best evidence for carcinogenicity of ethylene oxide is the report of leukemia in exposed workers.

Mutagenicity

U.S. EPA, CAG, 1980: Ethylene oxide is a direct acting alkylating agent. It reacts with mammalian DNA and is a classical chemical mutagen. It induces base pair substitutions in the Ames test, gene mutations in plants and animals, breaks chromosomes of plants, animals and humans, and causes DNA damage in the spermatids of mice.

NTP, 1980: Mutagenesis Salmonella typhimirium test result: Positive

Teratogenicity & Embryotoxicity

Ethylene oxide was tested for teratogenesis in FY 80. It was found to be teratogenic in mice at doses of 150 mg/kg (IARC, 1979).

Aquatic Toxicity

Aquatic toxicity rating: TLm 96 is 10-100 ppm (RTECS, 1982). Fish toxicity: critical concentration 100-1000 mg/l. Goldfish LD50 (24 hours): 90 mg/l.

ENVIRONMENTAL DATA

Air

No data are available regarding the presence of ethylene oxide in ambient air. The methods available for the determination of ethylene oxide in air for industrial hygiene purposes are not as precise or as reliable as desired (Patty, 1963). This substance has an estimated atmospheric residence time of 5.8 days, and a mean detectable (odor) concentration of 700 ppm (Verschueren, 1977).

Water

No data are available. Ethylene oxide hydrolyzes slowly in water, and has an estimated half-life of 76 hours at 37°C and 6 months at 4°C. This substance is quite soluble in water.

Soil

No data are available

Biota When ingested by animals, ethylene oxide spreads rapidly to all major organs, and is subsequently excreted rather quickly. This substance has a biological half-life of 9 minutes.

Other When bread in sealed plastic bags was treated with ethylene oxide, the initial concentration of the fumigant present in the package atmosphere was reduced by half immediately after the treatment, and was negligible after 3 days. None was found in fish or bone meals 12 hours after treatment, whereas meat meal contained traces 24 hours later. Ethylene oxide reacts with inorganic chloride in foods to form ethylene chlorohydrin.

The ethylene oxide content of cigarette smoke was low in untreated cigarettes but increased with longer treatment time and/or higher concentrations of ethylene oxide. In experiments with Austrian cigarettes, concentrations were found to be 0.02 µg/ml for untreated tobacco, 0.05 µg/ml for tobacco treated with 150 g ethylene oxide per cu m and up to 0.3 µg/ml for tobacco exhaustively fumigated.

Residues of up to 50 mg/kg in walnut meats, copra and whole spices are tolerated in the U.S., where ethylene oxide is used as a post-harvest fumigant for these crops (IARC, 1976).

A partial list of occupations in which exposure may occur includes:

- Acrylonitrile makers
- Detergent makers
- Disinfectant makers
- Ethanolamine makers
- Fungicide workers
- Grain elevator workers
- Organic chemical synthesizers
- Polyglycol makers
- Polyoxirane makers
- Rocket Fuel handlers
- Surfactant makers
- Textile fumigators

INDUSTRIAL DATA

Production

No production in North Carolina is reported in the Toxic Substance Control Act (TSCA) Chemical Substance Inventory (U.S. EPA, TSCA Inventory, 1980).

U.S. production in 1976 was estimated to be 4200 million pounds (1900 kg) (NTP, March 1979).

Consumption and Use

Estimated U.S. Consumption in 1972:

Ethylene glycol	60%
Non-ionic surface active agent	12%
Diethylene glycol	7%
Glycol ethers	7%
Ethanolamines	5%
Triethylene glycols	2%
Polyethylene glycol	1%
Miscellaneous	6%

(MEDLARS, TDB, 1981)

Reported uses of ethylene oxide and the corresponding SIC codes are listed below:

Production of ethylene glycol which is used mainly in anti-freeze products	28
Production of nonionic surface active agents and other organic chemicals	2843
Production of polyethylene terephthalate polyester fiber and film	285
Fungicide for treating many items including books, pharmaceuticals, medical equipment, food, etc.	-
Accelerate the maturing of tobacco (IARC, 1976)	21
In veterinary medicine as a sporicidal and virucidal agent	283

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air
Under evaluation for possible designation as a Hazardous Air Pollutant by the U.S. Environmental Protection Agency.

Workroom Air

ACGIH The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air is 10 ppm (20 mg/cu m) as a time-weighted average.

NIOSH — The National Institute of Occupational Safety and Health (NIOSH) recommends a standard of 50 ppm (90 mg/cu m) as a time-weighted average and a ceiling limit of 75 ppm for 15 minutes.

OSHA — The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 50 ppm (90 mg/cu m) as a time-weighted average.

Water

No guidelines for water have been established.

Other

Regulated as a hazardous material by the U.S. Department of Transportation. The regulations pertain to the identification and transportation of hazardous materials in commerce (Code of Federal Regulations, Title 49, Part 172.101). Ethylene oxide is classified as a flammable liquid and shipments must carry a label which reads "flammable liquid".

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Addressed by the Rebuttable Presumption Against Registration (RPAR) through the U.S. Environmental Protection Agency.

Agencies Concerned with this Chemical

Appears on the 1976 Priority List of the Chemical Industry Institute of Toxicology (CIIT).

Designated a candidate substance by the Occupational Safety and Health Administration.

Subject of a Risk Assessment Document prepared by the Carcinogen Assessment Group (CAG) of the U.S. Environmental Protection Agency.

Subject of a monograph prepared by the International Agency for Research on Cancer (IARC).

Appears on the Priority List of the Interagency Testing Committee (ITC) (alkyl epoxides).

Addressed by a development plan prepared by the Interagency Regulatory Liaison Group (IRLG).

Under toxicological evaluation through the National Toxicology Program to determine carcinogenicity, mutagenicity, and teratogenicity (National Toxicology Program, Fiscal Year 1980 Annual Plan (NTP-80-62, 1980).

Addressed by a National Toxicology Program (NTP) Executive Summary and included in the list of 100 compounds nominated for NTP testing.

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

International Agency for Research on Cancer (IARC). IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon, France, Volume 19. A World Health Organization Publication (WHO), Geneva (1979).

National Institute for Occupational Safety and Health/Occupational Safety and Health Administration (NIOSH/OSHA). NIOSH/OSHA Pocket Guide to Chemical Hazards. DHEW (NIOSH) Publication No. 78-210 (September 1978).

National Toxicology Program. Fiscal Year 1981 Annual Plan. NTP 80-62 (1980).

National Toxicology Program. NTP Executive Summaries. Prepared by the National Center for Toxicological Research, Office of Scientific Intelligence, Jefferson, Arkansas (March 1979).

Patty, F. A., ed. (1963) Industrial Hygienists and Toxicology, 2nd edition, Vol. 2, New York.

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfiche Issue, R. J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville, MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 80-111-4 (1980).

U.S. Environmental Protection Agency, Carcinogen Assessment Group (CAG). Carcinogen Assessment Group's Preliminary Risk Assessment on Ethylene Oxide. Washington, DC (February 11, 1980).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA PB-80-155-153 (1980).

Verschueren, Karel. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York, NY (1977).

ETHYLENE THIOUREA

Executive Summary

CAS Number: 00096-45-7

Ethylene thiourea (ETU) is a white crystalline solid. ETU is used predominantly as a rubber processing chemical, but is also present as a degradation product of ethylene bisdithiocarbamate fungicides. In 1972, more than 4.54 x 10^5 g (1,000 pounds) were produced in the United States.

Health Effects

ACUTE. When administered orally, ETU was toxic to rats with an LDLo value of 656 mg/kg and an LD50 value of 1832 mg/kg.

CARCINOGENICITY. ETU is classified as a positive animal carcinogen. Ingestion of ETU has produced thyroid carcinomas in rats and increased incidence of liver-cell tumors in mice.

MUTAGENICITY. ETU is a potential mutagen.

TERATOGENICITY & EMBRYOTOXICITY. ETU has been shown to be a teratogen, particularly to the Central Nervous System, in laboratory rats and other species. Teratogenesis at doses which did not produce maternal toxicity or fetal deaths suggests that placental transfer does occur.

There is no evidence of embryotoxicity due to ETU.

CHRONIC. All chronic studies have been concerned with ETU's cancer causing potential.

Occupational Health

No standards for ETU in workroom air exist at present. In the interim, the National Institute of Occupational Safety and Health suggests treating ETU as if it were a human carcinogen and teratogen.

Routes of Human Exposure

OCCUPATIONAL. At least 3500 workers in the rubber industry have potential occupational exposure to ETU. ETU has been found among the principle degradation products of the metal salts of ethylene bisdithiocarbamic acid, a widely used agricultural fungicide.

AMBIENT. ETU is probably not persistant in air, suggesting that exposure via ambient air is unlikely.

CONSUMER. Residues of 0.6 mg/kg ETU have been found on treated kale and lettuce within 7 days after application of ethylene bisdithiocarbamic acid fungicide. Levels of 0.018-0.044 mg/kg have been reported on commercial apples in Ottawa, Canada. ETU can also be formed when foods containing these fungicides are cooked.

Environmental Significance

ETU probably undergoes photodegradation in air, which makes aerial persistance unlikely.

ETU is biologically reactive and is metabolized in its reaction as a carcinogen which may imply that ETU is not persistant in biota.

Aquatic toxicity data is unavailable.

Recommended Reviews

NIOSH Current Intelligence Bulletin 22 - Ethylene Thiourea. National Institute of Occupational Safety and Health, Washington, DC (April 11, 1978).

IARC MONOGRAPHS ON THE EVALUATION OF THE CARCINOGENIC RISK OF CHEMICALS TO MAN: Some antithyroid and related substances, nitrofurans and industrial chemicals Vol. 7, p. 45-52. International Agency for Research on Cancer (1979).

FIRST AID AND EMERGENCY RESPONSE INFORMATION

ETHYLENE THIOUREA

First Aid

Very little information is available on ETU. Consider that ETU is an animal positive carcinogen and teratogen, potentially a human carcinogen and teratogen, and take every possible precaution to avoid contact and exposure.

Eyes:	Wash with large amounts of water immediately, occasionally lifting upper and lower lids. Seek medical attention immediately.
Skin:	Remove contaminated clothing, wash with water. Seek medical attention.
Inhalation:	Seek medical attention immediately.
Ingestion:	Seek medical attention immediately.

Procedures for Spills and Leaks

Very little information is available on ETU. Because ETU is an animal positive carcinogen and teratogen, proceed with extreme caution. Isolate hazard area and restrict entry. Avoid any contact with spilled material. Shovel into fiber drums and wash area with copious quantities of water.

Fire and Explosion Information/Reactivity

No information was available for ETU. Use caution.

Protective Measures

STORAGE AND HANDLING: Store in fiber drums. It is recommended that ETU be handled as a human carcinogen and teratogen. Limit employee exposure. Minimize workplace exposure levels.

ENGINEERING: The most effective control of ETU is at the source of contamination by enclosure of the operation and/or local exhaust ventilation. If feasible, the process or operation should be enclosed with a slight vacuum so leakage will result in air flow into the enclosure. The next most effective control is a local exhaust ventilation system that physically encloses the process as much as possible, with sufficient capture velocity to keep the contaminant from entering the work atmosphere. Effectiveness of the ventilation system should be checked at least every three months and after any process changes which result in increase airborne exposure to ETU. The third alternative is employee isolation. This involves the use of automated equipment operated from a pressurized control room. In the event of a leak, air will flow out of the control room. However, this method will not protect employees who do process checks, adjustments, maintainance and related operations.

PROTECTIVE CLOTHING: Should not be used as the only means to prevent or minimize exposure during routine operations. Personal protective equipment may include respirators, goggles, gloves and related items. Exposure to ETU should not be controlled with the use of respirators except during non-routine system work, for operations requiring entry into tanks or closed vessels, or in emergencies.

ETHYLENE THIOUREA

Profile

Chemical Identification

Alternative Names:

4,5-Dihydroimidazole-2(3H)-thione
4,5-Dihydro-2-mercaptoimidazole
N,N'-(1,2-Ethanediyl)thiourea
Ethylenethiourea
1,3-Ethylene-2-thiourea
1,3-Ethylenethiourea
N,N'-Ethylenethiourea
ETU
Imidazolidinethione
Imidazoline-2-thiol
2-Imidazolidinethione
2-Imidazoline-2-thiol
Imidazoline-2(3H)-thione
Mercaptoimidazoline
2-Mercaptoimidazoline
2-Mercapto-2-imidazoline
NA 22
NA-22-D
Pennac CRA
Rhodanin S 62
Sodium-22-Neoprene accelerator
Tetrahydro-2H-Neoprene accelerator
Tetrahydro-2H-imidazolie-2-thione
2-Thiol-dihydroglyoxaline
Warecure C

Chemical Abstract Services (CAS) Registry Number: 00096-45-7

Registry of Toxic Effects of Chemical Substances (RTECS) Number: NI 9625000

Hazardous Materials Table Identification Number: None

RCRA Identification Number: U116

Molecular Weight: 102.17

Molecular Formula: $C_3H_6N_2S$

Classification: imide

Description: White crystalline solid

Use: Rubber processing chemical

Chemical/Physical Data

Boiling point:
Melting point: 203°-204°C
Vapor pressure:
Vapor density:
Solubility in water: 9 g at 30°C

HUMAN TOXICITY

IARC, 1979 — No case studies or epidemiological studies were available to the Working Group.

Carcinogenicity

IARC, 1979 — Ethylene Thiourea (ETU) is classified as a positive animal carcinogen. ETU has been tested only by oral route in rats, producing thyroid carcinomas. They reported increased incidence of liver-cell tumors in 2 strains of mice following oral administration.

No human case reports or epidemiological studies were available.

NIOSH, 1978 — ETU was found to be carcinogenic in rats based on a review of available studies. It should be handled as if it were a human carcinogen.

Mutagenicity

RTECS, 1982 — ETU is listed as a mutagen.

Teratogenicity

NIOSH, 1978 — A review of available studies shows ethylene thiourea to be a teratogen, particularly to the central nervous system, in laboratory rats with supportive studies in other species.

IARC, 1979 — ETU was teratogenic in rats at doses that did not produce maternal toxicity or fetal deaths, suggesting that placental transfer does occur.

ANIMAL TOXICITY

ETU can cause decreased output of thyroid hormone, resulting in slow down of physical and mental activity, goiter and related effects (NIOSH, 1978).

Results of toxicity studies for several species as reported in the TDB, 1982, and RTECS, 1982, are listed below:

Acute Toxicity

Route	Species	Dose	Toxic Effect
Oral	Rat	656 mg/kg	Lowest lethal dose (LDLo)
	Rat	1821 mg/kg	LD50

Chronic Toxicity

Route	Species	Dose	Toxic Effect
Oral	Rat	200 ug/kg, 6-15 d, preg.	teratogenesis
	Mice	43 g/kg/82 wks - interm.	lowest toxic dose, (TDLo, carcinogenesis
	Rat	7.56 g/kg/96 wks - inter mittent	TDLo, carcinogenesis
	Mice	77 6/kg/82 2ks - interm.	TDLo, carcinogenesis

Aquatic Toxicity

Critical concentration range for creek chub (fish) is 6-8 g/l, 24 hours (Verschueren, 1977).

Phytotoxicity

No data on the phytotoxicity of ETU were available.

ENVIRONMENTAL DATA

Air
Insufficient data are available concerning the existance and accumulation of ETU in air. However, ETU may absorb light and subsequent photodegradation may occur based on ring structure. This implies that ETU is probably not persistent in air.

Water
Insufficient data on the behavior of ETU in water preclude predicting its environmental fate.

Biota
Insufficient data exist concerning the accumulation and magnification of ETU by biota. However, ETU is biologically reactive and is metabolized in its reaction as a carcinogen which may imply that ETU is not persistent in biota.

Soils
ETU is a breakdown product of ethylene bisdithiocarbamate fungicides and is found in the soil after fungicide application. But the soil residues disappear quickly and are not detectable in less than one week (IARC, 1979).

Other
Ethylene thiourea has been found by many investigators to be among the principal degradation products of the metal salts of ethylene bisdithiocarbamic acid, widely used as agricultural fungicides. Initial residues of 0.6 mg/kg ethylene thiourea have been found in fungicide treated kale and lettuce; these levels were undetectable within 7 days of application. Levels of 0.018-0.044 mg/kg have been reported in commercial apples in Ottawa, Canada (IARC, 1979). ETU can also be formed when foods containing these fungicides are cooked (NIOSH, 1978) At least 3500 workers in the rubber industry have potential occupational exposure (NIOSH, 1978).

INDUSTRIAL DATA

Production

No production in North Carolina is reported in the Toxic Substances Control act (TSCA) Chemical Substances Inventory (U.S. EPA, TSCA, 1980).

U.S. production was estimated at greater than 4.54×10^5 g (1000 pounds) in 1972 (TDB, 1982).

Consumption and Use

No data were available on U.S. consumption.

Reported uses of ethylene thiourea and the corresponding SIC codes are listed below:

Accelerator for neoprene rubber	2822, 30
Curing agent for polyacrylate rubber IARC, 1974)	2822, 30
Ethylene bisdithiocarbamate fungicides (NIOSH, 1978)	2879

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air
No guidelines for ambient air have been established.

Workroom Air NIOSH The National Institute of Occupational Safety and Health has established no standards for ethylene thiourea as of yet. Until such standards are set NIOSH suggests minimizing workroom exposure and treating ETU as if it were a carcinogen and teratogen (NIOSH, 1978).

Water
No guidelines for water have been established.

Other
Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

AGENCIES CONCERNED WITH THIS CHEMICAL

Subject of a monograph prepared by the International Agency for Research on Cancer (IARC).

Subject to a proposed rule under the Toxic Substances Control Act that would require all chemical manufacturers to report production and exposure-related data to the U.S. Environmental Protection Agency.

Under toxicological evaluation through the National Toxicology Program to determine carcinogenesis.

REFERENCES

International Agency for Research on Cancer (IARC). IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon France, Volume 19. A World Health Organization Publication (WHO), Geneva (1976).

National Institute for Occupational Safety and Health (NIOSH). Criteria for a Recommended Standard...Occupational Exposure to Ethylene Thiourea. U.S. Department of Health, Education and Welfare. DHEW(NIOSH) Publication No. 77-226, (September, 1977).

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfiche Issue, R. J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville, MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication (1982).

Toxicology Data Bank - The National Library of Medicine, Bethesda, Maryland (1982).

Verschueren, Karel. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York, NY (1977).

ETHYL METHANE SULFONATE

Executive Summary

CAS NUMBER 00062-50-0

Ethyl methane sulfonate is a colorless liquid which is produced only for research purposes. There is no known commercial use, though this substance could have a potential use as a reversible male chemosterilant for the control of insect and mammalian pests. Ethyl methane sulfonate is one of a class of compounds (monoesters of methanesulfonic acid) that has been considered as a possible human male contraceptive. Ethyl methane sulfonate is regulated as a hazardous waste under RCRA.

Health Effects

ACUTE. No reports were found concerning the effects of this chemical on human health. A lethal dose of 200 mg/kg (intraperitoneal injection) in the mouse has been reported.

CARCINOGENICITY. Ethyl methane sulfonate is carcinogenic in mice and rats following subcutaneous or intraperitoneal injection. These are the only species and routes tested. It produced lung and kidney tumors in both species. It is carcinogenic following administration of a single dose. No human studies have been reported.

MUTAGENICITY. Numerous short-term mutagenicity tests have been conducted and positive results have been reported in many systems.

CHRONIC. A single injection of 100 mg/kg in rats produced subfertility for three weeks. A dose of 300 mg/kg caused complete sterility.

Routes of Human Exposure

No data were found on the occurrence of ethyl methane sulfonate in air or water and there is no known commercial production. It is possible that only researchers working with the chemical are exposed.

Environmental Significance

Hydrolysis can occur in 14-17 hours (based on sulfonate esters). Bioaccumulation in aquatic organisms and adsorption to sediments are both negligible for sulfonate esters. Estimated oxidative half-life in air is over 50 hours for sulfones.

North Carolina Production and Users

Production: None reported under TSCA.
Users: No information.

Recommended Reviews

IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Volume 7, World Health Organization (1974).

FIRST AID AND EMERGENCY RESPONSE INFORMATION

ETHYL METHANE SULFONATE

First Aid (MEDLARS, 1981)

Eyes:	Flush with large quantity of tap water.
Skin:	Wash with soap and water
Ingestion:	Induce vomiting with finger or by administration of syrup of ipecac. Seek immediate medical attention.

ETHYL METHANE SULFONATE

Profile

Alternative Names:

Ethyl Ester of Methanesulfonic Acid
Ethyl Ester of Methylsulfonic Acid
EMS
Ethyl Methanesulfonate
Ethyl Methansulfonate
Half Myleran
Methanesulfonic Acid Ethyl Ester
Methylsulfonic Acid, Ethyl Ester
NSC 26805

Chemical Abstract Services (CAS) Registry Number: 00062-50-0

Registry of Toxic Effects of Chemical Substances (RTECS) Number: PB 2100000

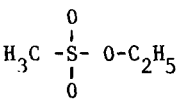
Hazardous Materials Table Identification Number: None

RCRA Identification Number: U 119

Molecular Weight: 124.17

Molecular Formula: $C_3H_8O_3S$

Structure:



Classification: Ester of methanesulfonic acid; an alkylating agent

Description: Colorless liquid

Uses: No known commercial use

Chemical/Physical Data

Boiling point: 213-213.5°C
Melting point: 20°C
Vapor pressure: 14 mm Hg at 104°C
Solubility in water: Very soluble

GENOTOXICITY

The conclusions of several agencies pertaining to the genotoxic potential of ethyl methane sulfonate are summarized below:

Carcinogenicity

OSHA, 1980 — Sprague-Dawley rats developed carcinomas of the lung and carcinomas in the abdominal wall that were thought to be mammary carcinomas. Tumor incidence was much higher in females than in males. Newborn mice injected with the chemical developed lung tumors.

IARC, 1979 — Animal Data: Ethyl methane sulfonate (EMS) is carcinogenic in mice and rats following subcutaneous or intraperitoneal injection, the only species and routes tested. It produced mainly lung and kidney tumors in both species. It is carcinogenic following administration of a single dose.

Human Data: No case reports or epidemiological studies were available to the Working Group.

Mutagenicity

RTECS, 1980 — Numerous short-term mutagenicity tests have been conducted. Positive results are reported in many systems.

Teratogenicity

Intraperitoneal injections of 200 mg/kg in pregnant rats on the 13th day of gestation, caused teratogenic effects in offspring (RTECS, 1980).

Reproductive Effects

A single injection of 100 mg/kg in rats produced subfertility in rats during the first 3 weeks. A dose of 300 mg/kg caused complete sterility

ANIMAL TOXICITY

Acute toxicity of ethyl methane sulfonate is not well-documented. A lethal dose of 200 mg/kg (intraperitoneal injection) in the mouse is reported (RTECS, 1980).

Chronic Toxicity

The reported half-life ($^{14}C_2H_5$-EMS) in rat blood serum is 6.5 hours (IARC, 1974).

AQUATIC AND TERRESTRIAL TOXICITY

Data on aquatic toxicity and phytotoxicity were not available.

ENVIRONMENTAL DATA

Air
No data were found on the occurrence of ethyl methane sulfonate in air, an estimated oxidative half-life in air of over 50 hours (Radding, 1977). Sulfones have the persistence of this substance in air has not been determined.

Water
No data regarding this substance's occurrence in water were found. Ethyl methane sulfonate is expected to degrade in water. It has an estimated half-life based on hydrolysis of 14-17 hours (Radding, 1977).

Name: Ethyl Methane Sulfonate
CAS Number: 00062-50-0

Soil
Degradation via hydrolysis and microbial action are expected, this substance is not expected to accumulate in soils (Radding, 1977).

Biota
Ethyl methane sulfonate undergoes degradation in biota through hydrolysis and metabolism. As a highly polar substance, it is not expected to accumulate or biomagnify.

Ethyl methane sulfonate is not known to occur in nature (IARC, 1974).

INDUSTRIAL DATA

Production

No production was reported in North Carolina in the Toxic Substances Control Act (TSCA) Chemical Substances Inventory (U.S. EPA, 1980).

Ethyl methane sulfonate is produced for research purposes only (IARC, 1974).

Consumption and Use

There is no known commercial production or use. It has the potential use as a reversible male chemosterilant for the control of insect and mammalian pests (IARC, 1974).

It is one of the class of compounds (monoesters of methanesulfonic acid) that has been considered as a possible human male contraceptive (Hreshesky, 1972).

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air
No guidelines for air have been established.

Workroom Air
No guidelines for workroom air have been established.

Water
No guidelines for water have been established.

Other
Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Agencies Concerned with this Chemical

Designated a candidate substance by the Occupational Safety and Health Administration.

Subject of a monograph prepared by the International Agency for Research on Cancer (IARC).

Subject to a proposed rule under the Toxic Substances Control Act that would require all chemical manufacturers to report production and exposure-related data to the U.S. Environmental Protection Agency (Federal Register, Vol. 45, No. 42, 1980).

ENVIRONMENTAL FATE

The fate of a substance released into the environment is influenced by the chemical/physical/biological properties of the substance as well as local environmental conditions. The lack of data concerning the behavior of most chemical substances in natural environments precludes detailed predictions of environmental fate. However, an indication of the potential for environmental persistence can be based on the data which are available. The environmental fate assessment presented below reflects a subjective evaluation based on the quantitative data presented in the properties profile, Page II-2.

Summary

Medium of Degradation: Biota
Medium of Accumulation: Insufficient data
Dispersion: Insufficient data

Scoring Based on Persistence

Medium	Type	Score*	Basis
Air	Overall	3	Insufficient data
	Degradation	3	Insufficient data
	Accumulation	3	Insufficient data
Water	Overall	2	Expected to degrade
	Degradation	2	Estimated half-life based on hydrolysis less than 2 days (Radding, 1977)
	Accumulation	3	Insufficient data
Biota	Overall	2	Degradation expected
	Degradation	2	Hydrolysis and metabolism occur (MEDLARS, 1981)
	Accumulation	2	Accumulation of highly polar substances is rare
	Magnification	2	No accumulation expected
Soils	Overall	2	Degradation likely
	Degradation	2	Hydrolysis and microbial degradation likely
	Accumulation	2	No accumulation in soils expected (Radding, 1977)

* Scoring: 1-Not persistent, 2-Implied not persistent, 3-Insufficient data, 4-Implied persistent, 5-Persistent

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Hrushesky, W., D. Sampson, and G. P. Murphy. Carcinogenicity of Ethyl Methane-Sulfonate. J. National Cancer Institute, Vol. 49 (1972).

International Agency for Research on Cancer (IARC). IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon France, Volume 7. A World Health Organization Publication (WHO), Geneva (1974).

MEDLARS II Toxicology Data Bank (TDB) Record of Ethyl Methane Sulfonate. National Library of Medicine (May 1981).

Merck Index: An Encyclopedia of Chemicals and Drugs, Ninth Edition, M. Windholz, Ed. Merck and Co., Rahway, NJ (1976).

National Institute for Occupational Safety and Health. National Occupational Hazard Survey. Available from Division of Technical Services. Cincinnati, OH, DHEW 74-127, 77-123, and 78-114 (1980).

Occupational Safety and Health Administration (OSHA). Candidate Substance Data Summary Sheet. Chemical: Methanesulfonic acid, ethyl ester (1980).

Radding, S., et al. Review of the Environmental Fate of Selected Chemicals. Prepared for the U.S. Environmental Protection Agency. Available from the Natioal Technical Information Service, Springfield, VA, PB 267 121 (1977).

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfiche Issue, R. J. Lewis, and R. L Tatkins. Prepared by Tracor Jitco, Inc., Rockville, MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 80-111-4 (1980).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA PB-80-155-153 (1980).

The North Carolina Toxic Substances Management Guide

FORMALDEHYDE

Executive Summary

CAS NUMBER 00050-00-0

Formaldehyde is a colorless gas with a pungent odor. It is usually stored and transported as an aqueous solution containing 37-50% formaldehyde by weight and 1-15% methanol. Methanol (wood alcohol) is the starting feedstock for the commercial production of formaldehyde. On the basis of production (3.3×10^9 lbs. of anhydrous material in 1978), it is the most important aldehyde in the U.S. It has been estimated that 65% of the formaldehyde produced is used in the same plant in which it is produced. About 55% of the formaldehyde produced is used in the production of urea-formaldehyde and phenol-formaldehyde resins. These resins are used in the production of plywood, particle board, foam insulation, and a wide variety of molded or extruded plastic items. Federal regulations require the reporting of formaldehyde spills if they exceed 1000 pounds (454 kg) or 111 gallons (420 liters). North Carolina requires the reporting of all spills if they occur near water.

Health Effects

ACUTE. The exposure of the human population to formaldehyde vapors may be the source of many complaints related to irritation of the eyes and respiratory tract, headache, tiredness, and thirst. Aqueous solutions damage the eye and irritate the skin on direct contact. Repeated exposure to dilute solution may lead to allergic contact dermatitis.

When administered orally, formaldehyde (formalin) is slightly toxic to rats with LD50 values reported in the range of 800 mg/kg. Systemic poisoning by ingestion is uncommon because of formaldehyde's irritating nature.

CARCINOGENICITY. The Chemical Industry Institute of Toxicology reported in 1982 that inhalation of formaldehyde vapor at concentrations of 2.7 and 15 ppm for 24 months resulted in significant increases in nasal carcinomas primarily in mice and occasionally in rats.

The National Institute for Occupational Safety and Health recommends that formaldehyde be handled as a potential occupational carcinogen and that appropriate controls be used to reduce worker exposure.

MUTAGENICITY. Formaldehyde has exhibited mutagenic activity in a wide variety of organisms including Salmonella typhimurium. The mutagenic potential of formaldehyde in mammalian systems has not been thoroughly studied.

TERATOGENICITY & EMBRYOTOXICITY. Formaldehyde has not been shown to be teratogenic or embryotoxic in animals.

CHRONIC. Formaldehyde has been shown to cause bronchial asthma in humans. In persons with bronchial asthma, the irritation caused by formaldehyde may precipitate an acute asthmatic attack.

Occupational Health

The American Conference of Governmental Industrial Hygienists has established a Threshold Limit Value for workroom air (time-weighted average concentration under which it is believed that all workers may be repeatedly exposed day after day without adverse effect) of 2 ppm (2.5 mg/cu m).

Routes of Human Exposure

OCCUPATIONAL. About 1.6 million persons are directly or indirectly exposed to formaldehyde on their jobs. The OSHA standard has a concentration limit of 3 ppm; however, NIOSH recommends a concentration of no more than 1 ppm.

AMBIENT. Formaldehyde concentrations in ambient air are lower than in the occupational or indoor residential environment. Outdoor concentrations vary, but are rarely more than 0.1 ppm and usually less than 0.05 ppm.

CONSUMER. It has been estimated that 11 million persons live in homes that contain either ureaformaldehyde (UF) foam insulation or particle board made with UF resins. Concentrations measures in homes have varied from 0.01 to 10.6 ppm. Formaldehyde concentrations from 0.03 to 2.4 ppm were found in mobile homes. These mobile homes are usually more tightly constructed and have less ventilation than conventional homes. Most conventional homes have shown less than 0.5 ppm. Exposures in the home could be substantial since people spend up to 70% of their time indoors.

Formaldehyde occurs naturally in apples and pineapples.

Laboratory studies have shown that gas stoves emit substantial amounts of aldehydes, primarily formaldehyde. Formaldehyde has also been measured in cigarette smoke in concentrations ranging from 0.18 to 1.44 mg per cigarette.

Formaldehyde is also used extensively in the manufacture of floor coverings, carpet backing, pesticides and adhesives.

Environmental Significance

The estimated atmospheric residence time of formaldehyde is from 0.1 to 1.2 days.

Bioaccumulation of formaldehyde is unlikely. A TLm above 10 ppm has been reported for sensitive aquatic animals; aquatic algae are affected at levels below 0.5 ppm.

Recommended Reviews

Formaldehyde and Other Aldehydes, National Research Council, National Academy of Sciences, Washington, DC (1981).

Formaldehyde: Evidence of Carcinogenicity, National Institute of Occupational Safety and Health Current Intelligence Bulletin 34 (DHS Publication No. 81-111), U.S. Department of Health and Human Services (April 15, 1981).

FIRST AID AND EMERGENCY RESPONSE INFORMATION

FORMALDEHYDE

First Aid (NIOSH/OSHA Pocket Guide to Chemical Hazards)

Eyes: Wash with large amounts of water immediately occassionally lifting upper and lower lids. Get medical attention immediately.

Skin: Flush the contaminated skin with water. Remove clothing if contaminated and wash skin.

Inhalation: Move to fresh air at once. Perform artificial respiration if necessary. Get medical attention as soon as possible.

Ingestion: Give person large amounts of water, then induce vomiting. Seek medical attention.

Note to physician: May require supportive measures for pulmonary edema when inhaled at high concentrations.

Procedures for Spills and Leaks (U.S. DOT Emergency Response Guidebook, 1980)

Isolate hazard area and deny entry. Stay upwind and keep out of low-lying areas. Wear self-contained breathing apparatus and full protective clothing. Isolate for ½ mile in all directions if tank or tankcar is involved in fire. No flares, smoking or flames in hazard area. Do not touch spilled material. Stop leak if it can be done without risk. Use water spray to reduce vapors. Do not get water inside containers.

SMALL SPILLS: Take up with sand, or other noncombustible absorbent material, then flush area with water.

LARGE SPILLS: Dike far ahead of spill for later disposal.

Fire and Explosion Information

GENERAL: In the gaseous state, formaldehyde will burn if exposed to a source of ignition. Ignites at 185°F, 85°C, (37%), 122°F, 50°C, (15%).

EXPLOSIVE LIMITS: Upper - 73%, lower - 7%.

EXTINGUISHER: Water spray, dry chemical, alcohol foam or carbon dioxide.

Reactivity

MATERIALS TO AVOID: Reacts violently with performic acid, mixtures of aniline and perchloric acid and nitrogen peroxide.

CONDITIONS TO AVOID: Any contact with sources of ignition or extreme high temperatures can cause fire or explosion.

Protective Measures

STORAGE AND HANDLING: Indoor storage should be in areas having floors pitched toward a trapped drain or in a curbed retention area. Polymerization of formaldehyde solution can occur if temperature should fall below 59°F.

ENGINEERING CONTROLS: Adequate ventilation or an entirely enclosed system should be employed. Showers, sinks and eyewash stations should be available.

PROTECTIVE CLOTHING (Should not be substituted for proper handling and engineering controls): Water-proof boots, gloves and apron should be worn along with safety goggles if contact with chemical is likely.

PROTECTIVE EQUIPMENT: For levels up to 50 ppm use a chemical cartridge respirator with a full facepiece and organic vapor cartridges, a gas mask with an organic vapor canister, a supplied-air respirator with a full facepiece or a self-contained breathing apparatus with a full facepiece. Up to 100 ppm use a Type C supplied-air respirator operated in a positive pressure mode. For escape from a contaminated area use a gas mask with an organic vapor canister or a self-contained breathing apparatus.

The North Carolina Toxic Substances Management Guide

FORMALDEHYDE

Profile

Chemical Identification

Alternative Names:

BFV	Hoch
Fannoform	Karsan
Formaldehyde, as formalin solution (DOT)	Methanal
Formalin	Methyl Aldehyde
Formalith	Methylene Oxide
Formic Aldehyde	NCI-C02799
Formol	Oxomethane
Fyde	Oxymethylene

Chemical Abstract Services (CAS) Registry Number: 00050-00-0

Registry of Toxic Effects of Chemical Substances (RTECS) Number: LP 8925000

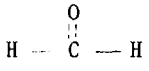
Hazardous Materials Table Identification Number: UN 2209, UN 1198

RCRA Identification Number: U 122

Molecular Weight: 30.03

Molecular Formula: CH_2O

Structure:



Classification: The simplest aldehyde

Description: Colorless gas with a pungent odor. Aqueous solutions are most common.

Uses: (Formaldehyde resins) in the production of plywood, particle board, form insulation and molded or extruded plastic items.

Chemical/Physical Data

Boiling point: -19.5°C
Melting point: -92.2°C
Vapor pressure: 10 mm at -88°C
Vapor density: 1.067 (relative to air = 1.0)
Solubility in water: Very soluble

HUMAN TOXICITY

The principal effect of low concentrations of formaldehyde observed in humans is irritation of the eyes and mucous membranes. The table below summarizes data on human responses to airborne formaldehyde at various concentrations. It shows a wide range in formaldehyde concentrations reported to cause specific health effects. The severity of symptoms appears to be dose-related at extremes of concentration (NRC, 1981).

REPORTED HEALTH EFFECTS OF FORMALDEHYDE AT VARIOUS CONCENTRATIONS
(NRC, 1981)

Health effects reported	Approximate formaldehyde concentration, ppm
None reported	0-0.05
Neurophysiologic effects	0.05-1.50
Odor threshold	0.05-1.0
Eye irritation	0.01-2.0*
Upper airway irritation	0.10-25
Lower airway and pulmonary effects	5-30
Pulmonary edema, inflammation, pneumonia	50-100
Death	100+

*The low concentration (0.01 ppm) was observed in the presence of other pollutants that may have been acting synergistically.

Skin contact with formaldehyde has been reported to cause a variety of cutaneous problems in humans, including irritation, allergic contact dermatitis, and urticaria. Allergic contact dermatitis from formaldehyde is relatively common. The response of formaldehyde-sensitive persons is related to the extent of exposure. Formaldehyde is a skin irritant and skin sensitizer. Aqueous formaldehyde solutions elicit a skin response in some sensitized people at concentrations as low as 0.01 percent (NRC, 1981).

The maximum level at which one could escape within 30 minutes without any escape-impairing symptoms or irreversible effects is suggested to be 100 ppm (NIOSH/OSHA, 1978).

Carcinogenicity

U.S. EPA, CAG, 1980 — CAG concluded that there is substantial evidence that formaldehyde is likely to be a human carcinogen. The unit risk calculation (the lifetime cancer risks associated with lifetime exposure at 1 ug/cu m) based on the preliminary result of CIIT is 3.4 x 10-5.

CIIT, 1982 — Rats and mice were exposed by inhalation to concentrations of 2.6 or 15 ppm of formaldehyde for 6 hrs/day, 5 days/week for 24 months. The inhalation of formaldehyde vapor for 24 months resulted in exposure-related increase in the frequency, severity and distribution of nasal carcinomas.

Carcinogenicity

NIOSH, 1981 — NIOSH recommends that formaldehyde be handled as a potential occupational carcinogen. The recommendation is based primarily on the CIIT findings.

Mutagenicity

OSHA, 1981 — Formaldehyde induced recessive lethal mutations in Drosophila larvae reared on a medium containing formaldehyde. It induced gene mutations in E. coli and Pseudomonas fluorescens, and it induced recombination in yeast.

Auerbach, 1977 — A critical review of genetic and cytogenic effects of formaldehyde was compiled by Auerbach and others.

NTP, 1980 — Mutagenesis Salmonella typhimurium test result: positive

Teratogenicity and Embryotoxicity

NTP, 1980 — No fetotoxicity or malformation was reported in mice when 200 mg/kg were administered on days 6 to 15 of gestation; however, there was evidence of maternal toxicity.

NRC, 1981 — Negative findings for teratogenicity have been reported in several studies involving rats and dogs.

Shepard, 1980 — No visible fetal malformations were observed when pregnant rats were exposed continuously to formaldehyde vapor at 0.8 ppm (1 mg/cu m).

ANIMAL TOXICITY

Considerable data are available on the effects of formaldehyde on laboratory animals. Sublethal as well as lethal studies by several routes have been conducted.

Acute Toxicity

Results of lethal studies in several species as reported in the RTECS, 1980 are listed below:

Route	Species	Lethal Dose or Lethal Concentration
Oral	Rat	800 mg/kg, LD50
	Guinea pig	260 mg/kg, LD50
Inhalation	Rat	250 ppm (312 mg/cu m) for 4 hours, lowest LC
	Mouse	721 ppm (900 mg/cu m) for 2 hours, lowest LC
	Cat	670 ppm (836 mg/cu m) for 8 hours, lowest LC
Dermal	Rabbit	270 mg/kg, LD50

Eye effects are also reported. Experimental application of 0.005 mg of 15 percent formalin to rabbit eyes caused a severe reaction producing corneal and conjunctival edema and iritis. Exposure of rabbits to formaldehyde vapors at 40-70 ppm caused slight tearing and eye discharge, but not corneal injury (NRC, 1981).

Chronic Toxicity

The Formaldehyde Institute is sponsoring studies on effects of virtually continuous inhalation of formladehyde in monkeys, hamsters, and rats. These are daily 22-hour exposures at 3, 1, and 0.2 ppm that are repeated for 26 weeks. Results of gross and microscopic evaluation of animals exposed at 0.2 and 1.0 ppm (now completed) showed no treatment-related effects. Final results on animals exposed at 3 ppm have shown no adverse effects in hamsters; in rats and monkeys, there is histologic evidence of squamous metaplasia of the nasal mucosa in exposed animals. The hamsters showed no histologic changes at any of the exposure concentrations (NRC, 1981).

Aquatic Toxicity

Aquatic toxicity rating: TLm 96 is 10-100 ppm (RTECS, 1980).

A TLm above 10 ppm is reported for sensitive aquatic organisms. At 2 ppm, formaldehyde is toxic to Daphnia. For guppies, the TLm ranges 50-200 ppm (Verschueren, 1977).

Tainting of fish flesh may occur at a concentration of 95 ppm (NAS/NAE, 1973).

Bioaccumulation is unlikely.

Phytotoxicity

Exposure for 2 days to levels below 0.2 ppm caused plant leaf symptoms and necrosis in petunia (Bond, 1972). Alfalfa suffered damage after 5 hours exposure to 7 ppm (Stahl, 1969).

Aquatic algae are affected by formaldehyde at levels below 0.5 ppm (Verschueren, 1977).

Data of vascular aquatic plants were not found.

Air

Formaldehyde is widely dispersed in the air; worldwide atmospheric concentrations range from 0.5-2 ppb. The major source of formaldehyde in

the environment is combustion processes, especially automobile emissions (U.S. EPA, CAG, 1979). Formaldehyde can be introduced into the air through natural processes, and concentrations in remote areas are probably due to local generation from hydrocarbon precursors and not to long-range transport.

Urban air concentrations generally range from 4.0-50 ppm (5-61 ug/cu m). Formaldehyde is the predominant aldehyde present in the atmosphere, constituting about 30-75 percent of the total on a volume basis (NRC, 1981).

Although formaldehyde may evidence transient accumulation in photochemical smog, it is not generally regarded as persistent in the atmosphere. Formaldehyde has an estimated atmospheric residence time of 0.1-1.2 days (Cupitt, 1980) and degrades rapidly in this medium by photolysis and reaction with the OH radical. This compound is soluble, and therefore removed from the air by rainwater.

Water

Aldehyde concentrations in the aquatic environment are generally less than 1 ppm (1 ug/l) (NRC, 1981). Formaldehyde has been detected in effluents from the latex and chemical industries and in an effluent from a sewage treatment plant on the Upper Catawba River, NC (Shackelford, 1977).

Quantitative data regarding the half-life of formaldehyde in water are not readily available, and would be dependent upon water temperature, turbulence and depth. The hydrated form of this compound is somewhat resistant to photolysis, although it does undergo degradation in this medium. Elevated concentrations have been found in drinking water supplies, suggesting that formaldehyde's persistence may result in accumulation in water.

Soil

Because of its low partition coefficient (-0.96, Radding, 1977), sorption and dispersion by soils is expected to be minimal. Although formaldehyde may undergo photolysis, predictions regarding degradation in this medium cannot be made due to insufficient data.

Biota

Formaldehyde is a normal metabolite in mammalian systems, and undergoes rapid degradation in this medium. Bioaccumulation is unlikely, but formaldehyde does appear as a metabolite of many compounds throughout nature (U.S. EPA CAG, 1980).

INDUSTRIAL DATA

Production

Production in North Carolina was reported by six companies in the Toxic Substances Control Act (TSCA) Chemical Substances Inventory:

Borden Adhesive, Fayetteville:	25,000-50,000	tons/year
E. I. DuPont, Denton:	5,000-25,000	tons/year
Georgia Pacific, Russellville:	5,000-25,000	tons/year
Hercofina-NC, Wilmington:	No report of production figures	
Reichold Chemical, Montclure:	5,000-25,000	tons/year
Wright Chemical, Riegelwood:	5,000-25,000	tons/year

In addition, Southeastern Adhesive, Lenoir, reported importing 500-5,000 tons/year. (U.S. EPA, TSCA Inventory, 1980)

Formaldehyde is produced as a 37-50 percent aqueous solution called formalin. U.S. production for 1981 is estimated at 6 billion pounds of formalin (NRC, 1981).

Consumption and Use

Estimated Current U.S. Consumption in 1981 (Greek, 1981)

Urea formaldehyde resins	30 percent
Phenol-formaldehyde resins	25 percent
Polyacetal resins	5 percent
Butanediol	5 percent
Pentaerythritol	5 percent

Reported uses of formaldehyde and the corresponding SIC codes are listed below. Industrial exposure was noted for all 20 two-digit SICs (NIOSH, 1980).

Yields protein denaturants in leather tanning		3111
In preservatives		283
In preparation of vaccines		283
Manufacture of phenolic, urea, and melamine resins		2821
Resins used in:	Particle board	2492
	Laminating veneer	243
	Plywood	2435, 2436
	Insulation	
	Dinnerware	326
	Protective coatings	
	Textile treatment	226
	Paper treatment	2641

(NRC, 1981)

Manufacture of urea formaldehyde, ethylene glycol, pentaerythritol, and hexamethylenetetramine	2869
Treatment of textiles for durable press	226, 223
Manufacture of dyes	2865
Manufacture of medicines	2832
Industrial sterilant (fungicide, germicide)	2879

Industrial Data (Continued)

Manufacture of rubber latex (NTP, 1979)	2822
Improving fastness of dyes	226
Mordanting and waterproofing fabric	226
In embalming fluid	
In photography for hardening gelatin plates and papers, toning gelatin-chloride papers, chrome printing, and developing	3861
To prevent mildew in wheat	
To render casein, albumin, and gelatin insoluble	20
Manufacture of artificial silk	2823
Manufacture of glass mirrors	3231
Manufacture of explosives (Merck, 1976)	2892

Miscellaneous Release to the Environment/Source of	Factors: Exposure
Automobile and diesel exhausts	41, 42, 47
Incinerators	
Residues from treated textiles	226
Residues from agriculture uses	01
Natural metabolic product (NTP, 1980)	
Cigarette smoke	
Photochemical smog	
Degassing of formaldehhyde resins in urea-formaldehyde foam insulation, plywood	2436
particle board (NTP, 1981)	2492

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air

Under evaluation for possible designation as a Hazardous Air Pollutant by the U.S. Environmental Protection Agency.

Workroom Air

ACGIH — The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists for workroom air is 2 ppm (2.5 mg/cu m) as a ceiling.

NIOSH — The National Institute of Occupational Safety and Health in 1976 recommended a level of 1 ppm (1.2 mg/cu m) as a 30-minute ceiling limit. In an April 1981 Current Intelligence Bulletin, NIOSH summarized recent evidence of carcinogenicity and recommended that formaldehyde be handled as a potential occupational carcinogen, with exposures reduced to the lowest feasible limit.

OSHA — The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 3 ppm (3.6 mg/cu m) as an 8-hour time-weighted average and 5 ppm (6.2 mg/cu m) as an acceptable ceiling concentration. A maximum peak of 10 ppm (12 mg/cu m) for 30 minutes is specified.

Water

Designated a hazardous substance by the U.S. Environmental Protection Agency.

Other

Regulated as a hazardous material by the U.S. Department of Transportation.

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

The subject of a proposed ban by the Consumer Product Safety Commission on any future use of urea-formaldehyde foam insulation. The material can release significant amounts of irritating and possibly cancer-causing formaldehyde fumes.

Agencies Concerned with this Chemical

Appears on the 1976 Priority List of the Chemical Industry Institute of Toxicology (CIIT).

Reviewed by the Occupational Safety and Health Administration, although not designated a candidate carcinogen substance.

Subject of a Risk Assessment Document prepared by the Carcinogen Assessment Group (CAG) of the U.S. Environmental Protection Agency.

Under review by the Interagency Testing Committee for possible recommendation for priority consideration by the U.S. Environmental Protection Agency (Federal Register, Vol. 45, No. 196, 1980).

Subject to a proposed rule under the Toxic Substances Control Act that would require all chemical manufacturers to report production and exposure-related data to the U.S. Environmental Protection Agency (Federal Register, Vol. 45, No. 42, 1980).

Addressed by a development plan prepared by the Interagency Regulatory Liaison Group (IRLG).

Addressed by a National Toxicology Program (NTP) Executive Summary (1979) and included in the list of 100 compounds nominated for NTP testing.

Under toxicological evaluation through the National Toxicology Program to determine carcinogenicity, mutagenicity, and teratogenicity.

Inhalation carcinogenesis bioassays in mice were started in Fiscal Year 1980. Mutagenicity studies were positive. Teratology assays in mice were completed in Fiscal Year 1980. No fetotoxicity or malformation was reported when 200 mg/kg were administered days 6 to 15 of gestation; however, there was evidence of maternal toxicity (National Toxicology Program. Fiscal Year 1981 Plan. Department of Health and Human Services, NTP-80-62, December, 1980).

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Auerbach, C., M. Moutschen-Dahmen, and J. Moutschen. Genetic and Cytogenical Effects of Formaldehyde and Related Compounds. Mutation Research, 39, pp. 317-362 (1977).

Bond, R. G., C. P. Straub, and R. Prober, Eds. Handbook of Experimental Control, Vol. 1: Air Pollution. The Chemical Rubber Company, Cleveland, OH (1972).

Chemical Industry Institute of Toxicology (CIIT). Progress report on CIIT Formaldehyde Studies-1/16/80. Research Triangle Park, NC (1980).

Cupitt, L. T. Fate of Toxic and Hazardous Materials in the Air Environment. EPA600/3-80-084, NTIS PB 80-221948 (September 1980).

Greek, B. Gas-Based Petrochemicals Set for A Good Year. Chemical and Engineering News 59(4): 15-19 (1981).

Merck Index: An Encyclopedia of Chemicals and Drugs, Ninth Edition, M. Windholz, Ed. Merck and Co., Rahway, NJ (1976).

National Academy of Sciences, National Academy of Engineering. Water Quality Criteria, 1972. A Report. National Academy of Sciences, Washington, DC EPA-R3-73-033 (1973).

National Institute for Occupational Safety and Health (NIOSH). Current Intelligence Bulletin 34. Formaldehyde: Evidence of Carcinogenicity. U.S. Department of Health and Human Services. DHHS (NIOSH) Publication No. 81-111 (April 15, 1981).

National Institute for Occupational Safety and Health/Occupational Safety and Health Administration (NIOSH/OSHA). NIOSH/OSHA Pocket Guide to Chemical Hazards. DHEW (NIOSH) Publication No. 78-210 (September 1978).

National Institute for Occupational Safety and Health. National Occupational Hazard Survey. Available from Division of Technical Services. Cincinnati, OH DHEW 74-127, 77-123, 1n3 78-114 (1980).

National Research Council. Formaldehyde and Other Aldehydes. National Academy Press, Washington, DC (1981).

National Toxicology Program (NTP). Fiscal Year 1981 Annual Plan. Department of Health and Human Services, NTP-80-62 (December 1980).

National Toxicology Program. NTP Executive Summaries. Prepared by the National Center for Toxicological Research, Office of Scientific Intelligence, Jefferson, Arkansas (March, 1979).

Occupational Safety and Health Administration (OSHA). Candidate Substance Data Summary Sheet. Chemical: Formaldehyde (January, 1980).

Radding, S. B., et al. Review of the Environmental Fate of Selected Chemicals. U.S. Environmental Protection Agency. Available through the National Technical Information Service, Springfield, VA PB-267-121 (May 1977).

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfiche Issue, R.J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 80-111-4 (1980).

Shackelford, W. M., and L. H. Keith. Frequency of Organic Compounds Identified in Water. U.S. Environmental Protection Agency, EPA 600/476/062 (December, 1976).

Shepard, T. H. Catalog of Teratogenic Agents. The John Hopkins University Press, Baltimore, MD (1973).

Stahl, Q. R. Preliminary Air Pollution Survey of Aldehydes. Prepared by Litton Systems, Inc., under Contract No. PH 22-68-25 for National Air Pollution Control Administration. Available from Clearinghouse for Federal Scientific and Technical Information, Springfield, VA. APTD 69-24 (1969).

U.S. Environmental Protection Agency. Carcinogen Assessment Group (CAG). Carcinogen Assessment Group's Preliminary Risk Assessment on Formaldehyde. Washington, DC (February 11, 1980).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA PB-80-155-153 (1980).

Verschueren, Karel. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York, NY (1977).

HEXACHLOROBUTADIENE

Executive Summary

CAS NUMBER 00087-68-3

Hexachlorobutadiene is a clear, colorless liquid which was produced as a by-product in the manufacture of chlorinated hydrocarbons. Estimated U.S. production in 1974 was 7.3 - 14.5 million pounds (3,650 - 7,250 tons) with another 0.5 million pounds (250 tons) imported. Hexachlorobutadiene is a persistent pollutant, and accumulation in soils and biota has been documented. It is regulated as a hazardous waste under RCRA. Federal regulations require reporting of spills in excess of 1,000 pounds. North Carolina requires the reporting of all spills if they occur near water.

Health Effects

ACUTE. Vineyard workers exposed seasonally to hexachlorobutadiene and polychlorobutane-80 showed multiple toxic effects contributing to the development of hypertension, cardiac disease, chronic bronchitis, disturbances of nervous function, and chronic hepatitis.

The oral LD50 in rats is 90 mg/kg.

CARCINOGENICITY. Hexachlorobutadiene is a suspect human carcinogen. It was tested in one experiment in rats by oral administration and produced benign and malignant tumors in the kidneys of animals of both sexes.

MUTAGENICITY. Hexachlorobutadiene was reported to be mutagenic in tests with Salmonella typhimurium TA 100, however, other S. typhimurium tests were negative.

TERATOGENICITY & EMBRYOTOXICITY. No signs of impaired reproduction or effects on offspring were reported in rats fed between 0.2, 2.0 and 20 mg/kg per day or in adult male and female Japanese quails fed 0.3 to 30 mg/kg per day for 90 days. In one study of rats receiving a 20 mg/kg body weight dose of hexachlorobutadiene before mating, all offspring died in 3 months.

CHRONIC. Hexachlorobutadiene is toxic to experimental animals by all routes. It affects the central nervous system and causes hepatic disorders. The kidney is the most sensitive organ. Red blood cell effects have also been observed. Dosages causing death by dermal absorption are in the same range as by oral administration.

The American Conference of Governmental Industrial Hygienists in 1980 set a Threshold Limit Value in air (time-weighted average concentration under which it is believed that all workers may be repeatedly exposed day after day without adverse effect) to 0.02 ppm (0.24 mg/cu m). The importance of skin exposure was noted.

Routes of Human Exposure

OCCUPATIONAL. Hexachlorobutadiene has been detected in air concentrations as high as 463 ug/cu m in samples taken onsite at chlorinated hydrocarbon producing plants. Reported uses of the substance include recovery of chlorine containing gas in chlorine plants, fluid for gyroscopes, intermediate in the production of lubricants and in the manufacture of rubber compounds, solvent for elastomers, heat transfer liquid in transformers, and hydraulic fluid.

AMBIENT. Air samples taken offsite and upwind of chlorinated hydrocarbon-producing plants generally contained from 0.003 to 0.3 ug/cu m. Hexachlorobutadiene has been detected in river water samples in the Hudson River, N.Y. at 2.0 ug/l and in Fields Brook at 22 ug/l. Residues of the chemical at varying concentrations have been found in fish.

Soil samples taken around tetrachloroethylene plants contained hexachlorobutadiene concentrations as high as 980 ug/g; levels of 0 - 0.01 ug/g were common for samples taken upwind and outside of plant boundaries.

CONSUMER. Hexachlorobutadiene has been detected in municipal drinking water in New Orleans at concentrations ranging from 0.07 - 0.7 ug/l. Samples of milk, eggs, and vegetables taken within a 25-mile radius of tetrachloroethylene and trichloroethylene plants showed no contamination with hexachlorobutadiene. It has been detected in samples of similar foodstuffs taken in Europe, at levels ranging from 0.08 to 42 ug/kg.

Environmental Significance

Accumulation has been documented in soils and biota and dispersion in all media appears to be possible. Concentration factors as high as 2,300 were reported for goldfish exposed for 49 days, and crayfish under field conditions showed concentration factors ranging from 7.8 to 300. Acute and chronic toxicity to freshwater aquatic life occur at concentrations as low as 90 and 9.3 ug/l, respectively. Acute toxicity to saltwater aquatic life occurs at concentrations as low as 32 ug/l.

A concentration factor of 160 was reported for the algae Oedogonium cardlacum, and five species of marine algae contained 0 to 8.9 ug/kg of hexachlorobutadiene.

North Carolina Production and Users

Production: None reported

Users: No information available

Recommended Reviews

Ambient Water Quality Criteria for Hexachlorobutadiene, U.S. Environmental Protection Agency, PB81-117640 (1980).

No first aid or emergency response data available.

The North Carolina Toxic Substances Management Guide

HEXACHLOROBUTADIENE

Profile

CHEMICAL IDENTIFICATION

Alternative Names:

C-46
Dolen-Pur
GP-40-66:120
HCBD
Hexachloro-1,3-butadiene
Perchlorobutadiene

Chemical Abstract Services (CAS) Registry Number: 00087-68-3

Registry of Toxic Effects of Chemical Substances (RTECS) Number: EJ 0700000

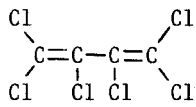
Hazardous Materials Table Identification Number:

RCRA Identification Number: U 128

Molecular Weight: 260.76

Molecular Formula: C_4Cl_6

Structure:



Classification: Chlorinated aliphatic hydrocarbon (unsaturated)

Description: Clear, colorless liquid

Chemical/Physical Data

Boiling point: 215°C
Melting point: -21°C
Vapor pressure: 22 mg Hg at 100°C; 500 mm at 200°C
Vapor density: 8.99 (Air = 1.0)
Solubility in water: 2 mg/l at 20°C (Callahan, 1979)

HUMAN TOXICITY

Very little information is available describing the effects of hexachlorobutadiene in humans. Vineyard workers exposed seasonally to hexachlorobutadiene and polychlorobutane-80 showed multiple toxic effects contributing to the development of hypertension, cardiac disease, chronic bronchitis, disturbances of nervous function, and chronic hepatitis (IARC, 1979).

Carcinogenicity

IARC, 1979 — Hexachlorobutadiene was tested in one experiment with rats by oral administration; it produced benign and malignant tumors in the kidneys of animals of both sexes. It was tested inadequately in one experiment with mice by intraperitoneal injection.

No case reports or epidemiological studies on human data were available to the Working Group.

There is limited evidence that hexachlorobutadiene is carcinogenic in rats.

U.S. EPA, WQC, 1980 — The U.S. EPA Carcinogen Assessment Group (CAG) has determined that hexachlorobutadiene is a suspect human carcinogen.

Mutagenicity

IARC, 1979 — Hexachlorobutadiene was reported to be mutagenic in spot tests with Salmonella typhimurium TA100.

NTP, 1980 — Mutagenesis Salmonella typhimurium test result: Negative.

Teratogenicity and Embryotoxicity

IARC, 1979 — Adult male and female Japanese quails were fed diets containing 0.3, 3, 10 or 30 mg/kg diet hexachlorobutadiene for 90 days. Dose levels had no effect on body weight, demeanor, food consumption, egg production, percent fertility and hatchability of eggs, survival of hatched chicks or eggshell thickness.

WQC, 1980 — Rats fed 0.2, 2.0 and 20 mg/kg-day showed no signs of impaired reproduction or effects on offspring.

NTP, 1980 — Reproduction and Fertility Assays in progress include Drosophila sex-linked recessive lethal, rat dominant lethal, mouse sperm head morphology, rat bone marrow cytology, and in vitro unscheduled DNA synthesis in human fibroblasts.

ANIMAL TOXICITY

Hexachlorobutadiene is toxic to experimental animals when inhaled, ingested, injected intraperitoneally or absorbed through the skin. It affects the central nervous system and causes hepatic disorders (IARC, 1979). The kidney is the most sensitive organ. Red blood cell effects have also been observed (U.S. EPA, WQC, 1980). Dosages causing death by dermal absorption are in the same range as by oral administration (ACGIH, 1980).

Acute Toxicity

Results of lethal studies in several species as reported in the RTECS, 1980 are listed on the next page:

Route	Species	Lethal Dose or Lethal Concentration
Oral	Rat	0.09 gm/kg, LD50
	Mouse	0.11 gm/kg, LD50
	Guinea pig	0.09 gm/kg, LD50
	Hamster	0.96 gm/kg, LD50
Inhalation	Mouse	235 ppm (2.5 gm/cu m) for 4 hours, lowest LC
Dermal	Rabbit	1.2 gm/kg, LD50

Chronic Toxicity

Feeding of 30-100 mg/kg-day to rats for 30 days caused renal tubular degeneration, necrosis, and regeneration (IARC, 1979).

A lifetime ingestion study in rats produced no discernible ill effects at 0.2 mg/kg-day; at 2 mg/kg-day, increased urinary excretion of coproporphyrin in females and increased hyperplasia of renal tubular epithelium resulted. At 20 mg/kg-day hexachlorobutadiene caused multiple toxicological effects, including mortality, and neoplasia of renal tubular epithelium (ACGIH, 1980).

Aquatic Toxicity

The available data for hexachlorobutadiene indicate that acute and chronic toxicity to freshwater aquatic life occur at concentrations as low as 90 and 9.3 µg/l, respectively.

The available data for hexachlorobutadiene indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 32 µg/l.

Bioaccumulation: Concentration factors as high as 2,300 were reported for goldfish exposed for 49 days (U.S. EPA, WQC, 1980). Crayfish under field conditions showed concentration factors ranging from 7.8 to 300 (Callahan, 1979).

Phytotoxicity

Data on phytotoxicity from air pollution are not available.

A concentration factor of 160 was reported for the algae Oedogonium cardlacum (U.S. EPA, WQC, 1980).

Five species of marine algae sampled contained 0 to 8.9 µg/kg of hexachlorobutadiene (IARC, 1979).

INDUSTRIAL DATA

Production

No hexachlorobutadiene production in North Carolina has been reported in the Toxic Substances Control Act (TSCA) Chemical Substances Inventory (U.S. EPA, TSCA, 1980).

Hexachlorobutadiene is produced deliberately as a byproduct of the manufacture of chlorinated hydrocarbons. Estimated U.S. production was 7.3-14.5 million pounds (3,650-7,250 tons) with another 0.5 million pounds (250 tons) being imported in 1974 (U.S. EPA, WQC, 1980).

Consumption and Use

Estimated U.S. Consumption:

No quantitative data on consumption patterns were found.

Reported uses of hexachlorobutadiene and the corresponding SIC codes are listed below:

Recovery of chlorine-containing gas in chlorine plants	2813
Fluid for gyroscopes	3811
Chemical intermediate in production of lubricants	29
Chemical intermediate in manufacture of rubber compounds	2822, 30
Solvent for elastomers	2822, 30
Hydraulic fluid in transformers (IARC, 1979)	3612
Byproduct in the manufacture of chlorinated hydrocarbons (U.S. EPA, WQC, 1980)	2869

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air

No guidelines for air have been established.

Workroom Air

ACGIH — The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air is 0.02 ppm (0.24 mg/cu m) as a time-weighted average. The importance of skin exposure has been noted.

Water

Addressed by Ambient Water Quality Criteria set by the U.S. Environmental Protection Agency.

Designated a toxic pollutant by the U.S. Environmental Protection Agency.

Designated a hazardous substance by the U.S. Environmental Protection Agency. Spills in excess of 1,000 pounds must be reported.

Other

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Agencies Concerned with this Chemical

Designated a candidate substance by the Occupational Safety and Health Administration.

Subject of a Risk Assessment prepared by the U.S. EPA's Carcinogen Assessment Group (CAG) for the Office of Water Planning and Standards.

Subject of a monograph prepared by the International Agency for Research on Cancer (IARC).

Appears on the Priority List of the Interagency Testing Committee (ITC).

Under toxicological evaluation through the National Toxicology Program to determine mutagenicity and reproductive effects (National Toxicology Program, Fiscal Year 1980 Annual Plan, NTP-80-62, 1980).

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Callahan, M. A., et al. Water-Related Fate of 129 Priority Pollutants. U.S. EPA Office of Water Planning and Standards, Washington, DC, EPA 440/4-79-029 (December 1979).

Ewing, B. B., E.S.K. Chian, and J.C. Cook. Monitoring to Detect Previously Unrecognized Pollutants in Surface Waters: Organic Analysis Data. Prepared by Illinois University at Urbana-Champaign for Environmental Protection Agency. Available from National Technical Information Service, Springfield, VA., PB-273-349 (1977).

International Agency for Research on Cancer (IARC). IARC monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon, France, Volume 20. A World Health Organization Publication (WHO), Geneva (1979).

Merck Index: An Encyclopedia of Chemicals and Drugs, Ninth Edition, M. Windholz, Ed. Merck and Col., Rahway, NJ (1976).

Midwest Research Institute. Sampling and Analysis of Selected Toxic Substances. Task 1B-Hexachlorobutadiene. Prepared for the U.S. Environmental Protection Agency. Available from National Technical Information Service, Springfield, VA, PB-253-941 (1976).

National Toxicology Program. Fiscal Year 1981 Annual Plan. NTP 80-62 (1980).

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfiche Issue, R. J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville, MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 80-111-4 (1980).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA PB-80-155-153 (1980).

U.S. Environmental Protection Agency, Office of Water Planning and Standards. Ambient Water Quality Criteria for Hexachlorobutadiene. PB-81-117640 (October 1980).

Verschueren, Karel. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York, NY (1977).

HEXACHLOROETHANE

Executive Summary

CAS NUMBER: 00067-72-1

Hexachloroethane is a colorless, nonflammable crystal with a camphorlike odor. It readily sublimes (changes from a solid to a gas without passing through a liquid intermediate phase). It was first produced commercially in the United States in 1921; production in the U.S. was last reported in 1967. Estimated imports in 1976 were 730,000 kg. North Carolina requires the reporting of all spills of hexachloroethane if they occur near water.

Health Effects

ACUTE. Neurologic and opthalmologic effects in man have occurred as a result of exposure to hexachloroethane. Specific effects reported include inability to close eyelid, eye irritation, tearing, inflammation of membrane lining the eye and visual intolerance to light.

No ill effects were reported among World War II workers who handled hexachloroethene with few precautions.

CARCINOGENICITY. There is limited experimental evidence that hexachloroethane is carcinogenic; it produced malignant liver tumors in laboratory mice. A statistically significant excess of tumors was not observed in rats; a few renal tumors, rarely seen in untreated animals, were found. NIOSH recommends handling of hexachloroethane as if it were a human carcinogen.

MUTAGENICITY. Tests for mutagenic activity in microbial assays, 1 to 500 micrograms per plate, were all negative.

TERATOGENICITY AND EMBRYOTOXICITY. No evidence was found to indicate that hexachloroethane causes birth defects or is embryotoxic. At dosages toxic to female rats, 500 mg/kg orally and 260 ppm by inhalation, only a slight slowing of fetal development was noted.

CHRONIC. Liver and kidney damage from exposure to hexachloroethane have been reported in mice, rats, cattle and sheep. All of the chloroethane compounds are known to cause central nervous system depression in laboratory animals.

Occupational Health

The American Conference of Governmental Industrial Hygienists has established a Threshold Limit Value for workroom air (time-weighted average concentration under which it is believed that all workers may be repeatedly exposed day after day without adverse effect) of 10 ppm (100 mg/cu m).

Routes of Human Exposure

OCCUPATIONAL. A 1974 National Occupational Health Survey indicated that workers primarily exposed to hexachloroethane are those in paper board mills. Other occupations listed by NIOSH which use hexachloroethane include: cleaners, charwomen, millwrights, machine operators, plumbers, pipefitters and electricians.

Among its numerous other applications, hexachloroethane is utilized as a constituent in pyrotechnic and smoke generating devices used by the U.S. Army.

NIOSH has estimated that 1500 workers are exposed to hexachloroethane.

AMBIENT. Hexachloroethane has been found in the effluent from one chemical plant at a level of 8.4 µg/l and one sewage treatment plant in the U.S. It has also been detected in effluent waters from kraft paper mills at levels of less than 1 ug/l.

CONSUMER. Hexachloroethane has been found in drinking water in 4 of 13 cities sampled, at levels of 0.03 - 4.3 µg/l. In a separate study, river water and tap water concentrations of hexachloroethane were measured at 4.4 µg/l.

Hexachloroethane is used as a constituent of various fungicidal and insectidal formulations and as a moth repellant.

Environmental Significance

Estimated half-life in water is 45 minutes, based on evaporation from a 1 ppm solution.

The log octanol/water partition coefficient indicates possible adsorption of hexachloroethane on sediments.

A concentration factor of 139 was observed in bluegills exposed for 28 days. An average bioconcentration potential of 86.9-fold was calculated for the edible portion of fish.

The available data for chlorinated ethanes indicate that toxicity increases greatly with increasing chlorination. Actute toxicity to freshwater organisms occurs at concentrations as low as 980 µg/l for hexachloroethane. Chronic toxicity occurs at concentrations as low as 540 µg/l.

Acute toxicity to saltwater fish and invertebrate species occurs at concentrations as low as 940 µg/l.

North Carolina Production and Uses

Production: No known producers.

Users: No information available.

Recommended Reviews

Ambient Water Quality Criteria for Chlorinated Ethanes, EPA Office of Water Planning and Standards, EPA/440-5-80-029 (1980).

Chloroethanes: Review of Toxicity, NIOSH Current Intelligence Bulletin 27 (August 21, 1978).

FIRST AID AND EMERGENCY RESPONSE INFORMATION

HEXACHLOROETHANE

First Aid (NIOSH/OSHA Pocket Guide to Chemical Hazards)

Eyes: Wash with large amounts of water immediately. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH HEXACHLOROETHANE. The eyes are the major target organ of this chemical.

Skin: Wash the contaminated skin immediately with soap and water. Remove clothing if contaminated and wash skin.

Inhalation: Move to fresh air at once. Perform artificial respiration if necessary. Seek immediate medical attention.

Ingestion: Induce vomiting by finger or by giving syrup of ipecac. Seek medical attention immediately.

Procedures for Spills and Leaks

Isolate hazard area and deny entry. Stay upwind and keep out of low areas. Wear selfcontained breathing apparatus and full protective clothing. Do not touch spilled materials. Stop leak if it can be done without risk.

SMALL SPILLS: Take up with sand, or other noncombustible absorbent material, then flush area with water.

SMALL DRY SPILLS: Shovel into dry containers and cover, move containers then flush area with water.

LARGE SPILLS: Dike far ahead of spill for later disposal.

Fire and Explosion Information

May burn, but does not ignite readily. No flash point listed.

SMALL FIRES: Dry chemical, CO_2, water spray or foam.

LARGE FIRES: Water spray, fog or foam.

Move container from fire area if it can be done without risk.

Reactivity

MATERIALS TO AVOID: Hot iron, zinc, aluminum, alkalies

Protective Measures

PROTECTIVE EQUIPMENT: At levels up to 10 ppm, wear a supplied-air respirator or a self-contained breathing apparatus. At levels up to 50 ppm, wear a supplied-air respirator with a full facepiece, or a self-contained breathing apparatus with a full facepiece. At levels up to 300 ppm, wear a supplied-air respirator in the continuous flow, positive pressure, or positive demand mode. For escape from a contaminated area, wear a self-contained breathing apparatus suitable for pesticides.

HEXACHLOROETHANE

Profile

CHEMICAL IDENTIFICATION

Alternative Names:

Avlothane	Ethane Hexachloride
Carbon Hexachloride	Ethylene Hexachloride
Distokal	Falkitol
Distopan	Fasciolin
Distopin	Mottenhexe
Egitol	Perchloroethane

Chemical Abstract Services (CAS) Registry Number: 00067-72-1

Registry of Toxic Effects of Chemical Substances (RTECS) Number: KI 4025000

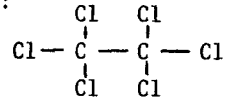
Hazardous Materials Table Identification Number: NA 9037

RCRA Identification Number: U 131

Molecular Weight: 236.74

Molecular Formula: C_2Cl_6

Structure:



Classification: Saturated aklyl halide; chlorinated hydrocarbon

Description: A colorless, nonflammable crystal with a camphor-like odor; readily sublimes (changes from a solid to a gas without a liquid intermediate phase).

Uses: As a chemical constituent in paint, lubricants, and fungicides/insecticides.

Chemical/Physical Data

Boiling point: 186.8°C
Melting point: Sublimes
Vapor pressure: 0.4 mm Hg at 20°C; 1 mm at 32.7°C
Solubility in water: 50 mg/l at 22°C
Specific gravity: 2.09

HUMAN TOXICITY

Hexachloroethane may be absorbed from the GI tract, through the lungs, and through the skin, and produces more potent (but slower-acting) central nervous system effects than chloroform or carbon tetrachloride (Gosselin, OTCP, 4th Ed).

Neurologic and opthalmologic effects in man have occurred as a result of exposure to hexachloroethane. Specific effects reported include inability to close eyelid, eye irritation, tearing, conjunctivitis (inflammation of membrane lining the eye), and photophobia (visual intolerance to light (NIOSH, 1978).

No ill effects are reported among workers who handled hexachloroethane with few precautions during World War II (ACGIH, 1980).

The maximum level at which one could escape within 30 minutes without any escape-impairing symptoms or irreversible effects is suggested to be 300 ppm (NIOSH/OSHA, 1978). Probable oral lethal dose for humans is estimated at 50-500 mg/kg, or between 1 teaspoon and 1 ounce for a 70 kg (150 lb) person (Gosselin).

Carcinogenicity

U.S. EPA, WQC, 1980 — The U.S. EPA Carcinogen Assessment Group (CAG) has determined that hexachloroethane is an animal carcinogen. Water Quality Criteria are based on incremental increase of cancer risk with increasing exposures. Nonthreshold behavior is assumed.

NIOSH, 1978 — NIOSH recommends handling of hexachloroethane as if it were a human carcinogen, based on National Cancer Institute data for mice. Liver cancer was induced in both sexes. NIOSH is not aware of any evidence associating chloroethane compounds with an increased risk of cancer in man.

IARC, 1979 — There is limited evidence that hexachloroethane is carcinogenic in experimental animals. In mice, it produced malignant liver tumors in males and females. In rats, no statistically significant excess of tumors was observed; however, a few renal tumors, rarely seen in untreated animals, were found .

Mutagenicity

IARC, 1979 — No data are available.

ACGIH, 1980 — Tests for mutagenicity in microbial assay were negative.

Teratogenicity and Embryotoxicity

No evidence was found to indicate that hexachloroethane causes birth defects or is embryotoxic (IARC, 1979).

At dosages toxic to female rats, 500 mg/kg orally and 260 ppm by inhalation, only a slight slowing of fetal development was noted (ACGIH, 1980).

ANIMAL TOXICITY

All of the chloroethane compounds are known to cause central nervous system depression in

laboratory animals. Chloroethanes are generally irritating to the eyes and skin (NIOSH, 1978).

Acute Toxicity

Results of lethal studies in several species are listed below:

Route	Species	Lethal Dose or Lethal Concentration	Reference
Oral	Rat	6.0 gm/kg, LD50	RTECS, 1980
	Rat	4.59 gm/kg, LD50	ACGIH, 1980
	Rabbits	1.0 gm/kg, approximate lethal dose	ACGIH, 1980
Inhalation	Rat	5,900 ppm (57.1 g/cu m) for 8 hours, lowest lethal concentration	ACGIH, 1980
Dermal	Rabbit	Greater than 32 g/kg, LD50	ACGIH, 1980

Rats showed no toxic effects when exposed at 260 ppm for 8 hours, but dogs developed symptoms (tremors, ataxia, hypersalivation and facial muscle fasciculations) when exposed at this level for 6 hours per day for 6 weeks. In similar studies using rats, quail, pigs, and dogs exposed to 15 and 48 ppm, no neuromuscular or other effects were detected (ACGIH, 1980).

Chronic Toxicity

Toxic kidney damage was observed in both mice and rats treated with hexachloroethane in carcinogen studies. Liver and kidney damage from exposure to hexachloroethane is reported in mice, rats, cattle and sheep (NIOSH, 1978).

Aquatic Toxicity

The U.S. EPA Water Quality Criteria (1980) for the protection of aquatic life are given below:

> The available freshwater data for chlorinated ethanes indicate that toxicity increases greatly with increasing chlorination and that acute toxicity occurs at concentrations as low as 980 µg/l for hexachloroethane. Chronic toxicity occurs at concentrations as low as 540 µg/l for hexachloroethane. The available saltwater data for chlorinated ethanes indicate that toxicity increases greatly with increasing chlorination and that acute toxicity to fish and invertebrate species occurs at concentrations as low as 940 µg/l for hexachloroethane.

Bioaccumulation: A concentration factor of 139 was observed in the bluegill exposed for 28 days. An average bioconcentration potential of 86.9-fold for the edible portion of fish is assumed in the derivation of a water quality criterion based on human health (U.S. EPA, WQC, 1980).

Phytotoxicity

No data are available on phytotoxicity to terrestrial or aquatic plants.

ENVIRONMENTAL DATA

Air

There are limited data available regarding the occurrence of hexachloroethane in ambient air. This substance is not expected to be an important air pollutant due to its very low vapor pressure (0.4 mm Hg at 20°C). By analogy to tetrachloromethane and other chlorinated hydrocarbons, hexachloroethane is expected to be resistant to atmospheric degradation.

Water

In water from 4 of 13 cities sampled, hexachloroethane was found at levels of 0.03 - 4.3 µg/l. In a separate study, river water and tap water concentrations were measured at 4.4 ug/l. It has been detected in effluent water from kraft paper mills at levels below 1 µg/l (IARC, 1979). Hexachloroethane has an estimated half-life in water of 45 minutes based on evaporation (Verschueren, 1977). Although it is resistant to degradation in this medium, it is removed by volatilization and accumulation is not expected to be significant.

Soil

Insufficient data to assess persistence. Partition coefficient (3.34, calculated U.S. EPA, WQC, 1980) indicates possible adsorption onto sediments (Callahan, 1979).

Hexachloroethane is not known to occur as a natural compound (IARC, 1979). Some dispersion in air, water and soil is likely.

INDUSTRIAL DATA

Production

No production in North Carolina has been reported in the Toxic Substances Control Act (TSCA) Chemical Substances Inventory (U.S. EPA, TSCA, 1980).

Production in the U.S. was last reported in 1967 (IARC, 1979).

Consumption and Use

Estimated U.S. Consumption: Estimated imports in 1976 were 730,000 kg (805 tons) (IARC, 1979).

Reported uses of hexachloroethane and the corresponding SIC codes are listed below:

Constituents of grenades for the generation of fog or smoke	-
Degassing agent for magnesium	34
Component of pressure lubricants	29

SIC Codes (Continued)

Ignition suppressant in combustible liquids	-
Moth repellant	2879
Plasticizer for cellulose esters	282
Anthelminthic agent in veterinary medicine	283
An accelerator in rubber	30
Retardant in fermentation	2035
Component of submarine paints	285
Additive to fire extinguishing fluids	-
Constituent of various fungicides and insecticides	2879
Degassing in the aluminum casting industry	3334

(IARC, 1979)

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air

No guidelines for hexachloroethane in air have been established.

Workroom Air

ACGIH — The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists ACGIH) for workroom air is 10 ppm (100 mg/cu m) as a time-weighted average. The importance of avoiding skin exposure is noted.

NIOSH — The National Institute of Occupational Safety and Health (NIOSH) has tentative plans for a Criteria Document for a Recommended Standard. Based on the evidence of carcinogenicity of hexachloroethane in animals, NIOSH recommends that exposure to the compound be minimized.

OSHA — The Occupational Safety and Health Administration (OSHA) standard for workroom air is 1 ppm (10 mg/cu m) as a time-weighted average.

Water

Addressed by Ambient Water Quality Criteria set by the U.S. Environmental Protection Agency.

Designated a toxic pollutant by the U.S. Environmental Protection Agency.

Designated a hazardous substance by the U.S. Environmental Protection Agency. Discharges in excess of 1,000 pounds must be reported.

Other

Regulated as a hazardous material by the U.S. Department of Transportation.

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Agencies Concerned with this Chemical

Designated a candidate substance by the Occupational Safety and Health Administration.

Subject of A Risk Assessment Document prepared by the Carcinogen Assessment Group (CAG) of the U.S. Environmental Protection Agency.

Subject of a monograph prepared by the International Agency for Research on Cancer (IARC).

Chlorinated paraffins are included on the Priority List of the Interagency Testing Committee (ITC).

Under toxicological evaluation through the National Toxicology Program to determine carcinogenicity. Bioassay is scheduled to start in Fiscal Year 1981.

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Callahan, M. A., et al. Water-Related Fate of 129 Priority Pollutants. U.S. EPA Office of Water Planning and Standards, Washington, DC, EPA 440/4-79-029 (December 1979).

International Agency for Research on Cancer (IARC). IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon France, Volume 20. A World Health Organization Publication (WHO), Geneva, (1979).

National Institute for Occupational Safety and Health (NIOSH). Current Intelligence Bulletin No. 27. Chloroethane: A Review of Toxicity. U.S. Department of Health, Education, and Welfare. DHEW (NIOSH) Publication No. 78-181 (1978).

National Institute for Occupational Safety and Health/Occupational Safety and Health Administration (NIOSH/OSHA). NIOSH/OSHA Pocket Guide to Chemical Hazards. DHEW (NIOSH) Publication No. 78-210 (September 1978).

National Toxicology Program. Fiscal Year 1981 Annual Plan, Department of Health and Human Services. NTP-80-62 (December 1980).

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfiche Issue, R. J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville, MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 80-111-4 (1980).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA PB-80-155-153 (1980).

U.S. Environmental Protection Agency, Office of Water Planning and Standards. Ambient Water Quality Criteria for Chlorinated Ethanes. EPA-440/5-80-029, PB 8-117400 (October 1980).

Verschueren, Karel. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York, NY (1977).

HEXANE DIAMINE

Executive Summary

CAS NUMBER 00124-09-4

1,6-Hexanediamine is a colorless, combustible solid with the odor of piperidine (peppery, ammoniacal odor). One billion pounds were produced in the U.S. in 1978 and five companies are currently manufacturing the chemical. It is regulated as a hazardous material by USDOT. Spills usually do not present a serious problem.

Health Effects

ACUTE. A study of workers exposed to epoxy resins and hardeners, including 1,6-hexanediamine, showed that prolonged contact caused skin damage, allergic rhinitis, bronchial asthma, impairment of bronchial permeability, toxico-allergic hepatitis, gastritis, colitis, hypergammaglobulinemia, increased transaminase activity, and eosinophilia of peripheral blood.

Conjunctival and upper respiratory tract irritations have been observed in workers handling 1,6-hexanediamine. ACGIH has not established a Threshold Limit Value for workroom air.

CARCINOGENICITY. No studies are reported.

MUTAGENICITY. 1,6-Hexanediamine is reported to inhibit DNA and RNA formation in *in vitro* studies using rat embryo and human amnion cell cultures.

TERATOGENICITY AND EMBRYOTOXICITY. No evidence was found to indicate that 1,6-hexanediamine causes birth defects.

CHRONIC. Introduction of a second amine group into the alkyl radical of 1,6-hexanediamine tends to decrease systemic toxicity. However, the diamines are also absorbed through the skin and distributed systemically.

Routes of Human Exposure

OCCUPATIONAL. 1,6-Hexanediamine is used in the production of nylon, plastics, urethane coatings, polyamides for printing inks, dimer acids, paints, and epoxy resins. It is also used as a lubricant and oil additive. According to the National Occupational Health Survey, approximately 1,100 people are estimated to be exposed to 1,6-hexanediamine. In two plants, air concentrations varied from 2 to 5.5 mg/cu m during normal operations and from 32.7 to 131.5 mg/cu m during autoclave operations.

AMBIENT. The estimated release of 1,6-hexanediamine to the environment is 12.8 million pounds per year. However, the chemical was not found in U.S. drinking water supplies, industrial effluent discharges or European water supplies. No information is available on levels in ambient air.

CONSUMER. 1,6-Hexanediamine may be present in consumer products, but little information is available.

Environmental Significance

1,6-Hexanediamine is freely soluble in water and reactive to oxidizing agents. It may react in air to form nitrosamines (see Nitrosamine Summary). Limited environmental data are available.

North Carolina Production and Users

Production: No known producers.
Users: No information is available.

Recommended Reviews

Chemical Hazard Information Profile: 1,6-Diaminohexane, U.S. Environmental Protection Agency, EPA-560/11-80-011 (1980).

FIRST AID AND EMERGENCY RESPONSE INFORMATION

HEXANE DIAMINE

First Aid (NIOSH/OSHA Pocket Guide to Chemical Workers)

Not listed in NIOSH/OSHA. Adequate ventilation should be provided. Wash from skin immediately upon contact.

Environmental Spills (U.S. Department of Transportation Emergency Response Guidebook, 1980)

1,6-Hexanediamine is not listed.

HEXANE DIAMINE

Profile

CHEMICAL IDENTIFICATION

Alternative Names:

1,6-Diaminohexane
Hexamethylenediamine
1,6-Hexamethylenediamine
Hexamethylene diamine
HMDA

Chemical Abstract Services (CAS) Registry Number: 00124-09-4

Registry of Toxic Effects of Chemical Substances (RTECS) Number: MO 1180000

Hazardous Materials Table Identification Number: UN 2280 (Solid); UN 1783 (Solution)

RCRA Identification Number: None

Molecular Weight: 116.24

Molecular Formula: $C_6H_{16}N_2$

Structure: $H_2N(CH_2)_6NH_2$

Classification: A saturated symmetrical alkylene diamine

Uses: In the production of nylon, plastics, inks, acids and paints

Description: Colorless combustible solid with the odor of piperidine

Chemical/Physical Data

Boiling point: 204-205°C (Sublimes)
Melting point: 41-42°C
Vapor density: 4.01 (Air = 1.0)
Solubility in water: Freely soluble in water

HUMAN TOXICITY

A study of workers exposed to epoxy resins and hardeners, including 1,6-hexanediamine, showed that prolonged contact caused skin damage, allergic rhinitis, bronchial asthma, impairment of bronchial permeability, toxico-allergic hepatitis, gastritis, colitis, hypergammaglobulinemia, increased transaminase activity, and eosinophilia of peripherial blood (U.S. EPA, CHIP, 1980).

An in vitro study showed 1,6-hexanediamine to inhibit collagen-induced human platelet aggregation (NTP, 1980; U.S. EPA, CHIP, 1980).

Conjunctival and upper respiratory tract irritation have been observed in workers handling 1,6-hexanediamine. One worker, out of the 20 studied, developed acute hepatitis followed by dermatitis which was attributed to the chemical. No anemia was observed. Air concentrations varied from 2 to 5.5 mg/cu m during normal operations and from 32.7 to 131.5 mg/cu m during autoclave operations in two plants (Sutton, 1963).

Because of the paucity of data regarding the toxic effects of hexanediamine and the recognition of its high production volume, the U.S. EPA has nominated the chemical for high priority testing through the National Toxicology Program.

In discussing the toxic effects of aliphatic diamines, Sutton (1963) has made the following generalizations:

> Introduction of a second amine group into the alkyl radical tends to decrease systemic toxicity....The histamine-releasing activity of the diamines is slight at C_4 (tetramethylenediamine) and increases to a maximum at C_{10} (1, 10-decanediamine)....The diamines are strong bases and exhibit skin sensitization properties not experienced with the corresponding monoamines. They are absorbed through the skin. The acute percutaneous toxicity is often approximately equilavent to that of the corresponding monoamine.

Carcinogenicity

Studies to determine carcinogenic potential of 1,6-hexanediamine are not reported.

Mutagenicity

1,6-Hexanediamine is reported to inhibit DNA and RNA formation in in vitro studies using rat embryo and human amnion cell cultures (U.S. EPA, CHIP, 1978).

Teratogenicity and Embryotoxicity

No evidence was found to indicate that 1,6-hexanediamine causes birth defects.

Intraperitoneal injection of 1,6-hexanediamine into rats inhibited ovarian ornithine decarboxylase activity which had been stimulated by human chorionic gonadotropin (U.S. EPA, CHIP, 1980).

ENVIRONMENTAL DATA

Air
No information on ambient air levels was found. Primary amines are reactive toward oxidizing agents in the air, and may react to form more toxic nitrosamines (U.S. EPA, CHIP, 1980). The persistence of 1,6-Hexanediamine in air has not been established.

Water
1,6-Hexanediamine was not found in drinking water supplies, industrial effluent discharges, or European water supplies (NTP, 1980). The potential for degradation, accumulation and dispersion in this medium has not been objectively determined.

Soil
No information available.

Biota
Limited information available. No effect level in rodents (1 ppm, inhalation) (Verschueren, 1977) indicates that some metabolism may occur in this medium. No bioaccumulation or biomagnification is expected.

The estimated release of 1,6-hexanediamine to the environment is 12.8 million lb/yr. Hexanediamine may be present in consumer products (paints, epoxy resins, nylons, plastics), and may play a part in nitrosamine formation (U.S. EPA, CHIP, 1980).

ANIMAL TOXICITY

Results of Acute Toxicity Studies

Lethal animal doses reported in the RTECS (1980) are 750 mg/kg (LD50, oral rat) 1.1 gm/kg (LD50, skin, rabbit), and 750 mg/cu m for 10 minutes inhalation (lowest lethal concentration, mouse).

Results of Chronic Toxicity Studies

1,6-Hexanediamine causes anemia, weight loss, and degenerative microscopic changes in the kidneys and liver and to a lesser degree in the myocardium of guinea pigs after repeated doses (Sutton, 1963). More recently a chronic inhalation study with hexamethylenediamine reported noticeable alterations in the cardiovascular system of exposed rats (Verich, 1979).

Continuous 90-day inhalation of 1 mg/cu m of 1,6-diaminohexane by albino rats caused an increase in the number of recticulocytes (only at the beginning of the exposure) and an increase in the Vi antibody concentration. The animals also exhibited a decrease in the number of eosinophils, suppressed leukocytic activity, retarded growth, and a disturbance of the chronaxy correlation of the muscle antagonists. 1,6-Diaminohexane at a concentration of 0.04 mg/cu m caused similar but less pronounced changes. 1.6-Diaminohexane at 0.001 mg/cu m had no effect. Exposing rats to an atmosphere containing 1.25 mg/cu m of 1,6-diaminohexane for 4 hr/day for 8 days decreased the threshold of neuromuscular excitability, increased blood leucocyte and liver glycogen levels, caused disorders of renal excretory capacity, and altered the phagocytic activity of neutrophils (U.S. EPA, CHIP, 1980).

AQUATIC AND TERRESTRIAL TOXICITY

Aquatic toxicity rating: TLm 96 is 10-100 (RTECS, 1980).

For aliphatic diamines, there is increasing toxicity to paramecia from C_6 to C_{15} (Sutton, 1963).

No other aquatic, wildlife, or phytotoxicity data on hexanediamine are available.

INDUSTRIAL DATA

Production

No production in North Carolina is reported in the Toxic Substances Control Act (TSCA) Chemical Substance Inventory (U.S. EPA, TSCA, 1980).

U.S. production in 1975 was estimated at 750 million pounds (375,000 tons) (U.S. EPA, CHIP, 1980). Five companies are listed as currently manufacturing 1,6-hexanediamine; three in Texas, one in Alabama, and one in New York (MEDLARS, 1981). One billion pounds of 1,6-hexanediamine were produced in 1978 (NTP, 1980).

Consumption and Use

Estimated U.S. Consumption:

There is no data on U.S. consumption. However, 88% of total use is in the production of Nylon 66. The remaining 12% includes the production of Nylon 610 and 612 (MEDLARS, 1981).

Reported uses of 1,6-hexanediamine and the corresponding SIC codes are listed below:

Uses

Raw material for nylon fiber	2823, 22
Raw material for plastics	2821
Manufacture of urethane coatings	2851
Manufacture of polyamides for printing inks	2893, 27
Manufacture of dimer acids	2869
As a lubricant and oil additive	2851
Used in paints	2851
Used in epoxy-resins	2821

(U.S. EPA, CHIP, 1980)

Intermediate in production of nylon 2823, 22
(Merck, 1976)

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air
No guidelines for air have been established.

Workroom Air
No guidelines for workroom air have been established.

Water
No guidelines for water have been established.

Other
Regulated as a hazardous material by the U.S. Department of Transportation. 1,6-Hexanediamine is classified as a "Corrosive Material" and shipments must be so labeled.

Agencies Concerned with this Chemical

Chemical Hazard Information Profile (CHIP) compiled by the Office of Testing and Evaluation, U.S. Environmental Protection Agency.

Considered by the International Agency for Research on Cancer (IARC) Working Group, but no monograph was prepared because of insufficient data.

Subject to a proposed rule under the Toxic Substances Control Act that would require all chemical manufacturers to report production and exposure-related data to the U.S. Environmental Protection Agency (Federal Register, Vol. 45, No. 42, 1980).

Addressed by a National Toxicology Program (NTP, 1980) Executive Summary and included in the list of 100 compounds nominated for NTP testing.

REFERENCES

MEDLARS II Toxicology Data Bank (TDB) Record of 1,6-Hexanediamine. National Library of Medicine (May 1981).

Merck Index: An Encyclopedia of Chemicals and Drugs, Ninth Edition, M. Windholz, Ed. Merck and Co., Rayway, NJ (1976).

National Toxicology Program. Classification of 102 NTP Compounds for FY 81 by the Chemical Nomination and Selection Committee. U.S. Department of Health, Education, and Welfare, Jefferson, Arkansas (1980).

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfiche Issue, R. J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville, MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 80-111-4 (1980).

Sutton, W. L. Aliphatic and Alicyclic Amines. Industrial Hygiene and Toxicology, Second Revised Edition, Vol. 2, F. A. Patty, Ed. Interscience Publishers, New York, NY (1963).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Chemical Hazard Information Profiles (CHIPs). EPA-560/11-80-011 (1980).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA PB-80-155-153 (1980).

Verich, G. E. Experimental Data on the Effect of Hexamethylenediamine on the cardiovascular system. (1979).

Verschueren, Karel. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Col., New York, NY (1977).

HYDROGEN SULFIDE

Executive Summary

CAS NUMBER: 07783-06-4

Hydrogen sulfide is a flammable, poisonous gas with a characteristic odor of rotten eggs. It is found primarily as an anaerobic degradation product of both organic sulfur compounds and inorganic sulfates. North Carolina requires the reporting of all spills if they occur near water.

Health Effects

ACUTE. Absorption is mainly through the respiratory tract, though absorption through the skin has been demonstrated. In high concentrations (500-1,000 ppm), hydrogen sulfide acts primarily as a systemic poison, causing unconsciousness and death through respiratory paralysis. These acute systemic effects occur whenever the gas is absorbed faster than it can be oxidized to pharmacologically inert compounds such as thiosulfate and sulfate. Such oxidation occurs rapidly in man or animals; a biological half-life of less than 20 minutes has been estimated.

Exposure to hydrogen sulfide at low concentrations may irritate the mucous membranes of the eyes and respiratory tract.

CHRONIC. Conclusive evidence of adverse health effects from repeated, long-term exposure to hydrogen sulfide at low concentrations was not found. However, there is some evidence that hydrogen sulfide alone at low concentrations or in combination with other chemical substances (e.g., hydrocarbons or carbon disulfide) has caused nervous system, cardiovascular, gastrointestinal and ophthalmic disorders.

Occupational Health

The American Conference of Governmental Industrial Hygienists has established a Threshold Limit Value for workroom air (time-weighted average concentration under which it is believed that all workers may be repeatedly exposed day after day without adverse effect) of 10 ppm (15 mg/cu m). The recommended Short Term Exposure Limit (the maximum concentration to which workers may be exposed for a period up to 15 minutes) is 15 ppm (23 mg/cu m). The Occupational Safety and Health Administration Standard for workroom air is 20 ppm (30 mg/cu m) as a ceiling and a 10-minute peak limit of 50 ppm (75 mg/cu m). The National Institute of Occupational Safety and Health recommends a 10-minute ceiling limit of 10 ppm (15 mg/cu m).

There is no evidence that hydrogen sulfide is carcinogenic, mutagenic, teratogenic or embryotoxic in any species. No test results are reported.

Routes of Human Exposure

OCCUPATIONAL. Hydrogen sulfide is a leading cause of sudden death in the workplace. It is especially dangerous when it occurs in low-lying areas or confined workspaces or when it exists in high concentrations under pressure. A serious health hazard exists for workers employed in the following:

Energy production from hydrocarbon or geothermal sources
Production of fibers and sheets from viscose syrup
Sewers, sewage treatment and animal waste disposal
Work below ground
Fishing boats
Gas and oil industry
Chemical operations

AMBIENT. Hydrogen sulfide has been measured in ambient air in Maine at concentrations ranging from 0-4.0 ppb. The concentration measured in rural Illinois air ranged from 0.1-0.15 ppb.

Hydrogen sulfide occurs naturally in volcanic gases, sulfur springs, fumaroles, and in decaying plant and animal protein. It occurs to some extent in most petroleum and natural gas deposits and in many mines. It may be found in excavating swampy or filled ground or in wells, caissons, or tunnels. It is estimated that 0.07 tons of hydrogen sulfide are emitted daily per 1,000 square miles from natural sources. Sulfides are constituents of many industrial wastes such as those from tanneries, paper mills, chemical plants, and gas works. The anaerobic decomposition of sewage, sludge beds, algae, and other naturally deposited organic material is a major source of hydrogen sulfide.

CONSUMER. Hydrogen sulfide has been measured in cigarette smoke at 40 ppm (56 mg/cu m). It occurs naturally in the intestines as a result of bacterial action.

Environmental Significance

Hydrogen sulfide oxidizes readily in air, though quantitative data on oxidative half-life are not available. Persistence in water is pH dependent.

The degree of hazard exhibited by hydrogen sulfide to aquatic animal life is dependent on the temperature, pH, and dissolved oxygen content of the water. At lower pH values, a greater proportion is in the form of the toxic undissociated hydrogen sulfide. In winter when the pH is neutral or below (i.e., acid pH) or when dissolved oxygen levels are low but not lethal to fish, the hazard from sulfides is increased.

On the basis of chronic tests evaluating growth and survival, the safe hydrogen sulfide level for bluegill, Lepomis machrochirus, juveniles and adults, was 2 µg/l. Egg deposition in bluegills was reduced after 46 days in 1.4 ug/l. White sucker eggs were hatched at 15 µg/l, but juveniles showed growth reductions at 1 µg/l. Safe levels for fathead minnows were between 2 and 3 µg/l.

It is recognized that the hazard from hydrogen sulfide to aquatic life is often localized and transient. Available data indicate that water containing concentrations of 2.0 ug/l undissociated hydrogen sulfide would not be hazardous to most fish and other aquatic wildlife but concentrations in excess of 2.0 µg/l would constitute a long-term hazard.

Exposure to hydrogen sulfide in air is reported to cause marking of leaves of plants,

particularly young plants; 150 mg/cu m for 4 hours caused 100 percent marking of leaf area of lamb's quarters (Chemopodium murale).

Data on aquatic plants or algae are not reported.

North Carolina Production and Users

Production: No known producers.

Users: No information available.

Recommended Reviews

Criteria for a Recommended Standard for Hydrogen Sulfide, National Institute of Occupational Safety and Health, DHEW Publication 77-158 (1977).

Hazard Assessment Sheet for Hydrogen Sulfide, Michigan Department of Natural Resources, Critical Materials Register, 1980.

FIRST AID AND EMERGENCY RESPONSE INFORMATION

HYDROGEN SULFIDE

First Aid (NIOSH/OSHA Pocket Guide to Chemical Hazards)

Eyes: Wash with large amounts of water immediately. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH HYDROGEN SULFIDE.

Skin: Flush contaminated skin with water immediately. Remove clothing immediately if contaminated and flush skin with water.

Inhalation: Move to fresh air at once. Perform artificial respiration if necessary. Seek immediate medical attention.

Procedures for Spills and Leaks (U.S. DOT Emergency Response Guidebook)

Isolate hazard area and deny entry. Stay upwind and keep out of low areas. Wear positive pressure breathing apparatus and special protective clothing. Evacuate area endangered by gas. Isolate for ½ mile in all directions if tank or tankcar is involved in fire.

SPILL OR LEAK: Do not touch spilled material. No flares, smoking or flames in hazard area. Stop leak if it can be done without risk. Use water spray to reduce vapors and isolate area until gas is dispersed.

Fire and Explosion Information

Extremely flammable, may be ignited by heat, sparks and flames. Flammable vapor may spread away from spill. Vapor explosion and poison hazard indoors or in sewers. Container may explode in heat of fire. Let fire burn unless leak can be stopped immediately.

SMALL FIRES: Dry chemical or CO_2
LARGE FIRES: Water spray, fog or foam.

Move containers from fire area if it can be done without risk. Stay away from ends of tanks. Cool containers with water using unmanned device until well after fire is out. Isolate area until gas has dispersed.

Reactivity

MATERIALS TO AVOID: Strong oxidizers, metals

Protective Measures

PROTECTIVE CLOTHING: Wear protective clothing to protect skin from freezing, and chemical goggles.

PROTECTIVE EQUIPMENT: At levels up to 300 ppm, wear a supplied-air respirator with a full facepiece or hood, or a self-contained breathing apparatus with a full facepiece. For escape conditions, wear a gas mask with an acid gas canister providing protection against hydrogen sulfide, or a self-contained breathing apparatus.

HYDROGEN SULFIDE

Profile

Chemical Identification

Alternative Names:

Dihydrogen Sulfide
Dihydrogen Monosulfide
Hydrosulfuric Acid
Stink Damp
Sulfureted Hydrogen

Chemical Abstract Services (CAS) Registry Number: 07783-06-4

Registry of Toxic Effects of Chemical Substances (RTECS) Number: MX 1225000

Hazardous Materials Table Identification Number: UN 1053

RCRA Identification Number: U 135

Molecular Weight: 34.08

Molecular Formula: H_2S

Structure: H — S — H

Classification: Reduced sulfur

Description: Flammable, poisonous, colorless gas with characteristic odor of rotten eggs

Uses: Chemical intermediate and reagent

Chemical/Physical Data

Boiling point: -60.33°C
Melting point: -85.49°C
Vapor pressure: 20 atm at 25.5°C
Vapor density: 1.19 (Air = 1.0)
Solubility in water: 4 mg/l at 20°C; dissociates to HS-, S-2 and H+
Ignition temperature: 260°C
Explosive limits: 4.3-46 percent by volume in air

HUMAN TOXICITY

The absorption of hydrogen sulfide is almost exclusively through the respiratory tract, although absorption through the skin has been demonstrated. By far, the greatest danger from the inhalation of hydrogen sulfide is from its acute effects. The nature of the effects is dependent upon the concentration of the gas. Upon acute exposure to concentrations in excess of 448 ppm, hydrogen sulfide may cause immediate coma which may occur with or without convulsions. This condition has been characterized by rapid and often instantaneous loss of consciousness followed by convulsions and respiratory failure. Concentrations of 700 ppm are associated with systemic effects from absorption of hydrogen sulfide into the bloodstream. These acute systemic effects occur whenever the gas is absorbed faster than it can be oxidized to pharmacologically inert compounds such as thiosulfate and sulfate. Such oxidation occurs rapidly in man or animals (Patty, 1963). A biological half-life of less than 20 minutes has been estimated (Roach, 1966).

Exposure to hydrogen sulfide at low concentrations may irritate the mucous membranes of the eyes and respiratory tract.

The maximum level at which one could escape within 30 minutes without any escape-impairing symptoms or irreversible effects is suggested to be 300 ppm (NIOSH/OSHA, 1978).

There is no evidence that hydrogen sulfide is carcinogenic, mutagenic, or teratogenic in any animal species. Also, reproduction toxicity apparently has not been evaluated in animals. No test results are reported.

AQUATIC AND TERRESTRIAL TOXICITY

Aquatic Toxicity

The U.S. EPA (1976) proposed a water quality criterion of 2 µg/l for undissociated hydrogen sulfide for protection of fish and other aquatic life. The rational for the criterion is given below:

> The degree of hazard exhibited by sulfide to aquatic animal life is dependent on the temperature, pH, and dissolved oxygen. At lower pH values, a greater proportion is in the form of the toxic undissociated hydrogen sulfide. In winter when the pH is neutral or below (i.e., acid pH) or when dissolved oxygen levels are low but not lethal to fish, the hazard from sulfides is exacerbated.
>
> On the basis of chronic tests evaluating growth and survival, the safe hydrogen sulfide level for bluegill, Lepomis machrochirus, juveniles and adults, was 2 µg/l. Egg deposition in bluegills was reduced after 46 days in 1.4 µg/l. White sucker eggs were hatched at 15 µg/l, but juveniles showed growth reductions at 1 µg/l. Safe levels for fathead minnows were between 2 and 3 µg/l.
>
> It is recognized that the hazard from hydrogen sulfide to aquatic life is often localized and transient. Available data indicate that water containing concentrations of 2.0 µg/l undissociated hydrogen sulfide would not be hazardous to most fish and other aquatic wildlife, but concentrations in excess of 2.0 µg/l would constitute a long-term hazard.

Phytotoxicity

Exposure to hydrogen sulfide in air is reported to cause marking of leaves of plants, particularly young plants; 150 mg/cu m for 4 hours caused 100 percent marking of leaf area of

lamb's quarters (Chemopodium murale) (Bond, 1972).

Data on aquatic plants or algae are not reported.

ENVIRONMENTAL DATA

Air

It is estimated that 0.07 tons of hydrogen sulfide are emitted daily into the atmosphere per 1,000 square miles of earth (Verschueren, 1977). Hydrogen sulfide has been measured in ambient air in Maine at concentrations ranging from 0 - 4.0 ppb (Woodard, 1969) and in rural Illinois from 0.1 -0.15 ppb (Breeding, 1973).

Hydrogen sulfide has an estimated atmospheric residence time of 2 hours in surface atmosphere (Robinson, 1970). and oxidizes readily. High concentrations pose transient industrial hazards, as this substance degrades quickly in air.

Water

The persistence of hydrogen sulfide in water is pH dependent, it readily hydrolyzes at alkaline pH, and may accumulate in this medium and sediments at acid pH.

Soil

Hydrogen sulfide can be persistent in anerobic organic sediments. It will oxidize in aerobic systems (NAS, 1972).

Biota

Hydrogen sulfide is naturally formed in biota through bacterial action (NIOSH, 1977). It is highly reactive in this medium, hydrolizing with biological molecules. No bioaccumulation or biomagnification is expected, although wide dispersion may occue due to its natural formation.

Hydrogen sulfide occurs naturally in volcanic gases, sulfur springs, and fumaroles, in decaying plant and animal protein, and in animal intestines as a result of bacterial action (NIOSH, 1977). It occurs to some extent in most petroleum and natural gas deposits and in many mines. It may be found in excavating swampy or filled ground or in wells, caissons, or tunnels (Patty, 1963). It has been measured in cigarette smoke at 40 ppm (56 mg/cu m) (Verschueren, 1977).

INDUSTRIAL DATA

Production

No production in North Carolina has been reported in the Toxic Substances Control Act (TSCA) Chemical Substance Inventory (U.S. EPA, TSCA, 1980).

Consumption and Use

Estimated U.S. Consumption:

No quantitative data on U.S. consumption were found.

Reported uses of hydrogen sulfide and the corresponding SIC codes are listed below: (NIOSH, 1977)

Manufacture of chemicals	28
In metallurgy	33, 34
As an analytical reagent (Merck, 1976)	
Agricultural disinfectant	01, 2879
Intermediate for sulfuric acid, elemental sulfur, sodium sulfide, other sulfides, organic sulfur compounds	2813
Intermediate for additives in extreme pressure lubricants and cutting oils	2992

(MEDLARS, 1980)

Occupational hazard for workers employed in:

Energy production from hydrocarbon or geothermal sources	13
Production of fibers and sheets from viscose syrup	282
Production of deuterium oxide	281
Sewers, sewage treatment and animal waste disposal	495
Work below ground	
Fishing boats	091
Gas and oil industry	13

(NIOSH, 1977)

REGULATORY RESEARCH DATA

Existing Guidelines and Standards

Ambient Air

Addressed by the Prevention of Significant Deterioration (PSD) regulations established by the U.S. Environmental Protection Agency. The de minimus emission rate for hydrogen sulfide is 9 tonnes (10 tons) per year.

Addressed by New Source Performance Standards and existing source standards set by the U.S. Environmental Protection Agency to limit total reduced sulfur (including hydrogen sulfide) in emissions from Kraft pulp mills (Code of Federal Regulations, Title 40, Parts 51 and 52).

Workroom Air

ACGIH — The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air is 10 ppm (15 mg/cu m) as a time-weighted average. The recommended Short Term Exposure Limit (STEL) for an 8-hour period is 15 ppm (23 mg/cu m).

NIOSH — The National Institute of Occupational Safety and Health (NIOSH) recommends a 10-minute ceiling limit of 10 ppm (15 mg/cu m).

OSHA — The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 20 ppm (30 mg/cu m) as a ceiling and a 10-minute peak limit of 50 ppm (75 mg/cu m).

Water

Addressed by a National Secondary Drinking Water Standard proposed by the U.S. Environmental Protection Agency in 1977. The standard was not adopted because EPA concluded that the contaminant level will be set by the secondary standard for odor (established as three times the threshold odor number).

Designated a hazardous substance by the U.S. Environmental Protection Agency. Spills in excess of 100 pounds must be reported (Code of Federal Regulations, Title 40, Part 116).

Addressed by Ambient Water Quality Criteria set by the U.S. Environmental Protection Agency in 1976.

Limited (as sulfide) in industrial wastewater by U.S. EPA Effluent Guidelines applicable to certain inorganic chemicals manufacturing processes (Code of Federal Regulations (CFR), Title 40, Part 145), petroleum refining (40 CFR, Part 419), and iron and steel manufacturing byproduct coking (40 CFR, Part 420).

Other

Regulated as a hazardous material by the U.S. Department of Transportation. The regulations pertain to the identification and transportation of hazardous materials in commerce (Code of Federal Regulations, Title 49, Part 172,101). Hydrogen sulfide is classified as a "Flammable Gas" and shipments must carry a label which reads "Flammable Gas and Poison."

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Organizations Concerned with this Chemical

Appears on the 1978-1982 Priority Lists of the Chemical Industry Institute of Toxicology (CIIT).

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Bond, R. G., C. P. Straub, and R. Prober, Eds. Handbook of Experimental Control. Vol. 1: Air Pollution. The Chemical Rubber Company, Cleveland, OH (1972).

Breeding, R. J., et al. Background Trace Gas Concentrations in the Central United States. Journal Geophysical Research, 78(3), 7057-64 (1973).

Merck Index: An Encyclopedia of Chemicals and Drugs, Ninth Edition, M. Windholz, Ed. Merck and Co., Rahway, NJ (1976).

National Academy of Sciences, National Academy of Engineering. Water Quality Criteria 1972. A Report. National Academy of Sciences, Washington, DC (EPA-R3-73-033 (1973).

National Institute for Occupational Safety and Health/Occupational Safety and Health Administration (NIOSH/OSHA). NIOSH/OSHA Pocket Guide to Chemical Hazards. DHEW (NIOSH) Publication No. 78-210 (September 1978).

National Institute for Occupational Safety and Health (NIOSH). Criteria for a Recommended Standard...Occupational Exposure to Hydrogen Sulfide. U.S. Department of Health, Education and Welfare. DHEW (NIOSH) Publication No. 77-158 (1977).

Patty, F. A. Arsenic, Phosphorus, Selenium, Sulfur, and Tellurium. Industrial Hygiene and Toxicology, Second Revised Edition, Vol. 2, F. A. Patty, Ed., Interscience Publishers, New York, NY (1963).

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfiche Issue, R. J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville, MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 80-111-4 (1980).

Roach, S. A. A More Rational Basis for Air Sampling Programs. Am. Ind. Hyg. Assoc. J., 27, 1012 (1966).

Robinson, E., and R. C. Robbins. Sources, Abundance, and Fate of Gaseous Atmospheric Pollutants. SRI Project Report PR-6755, prepared for American Petroleum Institute, New York, NY, 123 p. (1968).

U.S. Environmental Protection Agency. National Secondary Drinking Water Regulations. Federal Register, Vol. 44, No. 140, p. 42200 (July 19, 1979).

INDENE

Executive Summary

CAS NUMBER 00095-13-6

Indene is a colorless liquid which oxidizes readily and forms polymers on exposure to air and sunlight. It is insoluble in water but miscible with most organic solvents. The chief use of indene is in the preparation of coumarone-indene resins. North Carolina requires the reporting of all indene spills if they occur near water.

Health Affects

ACUTE. Indene appears to be fairly well-tolerated when administered orally. A single dose of one gram did not cause systemic toxicity in rabbits. The acute toxicity dose to rats by inhalation was found to be 200 mg/cu m.

Indene is an irritant to the mucous membranes and lungs but not to the skin.

CARCINOGENICITY, MUTAGENICITY, TERATOGENICITY AND EMBRYOTOXICITY. No reports were found to indicate that indene has been tested for carcinogenicity, mutagenicity, teratogenicity, or embryotoxicity.

CHRONIC. Prolonged or repeated contact of liquid indene with the skin removes natural tissue fats and oils and may lead to dermatitis.

Continuous exposure for 105 days at 3 mg/cu m caused stimulation of blood cholinesterase and inhibition of catalase in rats. Liver, splenic, and renal injury occurred in rats exposed to the vapor of indene at concentrations of 800 to 900 ppm for six 7-hour periods.

Occupational Health

The American Conference of Governmental Industrial Hygienists has established a Threshold Limit Value for workroom air (time-weighted average concentration under which it is believed that all workers may be repeatedly exposed day after day without adverse effect) of 10 ppm (45 mg/cu m) and a Short Term Exposure Limit (the maximum concentration to which workers may be exposed for a period up to 15 minutes) of 15 ppm (70 mg/cu m).

Routes of Human Exposure

OCCUPATIONAL. Workers may be exposed to indene in the manufacture of paints, coatings and tile, and in coke processing.

AMBIENT. Indene is found in coal tars, lignite, crude petroleum, asphalt and naptha.

CONSUMER. No sources identified.

Environmental Significance

Half-life in air and water are unknown. There are no data available on bioaccumulation and aquatic toxicity.

North Carolina Production and Users

Production: None reported.

Users: No information available

Recommended Reviews

Documentation of the Threshold Limit Values, ACGIH, Fourth Edition, (1980).

FIRST AID AND EMERGENCY RESPONSE INFORMATION

INDENE

First Aid (NIOSH/OSHA Pocket Guide to Chemical Hazards)

Eyes:	Wash with large amounts of water.
Skin:	Wash contaminated skin promptly with water.
Inhalation:	Remove to fresh air.

No information on spills.

INDENE

Profile

CHEMICAL IDENTIFICATION

Alternative Names:

1H - Indene
Indonaphthene
Inden

Chemical Abstract Services (CAS) Registry Number: 0095-13-6

Registry of Toxic Effects of Chemical Substances (RTECS) Number: NK 8225000

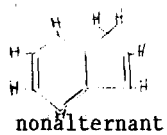
Hazardous Materials Table Identification Number: None

RCRA Identification Number: None

Molecular Weight: 116.17

Molecular Formula: C_9H_8

Structure:



Classification: Fused nonalternant two-ring hydrocarbon

Description: Colorless liquid

Uses: In preparation of coumarone-indene resins.

Chemical/Physical Data

Boiling point: 181.6°C
Melting point: -1.8°C
Vapor pressure: 1 mm Hg at 16.4°C; 5 mm at 44.3°C; 10 mm at 58.5°C; 20 mm at 73.9°C; 100 mm at 114.7°C.
Vapor density: Not available
Solubility in water: Insoluble (Merck, 1976)
Flash point (closed cup): 78.3°C
Specific gravity: 1.006

HUMAN TOXICITY

Human data related to the effects of indene are very sparse. The recommendations of the American Conference of Industrial Hygienists (ACGIH, 1980) for occupational exposure of indene are supported by animal studies and are established "to avoid the serious systemic response from overexposure to indene and by analogy with irritant action of naphthalene".

Liquid indene on prolonged or repeated contact with the skin removes natural tissue fats and oils which may lead to dermatitis (ACGIH, 1980).

No reports were found to indicate that indene has been tested for carcinogenicity, mutagenicity, teratogenicity or embryotoxicity.

ANIMAL TOXICITY

Indene appears to be fairly well-tolerated when administered orally. No evidence of systemic toxicity was found in rabbits ingesting one gram in a single dose. The threshold of acute toxicity to rats by inhalation was found to be 200 mg/cu m (ACGIH, 1980).

Acute Toxicity

Results of a single lethal study are reported in the RTECS (1980). The lowest lethal dose of the rat by subcutaneous administration was 1.0 gm/kg.

Although indene is an irritant to the mucous membranes and lungs, it is not a skin irritant. No local cutaneous or generalized systemic effects developed from painting the shaved skin of rats one to eight times with 0.1 ml of indene liquid. Guinea pigs were similarly unaffected by three applications of 0.5 ml of indene (ACGIH, 1980).

Chronic Toxicity

Continuous exposure for 105 days at 3 mg/cu m caused stimulation of blood cholinesterase and inhibition of catalase in rats. No toxicity was observed at 0.6 mg/cu m (ACGIH, 1980).

Liver damage was found and occasionally splenic and renal injury occurred in rats exposed to the vapor of indene at concentrations of 800 to 900 ppm for six 7-hour periods. Severe liver necrosis with hemorrhages occurred in some of the group. Histologic changes in the kidneys consisted of focal necrosis resembling small infarcts. No changes in blood constituents or in the adrenals, pancreas, pituitary, ovary and testis were found. No deaths resulted from these exposures (ACGIH, 1980).

AQUATIC AND TERRESTRIAL TOXICITY

There are no data available.

ENVIRONMENTAL DATA

Air
No information on the occurrence of indene in air was found, nor were quantitative data regarding oxidative half-life or residence time. Indene does oxidize readily in air and forms polymers on exposure to air and sunlight (ACGIH, 1980). Significant accumulation is not expected.

Water
No information available.

Soil
Insufficient data to assess persistence.

Biota
Rats continuously exposed to 0.6 mg/cu m showed no toxic effects, suggesting the occurrence of metabolism and excretion. Insufficient data are available to assess accumulation and magnification.

Name: Indene
CAS Number: 00095-13-6

Indene is found in coal tars, lignite, and crude petroleum (Merck, 1976). It is a constituent of asphalt and naphtha. It also occurs in coke processing (Verschueren, 1977).

INDUSTRIAL DATA

Production

No production in North Carolina is reported in the Toxic Substances Control Act (TSCA) Chemical Substances Inventory (U.S. EPA, TSCA, 1980).

Indene is produced during petroleum refining and coke processing (Verschueren, 1977).

Consumption and Use

Estimated U.S. consumption figures are not available.

The chief use is in the preparation of coumarone-indene resins (ACGIH, 1980). Reported uses of indene and the corresponding SIC codes are listed below:

Paint and coating manufacture	2851
Tile manufacture	3253
Preparation of coumarone-indene resins	2893
Chemical intermediate	2800
Asphalt and naphtha constituent	295

(Verschueren, (1977)

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air
No guidelines for air have been established.

Workroom Air

ACGIH — The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air is 10 ppm (45 mg/cu m) as a time-weighted average. The recommended Short Term Exposure Limit (STEL) is 15 ppm (70 mg/cu m).

Water
No guidelines for water have been established.

Agencies Concerned with this Chemical

Subject to a proposed rule under the Toxic Substances Control Act that would require all chemical manufacturers to report production and exposure-related data to the U.S. Environmental Protection Agency (Federal Register, Vol. 45, No. 42, 1980).

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Merck Index: An Encyclopedia of Chemicals and Drugs, Ninth Edition, M. Windholz, ed. Merck and Co., Rahway, NJ (1976).

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfishe Issue, R. J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco. Inc., Rockville, MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 80-111-4 (1980).

Shackelford, W. M., and L. H. Keith. Frequency of Organic Compounds Identified in Water. U.S. Environmental Protection Agency. EPA-600-4-76-062 (1976).

U. S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Services, Springfield VA PB-80-155-153 (1980).

Verschueren, Karel. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York, NY (1977).

ISOPHORONE

Executive Summary

CAS NUMBER 00078-59-1

Isophorone is a colorless liquid with an odor resembling peppermint. It is commercially prepared from acetone and is used primarily as a solvent for many oils, fats, gums and resins. Production for 1973 was estimated at 31.5 million pounds. North Carolina requires the reporting of all spills if they occur near water. Isophorone is soluble in water (12 gm/l).

Health Effects

ACUTE. Vapors of isophorone are quite irritating and have a strong odor. Short-term exposure to 25 ppm was irritating to the eyes, nose and throat in unconditioned human volunteers. Lethal doses include:

Oral Route	Rat	2.3 gm/kg LD50
Inhalation Route	Rat	1,840 ppm (10.3 g/cu m) for 4 hours Lowest lethal concentration
Dermal Route	Rabbit	1.5 gm/kg LD50

NIOSH has suggested 800 ppm as the maximal level from which a person could escape within 30 minutes without escape-impairing symptoms or irreversible health effects.

CARCINOGENICITY, MUTAGENICITY, TERATOGENICITY AND EMBRYOTOXICITY. No data were found related to studies on the carcinogenicity, mutagenicity, teratogenicity and embryotoxicity potential of isophorone.

CHRONIC. Guinea pigs and rats exposed at 500 ppm for 8 hours/day, 5 days/week for 6 weeks suffered severely injured kidneys and/or lungs, and death.

Occupational Health

The American Conference of Governmental Industrial Hygienists has established a Threshold Limit Value (time-weighted average concentration under which it is believed that all workers may be repeatedly exposed day after day without averse effect) of 5 ppm (25 mg/cu m) for workroom air. NIOSH recommends a standard of 4 ppm (23 mg/cu m) as a time-weighted average for a working lifetime.

Routes of Human Exposure

OCCUPATIONAL. NIOSH estimates that 1.5 million workers are exposed to isophorone. Isophorone is an intermediate in the manufacture of plasticisers, rubber chemicals and flotation agents, and workers in these operations are at high exposure risk.

AMBIENT. Isophorone has been detected in river water (0.01 ug/l) and in industrial effluents. No data on isophorone in air were found.

CONSUMER. The occurrence of isophorone in drinking water (1.5-9.5 ug/l) suggests that very large populations may be exposed to low levels. Isophorone has not been detected in soil or food.

Environmental Significance

The available data for isophorone indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 117 mg/l and to salt water aquatic life at concentrations as low as 12.9 mg/l.

A bioconcentration factor of 7 was reported for bluegill (4.38 for edible portions) based on 28-day exposure. This level of bioconcentration is not considered to be a significant environmental problem. The biological half-life is less than one day in bluegill.

North Carolina Production and Users

Production: None reported under TSCA.
Users: No information available.

Recommended Reviews

Ambient Water Quality Criteria for Isophorone, EPA 440/5-80-056, U.S. EPA, 1980.

Criteria for a Recommended Standard: Occupational Exposure to Ketones, DHEW Publication No. 78-173, National Institute for Occupational Safety and Health (1978).

FIRST AID AND EMERGENCY RESPONSE INFORMATION

ISOPHORONE

First Aid (NIOSH/OSHA Pocket Guide to Chemical Hazards)

Eyes:	Wash with large amounts of water immediately.
Skin:	Wash the contaminated skin promptly with soap or mild detergent and water.
Inhalation:	Move to fresh air immediately. Perform artificial respiration if necessary.
Ingestion:	If the victim is conscious, give large quantities of water. Induce vomiting by having victim touch the back of his throat with his finger. Get medical attention immediately.

Procedures for Spills and Leaks (U.S. DOT Emergency Response Guidebook, 1980)

Not listed

Fire and Explosion Information

FLASH POINT: 184°F

Reactivity

MATERIALS TO AVOID: Strong oxidizers

Protective Measures

PROTECTIVE EQUIPMENT: At levels up to 200 ppm, wear a supplied-air respirator or a self-contained breathing apparatus. At levels up to 800 ppm, wear a supplied-air respirator with a full facepiece, or a self-contained breathing apparatus with a full facepiece. For escape from a contaminated area, wear a gas mask with an organic vapor canister or a self-contained breathing apparatus.

ISOPHORONE

Profile

CHEMICAL IDENTIFICATION

Alternative Name:

2-Cyclohexan-1-one, 3,5,5-Trimethyl-
Isoacetophorone
Isoforon
Isophron
NCI-C55618
Trimethyl-2-cyclohexene-1-one
3,5,5

Chemical Abstract Services (CAS) Registry Number: 0078-59-1

Registry of Toxic Effects of Chemical Substances (RTECS) Number: GW 7700000

Hazardous Materials Table Identification Number: Not applicable

RCRA Identification Number: Not applicable

Molecular Weight: 138.21

Molecular Formula: $C_9H_{14}O$

Structure:

Classification: An unsaturated cyclic aliphatic ketone.

Description: Isophorone is a high-boiling, colorless liquid of low volatility with an odor resembling peppermint.

Uses: Commercial solvent

Chemical/Physical Data

Boiling point: 214°C
Melting point: -8.1°C
Vapor pressure: 0.2 mm Hg at 20°C; 1 mm at 38°C
Vapor density: 4.77
Solubility in water: 12 gm/l (Verschueren, 1977)
Specific gravity: 0.9229

HUMAN TOXICITY

Vapors of isophorone are quite irritating and have a strong odor. A moderately high degree of toxicity is associated with inhaled isophorone. Repeated inhalation produces kidney toxicity (NTP, 1979).

Complaints of fatigue and malaise were associated with isophorone levels of 5 to 8 ppm after a month's work. There were no complaints at levels of 1 to 4 ppm (ACGIH, 1980). Short-term exposure to 25 ppm was "definitely irritating to the eyes, nose, and throat" of unconditioned human volunteers (Rowe and Wolfe, 1963).

At least two early inhalation studies (conducted by Smyth et al. in 1940 and 1942) on isophorone have been judged invalid because of impure material used in the experiment. Care should be taken in interpreting statements on isophorone that are based on these studies (Rowe and Wolfe, 1963).

NIOSH has suggested 800 ppm as the maximum level from which one could escape within 30 minutes without escape-impairing symptoms or irreversible health effects (NIOSH/OSHA, 1978).

No data were found related to studies on the carcinogenic, mutagenic, teratogenic and embryotogenic potential of isophorone.

Isophorone is presently being tested for carcinogenesis in rats and mice. Administration is by gavage (direct introduction into the stomach) (NTP, 1980).

ANIMAL TOXICITY

Limited data are available on the toxicity of isophorone as determined through animal studies.

Acute Toxicity

Results of lethal studies in two species as reported in the RTECS (1980) are listed below:

Route	Species	Lethal Dose or Lethal Concentration
Oral	Rat	2.3 gm/kg, LD50
Inhalation	Rat	1,840 ppm (10.4 gm/cu m) for 4 hours, Lowest lethal dose
Dermal	Rabbit	1.5 gm/kg, LD50

Chronic Toxicity

Subacute 90-day feeding studies in rats and dogs have been conducted. Rats were fed isophorone at 750, 1,500, and 3,000 ppm in the daily diet. No significant differences were observed between the treated and control groups. Dogs fed up to 150 mg/kg/day for 90 days showed no adverse effects (U.S. EPA, WQC, 1980).

Subacute inhalation data compiled by the U.S. EPA (1980) are summarized in the table on the following page.

AQUATIC AND TERRESTRIAL TOXICITY

Aquatic Toxicity

The U.S. EPA Water Quality Criteria (1980) for protection of aquatic life are given below:

> The available data for isophorone indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 117 mg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of isophorone to sensitive freshwater aquatic life.

The available data for isophorone indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 12.9 mg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of isophorone to sensitive saltwater aquatic life.

Bioaccumulation: A concentration factor of 7 is reported for bluegill based on 28-day exposure. An average bioconcentration factor of 4.38 was calculated for the edible portions of fish and used in the formulation of the Water Quality Criterion for protection of human health. This level

ANIMAL TOXICITY

Limited data are available on the toxicity of isophorone as determined through animal studies.

Subacute Inhalation Toxicity of Isophorone[1]

Animal	Concentration[2] (ppm)	Hr/ Day	Duration (Days)	Mortality[3]	Details
Rats male, Winter 90-120 g	25	8	42 (30 exposures, 5 days/wk x 6 wks)	0%	No apparent signs of toxicity
	50	8	42 (30 exposures, 5 days/wk x 6 wks)	0%	Evidence of lung and kidney pathology
	100	8	42 (30 exposures, 5 days/wk x 6 wks)	20%	Evidence of lung, spleen and kidney pathology
	200	8	42 (30 exposures, 5 days/wk x 6 wks)	10%	Evidence of lung, spleen and kidney pathology; conjunctivitis and nasal irritation, urine albumin
Guinea pigs, both sexes,	25	8	42 (30 exposures, 5 days/wk x 6 wks)	0%	No apparent signs of toxicity
	100	8	42 (30 exposures, 5 days/wk x 6 wks)	0%	Evidence of lung and kidney pathology; weight loss
	200	8	42 (30 exposures, 5 days/wk x 6 wks)	25%	Evidence of lung and kidney pathology; weight loss
	500	8	42 (30 exposures, 5 days/wk x 6 wks)	40%	Evidence of lung, kidney and liver pathology; conjunctivitis and nasal irritation; weight loss; increase in polymorphonuclear while cells with a corresponding fall in lymphocytes

[1]Source: Smyth, 1941
[2]Rowe and Wolf (1963) have indicated that the isophorone used in this study was impure and that the reported concentrations are higher than actually present.
[3]percentage of animals dying; usually 10 animals were tested at each dosage.

(Table is reproduced from U.S. EPA, WQC, 1980).

Aquatic Toxicity

The U.S. EPA Water Quality Criteria (1980) for protection of aquatic life are given below:

The available data for isophorone indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 117 mg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of isophorone to sensitive aquatic life.

The available data for isophorone indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 12.9 mg/l. No data are available concerning the chronic toxicity of isophorone to sensitive saltwater aquatic life.

Bioaccumulation: A concentration factor of 7 is reported for bluegill based on 28-day exposure. An average bioconcentration factor of 4.38 was calculated for the edible portions of fish and used in the formulation of the Water Quality Criterion for protection of human health. This level of bioconcentration is not considered to be a significant environmental problem (U.S. EPA, WQC, 1980).

Phytotoxicity

Data on phytotoxicity from air pollution are not available.

Data describing effects on aquatic plants or algae were not found.

ENVIRONMENTAL DATA

Air

Isophorone has not been detected in ambient air (U.S. EPA, WQC, 1980). Degradation via photolysis and oxidation are probable fates. The potential for accumulation is uncertain.

Water

Isophorone has been detected in samples of municipal drinking water in the United States at 1.5-9.5 µg/l, in river water at 0.01 µg/l, and in industrial effluents including discharges from a latex plant, a chemical plant, and a tire plant (U.S. EPA, WQC, 1980). Isophorone is highly soluble, and may be somewhat persistent in water (Callahan, 1979). It may also degrade via photolysis. Dispersion in this medium is likely.

Soil

Very little data are available regarding the persistence of isophorone in ambient soils (Callaha, 1979). Isophorone probably remains in solution and is not appreciably sorbed onto sediments. It has not been detected in soil.

Biota

Isophorone is metabolized by fish and rodents. Accumulation is unlikely due to its high solubility and partition coefficient. Biomagnification is not expected.

Isophorone has not been detected in food (U.S. EPA. WQC, 1980).

Production

No production in North Carolina was reported in the Toxic Substance Control Act (TSCA) Chemical Substance Inventory (U.S. EPA, TSCA Inventory, 1980).

Production for 1973 was estimated at 31.5 million pounds (15,750 tons) per year based on consumption of raw materials (U.S. EPA, WQC, 1980).

Consumption and Use

Specific U.S consumption figures were not found.

Reported uses of isophorone and the corresponding SIC codes are listed below:

Solvent for vinyl resins	2821
Solvent for lacquers and finishers	2851
Intermediate in manufacture of dyes	2865
Intermediate in manufacture of plasticizers	2821
Intermediate in manufacture of rubber chemicals	2822
Intermediate in manufacture of flotation agents	

(NTP, 1979)

Intermediate for alcohols	2869
Raw materials for 3,5-dimethylaniline	2869
Solvent for nitrocellulose resins	2823
Pesticides	2879

(Verschueren, 1977)

Synthesis of plant growth inhibitors	2879

(U.S. EPA, WQC, 1980)

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air

No guidelines for air have been established.

Workroom Air

ACGIH — The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air is 5 ppm (25 mg/cu m) as a ceiling.

NIOSH — The National Institute of Occupational Safety and Health (NIOSH) recommends a standard of 4 ppm (23 mg/cu m) as a time-weighted average.

OSHA — The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 25 ppm (140 mg/cu m) as a time-weighted average.

Water

Addressed by Ambient Water Quality Criteria set by the U.S. Environmental Protection Agency.

Designated a toxic pollutant by the U.S. Environmental Protection Agency.

Agencies Concerned with this Chemical

Appears on the Priority List of the Interagency Testing Committee (ITC).

Subject to a proposed rule under the Toxic Substances Control Act that would require all chemical manufacturers to report production and exposure-related data to the U.S. Environmental Protection Agency (Federal Register, Vol. 45, No. 42, 1980).

Under toxicological evaluation through the National Toxicology Program to determine carcinogenicity. (National Toxicology Program, Fiscal Year 1980 Annual Plan, NTP-79-7, 1979).

Addressed by a National Toxicology Program (NTP) Executive Summary and included in the list of 100 compounds nominated for NTP testing.

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Callahan, M. A., et al. Water-Related Rate of 129 Priority Pollutants. U.S. EPA Office of Water Planning and Standards, Washington, DC, EPA 440/4-70-029 (December 1979).

National Institute for Occupational Safety and Health (NIOSH). Criteria for a Recommended Standard...Occupational Exposure to Ketones. U.S. Department of Health, Education, and Welfare. DHEW (NIOSH) Publication No. 78-173 (1978).

National Institute for Occupational Safety and Health/Occupational Safety and Health Administration (NIOSH/OSHA). NIOSH/OSHA Pocket Guide to Chemical Hazards. DHEW (NIOSH) Publication No. 78-210 (September 1978).

National Toxicology Program. Fiscal Year 1981 Annual Plan. Department of Health and Human Services. NTP-80-62 (December 1980).

National Toxicology Program. N.T.P. Executive Summaries. Prepared by the National Center for Toxicological Research, Office of Scientific Intelligence, Jefferson, Arkansas (March 1979).

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfiche Issue, R. J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville, MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 80-111-4 (1980).

Rowe, V. K., and M. A. Wolf. Ketones. Industrial Hygiene and Toxicology, Second Edition, Vol. 2, F. A. Patty, Ed., Interscience Publishers, New York, NY (1963).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA PB-80-155-153 (1980).

U.S. Environmental Protection Agency, Office of Water Planning and Standards. Ambient Water Quality Criteria for Isophorone. EPA 440/5-80-056. Available through the National Technical Information Service (NTIS), PB 81-117673.

Verschueren, Karel. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York, NY (1977).

MALEIC ANHYDRIDE

Executive Summary

CAS NUMBER 00108-31-6

Maleic anhydride is a white crystalline solid with an acrid odor. It is manufactured primarily from benzene. U.S. production for 1975 was estimated at 211 million pounds and was expected to increase by approximately 10 percent each year between 1975-80. Sixty-seven percent of the estimated U.S. consumption is as a chemical intermediate in the production of polyester resins and agricultural pesticides such as captan, malathion and maleic hydrazide. North Carolina requires the reporting of all spills if they occur near water.

Health Effects

ACUTE. Maleic anhydride dust or vapor is an acute skin, eye and respiratory tract irritant. A concentration of 2.5 ppm in air is extremely irritating. Inhalation can cause pulmonary edema and inflammatory changes that may be irreversible in kidneys and other organs. Direct contact with the skin may cause burns.

The lethal oral dose in rats is 481 mg/kg; no human deaths from maleic anhydride have been reported in the literature.

CARCINOGENICITY. No positive evidence has been reported. Maleic anhydride has been scheduled for testing through the National Toxicology Program.

MUTAGENICITY. Maleic anhydride gave negative results in the Salmonella typhimurium test.

TERATOGENICITY AND EMBRYOTOXICITY. There is no evidence that maleic anhydride causes birth defects or is embryotoxic.

CHRONIC. Chronic exposure in humans has caused asthma, chronic bronchitis and dermatitis. Direct eye contact with maleic anhydride powder has been shown to cause vision impairment in rabbits 7 weeks after exposure.

Occupational Health

The American Conference of Governmental Industrial Hygienists has established a Threshold Limit Value (time-averaged concentration under which it is believed that all workers may be repeatedly exposed day after day without adverse effect) of 0.25 ppm (1 mg/cu m). The Short Term Exposure Limit (maximum concentration to which workers may be exposed for a period up to 15 minutes) of 0.5 ppm (2 mg/cu m).

Routes of Human Exposure

OCCUPATIONAL. Workers in the unsaturated polyester resin industries
are at greatest risk of exposure to maleic anhydride.

AMBIENT. Maximum atmospheric concentrations due to industrial sources have been estimated (based on diffusion models) at 0.10 ppm as a 24-hour average. Maleic anhydride has not been detected in water.

CONSUMER. No reported sources.

Environmental Significance

The TLm for 24-hour exposure for bluegill sunfish is 150 ppm based on studies using tap water. No data are available on bioaccumulation, effects on vegetation or aquatic plants.

Emissions to air may also contain some benzene from which maleic anhydride is produced. No data are available on the potential impact of combinations of benzene and maleic anhydride.

North Carolina Production and Users

Production: No known producers
Users: No information available.

Recommended Reviews

Chemical Hazard Information Profile - Maleic Anhydride, U.S. Environmental Protection Agency, EPA 560/11-80-011 (April, 1980).

FIRST AID AND EMERGENCY RESPONSE INFORMATION

MALEIC ANHYDRIDE

First Aid (NIOSH/OSHA Pocket Guide to Chemical Hazards)

Eyes: Wash with large amounts of water immediately. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH MALEIC ANHYDRIDE.

Skin: Wash the skin immediately with soap or mild detergent and water. Remove clothing if contaminated and wash skin.

Inhalation: Move to fresh air at once. Perform artificial respiration if necessary.

Ingestion: Give large amounts of water and induce vomiting by finer. Seek medical attention.

Procedures for Spills and Leaks (DOT Emergency Response Guidebook, 1980)

Isolate hazard area and deny entry. Stay upwind and keep out of low areas. Wear self-contained breathing apparatus and full protective clothing. Do not touch spilled material. Stop leak if it can be done without risk.

SMALL SPILLS: Take up with sand, or other noncombustible absorbent material, then flush area with water.

SMALL DRY SPILLS: Shovel into dry containers and cover, move containers, then flush area with water.

LARGE SPILLS: Dike far ahead of spill for later disposal.

Fire and Explosion Information

May burn, but does not ignite readily. May ignite combustibles, (wood, paper, oil, etc.)

FLASH POINT: 215°F

SMALL FIRES: Dry chemical, CO_2, water spray or foam.

LARGE FIRES: Water spray, fog or foam.

Move containers from fire area if it can be done without risk. Cool containers that are exposed to flames with water from the side until well after fire is out.

Reactivity

MATERIALS TO AVOID: Strong oxidizers, alkali metals, caustics.

CONDITIONS TO AVOID: Amines at 150°F.

Protective Measures

ENGINEERING CONTROLS: Use with adequate ventilation. Shower, sinks and eyewash stations should be available.

PROTECTIVE EQUIPMENT (Should not be substituted for proper handling and engineering controls: Wear rubber-coated overalls, gloves and chemical goggles.

PROTECTIVE EQUIPMENT: At levels up to 12.5 ppm wear a chemical cartridge respirator with an organic vapor cartridge, a full facepiece and a dust and mist filter; or a self-contained breathing apparatus with a full facepiece. At levels from 12.5 to 250 ppm, wear a powered air-purifying respirator with a high-efficiency filter, an organic vapor canister and a full facepiece. At levels above 500 ppm, wear a supplied-air respirator with a full facepiece, helmet, or hood. For escape, wear a gas mask with and organic vapor canister with a facepiece and a particulate filter.

MALEIC ANHYDRIDE

Profile

CHEMICAL IDENTIFICATION

Alternative Names:

cis-Butenedioic Anhydride
2,5-Furandione
Maleic Acid Anhydride
Toxilic Anhydride

Chemical Abstract Services (CAS) Registry Number: 00108-31-6

Registry of Toxic Effects of Chemical Substances (RTECS) Number: ON 3675000

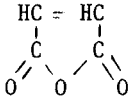
Hazardous Materials Table Identification Number: UN 2215

RCRA Identification Number: U 147

Molecular Weight: 98.06

Molecular Formula: $C_4H_2O_3$

Structure:



Classification: The anhydride of an unsaturated dicarboxylic acid, maleic acid

Description: White crystalline solid with an acrid odor.

Uses: Chemical intermediate

Chemical/Physical Data

Boiling point: 202°C
Melting point: 52.8°C
Vapor pressure: 0.1 mm Hg at 25°C; 1.0 mm at 44°C; 1.9 mm at 50°C
Vapor density: 3.4 (air = 1.0)
Solubility in water: Soluble in water (16 gm/100 gm) and most organic solvents
Specific gravity: 0.934
Flash temperature: 102°C (215°F)

HUMAN TOXICITY

Maleic anhydride dust or vapor is an acute skin, eye, and respiratory tract irritant. Inhalation can cause pulmonary edema and inflammatory changes that may be irreversible in kidneys and other organs. Direct contact with the skin may cause burns. It is also a respiratory tract sensitizer.

Chronic exposure in humans also caused asthma, chronic bronchitis, and dermatitis (U.S. EPA, CHIP, 1980; U.S. EPA, CAG, 1979).

Maleic anhydride is recognized to be somewhat more potent as an irritant than phthalic anhydride (ACGIH, 1980). No deaths from maleic anhydride are reported in the literature (Patterson, 1976).

Effects associated with various exposure levels are listed below (ACGIH, 1980):

Exposure Level in Air	Effect Reported
0.22 ppm (0.9 mg/cu m)	No effect
0.25 ppm (1 mg/cu m)	Eye irritation
0.5 ppm (2 mg/cu m)	Faint odor
1.5 to 2 ppm (6 to 8 mg/cu m), for 1 minute	Nasal irritation
1.5 to 2 ppm, for 15 minutes	Eye irritation
2.5 ppm (10 mg/cu m)	Extremely irritating

Because maleic anhydride is produced primarily in the U.S. through oxidation of benzene, its occurrence in air will be accompanied by the presence of benzene. Data on the potential impacts of benzene and maleic anhydride in combination are not available (U.S. EPA, CHIP, 1980).

Carcinogenicity

U.S. EPA, CAG, 1979 — The data base for evaluating the carcinogenicity of maleic anhydride is almost nonexistent. One inadequate study treated three rats for 61 weeks with maleic anhydride. In one treated rat, two fibrosarcomas occurred at the site of injection. No tumors were observed in four untreated rats.

CIIT, 1980 — Maleic anhydride is being added to the diets of Fischer-344 rats at daily doses of 100, 32 and 10 mg/kg in a 24-month toxicity and carcinogenicity study. An interim sacrifice following 18 months of dietary exposure was completed in July 1979. No toxic effects related to maleic anhydride ingestion have been noted. (Results from 24 months' exposure are to be published Spring, 1981).

Mutagenicity

NTP, 1980 — Mutagenesis Salmonella typhimurium test result: Negative.

Teratogenicity and Embryotoxicity

No evidence was found to indicate that maleic anhydride causes birth defects.

ANIMAL TOXICITY

As in man, maleic anhydride dust and vapor act as an acute irritant on the eyes, skin, and upper respiratory tract of animals. Animals may also become sensitized to the chemical so that effects occur at lower than expected levels.

Name: Maleic Anhydride
CAS Number: 00108-31-6

Results of lethal studies in several species as reported in the RTECS, 1980, are listed below:

Route	Species	Lethal Dose or Concentration		
Oral	Rat	481	mg/kg,	LD50
	Mouse	465	mg/kg,	LD50
Dermal	Rabbit	2.6	gm/kg,	LD50

In rabbits, direct eye contact with a 5 percent solution produced membrane irritation and cloudiness of the cornea which persisted for a day. Direct eye contact (rabbits) with maleic anhydride powder resulted in corneal effects with obvious vision impairment after 7 weeks (Patterson, 1976).

Oral administration of 85 mg/kg for 20 days caused no cumulative toxic effects in white rats (Patterson, 1976).

In a chronic study, no adverse effects were observed in Fischer 344 rats when administered maleic anhydride by dietary administration over a period of 12 months (CIIT Docket # 43059; April, 1979).

Aquatic Toxicity

The TLm (24 to 96 hours) for mosquito fish is reported to be 240 to 230 ppm. The 24-hour TLm for bluegill sunfish is 150 ppm based on studies using tap water (Verschueren, 1977).

Bioaccumulation: No data are available concerning bioaccumulation of maleic anhydride in aquatic organisms.

Phytotoxicity

No data are available on the effects on vegetation from maleic anhydride in air.

Data on effects on aquatic plants and algae were not found.

ENVIRONMENTAL DATA

Air

Atmosphere emissions of maleic anhydride result mostly from the manufacturing of phthalic anhydride and maleic anhydride (Patterson, 1976). Maximum atmospheric concentrations due to industrial sources have been estimated at 0.10 ppm (440 µg/cu m) as a 24-hour average and 0.20 ppm (800 µg/cu m) for a one-hour average. Estimates are based on single, worst-case diffusion models (Patterson, 1976).

Maleic anhydride has an estimated atmospheric residence time of 0.1 days or 2.4 hours (Cupitt, 1980). It reacts rapidly with OH radicals and ozone, and although some accumulation occurs near industrial sources, general elevated concentrations are unlikely (Patterson, 1976).

Water

No occurrence of maleic anhydride in water was found. This substance hydrolyzes slowly in water to form maleic acid, and accumulation in this medium is not expected.

Soil

Maleic anhydride is reactive in soil, undergoing degradation by hydrolysis, oxidation or biodegradation. No accumulation is expected.

Biota

Maleic anhydride is readily degraded in this medium (including sludge), and no accumulation or biomagnification is expected.

This substance is not reported to occur naturally. Wide dispersion of maleic anhydride is not expected due to its reactivity. Environmental releases and subsequent dispersion which do occur are primarily in air.

INDUSTRIAL DATA

Production

No production in North Carolina is reported in the Toxic Substances Control Act (TSCA) Chemical Substances Inventory (U.S. EPA, TSCA, 1980).

U.S. production for 1975 was estimated at 211 million pounds (105,000 tons). Production was expected to increase by approximately 10 percent each year between 1975-1980 (U.S. EPA, CHIP, 1980).

Consumption and Use

Estimated U.S. consumption for 1975:

Polyester resins	58 percent
Production of fumaric acid	4 percent
Production of agricultural chemicals (including malathion, maleic hydrazide, and captan)	9 percent
Production of alkyd resins	3 percent
Miscellaneous applications	26 percent

(U.S. EPA, CHIP, 1980)

Reported uses of maleic anhydride and the corresponding SIC codes are listed below:

All uses involve application as a chemical intermediate.

Polyester resins	2821
Production of fumaric acid and malic acid	2869
Production of agricultural chemicals including malathion, maleic hydrazide, and captan	2879
Production of alkyd resins	2821
Lubricating additives	2911
Chlorendic anhydride and acids	2869
Copolymers	28
Reactive plasticizers	2821
Surface-active agents	2843

(U.S. EPA, CHIP, 1980)

Diene synthesis	2869
Copolymerization reactions	28
Manufacture of dye intermediates	2865
Manufacture of pharmaceuticals	283

(Merck, 1976)

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air

Under evaluation for possible designation as a Hazardous Air Pollutant by the U.S. Environmental Protection Agency.

Workroom Air

ACGIH — The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists for workroom air is 0.25 ppm (1 mg/cu m) as a time-weighted average.

OSHA — The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 0.25 ppm (1 mg/cu m) for an 8-hour time-weighted average.

Water

Designated a hazardous substance by the U.S. Environmental Protection Agency. The hazardous substance designation and the proposed reporting regulations are to limit the discharge of toxic and hazardous substances to the nation's water. Spills in excess of 5,000 pounds must be reported (Code of Federal Regulations, Title 40, Part 116).

Other

Regulated as a hazardous material by the U.S. Department of Transportation.

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Agencies Concerned with this Chemical

Chemical Hazard Information Profile (CHIP) compiled by the Office of Testing and Evaluation, U.S. Environmental Protection Agency.

Appears on the 1976 Priority List of the Chemical Industry Institute of Toxicology (CIIT).

Subject of a Preliminary Risk Assessment Document prepared by the Carcinogen Assessment Group (CAG) of the U.S. Environmental Protection Agency. No finding was made because of inadequate data.

Scheduled for testing through the National Toxicology Program in Fiscal Year 1980 using Salmonella mutagenicity assay. (National Toxicology Program. Annual Plan for Fiscal Year 1980. NTP-79-7, November, 1979).

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Chemical Institute of Toxicology (CIIT). 1979 Annual Report and Scientific Review: Science in the Public Interest. Research Triangle Park, NC (1980). (To be updated soon for 24 months.)

Cupitt, L. T. Fate of Toxic and Hazardous Materials in the Air Environment. EPA-600/3-80-084, NTIS PB 80-221948 (September 1980).

Merck Index: An Encyclopedia of Chemicals and Drugs, Ninth Edition, M. Windholz, Ed. Merck and Co., Rahway, NJ (1976).

National Toxicology Program (NTP). Annual Plan for Fiscal Year 1980. U.S. Department of Health, Education and Welfare, NTP-79-7 (November 1979).

National Toxicology Program. Review of Current DHEW Research Related to Toxicology, Fiscal Year 1980. Department of Health, Education, and Welfare, Public Health Service (1980).

Patterson R. M., M. R. Bernstein, and E. Garshick. Assessment of Maleic Anhydride as a Potential Air Problem, Vol XI. Prepared by the GCA Corporation for the U.S. Environmental Protection Agency. Available through the National Technical Information Service, PB-258363 (January 1976).

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfiche Issue, R. J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville, MD for National Institute for Occupational Safety and Health.. DHHS (NIOSH) Publication No. 80-111-4 (1980).

U.S. Environmental Protection Agency, Carcinogen Assessment Group (CAG). Carcinogen Assessment Group's Preliminary Risk Assessment on Maleic Anhydride. Washington, DC (February 16, 1979).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Chemical Hazard Information Profiles (CHIPs). EPA-560/11-80-011 (1980).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA PB-80-155-153 (1980).

Verschueren, Karel. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York, NY (1977).

The North Carolina Toxic Substances Management Guide

METHANOL

Executive Summary

CAS NUMBER 00067-56-1

Methanol (methyl alcohol) is a colorless, flammable, mobile liquid with a characteristic sharp, sweet/sour odor. Originally obtained by the destructive distillation of wood, it is now usually manufactured from hydrogen and carbon monoxide or carbon dioxide, or by oxidation of hydrocarbons. Annual U.S. production for 1975 was estimated at 2,600,000 tons. North Carolina requires the reporting of all spills if they occur near water.

Health Effects

ACUTE. Methanol toxicity is characterized by visual disturbances and metabolic acidosis. Other commonly reported symptoms include dizziness, nausea and vomiting, and headaches. Severe toxicity may develop after inhalation, ingestion or percutaneous exposure. Numerous cases of blindness and death have been reported.

A wide range of variability in toxicity exists among individuals exposed to methanol. General correlations between exposure and effect are therefore difficult to make. Concentrations ranging from 1,200 - 8,300 ppm can lead to impaired vision. Toxicity can be mediated by ethanol which slows the metabolism of methanol to formic acid.

Direct skin contact with methanol has been said to cause dermatitis. Direct contact of methanol with the eyes resulted in chemosis and superficial lesions of the cornea which were rarely of a serious nature.

CARCINOGENICITY. There is no evidence that methanol is carcinogenic in man or animals.

MUTAGENICITY. Methanol is not mutagenic is the Ames' Salmonella typhimurium assay.

TERATOGENICITY AND EMBRYOTOXICITY. There is no evidence to indicate that methanol causes birth defects or is embryotoxic.

CHRONIC. Methanol is slowly eliminated from the body. Often, increased concentrations are found in the blood and tissue after repeated exposures.

Alterations in light sensitivity and variations in EEG patterns have been detected after exposure to low concentrations (0.77 ppm) of methanol. However, chronic occupational exposure to 25 ppm apparently has no harmful effect.

Occupational Health

The American Conference of Governmental Industrial Hygienists has established a Threshold Limit Value for workroom air (time-weighted average concentration under which it is believed tht all workers may be repeatedly exposed day after day without adverse effect) of 200 ppm (262 mg/cu m). The recommended Short Term Exposure Limit (the maximum concentration to which workers may be exposed for a period up to 15 minutes) is 250 ppm (328 mg/cu m). The importance of skin exposure is noted.

Routes of Human Exposure

OCCUPATIONAL. Methanol is used in the production of formaldehyde and other chemicals and also as an industrial solvent. Use as a solvent accounts for approximately 90 percent of methanol losses to the environment. Seventy-two occupations that offer exposure to methanol have been reported by the U.S. Department of Labor. A urinary methanol concentration of 10 ug/l measured at the end of the work shift is suggested by one research team as the level above which significant occupational exposure should be expected.

AMBIENT. Methanol has detected in the municipal drinking water of nine cities, including Durham, North Carolina. It has also been detected in effluents from sewage treatment plants, and latex, paper, and chemical industries, including one chemical company on the upper Catawba River, North Carolina.

An urban air concentration of 13.0 ug/cu m is reported as a "typical value" in samples taken in Pasadena, California.

CONSUMER. Most of the serious cases of methanol poisoning reported during the last 40 years (many of them fatal, while others involved permanent or temporary loss of vision) resulted from the ingestion of methyl alcohol in the belief that it was ethyl alcohol. Death from ingestion of less than 30 ml has been reported.

Environmental Significance

No quantitative data are available on half-life in air or water, nor on bioaccumulation in aquatic organisms. Methanol is reactive with oxidizing material in the atmosphere and is removed by rain. It is highly miscible with water. Sludge digestion is inhibited at 800 mg/l. The aquatic toxicity TLm 96 is more than 1,000 ppm.

Concentrations above 0.15 ppm (0.2 mg/cu m) produced a decrease in photosynthesis in several different tree species.

Data on aquatic plants or algae have not been reported.

North Carolina Production and Users

Production in North Carolina was reported by five companies in the Toxic Substances Control Act (TSCA) Chemical Substance Inventory:

Carodel Corporation, Fayetteville: 50-500 tons/year
E.I. DuPont, Brevard: 500-25,000 tons/year
Hercofina-NC, Wilmington: No report of production figures
New Bern Polyester, New Bern: 500-5,000 tons/year
Wright Chemical, Riegelwood: 500-5,000 tons/year

Users: No information available

Recommended Reviews

Chemical Hazard Information Profiles (CHIPs), TSCA Chemical Assessment Series, U.S. EPA-500/11-80-011, pages 187-198 (April, 1980).

1979 Annual Report and Scientific Review, Chemical Industry Institute of Toxicology (CIIT), Research Triangle Park, N.C.

Prepared June 1982

FIRST AID AND EMERGENCY RESPONSE INFORMATION

METHANOL

First Aid (NIOSH/OSHA Pocket Guide to Chemical Hazards)

Eyes:	Wash with large amounts of water immediately. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH METHANOL.
Skin:	Wash the contaminated skin with water. Remove clothing immediately if contaminated and wash skin. If irritation persists after washing, get medical attention.
Inhalation:	Move to fresh air at once. Perform artificial respiration if necessary. Seek immediate medical attention.
Ingestion:	Induce vomiting by finger or by giving syrup of ipecac. Seek medical attention immediately.
Note to Physician:	Gastric lavage with 3-5% sodium bicarbonate. Prompt hemodialysis if blood methanol level is above 50 mg/dl or if there is evidence of acidosis.

Procedures for Spills and Leaks (U.S. DOT Emergency Response Guidebook, 1980)

Isolate hazard area and deny entry. Stay upwind and keep out of low areas. Wear positive pressure breathing apparatus and special protective clothing. No flares, smoking or flames in hazard area. Do not touch spilled material. Stop leak if it can be done without risk. Use water spray to reduce vapors. Isolate for ½ mile in all directions if tank or tankcar is involved in fire.

SMALL SPILLS:	Take up with sand, or other noncombustible absorbent material, then flush area with water.
LARGE SPILLS:	Dike far ahead of spill for later disposal.

Fire and Explosion Information

GENERAL:	Burns with a very pale blue flame that is not usually visible in normal light. Fumes may form explosive mixtures in air. Ignites at 12°C (54°F).
EXPLOSIVE LIMITS:	Upper - 36.5%, Lower - 6.0%
EXTINGUISHER:	Dry chemical or foam; water may not be effective but can be used to cool containers during a fire.

Reactivity

CONDITIONS TO AVOID: Heat, flame

MATERIALS TO AVOID: Strong oxidizers such as chromates, permanganates, hypochlorites and peroxides. Reacts violently with chloroform in strongly caustic solutions (example: with lye or potassium hydroxide). Also reacts strongly with magnesium, bromine and nitric acid.

Protective Measures

HANDLING AND STORAGE: Store in a cool place away from sources of flame and ignition.

ENGINEERING CONTROLS: Provide adequate ventilation; eye wash stations, sinks and showers should be available.

PROTECTIVE CLOTHING (Should not be substituted for proper engineering and handling controls): Wear splash proof goggles, rubber gloves, apron and boots if contact is likely.

PROTECTIVE EQUIPMENT: For levels up to 2,000 ppm use a supplied-air or self-contained breathing apparatus; for levels up to 10,000 ppm use the above with a full facepiece, helmet or hood; for levels up to 25,000 ppm use a supplied-air Type C respirator with full facepiece used in a positive pressure or continuous flow mode.

METHANOL

Profile

Chemical Identification

Alternative Names:

Carbinol	Monohydroxymethane
Colonial Spirit	Pyroxylic Spirit
Columbian Spirits	Wood Alcohol
Methyl Alcohol	Wood Naphtha
Methyl Hydroxide	Wood Spirit

Chemical Abstract Services (CAS) Registry Number: 00067-56-1

Registry of Toxic Effects of Chemical Substances (RTECS) Number: PC 1400000

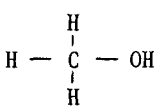
Hazardous Materials Table Identification Number: UN 1230

RCRA Identification Number: U 154

Molecular Weight: 32.05

Molecular Formula: CH_4O

Structure:



Classification: The simplest of the aliphatic alcohols.

Description: A colorless, flammable liquid with a characteristic sour, sharp, sweet odor.

Uses: Industrial solvent, fuel and in manufacturing of formaldehyde.

Chemical/Physical Data

Boiling point: 64.7°C
Melting point: -97.8°C
Vapor pressure: 100 mm Hg at 21.2°C
Vapor density: 1.11 (Air = 1.0)
Solubility in water: Miscible with water, alcohols, ketones and esters
Specific gravity: 0.8100
Flash point: 12°C closed cup (54°F)
Ignition temperature: 470°C
Explosive limits: 7.3 to 36 percent by volume in air

HUMAN TOXICITY

Methanol is slowly eliminated from the body. Increased concentrations occur in blood and tissue after repeated exposures (ACGIH, 1980).

NIOSH has reviewed the toxic effects of methanol in humans. The information below is taken from the NIOSH Criteria Document (1976).

Methanol toxicity is characterized by visual disturbances and metabolic acidosis. Other commonly reported symptoms include dizziness, nausea and vomiting, and headaches. Severe toxicity may develop after inhalation, ingestion or percutaneous exposure. Numerous cases of blindness and death have been reported.

A wide range of variability in toxicity exists between individuals exposed to methanol. General correlations between exposure and effect are therefore difficult to make. Alterations in light sensitivity and variations in EEG patterns have been detected after exposure to low concentrations (0.77 ppm) of methanol. However, chronic occupational exposure to 25 ppm apparently has no harmful effect. Concentrations ranging from 1,200-8,300 ppm can lead to impaired vision. Toxicity can be mediated by ethanol which slows the metabolism of methanol to formic acid.

Direct skin contact with methyl alcohol has been said to cause dermatitis. Direct contact of methyl alcohol with the eyes resulted in chemosis and superficial lesions of the cornea which were rarely of a serious nature (NIOSH, 1976).

Urinary methanol concentrations reflect levels in blood for exposed subjects. A urinary methanol concentration of 10 µg/l measured at the end of the work shift is suggested by one research team as the level above which significant occupational exposure should be suspected (Ferry et al., 1980).

The maximum level at which one could escape within 30 minutes without any escape-impairing symptoms or irreversible effects is suggested to be 2,500 ppm (NIOSH, 1978).

Death from ingestion of less than 30 ml has been reported (TDB, 1981).

Carcinogenicity

No evidence was found to indicate that methanol is carcinogenic in man or animals.

Mutagenicity

Simon, 1977 — Methanol was not mutagenic in the Ames' *Salmonella typhimurium* assay. For the test, the bacteria were exposed to methanol vapor in a desiccator.

NIOSH, 1976 — Injection of 0.3 percent methanol in grasshoppers produced an incidence of 3.5 percent chromosomal aberration in testicular tissue. This result is considered to be of questionable relevance to human mutagenicity.

Name: Methanol
CAS Number: 00067-56-1

Teratogenicity and Embryotoxicity

No evidence was found to indicate that methanol causes birth defects or is embryotoxic.

ANIMAL TOXICITY

Acute Toxicity

Results of lethal studies in several animal species as reported in the RTECS, 1980 are listed below:

Route	Species	Lethal Dose
Oral	Rat	13 gm/kg, LD50
	Mouse	0.4 gm/kg, lowest lethal dose
	Rabbit	7.5 gm/kg, lowest lethal dose
	Dog	7.5 gm/kg, lowest lethal dose
	Monkey	7.0 gm/kg, lowest lethal dose
Dermal	Monkey	0.5 gm/kg, lowest lethal dose
Ocular	Rabbit eye	40 mg, moderately toxic
Inhalation	Rat	64,000 ppm/4 hours, lowest lethal concentration

Acute and Chronic Inhalation Data

Results of inhalation studies in animals have been summarized by Treon in a review of methyl alcohol published in Industrial Hygiene and Toxicology, F.A. Patty, Ed. (Treon, 1963). Tabulated effects reproduced from the Treon review are given in the table on the following page.

AQUATIC AND TERRESTRIAL TOXICITY

Aquatic Toxicity

Aquatic toxicity rating: TLm 96 is more than 1,000 (RTECS, 1980).

Verschueren reports a 48-hour TLm for trout as 8,000 ppm and a 24-hour no-effect level for creek chub at 8,000 ppm. Daphnia suffered no effects after 48-hour exposure to 10,000 ppm. The 24-hour TLm for brine shrimp is 10,000 ppm (Verschueren, 1977).

No reports were found on bioaccumulation or biodegradation in aquatic species.

Phytotoxicity

Concentrations above 0.15 ppm (0.2 mg/cu m) produced a decrease in photosynthesis in several different tree species according to the report (U.S. EPA, CHIP, 1980).

No data on aquatic plants or algae were found.

Table 1. Physiological Effects upon Animals of the Inhalation of Methyl Alcohol Concentration

Animal	ppm	mg/liter	Duration of exposure, hr	Signs of intoxication	Outcome
Cat	132,000	173.0	5-5.5	Narcosis	Died
	65,000	86.0	4.5	Onside	50% died
	33,600	44.0	6	Incoordination	50% died
	18,300	24.0	6	None, but salivation	Survived
Mouse	72,600	95.0	54	Narcosis	Died
	72,600	95.0	28	Narcosis	Died
	54,000	70.7	54	Narcosis	Died
	48,000	62.8	24	Narcosis	Survived
	10,000	13.1	230	Ataxia	Survived
	152,800	200.0	94 min.	Narcosis	
	101,600	133.0	91 min.	Narcosis	
	91,700	120.0	95 min.	Narcosis	Over-all
	76,400	100.0	89 min.	Narcosis	mortality
	61,100	80.0	134 min.	Narcosis	45%
	45,800	60.0	153 min.	Narcosis	
	30,600	40.0	190 min.	Narcosis	
	173,000	227.0			Died
	139,000	182.0		Highest concentration endurable	
Rat	60,000	78.5	2.5	Narcosis, convulsions	
	31,600	41.4	18-20		Died
	22,500	29.5	8	Narcosis	
	13,000	17.0	24	Prostration	
	8,800	11.5	8	Lethargy	
	4,800	6.3	8	None	
	3,000	4.0	8	None	
	50,000	65.4	1	Drowsiness	Survived
Dog	37,000	48.4	8	Prostration, incoordination	
	13,700	17.9	4	None	
	2,000	2.6	24	None	
	10,000	13.1	3 min. 8 times each day at hourly intervals for 100 days	None	Survived
Dogs & pups	450-500	0.59-0.65	8 hr/day, 7 days/week for 379 days	None	Survived

Physiological Effects (Continued)

Monkey,	40,000	52.4	4	Illness	Death
rabbit,	40,000	52.4	1 daily		Delayed death
rat	10,000	13.1	18 daily		Death
	10,000	13.1	7 daily for several weeks		Delayed death
	1,000	1.3	41		Death

Table reproduced from Treon, 1963.

ENVIRONMENTAL DATA

Air
An urban concentration of 1.30 µg/cu m is reported as a "typical value" in samples taken in Pasedena, California (Hanst, 1974). No quantitative data are available regarding estimated atmospheric residence time. Methanol is removed by rainfall and is reactive with oxidizing materials in the atmosphere (U.S. EPA, CHIP, 1980). This substance is not photoreactive, and can accumulate to high levels in this medium. A vapor pressure of 1.11 (Air = 1.0) indicates some potential for dispersion in the atmosphere.

Water
Methanol has been detected in the municipal drinking water of nine cities including Durham, North Carolina. It has also been detected in effluents from sewage treatment plants, and latex, paper and chemical industries, including one chemical company on the Upper Catawba River, North Carolina (Shackelford, 1977). Estimated half-life and hydrolysis rate data are not available for this substance. Water is likely to be methanol's primary medium of dispersion because of its miscibility. Evaporation from water can be expected to limit the amount of accumulation in this medium (U.S. EPA, CHIP, 1980). Degradation occurs through reaction with oxidative materials.

Soil
Limited data are available regarding the persistence of methanol in soils. The substance is volatile in this medium, and undergoes biodegradation by soil micro-organisms.

Biota
Methanol acts as a cumulative poison in biota, but can be metabolized to formic acid and formaldehyde (NIOSH, 1976). No quantitative data is available regarding bioaccumulation in aquatic organisms, although some accumulation can be expected with repeated exposure. Similarly, biomagnification is not expected.

Methanol inhibits sludge digestion at 800 mg/l (Verschueren, 1977).

INDUSTRIAL DATA

Production

Production in North Carolina was reported by five companies in the Toxic Substances Control Act (TSCA) Chemical Substance Inventory:

Carodel Corporation, Fayetteville: 50-500 tons/year
E. I. DuPont, Brevard: 5,000-25,000 tons/year
Hercofina-NC, Wilmington: No report of production figures
New Bern Polyester, New Bern: 500-5,000 tons/year
Wright Chemical, Riegelwood: 500-5,000 tons/year
(U.S. EPA, TSCA Inventory, 1980)

Annual U.S. production for 1975 was estimated at 2,600,000 tons. (U.S. EPA, CHIP, 1980)

Consumption and Use

Estimated U.S. Consumption in 1973:

Production of formaldehyde	39 percent
Solvent usage	7.9 percent
Production of dimethyl teraphthalate	6.1 percent
Production of methyl halides	6.1 percent
Production of methylamines	3.3 percent
Production of methyl methacrylate	3.7 percent
Production of acetic acid	3.4 percent
Production of glycol methyl ethers	1.1 percent
Inhibit polymerization of formaldehyde	0.9 percent
Exports	11.6 percent
Miscellaneous	16.9 percent

(U.S. EPA, CHIP, 1980)

Reported uses of methanol and the corresponding SIC codes are listed below:

Production of formaldehyde, dimethyl terephthalate, methyl halides, methylamines, methyl methacrylate, acetic acid, glycol methyl ethers	2869
Glycol methyl ethers used in jet fuel	2911, 45
Lacquers	2851
Textile dyeing	226
Phthalate production	2869, 2821
Inhibit polymerization of formaldehyde	28
Motor fuel	29
Possible sewage treatment applications	4959
Possible fermentation substrate for animal feed	20

(U.S. EPA, CHIP, 1980)

Industrial solvent	
Raw material for making formaldehyde and methyl esters	2869
In antifreeze for automotive radiators and air brakes	
As a fuel for picnic stoves	
As a fuel for soldering torches	
As an extractant for animal and vegetable oils	207

To denature ethanol
Softening agent for pyroxylin plastics
Solvent adjuvant for polymers
Solvent in the manufacture of pharmaceuticals 283
(Chloesterol, streptomycin, vitamins, hormones)
(Merck, 1976)

REGULATORY AND RESEARCH DATA

Existing Guidelines and Standards

Ambient Air
Caution should be exercised in prolonged exposure to elevated concentrations of methanol (Occupational Health Guidelines for Methyl Alcohol (NIOSH/OSHA Sept. 1978)).

Workroom Air

ACGIH — The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air is 200 ppm (262 mg/cu m) as a time-weighted average. The recommended Short Term Exposure Limit (STEL) for 15 minutes is 250 ppm (328 mg/ cu m). The importance of skin exposure is noted.

NIOSH — The National Institute of Occupational Safety and Health (NIOSH) recommends a standard of 200 ppm (262 mg/cu m) as a time-weighted average and a 15-minute ceiling limit of 800 ppm (1.05 g/cu m).

OSHA — The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 200 ppm (262 mg/cu m) as a time-weighted average.

Water
No guidelines for water have been established.

Other
Regulated as a hazardous material by the U.S. Department of Transportation. Methanol is classified as a flammable liquid and shipments must carry this label.

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Organizations Concerned with this Chemical

Chemical Hazard Information Profile (CHIP) compiled by the Office of Testing and Evaluation, U.S. Environmental Protection Agency.

Appears on the 1977-1982 Priority Lists of the Chemical Industry Institute of Toxicology, (CIIT).

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Ferry, D. G., W. A. Temple, and E. G. McQueen. Methanol Monitoring Comparison of Urinary Methanol Concentration With Formic Acid Excretion Rate as a Measure of Occupational Exposure. International Archives of Occupational and Environmental Health, Vol. 47: 155-163 (1980).

Hanst, P. L., W. E. Wilson, R. K. Patterson, B. W. Gay, and L. W. Chaney. A Spectroscopic Study of Pasadena Smog. American Chemical Society Division of Environmental Chemistry, 14(i), 287-294 (1974).

Merck Index: An Encyclopedia of Chemicals and Drugs, Ninth Edition, M. Windholz, Ed. Merck and Co., Rahway, NJ (1976).

National Institute for Occupational Safety and Health (NIOSH). Criteria for a Recommended Standard...Occupational Exposure to Methanol. U.S. Department of Health, Education, and Welfare. DHEW (NIOSH) Publication No. 76-148 (March 1976).

National Institute for Occupational Safety and Health/Occupational Safety and Health Administration (NIOSH/OSHA). NIOSH/OSHA Pocket Guide to Chemical Hazards. DHEW (NIOSH Publication No. 78-210 (September 1978).

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfiche Issue, R. J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 80-111-4 (1980).

Shackelford, W. M., and L. H. Keith. Frequency of Organic Compounds Identified in Water. U.S. Environmental Protection Agency, EPA-600/76-062, December 1977.

Simmon, V. F., K. Kanhanen, and R. G. Tardiff. Mutagenic Activity of Chemicals Identified in Drinking Water. Developments in Toxicology and Environmental Science, Vol. 2: 249-258 (1977).

Treon, J. F. Alcohols. Industrial Hygiene and Toxicology, Second Revised Edition, Vol. 2, F. A. Patty, Ed. Interscience Publishers, New York, NY (1963).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Chemical Hazard Information Profiles (CHIPs). EPA-560/11-80-011 (1980).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA, PB-80-155-153 (1980).

Verschueren, Karel. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold, Co., New York, NY (1977).

METHYLENE BIS (2-CHLOROANILINE)

Executive Summary

CAS NUMBER 00101-14-4

Methylene bis (2-chloroaniline) is a yellow-to-tan solid usually prepared in pellet form. Commercial production of this chemical began in 1962. It has been used extensively in the dye, plastic and rubber industries. It is produced in relatively small quantities (slightly more than one ton in 1975) and imported (5.3 tons in 1976) in larger amounts. North Carolina requires the reporting of all spills if they occur near water.

Health Effects

ACUTE. The approximate lethal oral dose level is 1,000 mg/kg in the rat. Symptoms of toxicity include rapid and irregular respiration, pallor, cyanosis, weakness, polyuria and coma. Methylene bis (2-chloroaniline) exhibits the general toxicity characteristics of aromatic amines which include eye irritation, respiratory irritation with cough, cyanosis and methemoglobinemia. A significant route of exposure is by skin absorption.

CARCINOGENICITY. Results reported by five independent groups of investigators clearly demonstrate that methylene bis (2-chloroaniline) induces tumors in the rat, mouse and dog. Ingestion of daily doses by mice and rats has resulted in the appearance of cancers of the liver, kidneys, lungs, skin and mammary glands. NIOSH recommends that this chemical be treated as a potential occupational carcinogen.

MUTAGENICITY. Methylene bis (2-chloroaniline) is mutagenic in in-vitro tests using Salmonella bacteria. 2.7 revertants per nmol (1050 revertants/ plate) were reported in the "Ames" test.

TERATOGENICITY & EMBRYOTOXICITY. No information is available.

CHRONIC. Skin tests with guinea pigs indicated that methylene bis (2-chloroaniline) is mildly irritating but it does not produce allergic contact dermatitis.

Occupational Health

The American Conference of Governmental Industrial Hygienists has established a Threshold Limit Value (time-weighted average concentration under which it is believed that all workers may be repeatedly exposed day after day without adverse effects) for workroom air of 0.2 ppm (0.22 mg/cu m). This TLV was apparently not based on a consideration of the carcinogenic potential. The importance of skin exposure is noted.

Routes of Human Exposure

OCCUPATIONAL. A NIOSH national survey in the early 1970's estimated that approximately 55,000 U.S. workers were potentially exposed to this chemical. It is commercially important as a curing agent for diisocyanate-based polymers (polyurethanes) and epoxy resin systems.

AMBIENT. No data on the occurrence of methylene bis (2-chloroaniline) in air or water were found. It is almost insoluble in water.

CONSUMER. No data are available.

Environmental Significance

Estimated oxidative half-life in air is less than 1 day based on structural similarities with 3,3'-dichlorobenzidine. No data on the aquatic or phytotoxicity of methylene bis (2-chloroaniline) are available.

North Carolina Production and Users

Production: None reported under TSCA.
Users: No information available.

Recommended Reviews

Special Hazard Review With Control Recommendations for 4,4'-Methylene bis (2-chloroaniline), National Institute for Occupational Safety and Health, DHEW Publication No. 78-188 (September 1978).

The carcinogenic effect of 4,4'-Methylene bis (2-chloroaniline) in mice and rats, A. Russfield et al. Toxicology and Applied Pharmacology 31: 47 (1975).

FIRST AID AND EMERGENCY RESPONSE INFORMATION

METHYLENE BIS (2-CHLOROANILINE)

First Aid (NIOSH/OSHA Pocket Guide to Chemical Hazards)

Not listed. All human contact must be prevented.

Procedures for Spills and Leaks (NIOSH Special Hazard Review, 1978)

Isolate hazard area and deny entry. Do not touch spilled material.

SMALL SPILLS: Mechanically sweep up spilled material for reclamation or disposal. Place in a closed containers.

Protective Measures

PROTECTIVE CLOTHING: Protective clothing made of butyl rubber, neoprene or a spunbonded olefin should be worn, and should include gloves, bibtype aprons, boots and overshoes.

PROTECTIVE EQUIPMENT: Wear self-contained respirators with full facepiece when handling spilled material.

METHYLENE BIS (2-CHLOROANILINE)

Profile

CHEMICAL IDENTIFICATION

Alternative Names:

Aniline, 4,4'-methylenebis(2-chloro-
4,4'-Diamino-3,3'-dichlorodiphenylmethane
Benzenamine, 4,4'-methylenebis(2-chloro
3,3'Dichloro-4,4'-diaminodiphenylmethane
Bisamine
MBOCA
CL-MDA
Methylene-4,4'-bis(o-chloroaniline)
Curalin M
P,P'-Methylenebis(alpha-chloroaniline)
Curene 442
4,4'-Methylenebis(2-chloroaniline)
Cyanaset
MOCA
Dacpm
Di(4-amino-3-chlorophenyl)methane

Chemical Abstract Services (CAS) Registry Number: 00101-14-4

Registry of Toxic Effects of Chemical Substances (RTECS) Number: CY 1050000

Hazardous Materials Table Identification Number: None

RCRA Identification Number U 158

Molecular Weight: 267.17

Molecular Formula: $C_{13}H_{12}Cl_2N_2$

Classification: Chlorinated aromatic amine; a weak base

Description: Yellow to light grey-tan solid, nearly odorless; available in pellet form.

Uses: Chemical intermediate

Chemical/Physical Data

Boiling point: Not reported
Melting point: 110°C
Vapor pressure: less than 1.0 x 10-5 mm Hg at 25°C
Vapor density: Not reported
Solubility in water: Almost insoluble
Specific gravity: 1.44 at 24°C

HUMAN TOXICITY

Methylene bis(2-chloroaniline) exhibits the general toxicity characteristics of aromatic amines (i.e., cyanosis and methemoglobinemia). Kidney irritation has been reported (ACGIH, 1980). Mild hematuria (blood in the urine) occurred in workers exposed to methylene bis(2-chloroaniline) along with other chemicals. Other symptoms included eye irritation and respiratory irritation with cough and tightness in the chest. Cystitis was observed and attributed to the methylene bis(2-chloroaniline) exposure (NIOSH, 1978).

Insufficient epidemiological data exist to ascertain whether the chemical causes cancer in humans. The average latent period for development of occupational bladder cancer is 20 years, and records are available for exposures dating back only 15 years (IARC, 1974).

A significant route of exposure is by skin absorption (ACGIH, 1980; NIOSH, 1978), although a quantitative relationship between skin absorption and urinary levels has not yet been established.

GENOTOXICITY

Carcinogenicity

OSHA, 1980 — The incidence of hepatomas was significantly higher than controls in male and female random-bred mice at two dose levels in the diet. The incidence of adenomatosis and adenocarcinoma was significantly higher than controls in both sexes of Charles River CD rats receiving the chemical in the diet for up to 2 years.

IARC, 1973 — 4,4'-Methylene bis(2-chloroaniline) is carcinogenic in the mouse and rat after oral administration and producestumors in the rat after subcutaneous administration.

There are no conclusive epidemiological studies of human data on which an evaluation of the carcinogenic risk can be based.

NIOSH, 1978 — Results reported by five independent investigators demonstrate the chemical to be oncogenic in rat, mouse, and dog. Based on these findings, NIOSH recommends that 4,4'-methylene bis (2-chloroaniline) be treated as a potential occupational carcinogen.

ACGIH, 1980 — There is a possibility that high exposure may cause cancer in humans, most likely in the bladder or liver. The chemical is classified as a suspected carcinogen.

Mutagenicity

NTP, 1980 — Mutagenesis Salmonella typhimurium test result: Positive

Name: Methylene Bis (2-Chloroaniline)
CAS Number: 00101-14-4

Teratogenicity & Embryotoxicity

No evidence was found to indicate that methylene bis(2-chloroaniline) causes birth defects.

ANIMAL TOXICITY

The summary given below is reproduced from the NIOSH Special Hazard Review (1978).

> 4,4'-Methylene bis (2-chloroaniline) was found to be "moderately toxic" when administered orally in single doses to male rats, with an Approximate Lethal Dose (ALD) of 1,000 mg/kg. The report indicated that 4,4'-methylene bis (2-chloroaniline) affected the kidneys of the experimental animals, and interfered with the hemopoietic system, as evidenced by the formation of methemoglobin and formation of red blood cells at sites other than bone marrow. The clinical signs of toxicity at lethal doses included rapid and irregular respiration (eventually becoming labored), pallor, cyanosis, weakness, polyuria, and coma. Repeated sublethal oral doses (200 mg/kg) in the rat produced pallor, slight cyanosis, and a depressed rate of weight gain during treatment.
>
> In a separate report submitted from the same laboratory, the oral LD50 for 4,4'-methylene bis (2-chloroaniline) (as a 10 percent solution in acetone (15)/peanut oil (85)) in male rats was reported as 750 mg/kg, with gross pathological changes including congested kidneys, an enlarged spleen, and hemorrhagic serosa of the stomach found in a few select animals.
>
> Single 40 mg/kg doses of 4,4'-methylene bis (2-chloroaniline) produced marked methemoglobinemia in dogs. The methemoglobin level returned nearly to normal 24 hours after the single dose. When administered daily in gradually increasing doses, a slight methemoglobinemia and macrocytic anemia developed, accompanied by fecal excretion of urobilogen. The study also identified a major metabolite of 4,4'-methylene bis (2-chloroaniline) in the dog urine as 5-hydroxy-3,3'-dichloro-4,4'bis-aminodiphenylmethane. Clinical signs noted were weakness, vomiting, pallor, and cyanosis. Skin absorption studies on rabbits showed the ALD by this route to be greater than 4 mg/kg, with pallor and weight loss observed. No significant hematologic changes were found. Skin tests with guinea pigs indicated the compound to be mildly irritating. It did not produce allergic contact dermatitis.

AQUATIC AND TERRESTRIAL TOXICITY

Data on the aquatic or phytotoxicity of methylene bis (2-chloroaniline) were not available.

ENVIRONMENTAL DATA

Air

No data were found on the occurrence of methylene bis (2-chloroaniline) in air. It has an estimated half-life of less than 1 day (Radding, 1975).

Judging the persistence of this substance requires caution. It probably degrades through oxidation (Radding, 1977), and dispersion is not expected to be significant. Because of its similarity to DDT in structure, accumulation in air should be considered a possibility.

Water

No data available.

Soil

Methylene bis (2-chloroaniline) is similar to structures which are persistent in soils (Radding, 1975). Sorption to organic sediments is likely based on a partition coefficient of 4.02 (Radding, 1975).

Biota

This substance is probably persistent in biota. It has a structure similar to other compounds which are persistent, and appear unchanged in urine samples of exposed workers, indicating that metabolism does not occur to any significant degree (NIOSH, 1978).

INDUSTRIAL DATA

Production

No production in North Carolina is reported in the Toxic Substances Control Act (TSCA) Chemical Substance Inventory (U.S. EPA, TSCA, 1980).

The estimated U.S. production in 1975 is probably greater than 908 kilograms (1 ton). In 1976, 4,830 kilograms (5.3 tons) were imported (TDB, 1981).

Consumption and Use

Estimated U.S. Consumption:

No quantitative data were found on U.S. consumption patterns.

Reported uses of methylene bis(2-chloroaniline) and the corresponding SIC codes are listed below:

Curing agent for diisocyanatecontaining polymers and epoxy resins used in polyurethane foam, solid urethane, rubber moldings and industrial tires (IARC, 1974)	282, 3011, 306
Curing agent for liquidcastable polyurethane elastomers	282, 30

Uses and SIC Codes (Continued)

Frequently formulated with other aromatic diamines to prepare curing agents (IARC, 1974)	282
Used extensively in the dye, plastics, and rubber industry (Russfield, 1975)	2865, 282, 30

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Air
No guidelines for air have been established.

Workroom Air

ACGIH — The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air is 0.02 ppm (0.22 mg/cu m as a time-weighted average). The chemical is classified as a suspected carcinogen, and the importance of avoiding skin exposure is noted. The TLVs are intended for use in the practice of industrial hygiene.

NIOSH — The National Institute of Occupational Safety and Health (NIOSH) recommends a standard of 3 μg/cu m as a time-weighted average.

OSHA — Methylene bis (2-chloroaniline) was one of 14 substances for which the Occupational Safety and Health Administration (OSHA) promulgated an emergency temporary standard on May 3, 1973. Final, individual standards for these substances were promulgated by OSHA on January 29, 1974. On December 17, 1974, the standard for 4,4'-methylene bis (2-chloroaniline) was remanded for procedural reasons by the 3rd Circuit Court of the U.S. Court of Appeals (Synthetic Organic Chemicals Manufacturers' Association vs. Brennen 506.F2d 385, 1974). Subsequent to the court decision, the standard was deleted from the Code of Federal Regulations.

Water
No guidelines for water have been established.

Other
Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Agencies Concerned with this Chemical

Designated a candidate substance by the Occupational Safety and Health Administration. A candidate substance may undergo closer scientific review to determine its potential as an occupational carcinogen (Federal Register, Vol. 45, No. 15, 1980).

Subject of a monograph prepared by the International Agency for Research on Cancer (IARC).

Subject to a proposed rule under the Toxic Substances Control Act that would require all chemical manufacturers to report production and exposure-related data to the U.S. Environmental Protection Agency (Federal Register, Vol. 45, No. 42, 1980).

Under toxicological evaluation through the National Toxicology Program to determine mutagenicity (National Toxicology Program, Fiscal Year 1981 Annual Plan, NTP-80-62, 1980).

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

International Agency for Research on Cancer (IARC). IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon France, Volume 4. A World Health Organization Publication (WHO), Geneva (1973).

MEDLARS II Toxicology Data Bank (TDB) Record of Methylene bis(2-chloroaniline) National Library of Medicine (May 1981).

Merck Index: An Encyclopedia of Chemicals and Drugs, Ninth Edition, M. Windholz, Ed. Merck and Co., Rahway, NJ (1976).

National Institute for Occupational Safety and Health. Special Hazard Review with Control Recommendation for 4,4'-Methylene bis(2-chloroaniline). U.S. Department of Health, Education, and Welfare. DHEW (NIOSH) Publication No. 78-188 (1978).

National Toxicology Program. Fiscal Year 1981 Annual Plan. NTP 80-62 (1980).

Occupational Safety and Health Administration (OSHA). Candidate Substance Data Summary Sheet. Chemical: Aniline, 4,4'-methylenebis(2-chloro-) (1980).

Radding, S.B., et al. Review of the Environmental Fate of Selected Compounds. Prepared for the U.S. Environmental Protection Agency. Available from the National Technical Information Service, Springfield, VA, PB238-908 (1975).

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfiche Issue, R. J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville, MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 80-111-4 (1980).

Russfield, A.B., et al. The Carcinogenic Effect of 4,4-methylene-bis-(2-chloroaniline) in Mice and Rats. Toxicology and Applied Pharmacology 31:47-54 (1975).

Stula, E.F., et al. Experimental Neoplasia in Rats from Oral Administration of 3,3'-dichlorobenzidine, 4,4'-methylene-bis(2-chloroaniline), and 4,4'-methylenebis(2-methylaniline). Toxicology and Applied Pharmacology 31:159-176 (1975).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA PB-80-155-153 (1980).

METHYLENE CHLORIDE

Executive Summary

CAS NUMBER 00075-09-2

Methylene chloride, a chlorinated hydrocarbon, is a colorless, volatile liquid with a sweetish odor; nonflammable except under extreme conditions. Commercial production in the U.S. was first reported in 1934. Most organic paint removers contain methylene chloride as the major component. The reporting of any spill is required in North Carolina if it occurs near water.

Health Effects

ACUTE. Liquid methylene chloride is irritating to the eyes, respiratory passages, and on prolonged contact, to the skin. Inhalation of high concentrations produces a narcotic effect along with other complaints such as headache, giddiness, stupor, numbness, tingling in the limbs, and fatigue. Toxic effects are due in part to the metabolism of methylene chloride to carbon monoxide. Exposure results in the rapid production of carboxyhemoglobin. Toxicities of methylene chloride and carbon monoxide are additive.

CARCINOGENICITY. Human studies on workers exposed to methylene chloride at 30 to 120 ppm showed no statistical correlation with cancer induced fatalities over a 20-year period. No tumors were reported in inhalation studies on dogs, rabbits, guinea pigs and rats at 5,000 and 10,000 ppm for 6 months. Only one positive test has been reported. Groups of male strain A mice were injected intraperitoneally 3 times per week for 5½ weeks at 0, 160, 400 or 800 mg/kg. Results were not considered statistically different from control groups. The data available is considered inadequate to fully evaluate the carcinogenicity of methylene chloride.

MUTAGENICITY. No evidence of mutagenicity was observed in Drosophila using sex-linked recessive lethal tests. Methylene chloride is positive in the Ames test both with and without activation, and shows evidence that it is a direct acting mutagen in in vitro tests.

TERATOGENICITY AND EMBRYOTOXICITY. No teratogenic or embryotoxic effects were observed in rats and mice after exposure of pregnant animals to 1,250 ppm methylene chloride for 7 hours daily on days 6-15 of gestation.

CHRONIC. Damage to the liver and central nervous system has been reported as an effect of long-term occupational exposure.

Fatalities have been observed with acute or prolonged exposure to methylene chloride.

Occupational Health

The American Conference of Governmental Industrial Hygienists has established a Threshold Limit Value for workroom air (time-weighted average concentration under which it is believed that all workers may be repeatedly exposed day after day without adverse effect) of 100 ppm (360 mg/cu m) and a Short Term Exposure Limit (the maximum concentration to which workers may be exposed for a period up to 15 minutes) of 500 ppm.

NIOSH recommends a standard of 75 ppm (260 mg/cu m) as a time-weighted average and a 15-minute ceiling limit of 500 ppm (1,700 mg/cu m). NIOSH further recommends that permissible levels of methylene chloride be reduced where carbon monoxide is present.

Routes of Human Exposure

OCCUPATIONAL. It is estimated that 70,000 employees are potentially exposed to methylene chloride. Exposure occurs where degreasing is performed, where it is used as a solvent in the manufacture of photographic film and synthetic fiber, and when used as a grain fumigant. Beauticians are often exposed to 1-2 ppm from hair spray aerosols.

AMBIENT. Methylene chloride has been detected in ambient air at a concentration of 0.035 ppm (0.12 µg/cu m). It has also been detected in air containing cigarette smoke. Oxidation products are carbon monoxide, carbon dioxide and carbonyl chloride (phosgene).

Methylene chloride was found in raw water at a concentration of 1.0 µg/l. In two EPA surveys of water supplies, it was found in about 10 percent of the samples; median concentration was 1-2 µg/l. METHYLENE CHLORIDE IS FORMED DURING THE CHLORINATION OF WATER.

CONSUMER. Because of its wide use as a propellant in aerosol sprays, it has been found in very high concentrations in air where hair spray is used. As an oil and fat solvent, FDA allows methylene chloride in spice oleoresins up to 30 mg/kg and in decaffeinated coffee up to 10 mg/kg. It is also allowed in adhesives for food packaging.

Environmental Significance

Estimated half-life in air is 20 days to 1 year (based on photodecomposition) and in water, 19-24 minutes (based on evaporation from a 1 ppm solution at 25°C). Methylene chloride is not expected to bioaccumulate.

The available data for halomethanes indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 11 gm/l. No data are available concerning the chronic toxicity of halomethanes to sensitive freshwater aquatic life.

Acute and chronic toxicity to saltwater aquatic life occur at concentrations as low as 12 and 6.4 gm/l respectively.

No toxic effects on freshwater algae have been documented at concentrations as high as 662 gm/l. No data have been reported on plant toxicity from air pollution.

North Carolina Production and Users

Production: No known producers.

Users: No information available (Major uses in the U.S. include remover, solvent degreaser and aerosol propellant applications).

Recommended Reviews

Chloroform, Carbon Tetrachloride and Other Halomethanes. National Academy of Sciences, National Research Council (1978).

Some Halogenated Hydrocarbons. IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Humans, Volume 20, page 449 (October 1979).

Criteria for a Recommended Standard - Occupational Exposure to Methylene Chloride. NIOSH. HEW Publication (NIOSH) 76-138, 1976.

FIRST AID AND EMERGENCY RESPONSE INFORMATION

METHYLENE CHLORIDE

First Aid (NIOSH/OSHA) Pocket Guide to Chemical Hazards)

Eyes: Wash with large amounts of water immediately. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH METHYLENE CHLORIDE.

Skin: Wash the contaminated skin promptly with soap and water. Remove clothing if contaminated and wash skin with soap and water.

Inhalation: Move to fresh air at once. Perform artificial respiration if necessary. Seek immediate medical attention.

Ingestion: Induce vomiting by finger or by giving syrup of ipecac or solution of 2 tablespoons of salt per pint of warm water. Seek medical attention.

Note to physician: Gastric lavage with 3-5% sodium bicarbonate. Prompt hemodialysis if blood methanol level is above 50 mg/dl or if there is evidence of acidosis.

Procedures for Spills and Leaks (U.S. DOT Emergency Response Guidebook, 1980)

Isolate hazard area and deny entry. Stay upwind and keep out of low areas. Wear positive pressure breathing apparatus and special protective clothing. Do not touch spilled material. Stop leak if you can do it without risk. Use water spray to reduce vapors.

SMALL SPILLS: Take up with sand, or other noncombustible absorbent material, then flush area with water.

SMALL DRY SPILLS: Shovel into dry containers and cover; move containers; then flush area with water.

LARGE SPILLS: Dike far ahead of spill for later disposal.

Fire and Explosion Information

GENERAL: Considered non-flammable, but will burn in high concentrations such as near spills or in closed spaces. Ignites at 624°C (1224°F).

EXPLOSION LIMITS: Upper - 64.6%, Lower - 15.5% in oxygen

Reactivity

CONDITIONS TO AVOID: Avoid heat - decomposes to highly poisonous gases.

MATERIALS TO AVOID: Avoid contact with alkali metals (example: sodium or potassium), such contact may cause an explosion. Methylene chloride will corrode iron, stainless steel and copper especially at high temperatures and if the metals are wet.

Protective Measures

STORAGE AND HANDLING: Storage should be in a well ventilated area.

ENGINEERING CONTROLS: Use only in a well ventilated area. Eyewashers and showers should be readily accessible.

PROTECTIVE CLOTHING (Should not be substituted for proper handling and engineering controls): Wear gloves, coveralls, and splash proof goggles.

NOTE: Not all protective clothing is impervious and resistant to methylene chloride. Check with manufacturer's specification or your supervisor.

PROTECTIVE EQUIPMENT: For up to 750 ppm use a respirator with organic vapor cartridge. For 750 ppm to 3,750 ppm use any supplied-air respirator with full facepiece, helmet or hood, or any self-contained breathing apparatus with full facepiece. For more than 3,750 ppm use a self-contained breathing apparatus device, pressure demand mode (positive pressure) and full facepiece or a combination of supplied-air respirator, pressure demand mode with an auxiliary, self-contained air supply. For escape from a contaminated area, use any escape-type gas mask providing protection against methylene chloride.

METHYLENE CHLORIDE

Profile

CHEMICAL IDENTIFICATION

Alternative Names:

Aerothene MM
Dichloromethane
Freon 30
Methane Dichloride
Methylene Bichloride
Methylene Dichloride
Narkotil (Norkotel)
R 30
Solaesthin (Solaestine)
Solmethine

Chemical Abstract Services (CAS) Registry Number: 00075-09-2

Registry of Toxic Effects of Chemical Substances (RTECS) Number: PA 8050000

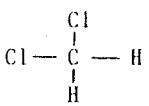
Hazardous Materials Table Identification Number: UN 1593

RCRA Identification Number: U 080

Molecular Weight: 84.94

Molecular Formula: CH_2Cl_2

Structure:



Classification: Alkyl halide; chlorinated hydrocarbon

Description: A colorless, volatile liquid with a sweetish odor; nonflammable except under extreme conditions.

Uses: As a solvent, degreasing and cleaning fluid, aerosol propellant, anesthetic and refrigerant.

Chemical/Physical Data

Boiling point: 39.75°C
Melting point: -95.1°C
Vapor pressure: 349 mm Hg at 20°C; 500 mm at 30°C
Vapor density: 2.93 (Air=1)
Solubility in water: 20 gm/l at 20°C; 16.7 gm/l at 25°C
Specific gravity: 1.335

HUMAN TOXICITY

Liquid methylene chloride is irritating to the eyes and respiratory passages. It is also irritating if confined on the skin by clothing. Inhalation of high concentrations produces a narcotic effect along with other complaints such as fatigue, headache, giddiness, stupor, numbness, and tingling in the limbs. Toxic effects are due in part to the metabolism of methylene chloride to carbon monoxide (ACGIH, 1980).

Controlled studies using human volunteers have been performed to assess acute toxicity. Exposure results in rapid production of carboxyhemoglobin. In subjects exposed to 50 ppm for 7.5 hours, carboxyhemoglobin levels returned to normal by the following morning. Carboxyhemoglobin remained elevated with daily exposure to 100 ppm and 250 ppm (NIOSH, 1976).

Damage to the liver and central nervous system has been reported as an effect of long-term occupational exposure (IARC, 1979).

An epidemiological study has been performed on workers at one plant where methylene chloride was used as the primary solvent. Exposures were estimated to range from 30 ppm to 120 ppm. No increase in neoplasms, heart disease or mortality was found compared to controls (U.S. EPA, CAG, 1980).

The maximum level at which one could escape within 30 minutes without any escape-impairing symptoms or irreversible effects is suggested to be 5,000 ppm (NIOSH/OSHA, 1978).

Carcinogenicity

U.S. EPA, CAG, 1980 — Human studies on workers exposed to methylene chloride at 30 to 120 ppm showed no statistical correlation with cancerinduced fatalities over a 20-year period. No tumors were reported in inhalation studies on dogs, rabbits, guinea pigs and rats at 5,000 and 10,000 ppm, 7 hours per day, 5 days per week for 6 months.

IARC, 1979 — Only one positive test has been reported. Groups of male strain A mice were injected intraperitoneally 3 times per week for a total of 16-17 injections at 0, 160, 400 or 800 mg/kg. Lung tumors were observed but were not considered statistically different from control groups.

Mutagenicity

U.S. EPA, CAG, 1980 — No evidence of mutagenicity was observed in Drosophila using sex-linked recessive lethal tests. An in vitro test of cell transformation was performed using Fischer rat embryo cell line F1706, and the transformed cells produced fibrosarcomas after injection, providing evidence that methylene chloride is a direct-acting mutagen.

Mutagenicity

IARC, 1979
CAG, 1980

Methylene chloride is positive in the Ames Test both with and without activation.

Teratogenicity

No teratogenic effects were observed in rats and mice after exposure of pregnant animals to 1,250 ppm methylene chloride for 7 hours daily on days 6-15 gestation (IARC, 1979).

ANIMAL TOXICITY

Both acute and chronic effects have been demonstrated in laboratory animals. Effects in animals as in humans are largely attributable to the carbon monoxide produced when methylene chloride is metabolized.

Acute Toxicity

Results of lethal studies in several species as reported in the RTECS, 1980 are listed below:

Route	Species	Lethal Dose or Lethal Concentration
Oral	Rat	167 mg/kg, LD50
	Rabbit	1,900 mg/kg, lowest lethal dose
	Dog	3,000 mg/kg, lowest lethal dose
Inha-	Rat	25,500 ppm (88 gm/cu m) for 0.5 hours, LC50
	Mouse	14,400 ppm (50 mg/cu m) for 7 hours, LC50
	Dog	14,108 ppm (49 gm/cu m) for 7 hours, lowest LC
	Cat	12,500 ppm (43.4 gm/cu m) for 4.5 hours, lowest LC
	Guinea pig	5,000 ppm (17.3 gm/cu m) for 2 hours, lowest LC

Carboxyhemoglobin formation from exposure to methylene chloride is well-documented in experimental animals. Carbon monoxide formed as a metabolite binds to several other biological molecules besides hemoglobin. The additive toxicity of methylene chloride and carbon monoxide was demonstrated in rats exposed to a mixture of these two chemicals (NIOSH, 1976).

Rats exposed to 1,300 ppm, 8 hours per day for 75 days showed slight liver changes. Both kidney and liver changes were observed in cats exposed to 7,200 ppm methylene chloride for four weeks (ACGIH, 1980).

AQUATIC AND TERRESTRIAL TOXICITY

Data on aquatic toxicity and phytotoxicity are provided below.

Aquatic Toxicity

The U.S. EPA Water Quality Criteria (1980) for protection of aquatic life are given below:

> The available data for halomethanes indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 11 mg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of halomethanes to sensitive freshwater aquatic life.
>
> The available data for halomethanes indicate that acute and chronic toxicity to saltwater aquatic life occur at concentrations as low as 12 and 6.4 mg/l, respectively, and would occur at lower concentrations among species that are more sensitive than those tested.

Bioaccumulation: A bioconcentration factor of 2.3 was calculated from the octanol/water partition coefficient. This level is not considered to be a significant environmental problem (U.S. EPA, WQC, 1980).

Phytotoxicity

No data were found on toxicity to plants from air pollution.

ENVIRONMENTAL DATA

Air

Methylene chloride has been detected in ambient air at a concentration of 0.035 ppb (0.12 µg/cu m) (NAS, 1978). A rural concentration of less than 0.0175 µg/cu m is reported (IARC, 1979). Based on photodecomposition, methylene chloride has an estimated half-life in air of 20 days to 1 year (Spence, et al., 1976; Person and McConnell, 1975). Moderate degradation rates and high volatility make an assessment of methylene chloride's persistence in air difficult (Callahan, 1979). Significant physical removal and degradation can be expected in this medium, although the compound may accumulate near production sources.

Water

Methylene chloride was found in raw water at a concentration of 1.0 µg/l (NAS, 1978). In two EPA surveys of water supplies, methylene chloride was found in about 10 percent of the samples; median concentration was 1-2 µg/l (U.S. EPA, WQC, 1980). Methylene chloride formed during the chlorination of water (IARC, 1979). This compound volatilizes rapidly in water, and has an estimated half-life (based on evaporation) of 19-24 minutes (Verschueren, 1977).

Water

Degradation by hydrolysis is very slow, and is significantly affected by the pH of the solution.

Accumulation is not expected although low concentrations have been shown to be widely dispersed in this medium (U.S. EPA, WQC, 1980).

Soil

There are limited data with which to assess the degradation of methylene chloride in soil. There is some evidence to suggest that it may absorb into certain sediments (Callahan, 1979).

Biota

Methylene chloride is metabolized by animals and there is no evidence of bioaccumulation (NAS, 1978). This compound has a low partition coefficient (1.25 calculated; Callahan, 1979), and biomagnification is not expected.

Because of its wide use as a propellant in aerosol sprays, it has been found in very high concentrations in air where hair spray is used. It has also been detected in a variety of spice oleoresins, and in air containing cigarette smoke (IARC, 1979).

INDUSTRIAL DATA

Industrial production information along with consumption and use data are presented below. Data specific to North Carolina are provided if available. Because uses that are cited in the literature are generally not specific to the State, Standard Industrial Classification (SIC) codes are matched with uses as a means of identifying those use categories that are of particular significance in North Carolina.

Production

No production in North Carolina has been reported in the Toxic Substances Control Act (TSCA) Chemical Substance Inventory (U.S. EPA, TSCA, 1980).

Reported U.S. production in 1976 from five U.S. companies was 244 million kg (270,000) tons). Imports for that year were 19.1 million kg (21,000 tons) (IARC, 1979). The consumption of methylene chloride is projected to increase based on its potential use as an aerosol component and as a blowing agent for polyurethane foams (NTP, 1979).

Consumption and Use

Estimated U.S. Consumption in 1976:

Paint remover	44 percent
Solvent degreaser	25 percent
Aerosol propellant	19 percent
Other applications	12 percent

(IARC, 1979)

Reported uses of methylene chloride and the corresponding SIC codes are listed below:

Paint remover	2851
Degreasing engine parts	35
Aerosol sprays -- as a replacement for trichloroethylene	-
Solvent for pharmaceuticals	283
Component of fire extinguishing components	-
Extraction of fats, caffeine, beer flavoring	20
Insecticide for grains, commodity fumigant	2879

(IARC, 1979)

Solvent for cellulose acetate	282

(Merck, 1976)

Plastics processing	282, 307

(MEDLARS)

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air

Under evaluation for possible designation as a Hazardous Air Pollutant by the U.S. Environmental Protection Agency.

Workroom Air

ACGIH — The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air is 100 ppm (.36 gm/cu m) as a time-weighted average. The recommended Short Term Exposure Limit (STEL) is 500 ppm (1.7 gm/cu m).

NIOSH — The National Institute of Occupational Safety and Health (NIOSH) recommends a standard of 75 ppm (.26 gm/cu m) as a time-weighted average and a 15-minute ceiling limit of 500 ppm (1.7 gm/cu m). NIOSH further recommends that permissible levels of methylene chloride be reduced where carbon monoxide is present.

OSHA — The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 500 ppm (1.7 gm/cu m) as a time-weighted average, with an acceptable ceiling level of 1,000 ppm. The maximum peak concentration is 2,000 ppm for 5 minutes in any 2-hour period.

Water

Addressed by Ambient Water Quality Criteria set by the U.S. Environmental Protection Agency.

Designated a toxic pollutant by the U.S. Environmental Protection Agency.

Other

Regulated as a hazardous material by the U.S. Department of Transportation.

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Organizations Concerned with this Chemical

Appears on the 1976 Priority List of the Chemical Industry Institute of Toxicology (CIIT).

Subject of a Problem-Oriented Carcinogen Assessment Report prepared by the Carcinogen Assessment Group (CAG) of the U.S. Environmental Protection Agency.

Subject of a monograph prepared by the International Agency for Research on Cancer (IARC).

Appears on the Priority List of the Interagency Testing Committee (ITC).

Subject to a proposed rule under the Toxic Substances Control Act that would require all chemical manufacturers to report production and exposure-related data to the U.S. Environmental Protection Agency (Federal Register, Vol. 45, No. 42, 1980).

Subject to a proposed rule by the U.S. Environmental Protection Agency (EPA) under the Toxic Substances Control Act, Section 4(a) that would require manufacturers and processors to test the chemical according to standards EPA has adopted. Proposed testing includes: acute effects -- dermal sensitization; subchronic cardiovascular toxicity; reproductive toxicity; aquatic vertebrates -- chronic toxicity, aquatic invertebrates -- chronic toxicity; birds -- acute and chronic toxicity; terrestrial plants -- early seedling growth; bioconcentration -- plant uptake/translocation; and bioconcentration -- aquatic vertebrate (Federal Register, Vol. 46, No. 108, June 5, 1981).

Under toxicology evaluation through the National Toxicology Program to determine carcinogenicity. Testing began in Fiscal Year 1980. Methylene chloride has been selected for teratology and reproductive toxicology assays to be initiated in fiscal years 1981-83. (National Toxicology Program, Fiscal Year 1981 Annual Plant NTP-80-62, 1980).

Addressed by a National Toxicology Program (NTP) Executive Summary and included in the list of 100 compounds nominated for NTP testing.

REFERENCES

American Conference of Governmental Industrial Hygienists, (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Callahan, M.A., et al. Water-Related Fate of 129 Priority Pollutants. U.S. EPA Office of Water Planning and Standards, Washington, DC, EPA 440/4-79-092 (December 1979).

Cupitt, L. T. Fate of Toxic and Hazardous Materials in the Air Environment. EPA-600/2-80-084, NTIS PB 80-221948 (September 1980).

International Agency for Research on Cancer (IARC). IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon France, Volume 19. A World Health Organization Publication (WHO), Geneva (1979).

Merck Index: An Encyclopedia of Chemicals and Drugs, Ninth Edition, M. Windholz, Ed. Merck and Co., Rahway, NJ (1976).

National Academy of Sciences, National Research Council. Chloroform, Carbon Tetrachloride and Other Halomethanes: An Environmental Assessment. Washington, DC (1978).

National Institute for Occupational Safety and Health/Occupational Safety and Health Administration (NIOSH/OSHA). NIOSH/OSHA Pocket Guide to Chemical Hazards. DHEW (NIOSH) Publication No. 78-210 (September 1978).

National Institute for Occupational Safety and Health (NIOSH). Criteria for a Recommended Standard...Occupational Exposure to Methylene Chloride. U.S. Department of Health, Education, and Welfare. DHEW, (NIOSH) No. 76-138 (1976).

National Toxicology Program. NTP Executive Summaries. Prepared by the National Center for Toxicological Research, Office of Scientific Intelligence, Jefferson, Arkansas (March 1979).

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfiche Issue, R. J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville, MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 80-111-4 (1980).

U.S. Environmental Protection Agency, Carcinogen Assessment Group (CAG). Problem Oriented Report-Carcinogen Assessment of Methylene Chloride. Washington, DC (June 27, 1980).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA PB-80-155-153 (1980).

U.S. Environmental Protection Agency, Office of Water Planning and Standards. Ambient Water Quality Criteria for Halomethanes. EPA-440/5-80-016, PB 81-117624 (October 1980).

Verschueren, Karel. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York, NY (1977).

METHYL ETHYL KETONE

Executive Summary

CAS Number: 00078-93-3

Methyl ethyl ketone (MEK) is a colorless, flammable liquid with an acetone-like odor. It is used as an industrial solvent, especially as a coatings solvent. Estimated U.S. production in 1975-76 was 524 million pounds. No federal regulations concerning spills exist at present. North Carolina requires the reporting of all spills if they occur near water.

Health Effects

ACUTE. MEK is readily absorbed by the lungs, gastro-intestinal tract and through the skin. Concentrated short-term exposure may constitute a major hazard to health, with serious residual injury potentially resulting, despite prompt treatment.

CARCINOGENICITY. No carcinogenic effects have been reported for MEK.

MUTAGENICITY. No data on the mutagenicity of MEK in standard tests are available.

TERATOGENICITY AND EMBRYOTOXICITY. Teratogenic and embryotoxic effects have been found after exposure of pregnant rats to MEK.

CHRONIC. MEK is moderately irritating when inhaled or applied to the skin. Symptoms which may occur range from eye, nose and throat irritation (with possible necrosis if inhaled), dermatitis and numbness in the arms to CNS effects.

Occupational Health

The American Conference of Governmental Industrial Hygienists has established a Threshold Limit Value for workroom air of 200 ppm (590 mg/cu m). The recommended Short Term Exposure Limit is 300 ppm (885 mg/cu m. A workroom air concentration of 200 ppm (590 mg/cu m) is both the standard of OSHA and the recommendation standard of NIOSH.

Routes of Human Exposure

OCCUPATIONAL. There is no record of serious human illness from industrial use of MEK.

AMBIENT. No data exist on ambient MEK concentrations.

CONSUMER. The use of MEK as a flavor ingredient is regulated by the Food and Drug Administration. MEK exists in cigarette smoke in concentrations to 500 ppm and in gasoline exhausts in concentrations from below 0.1 ppm to 1.0 ppm.

Environmental Significance

Stable and persistant low levels of MEK may be widely dispersed in water. Removal may be more important than degradation.

Photolytic degradation can be expected of MEK in the atmosphere. MEK is not expected to accumulate or biomagnify in the soil as it can be metabolized by the biota.

Recommended Reviews

Criteria for a Recommended Standard...OCCUPATIONAL EXPOSURE TO KETONES p. 164-166, 181-2. National Institute for Occupational Safety and Health (1978).

Documentation of the Threshold Limit Values, Fourth Edition 1980. American Conference of Governmental Industrial Hygienists, Inc.

FIRST AID AND EMERGENCY RESPONSE INFORMATION

METHYL ETHYL KETONE

First Aid (NIOSH/OSHA Pocket Guide to Chemical Hazards)

Eyes: Irrigate immediately with large amounts of water occasionally lifting upper and lower lids. Seek medical attention immediately. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH THIS CHEMICAL.

Skin: Promptly remove contaminated clothing. Wash with soap and water for at least 5 minutes. Seek medical attention, if necessary.

Inhalation: Move to fresh air. Give artificial respiration or oxygen if necessary. Seek medical attention.

Ingestion: Get medical attention immediately. If medical attention is not immediately available, induce vomiting by touching the back of his throat with his finger or administer syrup of ipecac.

Note to Physician: Induce emesis if greater than 1 mg/kg was ingested. Magnesium or sodium sulfate cathartics should be used after all ingestions.

Procedures for Spills and Leaks (U.S. DOT Emergency Response Guidebook, 1980)

Restrict entry. Stay upwind; keep out of low areas. Isolate hazard area. Wear self-contained breathing apparatus and full protective clothing. Isolate for ½ mile in all directions if tank or tankcar is involved in fire. No flares, smoking or flames in hazard area. Stop leak if it can be done without risk. Use water to reduce vapors.

SMALL SPILLS: Take up with sand or other noncombustible absorbent material, then flush area with water.

LARGE SPILLS: Dike far ahead of spill for later disposal.

Fire and Explosion Information

MEK will burn if exposed to a source of ignition. Ignites at 474°C.

EXPLOSIVE LIMITS: Upper - 10%, lower - 2%.

SMALL FIRES: Dry chemical, CO_2, water spray or alcohol foam.

LARGE FIRES: Water spray, fog or foam

EMERGENCY ACTION: Move container from fire if it can be done without risk, container may explode in heat of fire. Stay away from ends of tanks. Cool containers that are exposed to flames with water from the side until well after the fire is out. For massive fire in cargo area, use unmanned hose holder or monitor nozzles. Withdraw immediately in case of rising sound from venting safety device or discoloration of tank. Flammable vapor may spread away from spill. Runoff to sewer may create fire or explosion hazard.

Reactivity

MATERIALS TO AVOID: Very strong oxidizers present potentially hazardous incompatibilities.

CONDITIONS TO AVOID: Any contact with sources of ignition or extremely high temperatures can cause fire or explosion.

Protective Measures

Preclude from exposure those individuals with diseases of skin, blood or central nervous system. Make annual physical examinations, including blood cell count.

STORAGE AND HANDLING: Close tightly, store in a cool place, and check intermittently for leakage. During shipping, keep in a cool ventilated hold, more than 6 meters apart from the walls of such places with fire and heat as boiler room, kitchen, etc. Do not load together with explosives, oxidizing materials, poisons, organic peroxides and radioactive materials. Preferably provide electrical equipment with spark resistant construction.

ENGINEERING CONTROLS: Adequate ventilation. Shower, sink and eyewash stations should be available.

PROTECTIVE CLOTHING (Should not be substituted for proper handling and engineering controls): Wear appropriate protective clothings to prevent repeated or prolonged skin contact, including rubber gloves, apron and faceshield or goggles.

PROTECTIVE EQUIPMENT: For levels up to 1000 ppm wear a chemical cartridge respirator with organic vapor cartridges and full facepiece. For levels up to 3000 ppm, wear a gas mask with organic vapor canister, or supplied-air respirator with a full facepiece, or a self-contained breathing apparatus with a full facepiece. For escape, wear a gas mask with organic vapor canister or a self-contained breathing apparatus.

METHYL ETHYL KETONE

Profile

Chemical Identification

Alternative Names:

Acetone, Methyl-
Butanone
2-Butanone
Ketone, Ethyl Methyl
Meetco
MEK
Methyl Acetone

Chemical Abstract Services (CAS) Registry Number: 00078-93-3

Registry of Toxic Effects of Chemical Substances (RTECS) Number: EL6475000

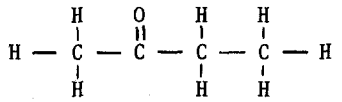
Hazardous Materials Table Identification Number: UN 1193

RCRA Identification Number: U 159

Molecular Weight: 72.10

Molecular Formula: C_4H_8O

Structure:



Classification: Ketone

Description: Colorless, flammable liquid with acetone-like odor

Use: Industrial solvent

Chemical/Physical Data

Boiling point: 79.6°C at 760 mm Hg
Melting point: -86.4°C
Vapor pressure: 71.2 mm Hg at 20°C
Vapor density: 2.41 (air = 1.0)
Density: 0.805
Solubility in water: 27.5% - decreasing at higher temperatures
Ignition temperature: 474°C
Flash point: (closed cup) 21°F
Explosion level: Upper - 10%; lower - 2%
Odor threshold in air:
absolute perception limit: 2.0 ppm
100% recognition limit: 6.0 ppm

HUMAN TOXICITY

Methyl ethyl ketone (MEK) is classified as a slight local irritant, causing readily reversible changes which disappear after exposure ends. Exposure by inhalation of 100 ppm for 5 minutes produced nasal and throat irritation (NIOSH, 1978). The threshold for eye and nose irritation is approximately 200 ppm for 50% of those unacclimated. Exposure to 200 ppm produce local eye and nose irritation and if inhaled, can cause necrosis. Dermatitis and numbness in the arms occurred in humans exposed to 300-600 ppm (882-1, 760 mg/cu m) (NIOSH, 1978). The lowest toxic concentration is reported as 300 ppm for humans.

MEK is readily absorbed by the lungs, gastrointestinal tract and through the skin. TDB (1982) states that MEK is a major hazard to health during concentrated short-term exposure, with serious residual injury potentially resulting despite prompt treatment. The maximum level at which one could escape within 30 minutes without any escape-impairing symptoms or irreversible effects is suggested to be 3000 ppm (8,820 mg/cu m) (NIOSH, 1978).

There is no record of serious human illness from industrial use of methyl ethyl ketone (TDB, 1982).

Carcinogenicity

No carcinogenic effects of MEK have been reported.

Mutagenicity

No data are available on the mutagenicity of MEK in standard tests.

Teratogenicity & Embryotoxicity

Evidence of teratogenicity was found when pregnant rats were exposed to methyl ethyl ketone at 1,126 and 2,618 ppm (3,320 and 7,720 mg/cu m) (NIOSH, 1978). There is limited evidence for the embryotoxicity of MEK, however, transplacental migration does occur with accumulation in the fetal blood (TDB, 1982).

ANIMAL TOXICITY

MEK is moderately irritating when inhaled or applied to the skin (TDB, 1982) and can affect the central nervous system (NIOSH, 1978).

Acute Toxicity

Results of lethal studies in two species, as reported in TDB (1982) are listed below:

Route	Species	Lethal Dose or Lethal Concentration
Oral	Rat	6.86 ml/kg, LD50
Oral	Rat	3400 mg/kg, LD50
Inhalation	Rat	2000 ppm for 4 hours, LCLo
Dermal	Rabbit	1300 mg/kg, LD50

Chronic Toxicity

Results of chronic toxicity studies, as reported in TDB (1982) and RTECS (1982) are listed below:

Name: Methyl Ethyl Ketone
CAS Number: 00078-93-3

Route	Species	Dose	Toxic Effect
Inhalation	Rat	1000 ppm (6-15 d preg)	TCLo, teratogenesis
Dermal	Rabbit	500 mg/24 hrs	moderate irritation
	Rabbit	402 mg/24 hrs	mild irritation
	Rabbit	13780 ug/24 hrs.	mild irritation

Aquatic Toxicity

Aquatic toxicity rating: TLM 96 hr is greater than 1000 ppm (TDB, 1982). TLm (24-96) for mosquito fish is 5600 mg/l (Verschueren, 1977).

MEK is easily degraded and is nontoxic to microorganisms at concentrations up to 800 mg/cu m (TDB, 1982).

Inhibition of cell multiplication in Microcystis aeruginosa begins at a concentration of 110 mg/l.

ENVIRONMENTAL DATA

Air

MEK can be formed as a degradation product of aldehyde and hydrocarbons in the atmosphere. However, it can be expected to degrade photolytically.

Water

By its chemical analogy to acetone, widespread dispersal of MEK in water is possible. Low levels can be expected to be quite stable and persistant. Removal may be more important than degradation.

Biota

MEK is metabolized by microorganisms and mammals (TDB, 1982). Therefore it is not expected to accumulate or biomagnify.

Soil

There is insufficient data to verify accumulation of MEK. However, the metabolisis of MEK by microorganisms in sludge and the volatility of ketones may prevent accumulation of MEK in soil.

Other

MEK is used as a commercial flavor ingredient in non-alcoholic beverages (70 ppm), ice cream (270 ppm), candy (100 ppm) and baked goods (100 ppm) (TDB, 1982).

INDUSTRIAL DATA

Production

No production in North Carolina reported in the Toxic Substances Control Act (TSCA) Chemical Substances Inventory (U.S. EPA, TSCA, 1980).

The estimated U.S. production for 1975-76 was 524 million pounds (262,000 tons) (NIOSH, 1978).

Consumption and Use

Estimated U.S. Consumption in 1971:

Vinyl coatings solvent	34 percent
Nitrocellulose coatings solvent	14 percent
Adhesives solvent	13 percent
Acrylic coatings solvent	10 percent
Catalyst initiator in terephthalic acid production	8 percent
Lube oil dewaxing	7 percent
Misc. coatings and applications	14 percent

(TDB, 1982)

Reported uses of methyl ethyl ketone and the corresponding SIC codes are listed below:

Manufacture of colorless synthetic resins	2821
Surface coatings solvent	252

(ACGIH, 1980)

Solvent for nitrocellulose, adhesives, hardwood pulping	2823, 2981, 2611
In artificial leather manufacture	282
In lacquer and varnish industry	2851
In pharmaceuticals and cosmetics	283
In synthetic rubber	2822, 30

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air

No guidelines for air have been established.

Workroom Air

ACGIH — The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air is 200 ppm (590 mg/cu m) as a time-weighted average. The recommended Short Term Exposure Limit (STEL) is 300 ppm (885 mg/cu m).

NIOSH — The National Institute of Occupational Safety and Health (NIOSH) recommends a standard of 200 ppm (590 mg/cu m) as a time-weighted average.

OSHA — The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 200 ppm (590 mg/cu m) as a time-weighted average.

Water

No guidelines for water have been established.

Other

Regulated as a hazardous material by the U.S. Department of Transportation. Methyl ethyl ketone is classified as a flammable liquid, and shipments must carry a label which reads "flammable liquid."

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Appears on the 1977 Priority List of the Chemical Industry Institute of Toxicology (CIIT).

Appears on the Priority List of the Interagency Testing Committee (ITC).

Subject to a proposed rule under the Toxic Substances Control Act.

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

International Agency for Research on Cancer (IARC). IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon France, Volume 19. A World Health Organization Publication (WHO), Geneva (1979).

National Institute for Occupational Safety and Health/Occupational Safety and Health Administration (NIOSH/OSHA). NIOSH/OSHA Pocket Guide to Chemical Hazards. DHEW (NIOSH) Publication No. 78-210 (September 1978).

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfiche Issue. R. J. Lewis and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 80-111-4 (1980).

Toxicology Data Bank - The National Library of Medicine, Bethesda, Maryland (1982).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA PB-80-155-153 (1980).

N-HEXANE

Executive Summary

CAS NUMBER: 00110-54-3

Normal hexane (n-hexane) is a clear, volatile liquid with a faint, gasoline-like odor. Commercial grades of hexane, which may contain anywhere from 20% to 80% n-hexane, are used as oil seed extractants, solvents, thermometer fillings and to determine the refractive index of chemicals. U.S. production in 1979 was estimated to be 4 billion pounds (2 million tons). n-Hexane is regulated as a hazardous material (flammable liquid) by the U.S. Department of Transportation.

Health Effects

ACUTE. n-Hexane is regarded as an "acute local" toxic hazard, causing readily reversible changes which disappear after the end of exposure. Acute intoxication is not well documented, but believed to involve transient central nervous system depression.

CARCINOGENICITY. No data available.

MUTAGENICITY. Limited data available.

TERATOGENICITY AND EMBRYOTOXICITY. No evidence was found to indicate that n-hexane causes birth defects or is embryotoxic. However, it is listed as a teratogen by RTECS (1982).

CHRONIC. Rats exposed for 5-6 months to an atmosphere containing 2,000 ppm hexane developed various neurological difficulties. Chronic intoxication in humans causes polyneuropathy.

Occupational Health Regulations

ACGIH: The Threshold Limit Value (TLV) for workroom air is 50 ppm (180 mg/cu m) as a time-weighted average.

NIOSH: The standard for workroom air is 100 ppm (350 mg/cu m) as a time-weighted average and the ceiling limit is 510 ppm.

OSHA: The standard for workroom air is 500 ppm (1,800 mg/cu m) as a time-weighted average.

Routes of Human Exposure

OCCUPATIONAL. Workers at risk include those in laminating plants, pharmaceutical plants, oil seed extraction operations and in the production of polyolefins and elastomers.

AMBIENT. No objective data available.

CONSUMER. n-Hexane is used as a food additive, an oil seed extractant, as an agent in cements and inks to control viscosity and reduce drying time, and is used extensively in school laboratories.

Environmental Significance

The aquatic toxicity rating (TLm 96) for n-hexane is over 1000 ppm. Significant amounts of n-hexane are released into the environment through oil seed extraction losses and mobile source emissions.

Recommended Reviews

Sax, N.I., Dangerous Properties of Industrial Materials, 4th Ed., Van Nostrand Reinhold, New York, 1975

Schaumburg, H.H. et al., Central and peripheral nervous system degeneration produced by pure n-hexane, an experimental study. Brain, 99, 183-192, 1976.

Prepared June 1982

FIRST AID AND EMERGENCY RESPONSE INFORMATION

N-HEXANE

First Aid (NIOSH/OSHA)

Eyes: Wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. If irritation persists after washing, get medical attention. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH THIS CHEMICAL.

Skin: Wash contaminated skin immediately with soap or mild detergent. Remove contaminated clothing immediately and wash skin with soap or mild detergent. If irritation persists after washing, seek medical attention.

Inhalation: Move exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep affected person warm and at rest. Get medical attention as soon as possible.

Ingestion: Do not induce vomiting. Get medical attention immediately.

Procedures for Spills and Leaks (U.S. DOT Emergency Response Guidebook, 1980)

Isolate hazard area and deny entry. Stay upwind and keep out of low areas. Wear self-contained breathing apparatus and full protective clothing. Isolate for ½ mile in all directions if tank or tankcar is involved in fire. No flares, smoking or flaames in hazard area. Stop leak if it can be done without risk. Use water spray to reduce vapors.

SMALL SPILLS: Take up with sand, or other noncombustible absorbent, material, then flush area with water.

LARGE SPILLS: Dike far ahead of spill for later disposal.

Fire and Explosion Information

Will burn. May be ignited by heat, sparks and flames. Flammable vapor may spread away from spill and flash back. Container may explode in heat of fire. Vapor explosion hazard indoors, outdoors or in sewers. Runoff to sewer may create fire or explosion hazard.

FLASH POINT: -21.7°C (-7°F) closed cup, flammable limits in air, % by volume: lower, 1.1; upper, 7.5

SMALL FIRES: Dry chemical, CO_2, water spray or foam

LARGE FIRES: Water spray, fog or foam

Move container away from fire if it can be done without risk. Stay away from ends of tanks. Cool containers that are exposed to flames with water from the side until well after fire is out. Withdraw immediately in case of rising sound from venting safety device or discoloration of tank.

Reactivity

MATERIALS TO AVOID: Strong oxidizers

Protective Measures

ENGINEERING CONTROLS: Process enclosure, general dilution ventilation, personal protective equipment, local exhaust ventilation. Sinks, showers and eyewash stations should be available.

PROTECTIVE CLOTHING: Impervious clothing, gloves, faceshields, (8 inch minimum) and splash-proof safety goggles

PROTECTIVE EQUIPMENT: For levels of 1000 ppm or less use any chemical cartridge respirator with an organic vapor canister, any supplied-air respirator, or any self-contained breathing apparatus. For levels of 5000 ppm or less use a gas mask with a chin-style or a front- or back-mounted organic vapor canister, any supplied-air respirator with a full facepiece, helmet or hood, or any self-contained breathing apparatus with a full facepiece. For levels greater than 5000 ppm or entry and escape from unknown concentrations, use a self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode, or a combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.

The North Carolina Toxic Substances Management Guide

N-HEXANE

Profile

Alternative Names:

Dipropyl
Hexane
Hexyl Hydride
Skellysolve B

Chemical Abstract Services (CAS) Registry Number: 00100-54-3

Registry of Toxic Effects of Chemical Substances (RTECS) Number: MN 9275000

Hazardous Materials Table Identification Number: UN 1208

Molecular Weight: 86.18

Molecular Formula: C_6H_{14}

Structure: $CH_3-CH_2-CH_2-CH_2-CH_2-CH_3$

Classification: Saturated straight-chain hydrocarbon

Description: Colorless, very volatile liquid with a faint, gasoline-like odor.

Uses: To determine refractive index of chemicals, thermometer filling, solvent for the extraction of oil seeds.

Chemical/Physical Data

Boiling point: 68.95°C
Melting point: -95°C
Vapor pressure: 150 mm Hg at 25°C
Vapor density: 2.97 (air = 1.0)
Solubility in water: Hexane is insoluble in water.
Solubility in ethyl alcohol: 50 g in 100 ml at 20°C

HUMAN TOXICITY

At the present, limited data exist to present a definitive correlation between hexane exposure concentrations and acute and chronic effects observed in humans or animals. Acute intoxication is believed to involve a transient central nervous system depression (NIOSH, 1980). n-Hexane is regarded as an "acute local"toxic hazard, causing readily reversible changes which disappear after the end of exposure (TDB, 1982). The probable oral lethal dose is 0.5-5 g/kg, or between 1 oz. and 1 pint (1 oz.) for a 70 kg (150 lb) person. The suggested maximum permissible exposure limit is 700 ppm (Patty, 1965).

Exposures of 2000 ppm for 10 minutes resulted in no effects in humans, but 5000 ppm caused dizziness and a sense of giddiness. Slight nausea, headache, eye and throat irritation were observed at 1400 to 1500 ppm. No irritation was observed in unacclimated subjects at a concentration of 500 ppm (ACGIH, 1980).

Chronic intoxication has only recently been established, and is generally agreed to cause polyneuropathy. There are many documented cases of the deleterious effects from n-hexane exposure in industrial situations. Average n-hexane levels in workroom air of 650 ppm, with peaks at 1,300 ppm, produced polyneuropathy in workers after a few months exposure (CHIP, 1978). Further research is needed to determine if multiple or continuous doses would produce effects at dose levels lower than the present standards predict (NTP, 1980).

ANIMAL TOXICITY

n-Hexane is three times as acutely toxic to mice as is pentane; concentrations of 30,000 ppm produced narcosis within 30 to 60 minutes, and convulsons and death resulted from 35,000-40,000 ppm (ACGIH, 1980).

Acute Toxicity

Results of lethal studies in several species are listed below:

Route	Species	Lethal Dose or Lethal Concentration
Oral	Rat	24-43.5 ml/kg, LD50 for rats (CHIP, 1978)
Inhalation	Mouse	120 mg/cu m, lowest LC (TDB, 1982)

Chronic Toxicity

Rats exposed for 5-6 months to an atmosphere containing 2,000 ppm hexane developed various neurological difficulties. n-Hexane alone had no neurological effect on pigeons when administered by inhalation or percutaneous means (8% pure n-hexane in an inhalation chamber for 5 hr/day, 5 days/week for 17 weeks), (CHIP, 1978).

Carcinogenicity

No data available.

Mutagenicity

Limited data available.

NTP, 1980 — Mutagenesis Salmonella typhimurium test result: n-Hexane is scheduled for testing in FY 1981 in Salmonella typhimurium mutagenesis assays.

Teratogenicity & Embryotoxicity

No evidence was found to indicate that n-hexane causes birth defects or is embryotoxic. However, it is listed as a teratogen by RTECS (1982).

Aquatic Toxicity

Aquatic toxicity rating: TLm 96 is 1000 ppm (RTECS 1982).

Bioaccumulation: No data available.

Biodegradation in aquatic species: No data available.

Phytotoxicity

n-Hexane, like other vapor-phase organic pollutants of hydrocarbon origin, produces no pronounced effect on the physical properties of the atmosphere, does not decrease visibility or affect the amount of solar radiation, and does not alter precipitation patterns. The possibility that n-hexane, as a relatively nonreactive paraffin, enters into the photochemical reaction leading to the formation of peroxyacetylnitrate (PAN) has not been reported. However, hydrocarbons similar to n-hexane (n-pentane and methyl pentane) have been implicated in PAN formation (CHIP, 1978).

INDUSTRIAL DATA

Production

No production in North Carolina is reported in the Toxic Substances Control Act (TSCA) Chemical Substances Inventory (U.S. EPA, TSCA, 1980).

U.S. production was estimated at 4 billion pounds (2 million tons) in 1979 (U.S. EPA, CHIP, 1980).

Consumption and Use

Estimated U.S. Consumption: No data were available.

Reported uses of n-hexane and the corresponding SIC codes are listed below:

Solvent for the extraction of oil from seeds	207
Reaction medium for the production of polyolefins, elastomers, and pharmaceuticals	282, 283
Cements and adhesives	2891, 324
Lacquers and inks	285
(U.S. EPA, CHIP, 1980)	
Thermometers (to replace mercury)	381
Solvent in the determination of refractive index of chemicals	-

ENVIRONMENTAL DATA

Air
There are no available data on n-hexane in the environment (NTP, 1980). Releases to the environment include:

- Oil seed extraction losses: 2.2×10^5 gallons annually
- Mobile source emissions: 0.17 million tons (1972) (NIOSH, 1980)

Water
No data available

Soil
No data available

Biota
No data available

Other
There is a significant population potentially exposed from the production and use of n-hexane. The extensive use in school laboratories suggests exposure of large numbers of students to potentially high dose levels (NTP, 1980). n-Hexane is used as a food additive, and as an oil seed extractant, and as an agent in cement and ink to control viscosity and reduce drying time (CHIP, 1978). Several documented cases of n-Hexane (or solvents containing n-hexane) induced polyneuropathy following deliberate chronic glue sniffing have been reported (CHIP, 1978).

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air

No guidelines for ambient air have been established.

Workroom Air

ACGIH — The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air is 50 ppm (180 mg/cu m) as a time-weighted average.

NIOSH — The National Institute of Occupational Safety and Health (NIOSH) recommends a standard of 100 ppm (350 mg/cu m) as a time-weighted average and a ceiling limit of 510 ppm.

OSHA — The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 500 ppm (1,800 mg/cu m) as a time-weighted average.

Water

No guidelines for water have been established.

Other

Regulated as a hazardous material by the U.S. Department of Transportation. The regulations pertain to the identification and transportation of hazardous materials in commerce (Code of Federal Regulations, Title 49, Part 172.101). n-Hexane is classified as a "Flammable Liquid" and shipments must carry that label.

Agencies Concerned with this Chemical

Chemical Hazard Information Profile (CHIP) compiled by the Office of Testing and Evaluation, U.S. Environmental Protection Agency.

Appears on the 1976 Priority List of the Chemical Industry Institute of Toxicology (CIIT).

Subject to a proposed rule under the Toxic Substances Control Act that would require all chemical manufacturers to report production and exposure-related data to the U.S. Environmental Protection Agency (Federal Register, Vol. 45, No. 42, 1980).

Under toxicological evaluation through the National Toxicology Program to determine carcinogenicity and mutagenicity (National Toxicology Program, Fiscal Year 1981 Annual Plan, NTP-80-62, 1980).

Addressed by a National Toxicology Program (NTP) Executive Summary and included in the list of 100 compounds nominated for NTP testing.

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

National Institute for Occupational Safety and Health/Occupational Safety and Health Administration (NIOSH/OSHA). NIOSH/OSHA Pocket Guide to Chemical Hazards. DHEW (NIOSH) Publication No. 78-210 (September 1978).

National Institute for Occupational Safety and Health. National Occupational Hazard Survey. Available from Division of Technical Services, Cincinnati, OH, DHEW 74-127, 77-123, and 78-124 (1980).

National Toxicology Program (NTP). Executive Summary for n-hexane. In Executive Summaries of n-hexane Nominated for FY 81 Testing. U.S. Department of Health, Education and Welfare, Jefferson, Arkansas (1980).

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfiche Issue, R. J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville MD for National Institute for Occupational Safety and Health/ DHHS (NIOSH) Publication No. 80-111-4 (1982).

Toxicology Data Bank - The National Library of Medicine, Bethesda, Maryland.

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Chemical Hazard Information Profiles (CHIPs). EPA-560/11-80-011 (1980).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA PB-80-155-153 (1980).

NITROBENZENE

Executive Summary

CAS NUMBER 00096-95-3

Nitrobenzene is a pale-yellow, oily liquid with an almond-like odor. Its predominant use (97 percent of U.S. production) is in closed systems in aniline manufacture. Federal regulations require reporting of nitrobenzene spills if the spill exceeds 1000 pounds (454 kilograms). North Carolina requires the reporting of all spills if they occur near water.

Health Effects

ACUTE. Nitrobenzene exhibits high toxicity and is absorbed readily through human skin and lungs because of its high fat solubility. It is metabolized slowly. Acute toxic effects include cyanosis, methemoglobinemia, and a variety of central nervous system effects, which may progress to liver damage and/or coma. Alcohol ingestion can increase its toxic effects. Vertigo, headache, and vomiting are often noted.

CARCINOGENICITY. No long-term animal carcinogenesis studies have been performed.

MUTAGENICITY. Nitrobenzene was negative in Salmonella typhimurium assays.

TERATOGENICITY & EMBRYOTOXICITY. Nitrobenzene should be avoided by pregnant women and those contemplating pregnancy. Some abnormalities associated with exposure to nitrobenzene have been observed in animals, and changes in the tissues of the chorion and placenta of pregnant women exposed to nitrobenzene have been reported.

CHRONIC. Subchronic and chronic exposure to nitrobenzene results in methemoglobinemia, histopathological changes in organ tissues such as liver, and central nervous system effects. Chronic exposure may cause menstrual disturbances in women.

Occupational Health

The American Conference of Governmental Industrial Hygienists has established a Threshold Limit Value for workroom air (time-weighted average concentration under which it is believed that all workers may be repeatedly exposed day after day without adverse effect) of 1 ppm (5 mg/cu m) and a Short Term Exposure Limit (the maximum concentration to which workers may be exposed for a period up to 15 minutes) of 2 ppm (10 mg/cu m).

Routes of Human Exposure

OCCUPATIONAL. Workers may be exposed to nitrobenzene in industrial solvents and dye intermediates, as well as wood cleaners and metal polishers. An estimated 19,000 workers are occupationally exposed to nitrobenzene.

AMBIENT. General population exposure can arise from environmental release from industry, but nitrobenzene may also form spontaneously in the atmosphere from the photochemical reaction of benzene with oxides of nitrogen. Nitrobenzene has been detected in raw water and drinking water supplies.

CONSUMER. Exposure to nitrobenzene can occur with the use of woodcleaners and metal polishes. Nitrobenzene was used as a food flavoring agent until 1949.

Environmental Significance

Half-life in air is estimated to be 190 days and in water, 185 hours. A steady-state bioaccumulation factor of 7.31 was calculated based on the octanol/ water coefficient. An average bioconcentration factor of 2.89 was calculated for the edible portion of fish.

Acute toxicity to freshwater aquatic life occurs at concentrations as low as 27 gm/l and to saltwater aquatic life at concentrations as low as 6.7 gm/l. More sensitive species may suffer toxic effects at lower concentrations. No definitive data are available concerning the chronic toxicity of nitrobenzene to sensitive freshwater or saltwater aquatic life.

Phytotoxicity from nitrobenzene in air has not been reported.

North Carolina Production and Users

Production: No known producers

Users: No information available

Recommended Reviews

Ambient Water Quality Criteria for Nitrobenzene, U.S. Environmental Protection Agency (EPA/ 440-5-80-061), Office of Water Planning and Standards.

Carcinogen Assessment Group's Preliminary-Risk Assessment on Nitrobenzene, U.S. Environmental Protection Agency, Carcinogen Assessment Group (June 8, 1979).

Acute Nitrobenzene Poisoning. Z. Myslak et al. Arch. Toxicology 28 (3): 208 (1971).

FIRST AID AND EMERGENCY RESPONSE INFORMATION

NITROBENZENE

First Aid (NIOSH/OSHA Pocket Guide to Chemical Hazards)

Eyes:	Wash with large amounts of water immediately. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH NITROBENZENE.
Skin:	Wash the contaminated skin immediately with soap or mild detergent and water. Remove clothing if contaminated and wash skin.
Inhalation:	Move to fresh air at once. Perform artificial respiration if necessary. Seek immediate medical attention.
Ingestion:	If conscious, give large quantities of water, then induce vomiting by finger. Seek medical attention immediately.
Note to Physician:	Poisoning closely resembles aniline. Treat for methemoglobin formation. Dialysis or transfusion may be necessary.

Procedures for Spills and Leaks (U.S. DOT Emergency Response Guidebook, 1980)

Isolate hazard area and deny entry. Stay upwind and keep out of low areas. Wear positive pressure breathing apparatus and special protective clothing. Do not touch spilled material. Stop leak if it can be done without risk. Use water spray to reduce vapors.

SMALL SPILLS:	Take up with sand, or other noncombustible absorbent material, then flush area with water.
SMALL DRY SPILLS:	Shovel into dry containers and cover; move containers; then flush area with water.
LARGE SPILLS:	Dike far ahead of spill for later disposal.

Fire and Explosion Information

GENERAL: Flammable, vapors may form explosive mixture in air. Ignites at 88°C (190°F).

Reactivity

CONDITIONS TO AVOID: Heat, flame and sources of ignition.

MATERIALS TO AVOID: Reacts violently with nitric acid, nitrogen tetroxide, silver perchlorate, mixtures of aniline and glycerine and mixtures of aluminum chloride and phenol. Reacts with active metals like tin and zinc and many caustic substances such as lye.

Protective Measures

STORAGE AND HANDLING: Protect from physical damage, heat and sources of ignition. Separate, detached storage preferred. Workers should change clothing and wash after each shift.

ENGINEERING CONTROLS: Provide adequate ventilation. Sinks, showers and eyewash stations should be easily available.

PROTECTIVE CLOTHING (Should not be substituted for proper engineering and handling controls): Impermeable clothing, butyl rubber boots and gloves, and chemical goggles or faceshield should be worn if contact with nitrobenzene is possible. Contaminated leather or plastic clothing should be discarded.

PROTECTIVE EQUIPMENT: For levels up to 10 ppm, use a chemical cartridge respirator with organic vapor cartridges, a supplied air-respirator, or a self-contained breathing apparatus. For up to 50 ppm, use the above with full facepiece or a gas mask with organic vapor canister. For up to 200 ppm, use a supplied-air respirator with full facepiece in pressure-demand, positive pressure or continuous-flow mode. For escape from a contaminated area, wear a gas mask with organic vapor canister or self-contained breathing apparatus.

NITROBENZENE

Profile

CHEMICAL IDENTIFICATION

Alternative Names:

Benzene, Nitro
Essence of Mirbane
Essence of Myrbane
Mirbane Oil
Nigrosine Spirit Soluble B
Oil of Bitter Almonds
Oil of Mirbane
Oil of Myrbane
Nitrobenzol
Solvent Black 5

Chemical Abstract Services (CAS) Registry Number: 00098-95-3

Registry of Toxic Effects of Chemical Substances (RTECS) Number: DA6475000

Hazardous Materials Table Identification Number: UN 1662

RCRA Identification Number: U 169

Molecular Weight: 123.12

Molecular Formula: $C_6H_5NO_2$

Structure:

Classification: The simplest of the aromatic nitro compounds.

Description: A pale-yellow oily liquid with an almond-like odor.

Uses: Manufacturing of soaps, explosives, dyes, glues, greases and cements.

Chemical/Physical Data

Boiling point: 210.8°C
Melting point: 5.6°C
Vapor pressure: 1 mm Hg at 44.4°C; 0.34 mm at 25°C
Vapor density: 4.1 (air = 1.0)
Solubility in water: 1.9 gm/l at 20°C
Explosion limit in air: 95.5°C 1.8% by volume
Flash point (closed cup): 87.8°C

HUMAN TOXICITY

Nitrobenzene is absorbed readily through human skin and lungs because of its high fat solubility (U.S. EPA, CAG, 1979). A worker exposed to the current occupational standard of 5 mg/cu m (1 ppm) nitrobenzene for an eight-hour day would absorb approximately 24 mg by inhalation and 9 mg cutaneously. Retention through the lungs may be as high as 2 mg/sq cm per hour (U.S. EPA, WQC, 1980). Reports of human poisonings from the absorption of nitrobenzene from shoe dyes and laundry marking dyes were common during the first half of the century (U.S. EPA, WQC, 1980).

Nitrobenzene is slowly metabolized. Acute toxic effects include cyanosis, methemoglobinemia, a variety of central nervous system effects which may progress to coma, and liver damage (U.S. EPA, CAG, 1979).

Reported effects of chronic exposure include changes in the bone marrow of workers using nitrobenzene solvents, predominantly hyperplasia of the lymphoid reticular cells. Chronic exposure to nitrobenzene may produce menstrual disturbances and changes in the chorion and placenta of pregnant women (U.S. EPA, CAG, 1979).

Alcohol ingestion can increase toxic effects (U.S. EPA, WQC, 1980). Among the metabolites of nitrobenzene found in human urine are p-aminophenol and p-nitrophenol (U.S. EPA, CAG, 1979).

The maximum level at which one could escape within 30 minutes without any escape-impairing symptoms or irreversible effects is estimated to be 200 ppm (NIOSH/OSHA, 1978).

Carcinogenicity

U.S. EPA, CAG, 1979 — No long-term animal carcinogenesis studies have been performed.

NTP, 1980 — Nitrobenzene was nominated for carcinogenesis bioassay, testing was scheduled via gavage to start in Fiscal Year 1981.

CIIT, 1981 — Preliminary range finding tests have been completed and 3-month inhalation toxicity study in rats and mice will be initiated (CIIT, 1982).

Mutagenicity

U.S. EPA, CAG, 1979 — The single Ames mutagenicity assay was negative, but only one strain of Salmonella typhimurium, a frame-shift mutant, was used. This is not conclusive evidence against mutagenicity because no base-substitution mutant of Salmonella typhimurium was used, and because the frame-shift mutant is not the most sensitive one available. A study reported that nitrobenzene was mutagenic to Drosophila when administered as a vapor but was not mutagenic when added to the liquid medium.

NTP, 1980 — Mutagenesis Salmonella typhimurium test result: Negative. Additional testing is scheduled for Fiscal Year 1981.

Teratogenicity & Embryotoxicity

The available data indicate that women who are or wish to become pregnant should avoid exposure to nitrobenzene. Some abnormalities associated with exposure to nitrobenzene have been observed in animals. Changes in the tissues of the chorion and placenta of pregnant women exposed to nitrobenzene are also reported (U.S. EPA, WQC, 1980).

ANIMAL TOXICITY

The in vivo production of methemoglobin by nitrobenzene has been demonstrated in dogs, rabbits and rats.

Acute Toxicity

Results of lethal studies in several species as reported in the RTECS, 1980, are listed below:

Route	Species	Lethal Dose or Lethal Concentration
Oral	Rat	640 mg/kg, LD50
	Dog	750 mg/kg, lowest lethal dose
	Cat	2,000 mg/kg, lowest lethal dose
	Rabbit	700 mg/kg, lowest lethal dose
Dermal	Rabbit	600 mg/kg, lowest lethal dose

Subchronic/Chronic Toxicity

Subchronic and chronic studies with different animal species exposed to nitrobenzene by various routes most often exhibit methemoglobinemia, followed by histopathological changes in a number of organ systems. These systems include the hemato-lymphoreticular system, central nervous system and liver (CIIT, 1981. Current Status Report - A Critical Review of the Literature on Nitrobenzene Toxicity).

AQUATIC AND TERRESTRIAL TOXICITY

Aquatic Toxicity

The U.S. EPA Water Quality Criteria (1980) for protection of aquatic life are given below:

Acute toxicity to freshwater aquatic life occurs at concentrations as low as 27 mg/l. Acute toxicity to saltwater aquatic life occurs at concentrations as low as 6.7 mg/l. More sensitive species may suffer toxic effects at lower concentrations. No definite data are available concerning the chronic toxicity of nitrobenzene to sensitive freshwater or saltwater aquatic life.

Radio-labeled nitrobenzene was studied for its effect in a model aquatic ecosystem. The results indicate that nitrobenzene is less likely to be stored in fatty tissues than DDT (Callahan, 1980).

A steady-state bioaccumulation factor of 7.31 was calculated based on the octanol/water partition coefficient. An average bioconcentration factor of 2.89 was calculated for the edible portion of fish (U.S. EPA, WQC, 1980).

Phytotoxicity

Phytotoxicity from nitrobenzene in air was not reported.

Reduction in cell number and inhibition of chlorophyll were observed in both freshwater and saltwater alga as a result of exposure to nitrobenzene. Toxic effects were noted at concentrations as low as 9.7 mg/l (U.S. EPA, WQC, 1980).

ENVIRONMENTAL DATA

Air

Nitrobenzene may form spontaneously in the atmosphere from the photochemical reaction of benzene with oxides of nitrogen (U.S. EPA, WQC, 1980). Nitrobenzene has a long oxidative half-life in air (190 days, Cupitt, 1980). Although there are no reports of accumulation in the atmosphere (Callahan, 1979), dispersion in this medium is likely. Some degradation through photoreduction is also possible.

Water

The persistence of nitrobenzene and its degradation products cannot be ascertained from existing data (Callahan, 1979). Nitrobenzene has been detected in raw water and drinking water supplies (Shackelford, 1976). Some photodegradation may occur; hydrolysis is not expected. There is insufficient evidence with which to evaluate nitrobenzene's potential for accumulation in this medium.

Soil

The degradation and adsorption of nitrobenzene in soil has been noted. Photoreduction on humus and acid-base catalyzed reactions of reduction products on clay are probable fates. Nitrobenzene's polar nature and miscibility with organic material assures adsorption, and accumulation is likely to some degree. Dispersion on soils and sediments can also be expected.

Biota

Nitrobenzene was neither stored nor magnified in model aquatic ecosystems. It is metabolized in mammals, and evidences low bioaccumulation in fish (U.S. EPA, WQC, 1980). Decomposition by soil microflora required at least 64 days. Nitrobenzene is probably not persistent in this medium.

INDUSTRIAL DATA

Production

Production of nitrobenzene in North Carolina is not reported in the Toxic Substances Control Act (TSCA) Chemical Substance Inventory (U.S. EPA, TSCA, 1980).

U.S. annual production estimates range from 200 million to over 700 million pounds (100,000-350,000 tons) (U.S. EPA, WQC, 1980).

Consumption and Use

Estimated U.S. Consumption:

Production of aniline	97 percent
Solvent and other uses	3 percent

Reported uses of nitrobenzene and the corresponding SIC codes are listed below:

Manufacture of aniline	2869
Manufacture of soaps	2841
Manufacture of shoe polishes	2842
For refining lubricating oils	2992
Manufacture of pyroxylin compounds	2869

(Merck, 1976)

Solvent for Friedel-Crafts reaction	28
Metal polishes	3471
Perfumes	2844
Dye intermediates	2865

Crystallizing solvent
Combustible propellent
(U.S. EPA, WQC, 1980)

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air
Under evaluation for possible designation as a Hazardous Air Pollutant by the U.S. Environmental Protection Agency.

Workroom Air

ACGIH — The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists for workroom air is 1 ppm (5 mg/cu m) as a time-weighted average. The recommended Short Term Exposure Limit (STEL) is 2 ppm (10 mg/cu m). The importance of skin exposure is noted.

OSHA — The Occupational Safety and Health Administration's standard for workroom air is 1 ppm (5 mg/cu m) as a time-weighted average.

Water
Addressed by Ambient Water Quality Criteria set by the U.S. Environmental Protection Agency.

Designated a toxic pollutant by the U.S. Environmental Protection Agency.

Designated a hazardous substance by the U.S. Environmental Protection Agency.

Other
Regulated as a hazardous material by the U.S. Department of Transportation.

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Organizations Concerned with this Chemical

Appears on the 1978 Priority List of the Chemical Industry Institute of Toxicology (CIIT). CIIT performs in-depth, extensive toxicity testing of commodity chemicals of high priority to the chemical industry (Chemical Industry Institute of Toxicology. 1979 Annual Report and Scientific Review: Science in the Public Interest, Research Triangle Park, N. C.; Current Status Report - A Critical Review of the Literature on Nitrobenzene Toxicity (1981)).

Reviewed by the Carcinogen Assessment Group (CAG) of the U.S. Environmental Protection Agency. No recommendation was made because of inadequate data.

Appears on the Priority List of the Interagency Testing Committee (ITC).

Subject to a proposed rule by the U.S. Environmental Protection Agency (EPA) under the Toxic Substances Control Act, Section 4(a) that would require manufacturers and processors to test the chemical according to standards EPA has adopted. Proposed testing includes: structural teratogenicity, reproductive effects; aquatic vertebrates -- acute and chronic toxicity, aquatic invertebrates -- chronic toxicity; birds -- acute and chronic toxicity; terrestrial plants -- early seedling growth, seed germination, root elongation; bioconcentration -- plant uptake/translocation; and soil adsorption (Federal Register, Vol. 46, No. 108, June 5, 1981). Nitrobenzene has been removed from the TSCA Section 4(e) priority list as a result of re-evaluation of existing data and testing, and proposed testing (47 FR 5456 - 5459 (Feb. 5, 1981).

Subject to a proposed rule under the Toxic Substances Control Act that would require all chemical manufacturers to report production and exposure-related data to the U.S. Environmental Protection Agency (Federal Register, Vol. 45, No. 42, 1980).

Under toxicological testing through the National Toxicology Program to determine carcinogenicity and mutagenicity (National Toxicology Program, Fiscal Year 1981 Annual Plan, NTP-80-62, December, 1980).

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH), Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Beard, R. R. and Noe, J. T. Aromatic Nitro and Amino Compounds. From G. O. Clayton and F. E. Clayton, Eds., Patty's Industrial Hygiene and Toxicology. 3rd Edition, pp, 2413-2489 (1981).

Callahan, M. A., et al. Water-Related Fate of 129 Priority Pollutants. U.S. EPA Office of Water Planning and Standards, Washington, DC, EPA-440/4-79-029 (December, 1979).

Cupitt, L. T. Fate of Toxic and Hazardous Materials in the Air Environment. EPA-600/3-80-084, NTIS, PB 90-2221948 (September, 1980).

Merck Index: An Encyclopedia of Chemicals and Drugs, Ninth Edition, N. Wind-holz, Ed. Merck and Co., Rahway, NJ (1976).

National Institute of Occupational Safety and Health/Occupational Safety and Health Administration (NIOSH/OSHA). NIOSH/OSHA Pocket Guide to Chemical Hazards. DHEW (NIOSH) Publication No. 78-210 (September, 1978).

National Toxicology Program. Annual Plan for Fiscal Year 1981. Department of Health and Human Services, NTP-80-62 (December, 1980).

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfiche Issue, R. J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 80-111-4 (1980).

U.S. Environmental Protection Agency, Carcinogen Assessment Group (CAG). Carcinogen Assessment Group's Preliminary Risk Assessment on Nitrobenzene. Washington, DC (June 8, 1979).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA PB-80-155-153 (1980).

U.S. Environmental Protection Agency, Office of Water Planning and Standards. Ambient Water Quality Criteria for Nitrobenzene. EPA-440/5-80-061, PB81 117-723 (October, 1980).

Verschueren, Karel. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York, NY (1977).

PHENOL

Executive Summary

CAS NUMBER: 00108-95-2

Phenol is a white or colorless crystalline substance with a distinct aromatic, acrid odor. It is used commercially in the manufacture of phenol resins, and as a solute for a variety of medically related purposes (disinfectant, anesthetic and antiseptic caustic). Phenol is highly toxic, and lethal doses may be readily absorbed through the skin. Federal regulations require the reporting of phenol spills if they exceed 1,000 pounds (454 kg). North Carolina requires the reporting of all spills if they occur near water.

Health Effects

ACUTE. Exposure to phenol through ingestion or skin contact may produce depressed CNS functions, including nausea, vomiting, circulatory collapse, paralysis, convulsions, coma and death.

Lethal oral doses for animals ranges from 80 mg/kg (LDLo, cat), to 420 mg/kg (LDLo, rabbit).

CARCINOGENICITY. Although phenol has been shown to be a tumor promoter, carcinogenicity or cocarcinogenicity have not been established.

MUTAGENICITY. Existing information regarding the mutagenicity of phenol is judged to be equivocal. Further testing is in progress.

TERATOGENICITY AND EMBRYOTOXICITY. No evidence of teratogenicity was found.

CHRONIC. Chronic poisoning is rarely reported. Symptoms include vomiting, difficulty in swallowing, lack of appetite, headache, skin rash and possible damage to the liver and kidney.

Occupational Health Regulations

ACGIH — The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air is 5 ppm (19 mg/cu m) as a time-weighted average. The importance of avoiding skin exposure is noted. The recommended Short Term Exposure Limit (STEL) is 10 ppm (38 mg/cu m).

NIOSH — The National Institute of Occupational Safety and Health (NIOSH) recommends a standard of 5 ppm (19 mg/cu m) as a time-weighted average and a ceiling limit of 60 mg/cu m.

OSHA — The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 5 ppm (19 mg/cu m) as a time-weighted average. The importance of avoiding skin exposure is noted.

Routes of Human Exposure

OCCUPATIONAL. The "at risk" population for industrial exposure to phenol is estimated to to 10,000 persons.

AMBIENT. Ambient exposure to phenol is primarily through drinking water. The intake of phenol from drinking water from a nonpolluted source is estimated to be 3 µg/day. Exposure through inhalation is considered insignificant (with the exception of industrial exposure).

CONSUMER. Consumer exposure to phenol occurs mainly through the consumption of smoked meat products. Medical preparations are also a minor source of exposure to this substance.

Environmental Significance

Phenol undergoes rapid degradation in most media, including biota where little or no bioaccumulation/biomagnification is expected. Phenol adversely affects indigenous biota including algae, protozoa, invertebrates and vertebrates. A TLm 96 of 10-100 ppm has been established.

Recommended Reviews

Buikema, A. L. Jr. et al., 1979. Phenolics in aquatic ecosystems: A selected review of recent literature. Mar. Environ. Res. 2, 87-181.

Deichman, W. B. and Keplinger, M. L., 1962. Phenols and phenolic compounds. In Industrial Hygiene and Toxicology, 1363-1375. Interscience, New York.

FIRST AID AND EMERGENCY RESPONSE INFORMATION

PHENOL

First Aid (NIOSH/OSHA)

Eyes: Wash eyes immediately with large amounts of water, lifting upper and lower lids during irrigation procedure. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH PHENOL.

Skin: Promptly wash the contaminated skin using soap or mild detergent and water. Remove contaminated clothing immediately and wash skin with mild soap and water. Get medical attention immediately.

Inhalation: Move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

Ingestion: Give large amounts of water immediately (if person is conscious). After water has been swallowed, induce vomiting by finger. Do not make an unconscious person vomit. Get medical attention immediately.

Procedures for Spills and Leaks (U.S. DOT Emergency Response Guidebook, 1980)

Isolate hazard area and deny entry. Stay upwind and keep out of low areas. Wear positive pressure breathing apparatus and special protective clothing. Do not touch spilled material. Stop leak if it can be done without risk. Use water spray to reduce vapors.

SMALL SPILLS: Take up with sand, or other noncombustible absorbent material, then flush area with water.

SMALL DRY SPILLS: Shovel into dry containers and cover, move containers, then flush area with water.

LARGE SPILLS: Dike far ahead of spill for later disposal.

Fire and Explosion Information

FLASH POINT: 79°C (174°F) (closed cup)
AUTOIGNITION TEMPERATURE: 715°C (1,319°F)
FLAMMABLE LIMITS IN AIR: Lower: 1.7%; Upper: 8.6%

Phenol may burn, but it does not ignite readily. Container cylinder may explode in heat of fire.

SMALL FIRES: Dry chemical, CO_2; water spray or foam
LARGE FIRES: Water spray, fog or foam.

Move container if it can be done without risk. Fight fire from maximum distance.

Reactivity

MATERIALS TO AVOID: Strong oxidizers, calcium hypochlorite.

Protective Measures

ENGINEERING CONTROLS: Process enclosure, local exhaust ventilation and protective equipment.

PROTECTIVE CLOTHING (Should not be substituted for engineering controls): Non-impervious clothing and gloves, dust and splash-proof safety goggles.

PROTECTIVE EQUIPMENT: For levels of 50 ppm or less use any chemical cartridge respirator with an organic vapor cartridge(s) and dust and mist filter(s), or any supplied-air respirator or any self-contained breathing apparatus. For levels up to 100 ppm use a chemical cartridge respirator with a full facepiece, organic vapor cartridge, and dust and mist filter, a gas mask with a chin-style or front- or back-mounted organic vapor canister and dust and mist filter, any suppliedair respirator with full facepiece, helmet or hood, or any self-contained breathing apparatus with a full facepiece. For levels greater than 100 ppm or entry and escape from unknown concentrations, use a self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode, or a combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.

PHENOL

Profile

CHEMICAL IDENTIFICATION

Alternative Names:

Carbolic Acid
Hydroxybenzene
Monohydroxybenzene
Oxybenzene
Phenic Acid
Phenylic Acid
Phenyl Hydrate
Phenyl Hydroxide

Chemical Abstract Services (CAS) Registry Number: 00108-95-2

Registry of Toxic Effects of Chemical Substances (RTECS) Number: SJ 3325000
SJ 3333000 (liquid)

Hazardous Materials Table Identification Number: UN 1671

RCRA Identification Number:

Molecular Weight: 94.11

Molecular Formula: C_6H_6O

Structure: 

Classification: A hydroxy aromatic; monohydroxy substituted benzene

Description: A white crystalline substance with a distinct aromatic, acrid odor

Uses: Disinfectant, anesthetic and antiseptic caustic; in manufacture of phenolic resins

Chemical/Physical Data

Boiling point: 182°C
Melting point: 43°C
Vapor pressure: 0.3513 mm Hg at 25°C
Vapor density: 3.24 (Air = 1.0)
Solubility in water: Soluble (6.6 mg/100 ml)

HUMAN TOXICITY

Phenol is toxic to humans by all routes of administration. When it comes in contact with the eyes, it may cause severe damage and blindness. On contact with the skin, it causes severe burns or systemic poisoning (Sittig, 1979). Crystaline phenol has produced gangrene after 30 minutes of skin contact. Phenol in solution rapidly penetrates the skin, and solutions containing 50-100% phenol have caused death after skin contact as brief as 5-20 minutes (Babich and Davis, 1981).

Systemic effects may occur from any route of exposure. Phenol depresses CNS functions, and acute exposure may result in nausea, vomiting, circulatory collapse, paralysis, convulsions, coma and death. Ingestion of phenol, even in small amounts, is hazardous to human life; 4.8 g of phenol by ingestion resulted in death in 10 minutes (Babich and Davis, 1981).

Due in part to its low volatility, phenol does not frequently constitute a respiratory hazard. Vapor concentrations at or below 20 mg/cu m (5.2 ppm) and skin exposure to vapor concentrations at or below 25 mg/cu m (6.8 ppm) produced no biologic disorders in humans (NIOSH, 1976).

Chronic phenol poisoning, caused by repeated or prolonged exposure to this substance, is very rarely reported. Symptoms of chronic poisoning include vomiting, difficulty in swallowing, diarrhea, lack of appetite, skin rash, headache and possible damage to the liver and kidney (Sittig, 1979). Daily contact with solutions containing phenol (1%) over long periods of time have caused invasive epithelioma and coma. Ingestion of 48 ml of 1-2% phenol solution (0.5-1.0 g of phenol) 3-5 times/day produced a burning sensation in the throat, giddiness, cold and profuse prespiration and weak pulse.

The maximum level at which one could escape within 30 minutes without any escape-impairing symptoms or irreversible effects is suggested to be 100 ppm (38 mg/cu m) (NIOSH, 1978).

Carcinogenicity

Phenol has been shown to be a "tumor promoter", although it is not carcinogenic or cocarcinogenic (Babich and Davis, 1981).

Mutagenicity

The existing information on the mutagenicity of phenol is inconclusive (U.S. EPA, CAG, 1980).

Mutagenesis Salmonella typhimurium test result: Phenol was scheduled for Salmonella mutagenesis assay in FY 1981.

Teratogenicity and Embryotoxicity

No evidence of teratogenicity or embryotoxicity was found.

ANIMAL TOXICITY

Animals given lethal doses of phenol exhibit symptoms of neuromuscular hyperexcitability and variations in pulse and blood pressure. Pathologies are dependent on the route of exposure, the concentration of the toxicant, and the duration of exposure. Dermal applications of phenol induce eczema, inflammation, discolorations, necrosis, sloughing and gangrene. Inhalation adversely affects the lungs, causing hyperemia, infarcts, pneumonia and bronchitis. Ingestion produces swellings, and necrosis of the mucous

membranes of the throat and esophagus. Other pathologic abnormalities induced by phenol include demyelination of nerve fibers, myocardial degeneration and necrosis, kidney damage and liver damage (Babich and Davis, 1981).

Acute Toxicity

Results of lethal studies in several species as reported in the RTECS, 1980 are listed below:

Route	Species	Lethal Dose or Lethal Concentration
Oral	Rat	530 mg/kg, LD50
	Rabbit	600 mg/kg, LD50
	Cat	100 mg/kg, LD50
Dermal	Rat	450 mg/kg, LD50
	Guinea pig	680 mg/kg, LD50
	Rabbit	500-600 mg/kg, LD50
	Cat	90 mg/kg, LD50

Chronic Toxicity

Guinea pigs were severely injured by inhalation for 20 days of phenol vapor at concentrations of from 25-50 ppm. Post mortem evidence of acute toxicity to the lungs, heart, liver, and kidney was found (NIOSH, 1976).

Aquatic Toxicity

Aquatic toxicity rating: TLm 96 is 10-100 ppm (RTECS, 1980).

A summary of the U.S. EPA water quality criteria for protection of aquatic life is given below.

> The available data for phenol indicate that acute and chronic toxicity to freshwater aquatic life occur at concentrations as low as 10-100 and 2,560 µg/l, respectively.

Phenol adversely affects indigenous biota, including algae, protozoa, invertebrates and vertebrates. It causes, in addition to overt toxicity, reduced fertility, decreased survival of the young and inhibition of growth. The toxicity of phenol is modified by salinity, water hardness, temperature, and biotic factors such as size and nutritional status of the organism (Babich and Davis, 1981).

ENVIRONMENTAL DATA

Air

Limited and incomplete data are available regarding the presence of phenol in ambient air. It is assumed that phenol undergoes rapid degradation in the troposphere through photooxidation. Removal by precipitation is also possible, and accumulation in this medium is unlikely (Callahan, 1979, Cupitt, 1980).

Water

Phenol has been detected in finished drinking water, surface waters and in industrial effluents. The level of phenol in industrial effluents varies from 10 mg/l (oil refinery wastewater) to 5,000 mg/l (coke oven effluents). The level of phenol in domestic wastewater varied from 0.1 to 1.0 mg/l (Coulston, 1981). A U.S. Geological Survey has determined the mean concentration of phenol in the lower Mississippi River to be 1-5 µg/l. Levels from less than 0.5-5 µg/l have been detected in the Detroit River, from 2-4 µg/l in the Delaware River, and 25 µg/l in the Ohio River (Babich and Davis, 1981). Phenol is not persistent in water due to rapid degradation and some volatilization (Callahan, 1979).

Soil

A low octanol/water partition coefficient of 1.46 suggests that phenol undergoes only slight sorption onto organic sediments, where it is rapidly biodegraded by a mixed population of soil microorganisms (Callahan, 1979). The formation and persistence of stable organic/inorganic aggregates is unlikely.

Biota

Phenol is a normal constituent of human and animal wastes, and of micro-biological decomposition of organic matter (EPA, WQC, 1980), as well as animal tissues (Babich and Davis, 1981). Microbial biodegradation and biotransformation by higher organisms is documented, and little or no bioaccumulation is expected. Biomagnification is unlikely.

Other

Consumer exposure to phenol occurs primarily through the consumption of meat, A level of 7 mg/kg phenol was detected in smoked summer sausage and of 38.6 mg/kg in smoked pork belly. The intake of phenol in nonpolluted water is estimated at 3 ug/day. Medicine preparations are a minor source of phenol (Babich and Davis, 1981).

The EPA estimates that the "at risk" population for industrial exposure to phenol is approximately 10,000 persons (EPA, WQC, 1980).

INDUSTRIAL DATA

Production

Production in North Carolina is reported by two firms in the U.S. EPA Toxic Substances Control Act (TSCA) Chemical Substance Inventory:

Morganton Plant, Morganton, N.C.	0.4-5 tons/year
Southeastern, Lenoir, N.C.	5-50 tons/year

(U.S. EPA, TSCA, 1980)

Consumption and Use

Estimated U.S. Consumption in 1971:

Phenolic resins	41 percent
Dodecylphenol	2 percent
Caprolactam	17 percent
Wonylphenol	2 percent
Bisphenol-A	10 percent
2,4-D	1 percent
Adipic acid	3 percent
Pentachlorphenol	1 percent
Salicylic acid	3 percent
Other chlorophenols	2 percent
Plasticizers	2 percent
Miscellaneous	16 percent

Reported uses of phenol and the corresponding SIC codes are listed below:

Production of phenolic resins, plastics, and in organic synthesis	28, 282
Production of drugs and pharmaceuticals	283
Disinfectant, fungicide and slimicide	2879
Production of explosives, fertilizer	2892, 287
Illuminated gas, coke, lamp black	3817, 3312
Production of paints and paint removers, rubber, asbestos goods, wood preservatives	2865, 30 2491
Production of textiles, perfumes (NTP, 1979 and MEDLARS, 1981)	22, 2844

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air
Under evaluation for possible designation as a Hazardous Air Pollutant by the U.S. Environmental Protection Agency.

Workroom Air

ACGIH — The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air is 5 ppm (19 mg/cu m) as a time-weighted average. The importance of avoiding skin exposure is noted. The recommended Short Term Exposure Limit (STEL) is 10 ppm (38 mg/cu m).

NIOSH — The National Institute of Occupational Safety and Health (NIOSH) recommends a standard of 5 ppm (19 mg/cu m) as a time-weighted average and a ceiling limit of 60 mg/cu m.

OSHA — The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 5 ppm (19 mg/cu m) as a time-weighted average. The importance of avoiding skin exposure is noted.

Water
Addressed by Ambient Water Quality Criteria set by the U.S. Environmental Protection Agency.

Designated a toxic pollutant by the U.S. Environmental Protection Agency.

Designated a hazardous substance by the U.S. Environmental Protection Agency.

Other
Regulated as a hazardous material by the U.S. Department of Transportation.

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Agencies Concerned with this Chemical

Appears on the 1976 Priority List of the Chemical Industry Institute of Toxicology (CIIT).

Under toxicological evaluation through the National Toxicology Program to determine teratogenicity (National Toxicology Program, Fiscal Year 1981 Annual Plan (NTP-80-62, 1980).

Addressed by a National Toxicology Program (NTP) Executive Summary and included in the list of 100 compounds nominated for NTP testing.

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Babich, H., and D. L. Davis. Phenol: A Review of Environmental and Health Risks. Regulatory Toxicology and Pharmacology, Vol 1, No. 1. F. Coulston, and A. Kolbye, eds. Academic Press, Inc., New York, NY (1981).

Callahan, M.A., et al. Water-Related Fate of 129 Priority Pollutants. U.S. EPA Office of Water Planning and Standards, Washington, DC, EPA 440/4-79-029 (December, 1979).

Cupitt, L. T. Fate of Toxic and Hazardous Materials in the Air Environment. EPA-600/3-80-084, NTIS PB 80-221948 (September 1980).

National Institute for Occupational Safety and Health/Occupational Safety and Health Administration (NIOSH/OSHA). NIOSH/OSHA Pocket Guide to Chemical Hazards. DHEW (NIOSH) Publication No. 78-210 (September 1978).

National Institute for Occupational Safety and Health. National Occupational Hazard Survey. Available from Division of Technical Services. Cincinnati, OH, DHEW 74--127, 77-123, and 78-114 (1980).

National Toxicology Program. Fiscal Year 1981 Annual Plan. NTP 80-62 (1980).

National Toxicology Program. NTP Executive Summaries. Prepared by the National Center for Toxicological Research, Office of Scientific Intelligence, Jefferson, Arkansas (March 1979).

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfiche Issue, R. J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville, MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 80-111-4 (1980).

Shepard, T. H. Catalog of Teratogenic Agents. The John Hopkins University Press, Baltimore, MD (1973).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA PB-80-155-153 (1980).

U.S. Environmental Protection Agency, Office of Water Planning and Standards. Ambient Water Quality Criteria for Phenol. EPA-440/5-80-066 (October 1980).

Verschueren, Karel. Handbook of Environmental Data on Organic Chemical. Van Nostrand Reinhold Co., New York, NY (1977).

SELENIUM

Executive Summary

CAS Number: 07782-49-2

Selenium, a group VIA element, is a dark red to bluish-black, amorphous solid; it also appears as dark red, gray or black crystals. It was first isolated from pyrite by Berzelius, and occurs naturally in air, water and soil in small concentrations. Selenium is currently produced commercially in the U.S. as a by-product of copper smelting. Four-fifths of the selenium consumed commercially in the U.S. is used in the manufacture of electronic components, ceramic and glass products. The primary interest in selenium is its toxicity to man (particularly through inhalation at industrial sites) and animals (through the ingestion of seleniferous plants).

Health Effects

ACUTE. The toxicity of selenium varies according to the chemical form involved: (Se^{-2}) $SeO_3)^{-2}$ $(SeO_4)^{-2}$ Se (HEW, 1969 & Ewan). Symptoms resulting from inhalation or dermal absorption are characterized by nasal and tracheobronchial mucosal irritation, nervousness, vomiting, somnolence, and eventually, death from respiratory failure and/or toxic action on the nervous system. Although the existence of chronic selenium toxicity of dietary origin has not been firmly established for humans, daily selenium intakes of 0.1 to 0.2 mg Se/kg body weight have produced clinical symptoms which include jaundice, vertigo, chronic gastrointestinal disease, and edema.

CARCINOGENICITY. Available data are insufficient to allow an evaluation of the carcinogenicity of selenium compounds. There is insufficient evidence to support a correlation between regional cancer death rates and selenium occurrence in the soil (IARC, 1975).

MUTAGENICITY. Because of the limited dose range in which weak activity was detected, additional evidence to confirm mutagenicity is needed (NTP. 1979).

TERATOGENICITY & EMBRYOTOXICITY. Although teratogenic effects have been observed in animals, they have not been established in man (NIOSH, 1978).

CHRONIC. A review of the effects of Se on industrial workers has revealed symptoms, but not deaths. Long-term intoxication causes kidney, liver and spleen damage. An accidental spray of selenium dioxide, in unspecified form and concentration, into the eyes of a chemist, caused superficial burns of the skin and irritation to the eyes. Acute burns and blistering of the skin can be caused by selenium oxychloride and selenium oxide.

Occupational Health

The American Conference of Governmental Industrial Hygienists (ACGIH) has established a Threshold Limit Value (TLV) of 0.025 ppm (0.2 mg/cu m) for selenium compounds, and 0.05 ppm (0.4 mg/cu m) for selenium hexafluoride, a colorless gas.

Routes of Human Exposure

OCCUPATIONAL. Primary exposure to man occurs during the mining, recovery, and purification of selenium compounds; the manufacture of glass, semiconductors, photocells, lubricants and rubber manufacture. The National Occupational Hazard Survey estimates that about 206,100 workers in approximately 870 plants are exposed to elemental selenium, sodium selenite and cadmium selenide.

AMBIENT. Selenium occurs naturally in air, water and soil in small concentrations. Selenium in the atmosphere can exist as a result of natural or industrial processes. Reported urban levels of selenium generally range from 2.5 mg/cu m to 9.7 mg/cu m (WQC, 1980). The major source of industrial emissions of selenium is the burning of coal. Average concentrations of selenium in tap water samples ranged from 1 ug/l (limit of detection) to 36.8 ug/l. River water in seleniferous areas had concentrations as high as 2.7 mg/l. Selenium is present in the earth's crust generally at concentrations of less than 1 ppm.

CONSUMER. Levels of selenium in food can be expected to reflect soil concentrations. Estimated daily consumption of selenium in the diet is 132 µg/day for nonseleniferous regions of the U.S. Selenium has been found in fossil fuels, and is currently used in the commercial preparation of some shampoos.

Environmental Significance

Because atmospheric selenium from conventional combustion is generally reduced to its elemental (relatively nontoxic) form, phytotoxicity from selenium air pollution is not expected to be a problem. Selenium accumulation from the soil can be extremely high and comparatively non-phytotoxic in some plants (notably legumes or "selenium accumulators"), while it is toxic to others (grains, grasses and crop plants) at concentrations of 300 ppm or less. Acute and chronic toxicity is well documented for livestock which have grazed on seleniferous plants. Symptoms of selenium intoxication in animals include ataxia, "blind staggers", labored respiration, atrophy and degeneration and necrosis of the myocardium. Chronic toxicity in animals results from the prolonged ingestion of dietary selenium at concentrations of 2-30 ppm. However, selenium has been demonstrated to be essential for growth and reproduction in animals. Deficiency of selenium results in stunted growth, liver necrosis, kidney damage, infertility and white muscle disease (Venugopal and Luckey, 1978).

Aquatic plants experience toxic effects at concentrations as low as 7.9 mg/l. A concentration factor of 78 was reported for rainbow trout exposed to sodium selenite-75 for 48 days. Since selenium is an essential nutrient in fish and is required at low dietary concentrations, specific mechanisms for uptake, metabolism and excretion can be postulated. The available data for inorganic selenate indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 760 µg/l.

North Carolina Production and Users

PRODUCTION: No known producers.
USERS: IRC, Inc., Boone Division

Recommended Reviews

Burk, R. F., Jr., et al. Selenium in Man, Trace Elements in Human Health and Disease. Vol. II. Essential and Toxic Elements. Academic Press, New York, 1976.

Fishbein, L. Toxicology of Selenium and Tellurium. Adv. Mod. Toxicol. 2.191. 1977.

SELENIUM

First Aid (NIOSH/OSHA Pocket Guide to Chemical Hazards)

Eyes: Wash with large amounts of water immediately. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH SELENIUM.

Skin: Wash contaminated skin with soap or mild detergent immediately. Remove clothing if contaminated.

Inhalation: Move to fresh air at once. Perform artificial respiration if necessary. Seek immediate medical attention.

Ingestion: Give large amounts of water, then induce vomiting by finger (touching the back of victim's throat). Seek medical attention immediately.

Procedures for Spills and Leaks U.S. DOT Emergency Response Guidebook, 1980

Isolate hazard area and deny entry. Stay upwind and keep out of low areas. Wear self-contained breathing apparatus and full protective clothing. Do not touch spilled material. Stop leak if it can be done without risk.

SMALL SPILLS: Take up with sand or other noncombustible absorbent material, then flush area with water.

SMALL DRY SPILLS: Shovel into dry containers and cover, move containers, then flush area with water.

LARGE SPILLS: Dike far ahead of spill for later disposal.

Fire and Explosion Information (for selenium compounds)

Some of these materials may burn, but they do not ignite readily.

SMALL FIRES: Dry chemical, CO_2, water spray or foam.

LARGE FIRES: Water spray, fog or foam

Move containers from fire area if it can be done without risk.

Reactivity

MATERIALS TO AVOID: Acids, strong oxidizing agents.

Protective Measures

PROTECTIVE EQUIPMENT: At levels up to 10 mg/cu m, wear a suppliedair respirator with a full facepiece or a self-contained breathing apparatus with a full facepiece. At levels up to 100 mg/cu m, wear a supplied-air respirator with a full facepiece in the positive pressure or continuous flow mode. For escape from contaminated area, wear a self-contained breathing apparatus with a full facepiece.

The North Carolina Toxic Substances Management Guide

SELENIUM

Profile

CHEMICAL IDENTIFICATION

Alternative Names: None

Chemical Abstract Services (CAS) Registry Number: 07782-49-2

Registry of Toxic Effects of Chemical Substances (RTECS) Number: VS 7700000

Hazardous Materials Table Identification Number:

RCRA Identification Number:

Molecular Formula:	Se	$(SeO_4)^{2}$	$(SeO_3)^{-2}$	Se^{-2}
Molecular Weight:	78.96	188.9	173	78.96

Structure: Se (May exhibit several valence states; -2 to +6)

Description: Dark red to bluish-black amorphous solid or dark red, gray or black crystals

Uses: In the manufacture of electronic components, ceramic and glass products

Chemical/Physical Data

	Se	$(SeO_3)^{-2}$ (+4)	$(SeO_4)^{-2}$ (+6)
Boiling point:	685°C	(760 mg Hg) Decomp	(760 mg Hg) Decomp
Melting point:	200-217°C	710°C Decomposes	Decomposes
Vapor pressure:	1 mm at 386°C	0.001 mg Hg at 20°C	0.001 mm at 20°C
Vapor density:	N.A.	N.A.	N.A.
Solubility in water:	Insoluble	g/100 g H_2O at 20°C	g/200 g H_2O at 20°C: 283

Possible oxidation states: -2, 0, +4, +6

HUMAN TOXICITY

The toxicity of selenium varies according to the chemical form involved. Primary routes of administration for humans include the ingestion of seleniferous foods and exposure at industrial sites where it is most commonly absorbed through the lungs or skin. Twenty selenium compounds have been identified as potentially hazardous to man; the most toxic of these is hydrogen selenide.

The acute or subacute toxicity of selenium caused by industrial exposure to selenium compounds is generally severe. The onset of symptoms resulting from inhalation or dermal absorption is characterized by irritation of the nasal tract and tracheobronchial mucosa, nervousness, vomiting, somnolence, falling blood pressure and, eventually, death from respiratory failure and/or toxic action on the nervous system. A review of the effects of selenium on industrial workers has revealed acute symptoms, but no deaths (Venugopal and Luckey, 1978). The limit for hydrogen selenide exposure has been set at 0.05 ppm or 0.2 mg/cu m of air (Cerwenka, 1961).

Although the existence of chronic selenium toxicity of dietary origin has not been firmly established for humans, daily selenium intakes of 0.1 to 0.2 mg/kg body weight have produced clinical symptoms which include jaundice, vertigo, chronic gastrointestinal disease, edema and fatigue (Doull, et al, 1980). Continued intoxication causes kidney, liver and spleen damage.

Acute Toxicity

Route/Compound	Lethal Dose/Lethal Concentration/Toxic Does
Oral (Sodium Selenate)	5 mg/kg LDLo (RTECS)
Dermal (Selenium Chloride)	710 ug/kg TDL. (RTECS)

Carcinogenicity

Selenium compounds were tested in mice and rats by the oral route. Although in one experiment in rats, selenium produced an increase in the incidence of liver tumors, the available data are insufficient to allow an evaluation of the carcinogenicity of selenium compounds.

The available data provide no suggestion that selenium is carcinogenic in man. There is insufficient evidence to support a correlation between regional cancer death rates and selenium content in the soil (IARC, 1975).

Mutagenicity

Sodium selenate and sodium selenite were tested by the Ames procedure on S. typhimurium strains TA1537 and TA100. The selenite appeared to be more active than the selenate. Because of the limited dose range in which weak activity was detected, additional evidence to confirm mutagenicity is needed (NTP, 1979).

Teratogenicity & Embryotoxicity

The possibility of teratogenic effects from exposure to selenium has been raised, based upon observations in animals, but it has not been established in man (NIOSH, 1978).

ANIMAL TOXICITY

In animals, selenium is both an essential trace element and a naturally occurring intoxicant. The toxicity of selenium to animals is modified by a variety of factors including the specific form involved, the animal's age, sex and species. Selenium poisoning occurs through the ingestion of seleniferous legumes (selenium accumulator plants). Estimated dietary threshold levels at which Se can cause physiologic and pathologic symptoms in animals are categorized in the table below by Venugopal and Luckey (1978).

Biologic Spectrum of Dietary Selenium

Characterization	ppm
Deficiency	0.03
Physiological	0.03-0.4
Pathological	0.4-3.0
Clinical	3-20
Lethal	20

Acute toxicity in animals is characterized by "blind staggers", ataxia, elevation of body temperature, labored respiration and death from respiratory failure.

Acute Toxicity

Below are the results of lethal studies in several species as reported in the RTECS (1980) and Venugopal and Luckey (1978).

Route (compound)	Species	Lethal Dose or Lethal Concentration
Intravenous (selenium)	Rat	6 mg/kg, LD50
Oral ($NaSeO_3$)	Mouse	7 mg*/kg, LD50
Intravenous (Na_2SeO_3)	Rabbit	2 mg*/kg, MLD
Oral (H_2SeO_3)	Rat	25 mg*/kg, MLD
IP (Na_2SeO_4)	Rat	13.8 mg*/kg, LD50
Oral (Na_2SeO_4)	Rabbit	7 mg*/kg, MLD

*Compound Weight

Chronic Toxicity

Ingestion of 2-30 ppm dietary Se over a prolonged period of time causes chronic toxicity; symptoms include loss of vitality, lameness, atrophy, cirrhosis of the liver and degeneration and necrosis of the myocardium. Dietary levels of 400-800 ppm Se as selenite are fatal to sheep, hogs and calves (Caravaggi et al 1970), report deaths in lambs when 1.5-3 mg/kg body weight was consumed.)

Aquatic Toxicity

The U.S. EPA Water Quality Criteria for protection of aquatic life are given below:

> For total recoverable inorganic selenite, the criterion to protect freshwater aquatic life (derived using the Guideline) is 35 µg/l as a 24-hour average and the concentration should not exceed 260 µg/l at any time.
>
> For total recoverable inorganic selenite, the criterion to protect saltwater aquatic life (derived using the Guideline) is 54 µg/l as a 24-hour average and the concentration should not exceed 410 µg/l at any time.
>
> The available data for inorganic selenate indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 760 µg/l and would occur at lower concentrations among species that are more sensitive than those tested. No data are available concerning the chronic toxicity of inorganic selenate to sensitive freshwater aquatic life.
>
> No data are available concerning the toxicity of inorganic selenate to saltwater aquatic.

Bioaccumulation: A concentration factor of 78 was reported for rainbow trout exposed to sodium selenite-75 for 48 days (U.S. EPA, WQC, 1980). Concentrations as high as 800 are reported for aquatic plants (Callahan, 1978).

Biodegradation in aquatic species: Estimates of biological half-life in fish may vary widely ranging from 1-70 days (U.S. EPA, WQC, 1980). Selenium is an essential nutrient in fish and specific mechanisms for selenium uptake, metabolism and excretion can be expected to exist (U.S. EPA, WQC, 1980).

Phytotoxicity

Data on phytotoxicity from air pollution were not available. Because atmospheric selenium from conventional combustion is generally reduced to its elemental (relatively nontoxic) form, phytotoxicity from selenium air pollution is not expected to be a problem.

Plants can be divided into three groups based on their ability to accumulate selenium from soil: (1) primary selenium accumulators or "Indicator" plants which only grow on highly seleniferous soils (e.g., species of Astralus, Machaeranthera, Haplopappus, and Stanleya); (2) secondary selenium absorbers which can accumulate selenium but grow in a variety of soil conditions (e.g., species of Aster, Atriplex, Castelleja, Gridelia, Gutierrezia, Machaeranthera, and Mentaelia); and (3) grains, grasses, and crop plants

Name: Selenium
CAS Number: 07782-49-2

which rarely contain more than 30 ppm of selenium and show injury at concentrations of 300 ppm. Snow-white chlorosis of the leaves, pink roots, reduced seed germination, and reduced growth have been observed as a result of selenium toxicity.

Acute and chronic selenium toxicity are well documented for livestock which have grazed on seleniferous plants. Herbivorous wildlife could be expected to exhibit similar toxicities (NAS, 1975).

Aquatic plants experience toxic effects at concentrations as low as 7.9 mg/l (U.S. EPA, WQC, 1980).

ENVIRONMENTAL DATA

Selenium, element 34 on the periodic table, occurs naturally in air, water and soil in small concentrations. Selenium is a member of the sulfur family and resembles sulfur in its various forms and compounds. In geologic deposits, selenium is usually associated with sulfide. Selenium can exist in several valence states (from -2 to +6), may be present as the free metal, covalently bound as a compound or present in ionic form usually as SeO_4^{-2} (selenate) or SeO_3^{-2} (selenide). Reports of selenium in ambient media, food and fossil fuels do not generally specify the valence state or form in which selenium is present and values should be interpreted to mean total selenium and not the amount of elemental selenium present.

The environmental fate of elements must be viewed differently from that of organic chemicals. With the exception of radioactive isotopes, elements do not decay and thus are infinitely persistent. Elements can exist in different valence states and can be found in a variety of inorganic, organometallic, or organic compounds. It is the distribution of the element in its different states that determines its environmental significance.

Valence States of Environmental Significance

Selenate (SeO_4^{2}): Valence +4

H_2SeO_4 is a strong acid. Selenate salts are often highly soluble resembling sulfates of the same metals in their solubilites. Selenate ion is most stable under alkaline conditions, is readily available to plants, and can be reduced to selenite or elemental selenium under natural conditions (Callahan, 1979).

Selenite (SeO_3)2: Valence +4

H_2SeO_3 is a weak acid. Selenites are generally less soluble than their corresponding selenates. Selenite complexes with iron and is readily reduced to elemental form in acidic conditions (Callahan, 1979).

Elemental Selenium (Se): Valence 0

Elemental selenium is extremely insoluble and is stable in the atmosphere and in soils. It can be methylated by biological processes. It is formed during the burning of coal via the reduction of SeO_2 by SO_2.

Selenide (Se^{-2}): Valence -2

H_2Se is a fairly strong acid, and rapidly decomposes to form elemental selenium. It is of minor importance to the overall fate of selenium in the environment (Callahan, 1979).

Ambient Air

Reported urban levels of selenium generally range from 2.5 mg/cu m to 9.7 mg/cu m (WQC, 1980). Selenium in the atmosphere can exist as a result of natural or industrial processes. Organoselenides such as dimethylselenide are volatile and can be produced by biologic activity. Selenium can also be found in volcanic gases (U.S. EPA, WQC, 1980). The major source of industrial emissions of selenium is the burning of coal. Significant selenium emissions result from nonferrous mining, smelting, and refining operations with smaller amounts expected from metal refinery operations, volatilized metal in glass manufacture, and burning of fuel oil (NAS, 1976).

Water

In a survey of 3,676 home tap water samples, selenium was detected in only 10 percent of samples. Average concentrations for the 35 areas in the study ranged from 1 µg/l (limit of detection) to 36.8 µg/l. Increased levels can be expected in seleniferous areas with levels as high as 2,680 µg/l being reported for river water (U.S. EPA, WQC, 1980).

Sea water contains 0.1 to 6 µg/l of selenium. Levels of 0.414 µg/l in precipitation indicate a removal mechanism from the atmosphere (NAS, 1976).

Soils

Selenium is present in the earth's crust generally at concentrations of less than 1 ppm. Selenium can be expected to be present as SeO_3^{-2} (selenite)$_2$ firmly bound to iron oxide colloid or as SeO_4^{-2} (selenate) which is quite soluble (NAS, 1976).

Other

Levels of selenium in food can be expected to reflect selenium soil concentrations. Estimated daily consumption of selenium in the diet is 132 µg/day for nonseleniferous regions of the U.S. (U.S. EPA, WQC, 1980).

Selenium has been found in fossil fuels at levels ranging from 0.46-10.65 ppm in coal and 0.006-2.2 ppm in oil (NAS, 1976).

Summary

The following summary identifies the valence states of selenium which are of most concern when considering accumulation and dispersion for different media.

Air	Water	Soil
Accumulation:		
Elemental	Selenate	Elemental, Selenite
Dispersion:		
Elemental (present on fly ash, organoselenium compounds		Elemental,
Selenate		Selenite

INDUSTRIAL DATA

Production

No production in North Carolina of selenium or selenium compounds is reported in the Toxic Substances Control Act (TSCA) Chemical Substances Inventory (U.S. EPA, TSCA, 1980).

Selenium is produced as a by-product of copper smelting. Estimated U.S. production is 1.2 million pounds (600 tons) (NTP, 1978).

Consumption and Use

Estimated U.S. consumption in 1973:

Electronic components	46 percent
Ceramic and glass	35 percent
Chemicals (pigments)	13 percent
Other uses	6 percent

(NAS, 1976)

In a list of 58 domestic merchandizers and consumers, only one plant from North Carolina was listed: IRC, Inc., Boone Division (Stahl, 1969).

Reported uses of selenium and the corresponding SIC codes are listed below:

Manufacture of glass (ammonium selenite, arsenic hemiselenide, sodium selenite)	321, 322
Semiconductors/semiconductor research (aluminum selenide, bismuth selenide, indium selenide, cadmium selenide, cupric selenide)	367, 3674
Photocells in instrument and photocopiers (cadmium selenide)	367, 38, 386
Pharmaceutical and cosmetic drugs (e.g., dandruff shampoos) (selenium monosulfide, selenium disulfide)	283, 2841
Pigments (cadmium sulfaselenide)	2816
Additive to steel	331
Veterinary therapeutic agent and livestock feed additive (sodium selenate, sodium selenite)	283, 02, 07
Rubber manufacture	30
Catalyst in making soaps, hardening fats, and making plastics	282, 284
Paint and varnish solvent (selenium oxychloride)	285, 25
In lubricants	2992
In pesticides and insect repellants	287
Photographic chemicals	386
Mercury vapor detectors	-
Fireproofing agents	2819
Phosphorescents and luminescents	2819

(NAS, 1976)

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air
No guidelines for air have been established.

Workroom Air
The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 0.05 ppm (0.4 mg/cu m) as a time-weighted average.

The National Institute of Occupational Safety and Health (NIOSH) recommends a standard of 0.2 mg/cu m as a time-weighted average and a ceiling limit of 100 mg/cu m.

The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air is 0.2 mg/cu m as a time-weighted average for selenium compounds, and 0.05 ppm (0.4 mg/cu m) for selenium hexafluoride.

Water
Addressed by National Interim Primary Drinking Water Regulations set by the U.S. Environmental Protection Agency.

Addressed by Ambient Water Quality Criteria set by the U.S. Environmental Protection Agency.

Designated a toxic pollutant by the U.S. Environmental Protection Agency.

Designated a hazardous substance by the U.S. Environmental Protection Agency.

Other
Selenic acid (liquid), selenium nitride, and selenium oxide are regulated as hazardous materials by the U.S. Department of Transportation. Selenic acid is classified as a "Corrosive Material", and shipments must carry a label which reads "Corrosive". Selenium must be labeled "Poison" also.

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Agencies Concerned with this Chemical

Designated a candidate substance by the Occupational Safety and Health Administration.

Subject of a Risk Assessment Document prepared by the Carcinogen Assessment Group (CAG) of the U.S. Environmental Protection Agency.

Subject of a monograph prepared by the International Agency for Research on Cancer (IARC).

Under toxicological evaluation through the National Toxicology Program to determine mutagenicity (National Toxicology Program, Fiscal Year 1981 Annual Plan, NTP-80-62, 1980).

Addressed by a National Toxicology Program (NTP) Executive Summary and included in the list of 100 compounds nominated for NTP testing.

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Callahan, M.A., et al. Water-Related Fate of 129 Priority Pollutants. U.S. EPA Office of Water Planning and Standards, Washington, DC, EPA 440/4-79-029 (December 1979).

Cupitt, L. T. Fate of Toxic and Hazardous Materials in the Air Environment. EPA-600/3-80-084, NTIS PB 80-221948 (September, 1980).

International Agency for Research on Cancer (IARC). IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon, France, Volume 9. A World Health Organization Publication (WHO), Geneva (1975).

Merck Index: An Encyclopedia of Chemicals and Drugs, Ninth Edition, M. Windholz, Ed. Merck and Co., Rahway, NJ (1976).

National Academy of Sciences, National Academy of Engineering. Water Quality Criteria 1972. A Report. National Academy of Sciences, Washington, DC. EPA-R3-73-033 (1973).

National Academy of Sciences, National Research Council. Selenium: Medical and Biologic Effects of Environmental Pollutants. National Academy of Sciences, Washington, DC (1976).

National Institute for Occupational Safety and Health/Occupational Safety and Health Administration (NIOSH/OSHA). NIOSH/OSHA Pocket Guide to Chemical Hazards. DHEW (NIOSH) Publication No. 78-210 (September 1978).

National Institute for Occupational Safety and Health. National Occupational Hazard Survey. Available from Division of Technical Services. Cincinnati, OH, DHEW 74-127, 77-123, and 78-114 (1980).

National Toxicology Program. Fiscal Year 1981 Annual Plan. NTP 80-62 (1980).

National Toxicology Program. N.T.P. Executive Summaries. Prepared by the National Center for Toxicological Research, Office of Scientific Intelligence, Jefferson, Arkansas (March 1979).

National Toxicology Program, NTP Technical Bulletin, Department of Health and Human Services, Vol. 1, Issue 3 (December 1980).

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfiche Issue, R. J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville, MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 80-111-4 (1980).

Shepard, T. H. Catalog of Teratogenic Agents. The John Hopkins University Press, Baltimore, MD (1973).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Chemical Hazard Information Profiles (CHIPs). EPA-560/11-80-011 (1980).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA PB-80-155-153 (1980).

U.S. Environmental Protection Agency, Office of Water Planning and Standards. Ambient Water Quality Criteria for Selenium. EPA-440/5-80-070 (October 1980).

U.S. Environmental Protection Agency. Quality Criteria for Water. EPA-440/ 7-76-023 (1976).

Verschueren, Karel. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York, NY (1977).

The North Carolina Toxic Substances Management Guide

SILVER

Executive Summary

CAS Number: 07440-22-4

Silver is a metallic element, atomic number 47, in Group IB of the periodic table. It is a hard, brilliant white, lusterous, ductile and malleable metal. Alloys of silver are used in the manufacture of jewelry, tableware, ornaments and mirrors. About 30% of the industrial consumption of silver in the U.S. is used in photography. Other uses of silver include dental alloys, electrical circuits, electroplating and food and beverage processing. The principal health concern in silver exposure is argyria, a cosmetic defect produced by the accumulation of silver in the body. Currently there are no federal or state regulations regarding spills of silver into the environment.

Health Effects

ACUTE. Argyria, a cosmetic defect, which consists of an unsightly blue-gray discoloration of the skin, mucous membranes and eyes, is the main pathologic effect resulting from the accumulation of silver in the body. Generalized argyria may result from inhalation of silver salts such as nitrate, fulminate or cyanide, while localized argyria may be caused by the penetration of the skin by fine particles of metallic silver.

CARCINOGENICITY. Studies on the carcinogenicity, tumor inhibiting and tumor promoting ability of colloidal silver and silver salts are not definitive.

MUTAGENICITY. Silver was found to be nonmutagenic in a variety of assays using silver nitrate ($AgNO_3$).

TERATOGENICITY AND EMBRYOTOXICITY. No evidence was found to indicate that silver nitrate ($AgNO_3$) causes birth defects or is embryotoxic.

CHRONIC. Chronic toxicity symptoms from prolonged intake of low doses of silver salts are fatty degeneration of liver and kidney, changes in blood cells, and argyria.

Occupational Health Regulations

ACGIH: Threshold Limit Value for workroom air is: 0.1 mg/cu m for silver metal dust and fumes, and 0.01 mg/cu m for soluble compounds.

OSHA: Time-weighted average standard for workroom air is 10 ug/cu m.

Routes of Human Exposure

OCCUPATIONAL. Exposure to silver metal and soluble silver compounds may occur during the following operations: liberation and purification of ore, use of silver nitrate in manufacturing processes, and the use or manufacture of silver salts.

AMBIENT. Ambient exposure occurs primarily through the ingestion of drinking water and food, neither of which has been shown to lead to toxicity.

CONSUMER. The use of silver as a component in medical treatment has declined due to its toxicity. Poisoning as a result of consumer exposure is rarely reported.

Environmental Significance

Silver is highly toxic to freshwater aquatic life, where it is accumulated rapidly. Toxic concentrations begin at 0.25 ug/l for Daphnia magna. An aquatic toxicity rating (TLm 96) has not been established. Silver is bioconcentrated 3,330-fold by marine invertebrates and fish. It is found in relatively low concentrations in the aquatic environment due to its low crustal abundance and the effectiveness of controls on its mobility. Silver is persistent in some soils and sediments.

Recommended Reviews

Browning, E., Toxicity of Industrial Metals (2nd Ed.), Butterworth, London, 1969.

Deichman, W. B., and Gerarde, H. W., Toxicology of Drugs and Chemicals, Academic Press, New York, 1969.

FIRST AID AND EMERGENCY RESPONSE INFORMATION

SILVER

First Aid (NIOSH/OSHA)

Eyes: Wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. Get medical attention immediately. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH SILVER.

Skin: Flush the contaminated skin with water. If clothing is contaminated, remove the clothing immediately and flush the skin with water. If irritation persists, get medical attention.

Inhalation: Move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

Ingestion: If person is conscious, give large amounts of water immediately. If silver nitrate or other corrosive soluble silver compounds have been swallowed, DO NOT MAKE THE PERSON VOMIT. If, however, non-corrosive soluble silver compounds have been swallowed, induce vomiting by finger after giving large amounts of water. Do not make an unconscious person vomit. Get medical attention immediately.

Procedures for Spills and Leaks (U.S. DOT Emergency Response Guidebook, 1980)

Isolate hazard area and deny entry. Stay upwind and keep out of low areas. Wear self-contained breathing apparatus and full protective clothing. Stop leak if it can be done without risk. Do not touch spilled material.

Silver Nitrate

SMALL SPILLS: Flush area with flooding amounts of water.

LARGE SPILLS: Dike far ahead of spill for later disposal.

Silver Arsenite
Silver Cyanide

SMALL SPILLS: Take up with sand, or other non-combustible absorbent material, then flush area with water.

SMALL, DRY SPILLS: Shovel into dry containers and cover; move containers; then flush area with water.

LARGE SPILLS: Dike far ahead of spill for later disposal

Fire and Explosion Information

Silver Nitrate

May ignite combustibles. Reaction with fuels may be violent. Explosive concentrations of gas may accumulate in tanks. Run-off to sewer may create fire or explosion hazard

SMALL FIRES: Water only; no dry chemical or CO_2

LARGE FIRES: Flood area with water.

Silver Arsenite
Silver Cyanide

May burn, but do not ignite readily.

SMALL FIRES: Dry chemical, CO_2, water spray or foam

LARGE FIRES: Water spray, fog or foam.

Reactivity

MATERIALS TO AVOID: Acetylene, ammonia, hydrogen peroxide

Protective Measures

ENGINEERING CONTROLS: Process enclosure, local exhaust ventilation, general dilution ventilation, personal protective equipment.

PROTECTIVE CLOTHING (Should not be substituted for proper engineering controls): Impervious clothing, gloves and face shields (8" minimum).

PROTECTIVE EQUIPMENT: For levels up to 0.5 mg/cu m use a high efficiency particulate filter respirator with a full facepiece, any supplied-air respirator with a full facepiece, helmet or hood, or any self-contained breathing apparatus with a full facepiece. For levels up to 10 mg/cu m use a powered air-purifying respirator with a full facepiece and a high efficiency particulate filter. For levels up to 20 mg/cu m use a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure mode or with a full facepiece, helmet, or hood operated in continuous-flow mode. For levels above 20 mg/cu m or entry and escape from unknown concentrations, use a self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode, or a combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.

SILVER

Profile

Chemical Identification

Alternative Names:

Argentum
Algaedyn
CI 77820
L-3
Shell Silver
Silver Atom
Silflake 135
TCG 7R
V 9

Chemical Abstract Services (CAG) Registry Number: 07440-22-4

Registry of Toxic Effects of Chemical Substances (RTECS) Number: VW 3500000

Hazardous Materials Table Identification Number:

RCRA Identification Number:

Atomic Weight: 107.87

Atomic Symbol: Ag

Classification: Transitionary metallic element

Description: Hard, brilliant white, lusterous, ductile and malleable metal

Uses: Silverware, electroplating, food processing, photography, ink manufacture, antiseptic

Chemical/Physical Data

Boiling Point: 2,212°C
Melting Point: 961.9°C
Vapor pressure: negligible
Solubility in water: Chloride, sulfide, phosphate, arsenate salts insoluble; NO_3 highly soluble; SO_4 moderately soluble
Specific gravity: 10.5

HUMAN TOXICITY

Argyria, a cosmetic defect, which consists of an unsightly blue-gray discoloration of the skin, mucous membranes and eyes, is the main pathological effect resulting from accumulation of silver in the body. Argyria may be generalized or localized in the conjunctiva of the eye, nasal septum or posterior pharnyx, or gum tissue. Localized argyria of the skin is rare. Generalized argyria from occupational exposure may result from inhalation of silver salts such as the nitrate, fulminate, or cyanide, while localized argyria may be caused by penetration of the skin by fine particles of metallic silver (ACGIH, 1980). Studies on the occurence of argyria following injection of silver arsphenanamine indicate that the onset of visible argyria begins at a total dose of about 0.9 grams of silver (Sittig, 1979). Argyria may also be caused by the deposition of the metabolic products of silver, Ag_2S and Ag_2Se (Luckey, 1978).

Argyria, localized argyria or argyrosis (argyria of the eyes unless otherwise specified) can occur as a result of occupational or therapeutic exposure. Silver salts are used most frequently for their antimicrobial properties in treating the wounds of burn patients, or in newborns' eyes to prevent the transmission of gonnorhea. Argyria has developed in as little as two days in a patient receiving urethral application for gonorrhea. Generally, the onset of argyria takes at least six weeks. Argyria may occur with chronic occupational exposure of 1-2 mg/cu m. The onset of argyria has been observed from 2-38 years in occupational settings. It is predicted that levels of 0.15 mg/cu m for 20 years could cause argyria (EPA, WQC, 1980).

Humans taking large doses of $AgNO_3$ therapeutically may suffer violent abdominal pain, abdominal rigidity, convulsions, appearance of shock and death. Bone marrow, liver and kidney necrosis were observed upon autopsy (EPA, WQC, 1980). Silver in all forms is extremely cumulative once it enters body tissues, and very little is excreted (Sittig, 1979). Biliary and fecal excretions predominate over urinary excretions for all silver compounds. Epidermal excretion may occur to a small extent (EPA, WQC, 1980).

Chronic toxicity symptoms from prolonged intake of low doses of silver salts are fatty degeneration of the liver and kidney and changes in blood cells. The toxicity of Ag ions can be attributed to their ability to form stable complexes with structural and functional proteins, and thereby disrupt life processes (Vanugopal, Luckey, 1978). Chronic silver flouride absorption may cause mottling to teeth and skeletal changes (Merck, 1976).

The TCLO for humans is 1 mg/cu m (RTECS, 1982).

Carcinogenicity

U.S. EPA CAG, 1980	Studies on the carcinogenicity, tumor inhibiting and tumor promoting ability of colloidal silver and silver salts are not definitive. Fibrosarcomas were observed in rats after silver foil was imbedded in the abdominal wall. The effects were similar to other metal foils indicating the physical shape may be important in the carcinogenicity of the foil. Studies of implanted smooth pellets of silverbased dental alloy and subcutaneous or intraperitoneal injection of silver disks did not indicate increased tumor rates.

Tumors were observed in rats given intravenous and subcutaneous injections of silver. Animals were dosed weekly for 17 months. Argyria was noticeable after 6-8 weeks. Sarcomas, leukemia and lamellar eipthelial carcinoma were observed.

Mutagenicity

U.S. EPA CAG, 1980 — Non-mutagenic in E. coli measured by back-mutation rate from streptomycin dependence. Silver nitrate used.

Non-mutagenic in Micrococcus pyrogenes measured by formation of antibiotic resistance to penicillin/streptomycin; silver nitrate used.

Non-mutagenic in Bacillus subtilis rec-assay. Silver nitrate used.

Silver appears in normal samples of calf thymus DNA in minute concentrations. Chromosome breaks were observed in 1 cm Pisum rootlets exposed to a solution containing 0.001 M silver ions.

NTP, 1980 — Mutagenesis Salmonella typhimurium test result: negative.

Teratogenicity and Embryotoxicity

No evidence was found to indicate that silver nitrate ($AgNO_3$) causes birth defects.

ANIMAL TOXICITY

Silver nitrate injected intravenously has been commonly used to produce acute pulmonary edema in dogs for experimental study. Other effects of intravenous administration include anorexia, anemia, hyperblastic bone marrow, hemolysis and death. In addition, kidney damage has been observed in rabbits.

Acute Toxicity

Results of lethal studies in several species as reported in Vanugopal and Luckey, 1978 are listed below:

Route	Species	Lethal Dose or Lethal Concentration (given in metal weight)
Oral		
(Ag coll.)	Mouse	100 mg/kg, LD50
(Ag_2O)	Rat	2,630 mg/kg, MLD
(AgF)	Guinea pig	255 mg/kg, MLD
($AgNO_3$)	Mouse	31.7 mg/kg, LD50
Lethal Dose (Continued)		
Intravenous ($AgNO_3$)	Rabbit	5.6 mg/kg, LD100
Dermal (AgF)	Guinea pig	680 mg/kg, MLD

Chronic Toxicity

In chronic studies of rats given silver in their drinking water, no effects were observed after 11 months for the three lowest silver concentrations, 0.005 mg/l, 0.1 mg/l and 0.2 mg/l. Hemorrhages were observed in the kidneys at concentrations greater than or equal to 4 mg/l. Other effects included lowered conditional reflex activity, lowered immunological resistance and increased brain nucleic acid content in rats given 5mg/l (EPA, WQC, 1980).

Silver is one of the most toxic elements to freshwater aquatic life. In natural waters, the monovalent species of silver is the form of environmental concern. The toxicity of silver compounds varies with solubility, the highly soluble silver nitrate showing greater toxicity than other silver salts. Toxicity also varies with water hardness, increasing with decreasing hardness. Chronic effects appear at levels similar to those reported for acute toxicity.

Aquatic Toxicity

The silver criterion should be established at 0.01 of the 96-hour LC50 as determined through bioassay using a sensitive resident species (EPA,WQC, 1980). The acute values of toxicity range from 0.25 µg/l for Daphnia magna to 4,500 µg/l for the scud, Gammarus pseudolimnaeus. Fish are intermediate in sensitivity with acute values that range from 3.9 µg/l for the fathead minnow in softwater to 280 µg/l for rainbow trout in hard water (EPA, WQC, 1980).

Available data indicated that chronic toxicity to freshwater aquatic life may occur at concentrations as low as 0.12 µg/l. For freshwater aquatic life the concentration (in µg/l) of total recoverable silver should not exceed the numerical value given by e(1.72 ln (hardness) -6.52) at any time.

For saltwater aquatic life the concentration of total recoverable silver should not exceed 2.3 µg/l at any time.

Bioaccumulation: Silver is accumulated by aquatic organisms. Bioconcentration factors for a variety of organisms are shown in the table below (Callahan, 1979):

Freshwater plants	200
Freshwater invertebrates	3,080
Freshwater fish	3,080
Marine plants	200
Marine invertebrates	3,330
Marine fish	3,330

Silver bioaccumulation is primarily a function of sorption/desorption from sediments. Silver is not present in aquatic animals at very high concentrations because most of its compounds are sparingly soluble in water. Although silver is one of the metals most toxic to aquatic life, there seems to be little foodchain magnification, and silver appears to accumulate mainly in the internal organs. Moreover, silver has a very short biological half-life (Callahan, 1979).

ENVIRONMENTAL DATA

Air

Exposure to silver in the atmosphere occurs primarily in occupational settings for which there are no epidemiological studies available. Silver is normally a minor component of the atmosphere, with rural and industrial areas having similar levels. Average background levels of silver in the ambient atmosphere range from 0.15-10.5 ug/cu m (Callahan, 1979).

Concentrations of less than 10 ug/cu m in occupational air are not expected to cause argyria (see human toxicity section of this guide) in exposed workers (ACGIH, 1980).

Water

Silver is found in relatively low concentrations in the aquatic environment due to its low crustal abundance and the effectiveness of controls on its mobility in water (Callahan, 1980). Seawater contains 0.15 ppb of silver. In 1,577 samples from 130 sampling points in the U.S., concentrations ranged from 1.0 to 38 µg/l, with a median concentration of 2.6 µg/l, Other studies have found public drinking water and river water concentrations at median concentrations of 0.23 and 0.09 µg/l respectively (Callahan, 1979). Some silver is accumulated in water, particularly in rivers receiving industrial waste. This accumulation is most likely partitioned into sediments.

Biota

The normal adult human body contains about 1 mg of silver, the result of lifelong accumulation. Bioaccumulation factors in marine species may be quite large. Biomagnification is not expected.

Other

Silver has been found in wheat bran (6.9 ppm Ag) and mushrooms (300 ppm Ag).

INDUSTRIAL DATA

Production

Production in North Carolina of silver compounds was reported by one company in the U.S. EPA Toxic Substances Control Act (TSCA) Chemical Substance Inventory:

E.I. Dupont, Brevard	.5-5 tons/year	(U.S. EPA, TSCA Inventory, 1980)

There were more than 300 U.S. silver producers in 1974, producing 33.76 million oz. (Patty, 1981).

Consumption and Use

Estimated U.S. Consumption in 1974:

Photography (half for x-ray film)	28 percent
Electrical contacts	18 percent
Coins, medallions	13 percent
Sterling ware	12 percent
Brazing alloys	8 percent
Electroplated ware	7 percent
Catalyst	3.5 percent
Jeweler	3.5 percent
Batteries	1-2 percent
Mirrors	1-2 percent
Medical supplies	1 percent

(Patty, 1981)

Reported uses of silver and the corresponding SIC codes are listed below:

Coinage, medallions, commemorative (metal)	39
Jewelry, ornaments, tableware (metal)	391
Mirrors, glass coloring, porcelain coloring, ceramics (metal, oxide, nitrate, sulfide)	32
Photography (bromide, nitrate, oxalate, phosphate)	3861
Plating (metal, chloride, cyanide, nitrate)	347
Antiseptic, eye lotion (Fluoride, citrate, iodide, lactate, nitrate, oxide, picrate)	283
Vessels for manufacture of medicines, food processing (metal)	283, 29
Reagent, catalyst, oxidizing agent, organic synthesis (metal, acetate, chromate, iodate, chlorate, fluoride, nitrate, nitrite)	28
Water purification (metal, oxide, difluoride)	-
Cloud percipitation (rain-making) (iodide)	
Inks, hair dyes (nitrate)	2865, 2893
Explosive (perchlorate)	2892
Dental alloys (metal)	283

Industrial Data (Continued)

Oxide-zinc batteries (suboxide)	36
Gas masks (permanganate)	-
Thermal sensor (tetraiodmercurate)	35, 36

(Merck, 1976; Patty, 1981; TDB, 1982)

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air

Designated a hazardous air pollutant by the U.S. Environmental Protection Agency.

Under evaluation for possible designation as a Hazardous Air Pollutant by the U.S. Environmental Protection Agency.

Addressed by National Ambient Air Quality Standards set by the U.S. Environmental Protection Agency.

Workroom Air

ACGIH — The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air is metal dust and fumes: 0.1 mg/cu m; soluble compounds 0.01 mg/cu m as a time-weighted average.

OSHA — The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 10 mg/cu m as a time-weighted average.

Water

Addressed by National Interim Primary Drinking Water Regulations set by the U.S. Environmental Protection Agency.

Addressed by Ambient Water Quality Criteria set by the U.S. Environmental Protection Agency.

Designated a toxic pollutant by the U.S. Environmental Protection Agency.

Designated a hazardous substance by the U.S. Environmental Protection Agency.

Other

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Callahan, M.A. et al. Water-Related Fate of 129 Priority Pollutants. U.S. EPA Office of Water Planning and Standards, Washington, DC, EPA 440/4-79-029 (December 1979).

Merck Index: An Encyclopedia of Chemicals and Drugs, Ninth Edition, M. Windholz, Ed. Merck and Co., Rahway, NJ (1976).

National Toxicology Program (NTP). Executive Summary for Silver. In Executive Summaries of Silver Nominated for FY 81 Testing. U.S. Department of Health, Education, and Welfare, Jefferson, Arkansas (1980).

Patty F. A., Ed. (1963). Industrial Hygienists and Toxicology, 2nd edition, Vol. 2, New York.

Sittig, M., Ed. Priority Toxic Pollutants. Noyes Data Corporation, Park Ridge, NJ (1980).

Registry of Toxic Effects, of Chemical Substances, October 1980 Quarterly Microfiche Issue. R. J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville, MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 80-111-4- (1980).

Toxicology Data Bank - The National Library of Medicine. Bethesda, Maryland.

Occupational Saftey and Health (OSHA). Candidate Substance Data Summary Sheet. Chemical: Silver.

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Chemical Hazard Information Profiles (CHIPs). EPA-560/11-80-011 (1980).

U.S. Environmental Protection Agency, Carcinogen Assessment Group (CAG). Carcinogen Assessment Group's Preliminary Risk Assessment on Silver, Washington, DC (February 11, 1980).

U.S. Environmental Protection Agency, Office of Water Planning and Standards. Ambient Water Quality Criteria for Silver. EPA/440-4-80-016 (October 1980).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA PB-80-155-153 (1980).

Venugopal, and Luckey, 1978 Metal Toxicology in Mammals-2, Plenum Press, New York.

TETRACHLOROETHANES

Executive Summary

1,1,2,2-Tetrachloroethane CAS NUMBER 00079-34-5
1,1,1,2-Tetrachloroethane CAS NUMBER 00630-20-6
Mixed isomers CAS NUMBER 25322-20-7

1,1,2,2-Tetrachloroethane is a liquid produced commercially by the reaction of acetylene with chlorine. It has been used as a chemical intermediate, a solvent, and as a pesticide. Estimated U.S. production in 1974 was 19,000 tons but the manufacture and use of tetrachloroethane is now very limited. Little information is available on the production, use, or effects of the 1,1,2-isomer. Tetrachloroethanes are regulated as hazardous materials by the U.S. Department of Transportation and as hazardous wastes under RCRA. Federal regulations require the reporting of spills in excess of 100 pounds. North Carolina requires the reporting of all spills if they occur near water.

Health Effects

ACUTE. Numerous deaths due to the ingestion, inhalation, and cutaneous absorption of 1,1,2,2-tetrachloroethane have been recorded. Tetrachloroethane is one of the most hepatotoxic of the simple chlorinated hydrocarbon solvents. Hepatic effects include liver function abnormalities, massive cell damage, toxic chemical hepatitis, jaundice, and sensation of pressure in the liver area. Neurologic effects include polyneuritis, paralysis, central nervous system depression, inebriation, and headache. Tetrachloroethane is also irritating to the eyes and skin.

Adverse human effects from occupational exposure to the 1,1,1,2-isomer have not been reported.

CARCINOGENICITY. There is limited evidence that 1,1,2,2-tetrachloroethane is carcinogenic in experimental animals. It has induced liver cancer in mice.

MUTAGENICITY. 1,1,2,2-Tetrechloroethane was mutagenic in two strains of Salmonella typhimurium and negative in one strain. It gave a positive result in the E. coli pol A- test, which indicates DNA damage.

TERATOGENICITY AND EMBRYOTOXICITY. 1,1,2,2-Tetrachloroethane produced embryotoxic effects and a low incidence of malformations in mice. It has also been reported to be an embryotoxin in rats and rabbits.

CHRONIC. Insomnia, general malaise, fatigue, excessive sweating, and weight loss are reported after exposure. About 97 percent of inhaled 1,1,2,2-tetrachloroethane was retained in the lungs 1 hour after exposure.

Occupational Health

The American Conference of Governmental Industrial Hygienists has established a Threshold Limit Value for workroom air (time-weighted average concentration under which it is believed that all workers may be repeatedly exposed day after day without adverse effect) of 1 ppm (7 mg/cu m) for 1,1,2,2-tetrachloroethane. The recommended Short Term Exposure Limit (the maximum concentration to which workers may be exposed for a period up to 15 minutes) is 5 ppm (35 mg/cu m). The importance of avoiding skin exposure is noted.

Routes of Human Exposure

OCCUPATIONAL. Use of 1,1,2,2-tetrachloroethane was reported in the following industries: electrical equipment and supplies, chemicals and allied products, electric, gas, and sanitary services, and stone, clay and glass products. In the past the chemical was primarily used as an intermediate in the production of chlorinated ethylenes. However, due to the availability of new processes and less toxic substitutes, the manufacture and use of tetrachloroethane is now very limited. An unspecified isomer has been detected in commercial solvent cleaners used in the electronics industry.

AMBIENT. 1,1,2,2-Tetrachloroethane was detected in approximately 10 percent of samples concentrations ranging from 1 to 6 ug/l. It has also been detected in vinyl chloride waste products dumped into the North Sea.

CONSUMER. Both isomers have been detected in municipal drinking water. 1,1,2,2-Tetrachloroethane has been detected in concentrations of 0.11 ug/l. An unspecified isomer has been detected in the volatile flavor components of boiled beef.

Environmental Significance

Evaporation and dispersion in the atmosphere accounts for much of the fate of this compound. Some removal in rainfall and transport in natural waters can also be expected.

Acute toxicity to freshwater aquatic life occurs at concentrations as low as 9.3 mg/l for the tetrachloroethanes. Chronic toxicity occurs at concentrations as low as 2.4 mg/l for the 1,1,2,2-isomer.

Acute toxicity to saltwater fish and invertebrate species occurs at concentrations as low as 9.0 mg/l for 1,1,2,2-tetrachloroethane.

The 1,1,2,2-isomer reduced cell numbers in the freshwater algae Selenastrum capriconutum at 146 mg/l. The saltwater algae Skeletonema costatum was affected at 6.4 mg/l and 6.2 mg/l, chlorophyl a and cell count, respectively.

A concentration factor of 8 was observed for the 1,1,2,2-isomer in bluegills exposed for 14 days. For the 1,1,2,2-isomer, a concentration factor of 34.6 was calculated based on the octanol/water partition coefficient.

Recommended Reviews

Ambient Water Quality Criteria for Chlorinated Ethanes, U.S. Environmental Protection Agency, EPA 440/5-80-029 (1980).

TETRACHLOROETHANES

Profile

Name: 1,1,1,2-Tetrachloroethane

Alternative Name:

Ethane, 1,1,1,2-tetrachloro-

Chemical Abstract Services (CAS) Registry Number: 00630-20-6

Registry of Toxic Effects of Chemical Substances (RTECS) Number: KI 8450000

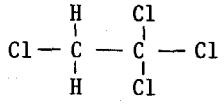
Hazardous Materials Table Identification Number: UN 1702

RCRA Identification Number: U 208

Molecular Weight: 167.84

Molecular Formula: $C_2H_2Cl_4$

Structure:



Classification: Saturated alkyl halide; chlorinated aliphatic hydrocarbon

Description: A yellowish red liquid

Uses: Chemical intermediate and solvent

Chemical/Physical Data

Boiling Point: 130.5°C
Melting Point: -70.2°C
Vapor pressure: Not available
Vapor density: Not available
Solubility in water: 2.85 g/l
Specific gravity: 1.54064

Name: 1,1,2,2Tetrachloroethane

Alternative Names:

Acetylene Tetrachloride
Bonoform
Cellon
1,1-Dichloro-2,2-Dichloroethane
TCE
Tetrachloroethane
Westron

Chemical Abstract Services (CAS) Registry Number: 00079-34-5

Registry of Toxic Effects of Chemical Substances (RTECS) Number: KI 8575000

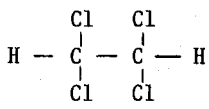
Hazardous Materials Table Identification Number: UN 1702

RCRA Identification Number: U 209

Molecular Weight: 167.84

Molecular Formula: $C_2H_2Cl_4$

Structure:



Classification: Saturated alkyl halide (symmetrical); chlorinated aliphatic hydrocarbon

Description: Heavy colorless mobile liquid with a chloroformlike odor

Uses: Chemical intermediate, solvent and pesticide

Chemical/Physical Data

Boiling point: 146.2°C
Melting point: -36°C
Vapor pressure: 5 mm Hg at 21°C; 8.5 mm at 30°C
Vapor density: 5.79 (Air = 1.0)
Solubility in water: 2,900 mg/l at 20°C (Verschueren, 1977)
Specific gravity: 1.60

CAS Number: 25322207*

HUMAN TOXICITY

Numerous deaths due to the ingestion, inhalation, and cutaneous absorption of 1,1,2,2-tetrachloroethane are recorded. Effects include polyneuritis and paralysis (IARC, 1979). Both industrial experience and toxicologic experiments indicate that tetrachloroethane is more toxic than carbon tetrachloride or chloroform; it is one of the most toxic to the liver of any of the simple chlorinated hydrocarbon solvents (ACGIH, 1980)

1,1,2,2-Tetrachloroethane is reported to affect a variety of human organs or systems including hematological, cardiovascular, pulmonary, renal urologic, gastrointestinal, hepatic biliary, neurologic, dermatologic, and others. Specific adverse neurological effects include central nervous system depression, inebriation, headache, and other effects. Hepatic effects include liver function abnormalities, massive cell damage, toxic chemical hepatitis, jaundice, and the sensation of pressure in the liver area. Insomnia, general malaise, fatigue, excessive sweating, and weight loss are also noted (NIOSH, 1978). About 97 percent of inhaled 1,1,2,2-tetrachloroethane was retained in the lungs 1 hour after exposure (IARC, 1979).

*For a mixture of isomers.

Name: Tetrachloroethanes
CAS Numbers: 00079-34-5
00630-20-6
25322-20-7

Adverse health effects from occupational exposure to 1,1,1-2 isomer are not reported (NIOSH, 1978).

The maximum level at which one could escape within 30 minutes without any escape-impairing symptoms or irreversible effects is suggested to be 150 ppm (1.0 gm/cu m) for the 1,1,2,2-isomer (NIOSH/OSHA, 1978).

Carcinogenicity

U.S. EPA, WQC, 1980	The U.S. EPA Carcinogen Assessment Group (CAG) has determined that 1,1,2,2-tetrachloroethane is carcinogenic in animals and therefore poses a risk to man. Water Quality Criteria for the 1,1,2,2-isomer are based on incremental increase of cancer with increasing exposures, assuming nonthreshold behavior.
IARC, 1979	There is limited evidence that 1,1,2,2-tetrachloroethane is carcinogenic in experimental animals.
NIOSH, 1978	Under the conditions of the bioassay, 1,1,2,2-tetrachloroethane is carcinogenic in mice, inducing liver cancer in both sexes.

Mutagenicity

IARC, 1979	1,1,2,2-Tetrachloroethane was mutagenic in two strains of Salmonella typhimurium and negative in one strain.
OSHA, 1980	1,1,2,2-Tetrachloroethane is mutagenic in S. typhimurium, and it gives a positive result in the E. coli pol A- test. The latter indicates DNA damage.

Teratogenicity & Embryotoxicity

IARC, 1979	1,1,2,2-Tetrachloroethane produced embryotoxic effects and a low incidence of malformations in mice.
NIOSH, 1978	1,1,1,2-Tetrachloroethane is reported to be an embryotoxin in rats and rabbits.

ANIMAL TOXICITY

All of the chloroethane compounds are known to cause central nervous system depression, usually expressed as abnormal weakness, intoxication, restlessness, irregular respiration, muscle incoordination, and unconsciousness. Chloroethanes are irritating to the eyes and skin (NIOSH, 1978).

The 1,1,2,2-isomer has been studied extensively in several species. Less data are available for the 1,1,1,2-isomer.

Acute Toxicity

Results of lethal studies in several species are reported for 1,1,2,2-tetrachloroethane in the MEDLARS (1981) are listed below:

Route	Species	Lethal Dose or Lethal Concentration
Oral	Dog	700 mg/kg, Lowest lethal dose
Inhalation	Rat	2,000 ppm (6.8 gm/cu m) for 4 hours, lowest LC
	Mouse	4,204 ppm (28.9 gm/cu m), LD50

Chronic Toxicity

Liver and kidney injury in several species are reported. In dogs and mice, 1,1,2,2-tetrachloroethane causes central nervous system depression and is highly hepatotoxic (IARC, 1979).

In a chronic toxicity study, rabbits were exposed to 0.3, 1.5, and 14.6 ppm of tetrachloroethane, 3 to 4 hours daily for 7 to 11 months. No effects were observed at 0.3 ppm and minimal hematologic changes were reported at 1.5 ppm. Morphologic changes were reported in the liver and kidneys of rabbits exposed at both 1.5 ppm and 14.6 ppm as well as several changes associated with suppression of the immunoresponse system (ACGIH, 1980).

Aquatic Toxicity

The U.S. EPA Water Quality Criteria for protection of aquatic life are given below:

> The available freshwater data for chlorinated ethanes indicate that toxicity increases greatly with increasing chlorination, and that acute toxicity occurs at concentrations as low as ...9.3 mg/l for two tetrachloroethanes...Chronic toxicity occurs at concentrations as low as 2.4 mg/l for 1,1,2,2-tetrachloroethane...Acute and chronic toxicity would occur at lower concentrations among species that are more sensitive than those tested.
>
> The available saltwater data for chlorinated ethanes indicate that toxicity increases greatly with increasing chlorination and that acute toxicity to fish and invertebrate species occurs at concentrations as low as 9.0 mg/l for 1,1,2,2-tetrachloroethane ...Acute and chronic toxicity would occur at lower concentrations among species that are more sensitive than those tested.

Bioaccumulation: A concentration factor of 8 was observed for the 1,1,2,2-isomer in bluegills exposed for 14 days. A concentration

factor of 34.6 was calculated for the 1,1,1,2-isomer based on the octanol/water partition coefficient (U.S. EPA, WQC, 1980).

Biodegradation in aquatic species: no data are available.

Phytotoxicity

1,1,2,2-Tetrachloroethane reduced cell numbers in the freshwater algae, Selenastrum capricornutum at 146 mg/l. The saltwater algae, Skeletonema costatum, was affected at 6.5 and 6.2 mg/l, chlorophyll a and cell count, respectively.

ENVIRONMENTAL DATA

Air

The concentration of 1,1,2,2-tetrachloroethane in rural air samples was less than the limit of detection of 0.03 µg/cu m (Grimsrud, 1975). No data were found on the occurrence of the 1,1,1,2-isomer. Estimates of the half-life in air for both isomers ranges from several months for the 1,1,1,2-isomer to several years for the 1,1,2,2-isomer (Callahan, 1979). The high volatility of these substances results in substantial atmospheric loading, and subsequent rapid degradation (mainly in vapor atmosphere). Release rates and accumulation are lower than for other chlorinated compounds such as tetrachloroethylene.

Water

Both isomers have been detected in municipal drinking water (Shackelford, 1976). 1,1,1,2-Tetrachloroethane has been detected at concentrations of 0.11 µg/l (U.S. EPA, WQC, 1980). 1,1,2,2,-Tetrachloroethane was detected in approximately 10 percent of water samples taken near industrialized areas. Concentrations ranged from 1-6 µg/l (Ewing, 1977). Although resistant to hydrolysis and oxidation, tetrachloroethanes volatize rapidly to the atmosphere. Low levels may be quite stable and widely dispersed.

Soil

Limited data suggest some preferential absorption onto organic sediments (Callahan, 1979) resulting in some accumulation. Volatilization is probably a more significant means of removal than degradation.

Biota

Tetrachloroethanes have a moderate bioaccumulation factor in fish (36.4 calculated from partition coefficent), and there is some evidence that they are resistant to microbial degradation (Callahan, 1979). No magnification is expected.

Tetrachloroethane (isomer unspecified) has been detected in the volatile flavor components of boiled beef (IARC, 1979). 1,1,2,2-Tetrachloroethane has been detected in vinyl chloride waste products dumped into the North Sea. An unspecified isomer has been detected in commercial solvent cleaners used in the electronics industry (IARC, 1979). Tetrachloroethanes are not known to occur as natural products.

INDUSTRIAL DATA

Production

No production of tetrachlorethane in North Carolina was reported in the Toxic Substances Control Act (TSCA) Chemical Substances Inventory (U.S. EPA, TSCA, 1980).

Estimated U.S. production for 1,1,2,2-tetrachloroethane in 1974 was 19,000 tons (IARC, 1979). No data are available for 1,1,1,2-tetrachloroethane.

Due to its toxicity and the availability of less toxic solvents and new processes for manufacturing chlorinated ethylenes, the manufacture and use of tetrachlorethane is now very limited (ACGIH, 1980).

Consumption and Use

No quantitative data were found on tetrachloroethane consumption patterns.

Reported uses of tetrachlorethanes and the corresponding SIC codes are listed below:

1,1,1,2-Tetrachloroethane
Solvent (U.S. EPA, WQC, 1980)

1,1,2,2-Tetrachloroethane
Intermediate in the production of trichloroethylene 2869
Extraction of ruthenium compounds from solutions 2819
(IARC, 1979)

Manufacture of dichloroethylene 2869
(U.S. EPA, WQC, 1980)

Solvents for fats, oils, waxes, resins, cellulose acetate, rubber, copal, phosphorus, and sulfur
Manufacture of paint, varnish, and rust removers
Soil steriliation, weed killer, and insecticide formulations
(Merck, 1976)

1,1,2,2-Tetrachloroethane is reported to be used in the following industries:
Electrical equipment and supplies, chemicals and allied products, electric, gas, and sanitary services, miscellaneous business services, and stone, clay, and glass products (NIOSH, 1978).

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air

No guidelines for air have been established.

Name: Tetrachloroethanes
CAS Number: 00079-34-5
00630-20-6
25322-20-7

Workroom Air

ACGIH The Threshold Limit Value (TLV) for 1,1,2,2-tetrachloroethane established by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air is 1 ppm (7 mg/cu m) as a time-weighted average. The importance of skin exposure is noted.

NIOSH The National Institute of Occupational Safety and Health (NIOSH) recommends that it would be prudent to handle 1,1,2,2-tetrachloroethane in the workplace as if it were a human carcinogen (1978). Earlier (1976) NIOSH had recommended a standard of 1 ppm (6.87 mg/cu m) as a time-weighted average. NIOSH recommends that the 1,1,1,2-isomer be treated with caution because of its relation to four carcinogenic chloroethanes.

OSHA Four 1,1,2,2-tetrachloroethane, the Occupational Safety and Health Administration's (OSHA) standard for workroom air is 5 ppm (35 mg/cu m) as a time-weighted average. The importance of skin exposure is noted.

Water

Addressed by Ambient Water Quality Criteria set by the U.S. Environmental Protection Agency.

Designated a toxic pollutant by the U.S. Environmental Protection Agency.

Designated a hazardous substance (1,1,2,2-tetrachloroethane) by the U.S. Environmental Protection Agency. Spills in excess of 100 pounds must be reported.

Other

Regulated as a hazardous material by the U.S. Department of Transportation.

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Agencies Concerned with this Chemical

Designated a candidate substance by the Occupational Safety and Health Administration.

Subject of a monograph prepared by the International Agency for Research on Cancer (IARC).

Under toxicological evaluation through the National Toxicology Program to determine mutagenicity (both isomers). Carcinogenesis bioassay of the 1,1,1,2-isomer is to be completed in Fiscal Year 1981. Reproduction and fertility assays for the 1,1,2,2-isomer are scheduled for completion in Fiscal Year 1981. (National Toxicology Program, Fiscal Year 1981 Annual Plan, NTP-80-62, 1980).

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Callahan, M. A., et al. Water-Related Fate of 129 Priority Pollutants. U.S. EPA Office of Water Planning and Standards, Washington, DC, EPA 440/4-79-029 (December 1979).

Ewing, B. B., E.S.K. Chian, and J. C. Cook. Monitoring to Detect Previously Unrecognized Pollutants in Surface Waters: Organic Analysis Data. Prepared by Illinois University at Urbana-Champaign for the U.S. Environmental Protection Agency. Available from National Technical Information Service, Springfield, VA, PB-273-349 (1977).

Grimsrud, E. P. and R. A. Rasmussen. Survey and Analysis of Halocarbons in the Atmosphere by Gas Chromatography-Mass Spectrometry. Atmospheric Environment, Vol. 9 (1975).

International Agency for Research on Cancer (IARC). IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon France, Volume 20. A World Health Organization Publication (WHO), Geneva (1979).

Merck Index: An Encyclopedia of Chemicals and Drugs, Ninth Edition, M. Windholz, Ed. Merck and Co., Rahway, NJ (1976).

National Institute for Occupational Safety and Health (NIOSH). Criteria for a Recommended Standard...Occupational Exposure to 1,1,2,2-Tetrachloroethane. U.S. Department of Health, Education, and Welfare. (DHEW/NIOSH) Publication No. 77-121 (1976).

National Institute for Occupational Safety and Health (NIOSH). NIOSH Current Intelligence Bulletin No 27. Chloroethanes: Review of Toxicity. U.S. Department of Health, Education, and Welfare. DHEW (NIOSH) Publication No. 78-181 (1978).

National Institute for Occupational Safety and Health/Occupational Safety and Health Administration (NIOSH/OSHA). NIOSH/OSHA Pocket Guide to Chemical Hazards. DHEW (NIOSH) Publication No. 78-210 (September 1978).

National Toxicology Program. Fiscal Year 1981 Annual Plan. NTP 80-62 (1980).

Occupational Safety and Health Administration (OSHA). Candidate Substance Data Summary Sheet. Chemical: 1,1,2,2-Tetrachloroethane (1980).

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfiche Issue, R. J. Lewis, and R. L. Tatkins. Prepared by Tracor

Jitco, Inc., Rockville, MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 80-111-4 (1980).

Shackelford, W, M., and L. H. Keith. Frequency of Organic Compounds Identified in Water. U.S. Environmental Protection Agency. EPA600/4-76-062 (December 1976).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA PB-80-155-153 (1980).

U.S. Environmental Protection Agency, Office of Water Planning and Standards. Ambient Water Quality Criteria for Chlorinated Ethanes. EPA-440/5-80-029 (October 1980).

Verschueren, Karel. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York, NY (1977).

TETRACHLOROETHYLENE

Executive Summary

CAS NUMBER 00127-18-4

Tetrachloroethylene is a colorless, nonflammable liquid with an ether-like odor. It is prepared from 1,2-dichloroethane or from methane, ethane or propane. In 1976, nine U.S. companies reported a total production of 304 million kilograms. The principal use of tetrachloroethylene is in dry cleaning and in processing and finishing textiles. It is regulated as a hazardous material by USDOT and as a hazardous waste under RCRA. North Carolina requires the reporting of all spills if they occur near water.

Health Effects

ACUTE. Tetrachloroethylene is a central nervous system depressant.
Vertigo, fatigue, confusion, impaired memory, irritability, loss of appetite, nausea, vomiting, tremors, numbness, coma and death have occurred after occupational exposure. Motor coordination following tetrachloroethylene exposure requires additional mental effort, which along with memory impairment and fatigue, have important implications for worker safety.

Tetrachloroethylene is toxic to the liver and kidneys. The vapor is irritating to the eyes and upper respiratory tract, and may cause frontal sinus congestion and headache. Direct contact with the skin can cause burns, blistering, and erythema. Tetrachloroethylene is most commonly absorbed through the lungs, with the skin being a less important absorption route.

CARCINOGENICITY. Tetrachloroethylene is carcinogenic in mice (oral dosage). There is suggestive evidence that exposure to tetrachloroethylene caused an increased incidence of cancer (lung, cervical, skin, liver and leukemia) in workers of dry cleaning establishments.

MUTAGENICITY. The available information on the mutagenicity of tetrachloroethylene is limited and inconclusive.

TERATOGENICITY AND EMBRYOTOXICITY. Teratogenic abnormalities were found in one study of mice exposed to tetrachloroethylene. Fetotoxicity was observed in mice and rats.

CHRONIC. Direct skin contact over a period of time can result in extreme dryness, with cracking and associated infection.

Occupational Health

The American Conference of Governmental Industrial Hygienists had established a Threshold Limit Value (time-weighted average concentration under which it is believed that all workers may be repeatedly exposed day after day without adverse effect) of 50 ppm (339 mg/cu m). This level was proposed and accepted by NIOSH.

Routes of Human Exposure

OCCUPATIONAL. In 1975, 70 percent of the dry cleaners in the U.S. used tetrachloroethylene, and it constituted over 65 percent of the total dry cleaning solvent usage. The chemical is used in cold cleaning and vapor degreasing of metals, as a chemical intermediate, as a heat exchange fluid, and as a drug for the control of hookworms and some nematodes.

AMBIENT. About 85 percent of the tetrachloroethylene used annually in the U.S. is lost to the atmosphere. In 1974, this amount was estimated to be 250 million kilograms. Concentrations in ambient air ranged from 0.03 to 4.5 ppb.

Tetrachloroethylene has been detected in seawater. Rainwater has been found to contain up to 0.15 µg/l. Residues have been detected in a variety of marine organisms.

CONSUMER. Tetrachloroethylene has been detected in dairy products, meat, oils and fats, beverages, fruits and vegetables, and breads. It may be formed in small quantities during chlorination of water supplies. This compound was reported in 9 of 105 drinking water supplies sampled, at concentrations ranging from 0.2 to 3.1 µg/l. It has been detected in human tissue in England.

Environmental Significance

The available data for tetrachloroethylene indicate that acute and chronic toxicity to freshwater aquatic life occur at concentrations as low as 5.3 and 0.8 mg/l, respectively. Acute and chronic toxicity to saltwater aquatic life occur at concentrations as low as 10.2 and 0.45 mg/l, respectively.

A bioconcentration factor of 4 was measured for tetrachloroethylene in bluegills.

No phytotoxic effects on the freshwater alga, Selenastrum capricornutum, were observed at concentrations as high as 816 mg/l.

Evaporation and dispersion in the atmosphere account for much of the fate of this compound. Some removal in rainfall and transport of low concentrations in natural waters can also be expected.

North Carolina Production and Users

PRODUCTION: Morganton Plastics, Morganton, N.C., 0.5-5 tons/year

USERS: No information available.

Recommended Reviews

Ambient Water Quality Criteria for Tetrachloroethylene, EPA-440/5-80-073, U.S. Environmental Protection Agency (October 1980).

Literature Review - Problem Definition Studies on Selected Chemicals, Tetrachloroethylene, Arthur D. Little, Inc. (1978). Pages 10-57.

FIRST AID AND EMERGENCY RESPONSE INFORMATION

TETRACHLOROETHYLENE

First Aid NIOSH/OSHA Pocket Guide to Chemical Hazards)

Eyes:	Wash with large amounts of water immediately. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH TETRACHLOROETHYLENE.
Skin:	Wash the contaminated skin promptly with soap or mild detergent and water. Remove clothing if contaminated and wash skin.
Inhalation:	Move to fresh air at once. Perform artificial respiration if necessary. Seek immediate medical attention.
Ingestion:	Seek immediate medical attention. Induce vomiting by finger or by giving syrup of ipecac.
Note to Physician:	Expired air analysis may be helpful in evaluating exposure. Give special attention to liver, kidney and CNS function. Alcoholism may be predisposing factor.

Procedures for Spills and Leaks (DOT Emergency Response Guidebook, 1980)

Do not touch spilled material. Stop leak if it can be done without risk. Use water spray to reduce vapors. Evacuate all personnel from spill area and wear proper protective gear.

SMALL SPILLS:	Take up with sand, or other noncombustible material, then flush area with water.
SMALL DRY SPILLS:	Shovel into dry containers and cover; move containers; then flush area with water.
LARGE SPILLS:	Dike far ahead of spill for later disposal.

Fire and Explosion Information

GENERAL: Considered nonflammable and nonexplosive. Container tanks may explode in heat of fire.

Reactivity

MATERIALS TO AVOID: Avoid contact with strong oxidizers such as permanganate, chlorine and dichromate. Decomposes slowly on contact with water to form highly irritating products.

Protective Measures

STORAGE AND HANDLING: Store in cool, dry, well-ventilated location.

ENGINEERING CONTROLS: Use only where there is an adequate ventilation system.

PROTECTIVE CLOTHING (Should not be substituted for proper handling and engineering controls): If direct contact is likely, wear protective clothing, gloves and eye protection or full facemask.

PROTECTIVE EQUIPMENT: For levels up to 500 ppm use a chemical cartridge respirator with organic vapor cartridges and a full facepiece, a gas mask with an organic vapor canister, or a contained breathing apparatus. For levels above 500 ppm or areas of unknown concentration use a combination Type C supplied-air respirator with a full facepiece and an auxiliary air supply both operated in a positive pressure mode or a self-contained breathing apparatus with a full facepiece operaed in a positive pressure mode. For escape from a contaminated area use a gas mask with an organic vapor canister or a self-contained breathing apparatus.

TETRACHLOROETHYLENE

Profile

CHEMICAL IDENTIFICATION

Alternative Names:

Ankilostin	Perchlor
Antisol 1	Perchloroethylene
Carbon Bichloride	Percosolve
Carbon Dichloride	Perk
Dee-Solv	Perkene
Didakene	Persec
Dow-Per	Tetlen
ENT 1,860	Tetracap
Enthylene Tetrachloride	Tetrachloroethene
Fedal-UN	1,1,2,2-Tetrachloroethylene
Nema	Tetralex
Per	Tetravec
Perawin	Tetraguer
PERC	Tetropil

Chemical Abstract Services (CAS) Registry Number: 000127-18-4

Registry of Toxic Effects of Chemical Substances (RTECS) Number: KX 3850000

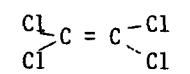
Hazardous Materials Table Identification Number: UN 1897

RCRA Identification Number: U 210

Molecular Weight: 165.82

Molecular Formula: C_2Cl_4

Structure:



Classification: Halogenated, unsaturated, aliphatic hydrocarbon

Description: A colorless, nonflammable liquid with an ethereal odor

Uses: As an industrial solvent, a dry-cleaning agent, a fumigant and chemical intermediate.

Chemical/Physical Data

Boiling point: 121°C
Melting point: -19°C
Vapor pressure: 15.8 mm Hg at 22°C
Density: 1.623 g/ml
Vapor density: 5.7 (Air = 1.0)
Solubility in water: 150 mg/l at 25°C (Verschueren, 1977)

HUMAN TOXICITY

The toxic properties of tetrachloroethylene as indicated by human response to the chemical are presented in the NIOSH Current Intelligence Bulletin. The NIOSH (1978) summary is given below. (Current Intelligence Bulletin 20)

Clinical evidence accumulated over the years clearly demonstrates that tetrachloroethylene is toxic to the liver and kidneys in humans. Liver impairment has been noted in cases of exposure to tetrachloroethylene as evidenced by abnormal liver function tests. Also, toxic chemical hepatitis, and enlargement of the liver and spleen have been asssociated with exposure to tetrachloroethylene. Tetrachloroethylene vapor is irritating to the eyes and upper respiratory tract, and may cause frontal sinus congestion and headache. Direct contact with skin can cause burns, blistering, and erythema due to the "degreasing" effect of tetrachloroethylene on the skin. Over a period of time this can result in extreme dryness with cracking and associated infection.

Altered physiological and behavioral responses observed in subjects exposed to tetrachloroethylene include vague nonspecific complaints generally attributed to CNS depression. These symptoms include vertigo, impaired memory, confusion, fatigue, drowsiness, irritability, loss of appetite, nausea and vomiting. Motor coordination following tetrachloroethylene exposure requires additional mental effort, which along with memory impairment and fatigue have important implications for worker safety. Various disturbances of the peripheral nervous system such as tremors and numbness have also been associated with exposure to tetrachloroethylene. Excessive absorption of tetrachloroethylene can cause severe depression of the CNS leading to coma; ultimately death may occur from respiratory paralysis or circulatory failure.

Tetrachloroethylene is most commonly absorbed through the lungs and can be absorbed from the intestines if ingested. The skin is a less important absorption site. Physical exercise can significantly increase the amount of tetrachloroethylene absorbed through the lungs because of greater respiration and increased blood flow (NIOSH, CIB, 1978).

The maximum level at which one could escape within 30 minutes without any escape-impairing symptoms or irreversible effects is suggested to be 500 ppm (3,350 mg/cu m) (NIOSH/OSHA, 2978).

Carcinogenicity

NIOSH, CIB, 1978	A long-term animal study reported by NCI demonstrates tetrachloroethylene to be carcinogenic in laboratory mice.
IARC, 1979	There is evidence that tetrachloroethylene is carcinogenic in mice (oral dosage), producing liver cancer.

Subsequent to the meeting of the Working Group, the Secretariat became aware of a study of 330 deceased laundry and drycleaning workers who had been exposed to carbon tetrachloride, trichloroethylene, and tetrachloroethylene. An excess of lung, cervical, and skin cancers, and a slight excess of leukemias and liver cancers were observed. There was a report of five cases of chronic lymphocytic leukemia in a family that operated a drycleaning business.

U.S. EPA, CAG, 1980 — There is suggestive evidence that exposure to tetrachloroethylene caused increased incidence of cancer (lung cancer, uterus, and skin) in workers of drycleaning establishments. This study does, however, have several limitations. There is animal evidence that the chemical poses a carcinogenic risk to man.

A CAG risk assessment is the basis for the U.S. EPA Water Quality Criteria for Tetrachloroethylene.

Mutagenicity

IARC, 1979 — Tetrachloroethylene was not mutagenic in Escherichia coli and was negative in cytogenetic tests in mice. Salmonella typhi-murium TA100 plate tests suggest tetrachloroethylene is mutagenic. In a host-mediated assay in mice, using S. typhimiurium TA1950, TA1951, TA1952, there was a significant increase in the number of mutations with doses equal to the LD50 and to half the LD50, but it was not dose related.

NTP, 1980 — Mutagenesis Salmonella typhimurium test result: Tetrachloroethylene was negative for mutagenicity in the Salmonella typhimurium test.

U.S. EPA, CAG, 1980 — The available information on the mutagenicity of tetrachloroethylene is limited and inconclusive.

Teratogenicity and Embryotoxicity

No evidence was found to indicate that tetrachloroethylene causes birth defects (IARC, 1979). Teratogenic fetal abnormalities were caused by tetrachloroethylene in mice in one study (NIOSH, CD, 1976).

Pregnant mice and rats were exposed to tetrachloroethylene vapor in concentrations which were twice the maximal allowable limit for human industrial exposure (300 ppm). Both species were exposed for 7 hour daily periods on days 6 through 15 of gestation. No fetal toxicity or teratogenicity was found (Shepard, 1980).

Teratogenic potential was seen in mouse and rat studies given the chemical on days 6 through 15 of gestation.

ANIMAL TOXICITY

The summary of animal toxicity to tetrachloroethylene presented below is from the NIOSH Current Intelligence Bulletin (1978).

The liver is a principal target organ of tetrachloroethylene exposure in animals. Typical toxic effects are fatty liver, liver enlargement, and abnormal liver function tests. Tetrachloroethylene has also been shown to cause kidney damage in mice following intraperitoneal injection and in rats and rabbits following inhalation.

Neurophysiological effects of tetrachloroethylene are reflected in the distinct alterations of the electroencephalogram (EEG) of rats. Central nervous system (CNS) depression, including abnormal weakness, handling intolerance, intoxication, restlessness, irregular respiration, muscle incoordination, and unconsciousness have been observed in exposed animals.

Tetrachloroethylene has been shown to be a primary eye and skin irritant in rabbits. Other effects of tetrachloroethylene exposure in laboratory animals include lung damage (excessive fluid accumulation, inflammation, congestion, or hemorrhage), cardiac depression, decreased blood pressure, depressed respiration, decreased oxygen consumption, and depression of growth rate.

Acute Toxicity

Results of lethal studies in several species as reported in the MEDLARS (1980) are listed below:

Route	Species	Lethal Dose or Lethal Concentration
Oral	Rabbit	5,000 mg/kg, Lowest lethal dose
	Mouse	8,850 mg/kg, LD50
	Dog	4,000 mg/kg, Lowest lethal dose
	Cat	4,000 mg/kg, Lowest lethal dose
Inhalation	Rat	4,000 ppm (2.7×10^4 mg/cu m) for 4 hours, lowest lethal concentration
	Mouse	6,000 ppm, Lethal concentration

AQUATIC AND TERRESTRIAL TOXICITY

Aquatic Toxicity

Aquatic toxicity rating: TLm 96 is 10-100 ppm (RTECS, 1980).

The U.S. EPA Water Quality Criteria for the protection of aquatic life is given below:

> The available data for tetrachloroethylene indicate that acute and chronic toxicity to freshwater aquatic life occur at concentrations as low as 5.3 and 0.8 mg/l, respectively.
>
> The available data for tetrachloroethylene indicate that acute and chronic toxicity to saltwater aquatic life occur at concentrations as low as 10.2 and 0.45 mg/l, respectively.

Bioaccumulation: A bioconcentration factor of 4 was measured for tetrachloroethylene in bluegills.

Phytotoxicity

No effects on the freshwater alga, Selenastrum capricornutum were observed at concentrations as high as 816 mg/l (U.S. EPA, WQC, 1980).

Environmental Data

Air

Concentrations of tetrachloroethylene in ambient air range from 0.03 to 4.5 ppb (0.2 to 30.5 ug/cu m) (IARC, 1979). The odor threshold in air is 4.68 - 50 ppm (32 - 345 mg/cu m) (Verschueren, 1977). About 85 percent of the tetrachloroethylene used annually in the United States is lost to the atmosphere, amounting to 250 million kg in 1974 (IARC, 1979). Tetrachloroethylene has an estimated atmospheric residence time of 67 days (Cuppitt, 1980 and Callahan, 1979). Elevated levels in the atmosphere have been observed worldwide (IARC, 1979) due to the high volatility of the substance and subsequent substantial atmospheric loading. Tetrachloroethylene degrades rapidly in the atmosphere, limiting accumulation.

Water

Tetrachloroethylene may be formed in small quantities during chlorination of water supplies. It is reported in 9 of 105 drinking water supplies sampled; concentrations ranged from 0.2 to 3.1 ug/l (U.S. EPA, WQC, 1980). Rainwater has been found to contain up to 0.15 ug/l of tetrachloroethylene, and this substance has also been found in seawater (IARC, 1979). The odor threshold in water is 0.3 - 5.0 mg/l (Verschueren, 1977). Tetrachloroethylene has an estimated half-life in water of 24-28 minutes based on evaporation (Verschueren, 1977), and is somewhat resistent to hydrolysis and oxidation (experimental hydrolytic half-life is about 9 months at 25°C (Callahan, 1979). Although rapid and significant volatilization to the atmosphere can be expected, low levels of tetrachloroethylene may be quite stable and widely dispersed.

Soils

Limited data suggests some preferential absorption onto organic sediments resulting in low levels of accumulation (Callahan, 1979). Volatilization is probably more significant than degradation.

Biota

Tetrachloroethylene residues have been detected in a variety of marine organisms (IARC, 1979) and in human tissue in England (U.S. EPA, WQC, 1980). Because of a moderate bioaccumulation factor in fish (4) and some evidence for metabolism in higher organisms, significant accumulation and magnification are not expected to occur in this medium.

Tetrachloroethylene can be widely distributed in the environment. It has been detected in dairy products, meat, oils and fats, beverages, fruit, vegetables and bread. Evaporation and dispersion in the atmosphere account for much of the fate of this compound. Some removal in rainfall and transport of low levels in natural waters can be expected.

INDUSTRIAL DATA

Production

Production in North Carolina is reported by one company in the Toxic Substances Control Act (TSCA) Chemical Substance Inventory:

Morganton Plastics, Morganton, N.C. 0.5-5 tons/year (U.S. EPA, TSCA, 1980).

Estimated U.S. production for 1976 was 304 million kg (304,000 tons) (IARC, 1979).

Consumption and Use

Estimated U.S. Consumption for 1976:

Textile Industry	68 percent
Industrial metal cleaning	15 percent
Chemical intermediate	14 percent
Miscellaneous	3 percent

Reported uses of tetrachloroethylene and the corresponding SIC codes are listed below:

Dry cleaning and processing and the finishing of textiles	22, 721
Cold cleaning and vapor degreasing of metals	34, 35
Chemical intermediate in the synthesis of 1,1,2-trichloro-1,2,2-trifluoroethane and other chlorofluorocarbons	2869
Heat exchange fluid	-
Drug for control of hookworms and nematodes	283

(IARC, 1979)

Name: Tetrachloroethylene
CAS Number: 00127-18-4

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air
Under evaluation for possible designation as a Hazardous Air Pollutant by the U.S. Environmental Protection Agency.

Workroom Air

ACGIH — The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air is 50 ppm (339 mg/cu m) as a time-weighted average. The importance of skin exposure is noted.

NIOSH — The National Institute of Occupational Safety and Health (NIOSH) recommends a standard of 50 ppm (339 mg/cu m) as a time-weighted average and a ceiling limit of 100 ppm (678 mg/cu m).

OSHA — The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 100 ppm (678 mg/cu m) as a time-weighted average with a ceiling of 200 ppm, and a peak limit of 300 ppm exposure for five minutes in any three hour period.

Water
Addressed by Ambient Water Quality Criteria set by the U.S. Environmental Protection Agency.

Designated a toxic pollutant by the U.S. Environmental Protection Agency.

Designated a hazardous substance by the U.S. Environmental Protection Agency.

Other
Regulated as a hazardous material by the U.S. Department of Transportation.

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Agencies Concerned with this Chemical

Appears on the 1977 Priority List of the Chemical Industry Institute of Toxicology (CIIT).

Designated a candidate substance by the Occupational Safety and Health Administration.

Subject of a Risk Assessment Document prepared by the Carcinogen Assessment Group (CAG) for the Office of Water Planning and Standards.

Subject of a monograph prepared by the International Agency for Research on Cancer (IARC).

Addressed by a development plan prepared by the Interagency Regulatory Liaison Group (IRLG).

Under toxicological evaluation through the National Toxicology Program to determine mutagenicity and carcinogenicity.

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Callahan, M A., et al. Water-Related Fate of 129 Priority Pollutants. U.S. EPA Office of Water Planning and Standards, Washington, DC, EPA 440/4-79-029 (December 1979).

Cupitt, L. T. Fate of Toxic and Hazardous Materials in the Air Environment. EPA-600/3-80-084, NTIS PB 80-221948 (September 1980).

International Agency for Research on Cancer (IARC). IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon France, Volume 20. A World Health Organization Publication (WHO), Geneva (1979).

Merck Index: An Encyclopedia of Chemicals and Drugs, Ninth Edition, M. Windholz, Ed. Merck and Co., Rahay, NJ (1976).

National Institute for Occupational Safety and Health. Criteria for a Recommended Standard... Occupational Exposure to Tetrachloroethylene (perchloroethylene). U.S. Department of Health, Education, and Welfare, DHEW (NIOSH) Publication No. 76-185 (July 1976).

National Institute for Occupational Safety and Health. Current Intelligence Bulletin 20. Tetrachloroethylene (Perchloroethylene). U.S. Department of Health, Education, and Welfare, DHEW (NIOSH) Publication No. 78-112 (January 10, 1978).

National Institute for Occupatoinal Safety and Health/Occupational Safety and Health Administration (NIOSH/OSHA). NIOSH/OSHA Pocket Guide to Chemical Hazards. DHEW (NIOSH) Publication No. 78-210 (September 1978).

National Toxicology Program. Fiscal Year 1981 Annual Plan. NTP 80-62 (1980).

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfiche Issue, R. J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 80-111-4 (1980).

Shepard, T. H. Catalog of Teratogenic Agents, Third Edition. The John Hopkins University Press, Baltimore, MD (1980).

U.S. Environmental Protection Agency, Carcinogen Assessment Group (CAG). Problem Oriented Report. Carcinogen Assessment of Tetrachloroethylene (Perchloroethylene). Washington, DC (July 25, 1980).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Chemical Hazard Information Profiles (CHIPs). EPA-560/11-80-011 (1980).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA PB-80-155-153 (1980).

U.S. Environmental Protection Agency, Office of Water Planning and Standards. Ambient Water Quality Criteria for Tetrachloroethylene. EPA-440/5-80-073 (October 1980).

Verschueren, Karel. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York, NY (1977).

THIOUREA

Executive Summary

CAS Number 00062-56-6

Thiourea is an almost colorless substance predominantly existing as rhombohedral crystals or needles. Thiourea is available in the United States as a laboratory chemical containing 99% active ingredient. It is used as a photographic chemical, a reagent in the manufacture of fungicides, insecticides and flame-retardants, in dry cleaning chemicals and as an antioxidant in fruit juices. No federal regulations for the reporting of thiourea spills. North Carolina requires the reporting of spills if they occur near water.

Health Effects

ACUTE. As an irritant, thiourea is only slightly toxic, causing readily reversible changes. Acute toxicity is variable, but ingestion of small quantities may result in death or permanent injury.

CARCINOGENICITY. No human case studies or epidemiological studies of carcinogenesis exist at present. Chronic administration of thiourea to rats has resulted in hepatic tumors and thyroid cancers.

MUTAGENICITY. Limited evidence suggests thiourea is a mutagenic agent.

TERATOGENICITY AND EMBRYOTOXICITY. Limited evidence suggests thiourea is a teratogenic agent. Evidence does not exist concerning embryotoxicity. However, thiourea has been shown to readily cross the rat placenta with an increase in fetal serum concentration of thiourea.

CHRONIC. Toxic effects of repeated exposure to thiourea include enlargement of the spleen, macropapular eruptions, depression of bone marrow with anemia, and other blood disorders such as leukopenia, agranulocytosis, thrombopenia and monocytosis.

Occupational Health

No standards presently exist for thiourea in the workplace, although it is designated by OSHA as a candidate carcinogen.

Routes of Human Exposure

OCCUPATIONAL. Exposure potential exists for workers in the photographic industry, in the manufacture of fungicides, insecticides and flame-retardants and in the dry cleaning industry.

AMBIENT. No data exist on ambient thiourea levels.

CONSUMER. Individuals pursuing non-occupational photographic developing may be exposed to thiourea. Thiourea is used as an antioxidant in fruit juices.

Environmental Significance

Thiourea has limited natural occurrence. A concentration of 75 µg/l was reported to reduce by 75% the nitrification process of bacteria in non-acclimated wastewater treatment sludge.

Recommended Reviews

IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man: Some anti-thyriod and related substances, nitrofurans and industrial chemicals. Vol. 7, P. 97109. International Agency for Research on Cancer (1979).

FIRST AID AND EMERGENCY RESPONSE INFORMATION

THIOUREA

First Aid

When exposure occurs, seek prompt medical attention.

Attention to Physician: Emetics or prompt gastric lavage with tap water. Saline catharsis with 15-30 g sodium sulfate in water. Avoid fat ingestion which may speed absorption. Use caution in giving oral or IV fluids because of danger of precipitating pulmonary edema. Use positive pressure oxygen and postural drainage. Allow absolute rest.

Procedures for Spills and Leaks

Isolate hazard area and restrict entry. No flames, smoking or flares in hazard area. Do not touch spilled material. Stop leak if it can be done without risk.

SMALL SPILLS: Take up with non-combustible absorbent material, then flush area with water.

LARGE SPILLS: Dike far ahead of spill for later disposal.

Reactivity

MATERIALS TO AVOID: May react violently with acrolein.

CONDITIONS TO AVOID: Any contact with temperatures over 150°C can cause decomposition with resulting toxic SO_x emissions.

Protective Measures

PROTECTIVE CLOTHING AND EQUIPMENT (Should not be substituted for proper handling and engineering controls): Wear rubber gloves and a gas mask or other suitable equipment.

The North Carolina Toxic Substances Management Guide

THIOUREA

Profile

Chemical Identification

Alternative Names:

beta-Thiopseudourea
Pseudourea
Thiocarbamide
2-Thiourea
THU

Chemical Abstract Services (CAS) Registry Number: 00062-56-6

Registry of Toxic Effects of Chemical Substances (RTECS) Number: YU2800000

Hazardous Materials Table Identification Number: None

RCRA Identification Number: U219

Molecular Weight: 76.13

Molecular Formula: CH_4N_2S

Structure:

Classification: Amide

Description: Almost colorless, rhombohedral crystals or needles.

Uses: As a photographic chemical, a reagent, in the manufacture of fungicides, insecticides, and retardants, in dry cleaning chemicals and as an antioxidant in fruit juices.

Chemical/Physical Data

Boiling point: Decomposes at 150°-160°C with emissions of toxic SO_x fumes
Melting point: 177°C
Vapor pressure:
Vapor density: 1.405 (Air = 1.0)
Solubility in water: 9%

HUMAN TOXICITY

Thiourea is rapidly absorbed from the gastrointestinal tract and may result in death or permanent injury after ingestion of small quantities. Toxic effects of repeated exposure include enlargement of the spleen, macropaular eruptions, depression of bone marrow with anemia, and other blood disorders such as leukopenia, agranulocytosis, thrombopenia, and monocytosis. The lowest toxic oral dose for a woman was found to be 1660 mg/kg body weight over a 5 week period. The lowest lethal dose for a man (route of exposure unreported) was found to be 147 mg/kg.

As an irritant, thiourea is only slightly toxic. Exposure may cause readily reversible changes which disappear after the end of exposure (TDB, 1982).

Carcinogenicity

IARC, 1979 — No case studies or epidemiological studies of human carcinogenicity were available to the IARC working group, but a review of 535 cases of humans exposed to thiourea made no specific mention of cancer among the adverse effects. Thiourea has been classified as an animal positive carcinogen. Neoplastic effects were reported after rats were given thiourea orally.

SAX, 1979 — A positive experimental carcinogen of liver and thyroid via oral route.

MERCK, 1976 — Chronic administration of thiourea to rats has resulted in hepatic tumors.

Mutagenicity

RTECS, 1982 — Thiourea is listed as a mutagen.

Teratogenicity & Embryotoxicity

RTECS, 1982 — Thiourea is listed as a teratogen.

No information on embryotoxicity was available. However, IARC (1979) reports that thiourea readily crosses the rat placenta with an increase in fetal serium concentration.

ANIMAL TOXICITY

Acute Toxicity

Results of lethal studies for several species, as reported in the RTECS (1982) are listed below:

Route	Species	Dose	Toxic Effect
Oral	Mouse	8500 mg/kg	LD50
Oral	Rabbit	6985 mg/kg	LDLo (lowest lethal dose)

Chronic Toxicity

Results of chronic toxicity studies reported by TDB (1982) and RTECS (1982) are listed below:

Route	Species	Dose	Toxic Effect
Oral	Rat	300 mg/kg/day-Continuous	LDLo, carcinogenesis
Oral	Rat	78g/kg/56 wk Continuous	TDLo, neoplastic effects
Oral	Rat	18g/kg/2yr Continuous	TD, suspect tumorgenesis

Name: Thiourea
CAS Number: 00062-56-6

Aquatic Toxicity

No aquatic toxicity data for thiourea exists at the present time.

ENVIRONMENTAL DATA

Air

Information on levels of thiourea in aimbient air does not exist at the present time. Thiourea can present a dangerous hazard; if heated to decomposition it emits highly toxic fumes of SO_x (SAX, 1979).

Water

No information on the presence or effect of thiourea in water exists at the present time.

Soil

No information on the presence or effect of thiourea in soil exists at present.

Biota

Verschueren (1979) reports a 75% reduction of nitrification processes of bacteria in non-acclimated wastewater treatment sludge at a thiourea concentration of 0.075 mg/1.

Thiourea has been found to occur naturally in viburnum shrubs and as a metabolite of Verticillium albo-atrum and Bertrylic cinerea (IARC, 1979).

INDUSTRIAL DATA

Production

No production in North Carolina reported in the Toxic Substance Control (TSCA) Chemical Substance Inventory (U.S. EPA, TSCA Inventory, 1980).

Production in U.S. is reported to have ended in 1954 (IARC, 1974). Imports in 1973 were estimated to be 1.7×10^9 grams (1,900 tons) (TDB, 1982).

Consumption and Use

Estimated U.S. consumption in 1964 (IARC, 1974):

Photosensitive paper	50%

Most of the remaining thiourea is used as a flame retardant, nylon treating agent, and also as a treatment for boiler water (TDB, 1982).

Reported uses of thiourea and the corresponding SIC codes are listed below:

Uses and SIC Codes (Continued)	
Boiler treatment to remove copper scale	-
Photographic chemical	3861
Silver cleaning	391
Wood treatment	2491
Hair preparations	723, 724
Dye intermediate and chemical synthesis	2865, 2869
Dry cleaning	721
Synthesis of pharmaceuticals and anti-thyroid drugs	283
Synthesis of insecticides, as a fungicide and as an agent for sprouting dormant tubers	2879
Dye bath adjuvant in textiles	226
Substitute for urea in resins	282
Pickling inhibitor	2035
In cleaning baths for metals	34
In preparation on non-glare mirrors	323
Liquifying animal glues	2891
In paper-making	26
In rubber industry	2822, 30

(IARC, 1979)

Anti-yellowing agent for photosensitive paper	26411
Fire-retardant resins for lacy fabrics and as a nylon treatment agent	2292, 23, 22, 282

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air

No ambient air guidelines exist at the present time.

Workroom Air

No standards for thiourea at present time, but it has been designated by OSHA as a candidate carcinogen.

Water

No water guidelines presently exist.

Other

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Agencies Concerned with this Chemical

Subject of a monograph prepared by the International Agency for Research on Cancer (IARC).

Subject to a proposed rule under the Toxic Substances Control Act.

REFERENCES

International Agency for Research on Cancer (IARC). IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon, France, Volume II. A World Health Organization Publication (WHO), Geneva (1976).

Merck Index: An Encyclopedia of Chemicals and Drugs, Ninth Edition, M. Windholz, Ed. Merck and Co., Rahway, NJ (1976).

Occupational Safety and Health Administration (OSHA). Candidate Substance Data Summary Sheet. Chemical: Thiourea (1981).

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfiche Issue, R. J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville, MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication (1982).

Toxicology Data Bank, National Library of Medicine, Bethesda, Maryland (1982).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA PB-80-155-153 (1980).

Verschueren, Karel. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York, NY (1977).

TOXAPHENE

Executive Summary

CAS NUMBER: 08001-35-2

Toxaphene is a yellow waxy solid with a pleasant piney odor. At least 177 compounds are present in toxaphene, most of which are chlorinated derivatives of camphene. The only commercial use is as a pesticide, for the control of grasshoppers, army worms, cutworms, cotton pests and livestock pests. Annual production for 1976 was 19 million kilograms. Toxaphene has replaced DDT in many agricultural applications. It is regulated as a hazardous material by USDOT and as a hazardous waste under RCRA. Federal regulations require the reporting of spills in excess of 1 pound.

Health Effects

ACUTE. Human poisoning by toxaphene is characterized by convulsions and hyperreflexia. Other major symptoms of oral intoxication include vomiting, cyanosis and coma. The minimum lethal dose for humans has been estimated to be between 2 and 7 grams per person (30-103 mg/kg body weight). The Oral LD50 in rats is 40 mg/kg.

CARCINOGENICITY. There is evidence that toxaphene is carcinogenic in mice and rats. In the absence of adequate data in humans, it is reasonable to regard toxaphene as a human carcinogen.

MUTAGENICITY. Toxaphene is mutagenic in Salmonella typhimurium. It did not induce dominant lethals in mice. Mixed results were reported in studies of chromosomal aberrations in occupationally exposed workers.

TERATOGENICITY & EMBRYOTOXICITY. No teratogenic effects were observed in mice receiving 25 mg/kg diet or rats receiving 25 or 100 mg/kg diet after 5 and 3 generation studies. Oral intubation at 15, 25, and 35 mg/kg per day produced marked maternal mortality in mice and rats (35 mg/kg dose) and a slight increase in fetal mortality (all three dose levels). No embryotoxicity was seen in chicken embryos exposed to toxaphene.

CHRONIC. Toxaphene is readily distributed throughout the body with highest residues found in fat tissue. Elimination is relatively rapid in mammals, with a half-life of 1 to 3 days in rats receiving a single oral dose.

Occupational Health

The American Conference of Governmenal Industrial Hygienists has established a Threshold Limit Value for workroom air (time-weighted average concentration under which it is believed that all workers may be repeatedly exposed day after day without adverse effect) of 0.5 mg/cu m. The recommended Short Term Exposure Limit (the maximum concentration to which workers may be exposed for a period up to 15 minutes) is 1.0 mg/cu m. The importance of avoiding skin exposure is noted.

Routes of Human Exposure

OCCUPATIONAL. Primary usage of toxaphene is in agricultural crop application, mainly for cotton. It is available in various formulations as an emulsifiable concentrate, wettable powder, dust granules, baits, and an oil solution.

AMBIENT. Toxaphene is a prevalent air contaminant in areas where it is used. Average monthly atmospheric levels in a primary cotton-growing area ranged from 0 to 1,540 ng/cu m, with maximum levels during the later summer months and minimal levels in winter.

Toxaphene has been found in watersheds which drain agricultural land in concentrations as high as 1.92 µg/l. It has also been found in city soils and sediments.

CONSUMER. Toxaphene has been detected in many food items at concentrations as high as 0.4 mg/kg. Fat samples from cattle show a consistent but low percentage of samples with levels in excess of 7.0 mg/kg. Toxaphene was measured in 96 percent of samples of 50 catfish taken from commercial ponds in the spring of 1970 at an average concentration of 1.98 mg/kg. It has also been found in tobacco plants.

Environmental Significance

Toxaphene is a very persistent substance, resistant to photolysis, hydrolysis, and oxidation. It is removed slowly from water by microorganisms and sediments and is reduced in eutrophic, anaerobic environments. Significant accumulation is possible in all media and dispersion by all media can be expected after toxaphene use. A concentration factor of 52,000 was reported for fathead minnow.

The EPA water quality criterion to protect freshwater aquatic life is 0.013 ug/l as a 24-hour average and the concentration should not exceed 1.6 ug/l at any time. For saltwater aquatic life, the concentration of toxaphene should not exceed 0.070 µg/l at any time.

A single test on a freshwater alga showed an effective concentration (50 percent) at 0.38 µg/l. Saltwater algae have been found to vary greatly in sensitivity to toxaphene, with inhibition of growth observed at levels as low as 0.15 µg/l for the dinoflagellate Monocrysis lutheri.

North Carolina Production and Users

Production: None reported.

Users: No information available.

Recommended Reviews

Ambient Water Quality Criteria for Toxaphene, U.S. Environmental Protection Agency, PB81-11783 (1980).

FIRST AID AND EMERGENCY RESPONSE INFORMATION

TOXAPHENE

First Aid (NIOSH/OSHA Pocket Guide to Chemical Hazards)

Eyes: Immediately wash the eyes with large amounts of water. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH TOXAPHENE.

Skin: Promptly wash skin with soap or mild detergent and water. Remove clothing is contaminated and wash the skin.

Inhalation: Move the exposed person to fresh air at once. Perform artificial respiration if necessary. Get medical attention as soon as possible.

Ingestion: Seek immediate medical attention. Give the person large quantities of water. Induce vomiting by use of finger. If: the toxaphene was in a petroleum based material, do not induce vomiting.

Procedures for Spills and Leaks (U.S. DOT Emergency Response Guidebook, 1980)

Isolate hazard area and deny entry. Stay upwind, keep out of low areas. Wear positive pressure breathing apparatus and special protective clothing. Do not touch spilled material. Stop leak if it can be done without risk. Use water spray to reduce vapors.

SMALL SPILLS: Take up with sand, or other noncombustible absorbent material, then flush area with water.

SMALL DRY SPILLS: Shovel into dry containers and cover; move containers; then flush area with water.

LARGE SPILLS: Dike far ahead of spill for later disposal.

Fire and Explosion Information

GENERAL: May burn, but does not ignire readily. Cylinder may explode in heat of fire.

SMALL FIRES: Dry chemical, CO_2, water spray or foam.

LARGE FIRES: Water spray, fog or foam.

FLASH POINT: 275°F

Reactivity

MATERIALS TO AVOID: Strong oxidizers

Protective Measures

PROTECTIVE EQUIPMENT: At levels up to 5 mg/cu m wear a chemical cartridge respirator meeting pesticide requirements, or a supplied air respirator/ self-contained breathing apparatus. At levels up to 25 mg/cu m, wear a chemical cartridge respirator with a full facepiece which meets pesticide requirements, or a gas mask which meets pesticide requirements, or a supplied air respirator with a full facepiece, or a self-contained breathing apparatus with a full facepiece. At levels up to 200 mg/cum, wear a powered-air purifying respirator which meets pesticide requirements, or a supplied-air respirator with full facepiece operating in positive pressure, pressure demand or continuous flow mode.

TOXAPHENE

Profile

CHEMICAL IDENTIFICATION

Alternative Names:

Agricide Maggot Killer	Cristoxo 9
Penphene	Alltex
ENT 9735	Phenacide
Alltox	Estonox
Phenatox	Camphechlor
Fasco-Terpene	Polychlorocamphene
Camphochlor	Geniphene
Polychlorinated Camphenes	Camphofene
Gy-Phene	Polychlorocamphene
Chem-phene	Hercules 3956
Strobane-T	Chlorinated Camphene
Hercules Toxaphene	Synthetic 3956
Chlorocamphene	Huileux
Toxadust	Chlor-chem T-590
M 5055	Toxakil
Compound 3956	Melipax
Toxon 63	Crestoxo
Motox	Vertac 90%
Cristoxo	Octachlorocamphene

Chemical Abstract Services (CAS) Registry Number: 08001-35-2

Registry of Toxic Effects of Chemical Substances (RTECS) Number: XW 5250000

Hazardous Materials Table Identification Number: NA 2761

RCRA Identification Number: U 224

Molecular Weight: 343 to 517; average of 413.8

Molecular Formula: $C_{10}H_{10}Cl_8$; $C_{10}H_{11}Cl_3$; $C_{10}H_9Cl_9$ and other chlorinated derivatives of camphene

Classification: At least 177 compounds are present in toxaphene. Most compounds identified are of the polychlorinated bornane structure (Callahan, 1979); chlorinated camphene

Description: Yellow waxy solid with a pleasant piney odor

Uses: Pesticide

Chemical/Physical Data

Boiling point: decomposition at temperatures greater than 120°C
Melting point: 65-90°C
Vapor pressure: 0.17-0.4 mm at 25°C
Solubility in water: 0.4 to 3 mg/l at 25°C

HUMAN TOXICITY

Human poisoning by toxaphene is characterized by convulsions and hyperreflexia. Other major symptoms of oral intoxication include vomiting: cyanosis, and coma. The minimum lethal dose for humans has been estimated to be between 2 and 7 grams per person (30-103 mg/kg body weight) (IARC, 1979; U.S. EPA, WQC, 1980).

The maximum level at which one could escape within 30 minutes without any escapeimpairing symptoms or irreversible effects is suggested to be 200 mg/cu m for chlorinated camphene (NIOSH/OSHA, 1978).

Carcinogenicity

U.S. EPA, WQC, 1980 — The U.S. EPA Carcinogen Assessment Group (CAG) has determined that toxaphene is an animal carcinogen. Water quality criteria are based on incremental increase of cancer risk with increasing exposures.

IARC, 1979 — Toxaphene (polychlorinated camphenes) was tested in one experiment in mice and in one in rats by oral administration: a dose-related increase in the incidence of hepatocellular carcinomas was observed in male and female mice, and an increased incidence of thyroid tumors was observed in male and female rats.

There is sufficient evidence that toxaphene is carcinogenic in mice and rats. In the absence of adequate data in humans, toxaphene should be regarded as a carcinogen in humans.

Mutagenicity

U.S. EPA, WQC, 1980 — A study of U.S. EPA completed in 1978 found no significant differences in the rates of chromosomal aberrations in leukocytes between groups of individuals occupationally exposed to toxaphene and groups with no occupational exposures to toxaphene.

IARC, 1979 — An increased frequency of chromosomal aberrations has been observed in the lymphocytes of workers exposed to toxaphene. Toxaphene is mutagenic in Salmonella typhimurium. It did not induce dominant lethals in mice.

Teratogenicity & Embryotoxicity

No teratogenic effects were observed in mice receiving 25 mg/kg diet or rats receiving 25 or 100 mg/kg diet after 5 and 3-generation studies.

Oral intubation at 15, 25, and 35 mg/kg-day produced some effects. No embryotoxicity was seen in chicken embryos exposed to toxaphene (IARC, 1979).

ANIMAL TOXICITY

Acute animal toxicity studies indicate that the vehicle used in the administration of toxaphene has a marked effect on lethality, probably due to the extent and/or rate of absorption. The chemical appears much more toxic when administered in corn oil or peanut oil than in an indigestible vehicle such as kerosene (U.S. EPA, WQC, 1980).

Acute Toxicity

Results of lethal studies in several species as reported in the RTECS, 1980 are listed below:

Route	Species	Lethal Dose or Lethal Concentration
Oral	Rat	40 mg/kg, LD50
	Mouse	112 mg/kg, LD50
	Dog	15 mg/kg, LD50
	Rabbit	780 mg/kg, lowest lethal dose
	Guinea pig	250 mg/kg, LD50
	Hamster	200 mg/kg, LD50
	Duck	71 mg/kg, LD50
Inhalation	Mouse	2,000 mg/cu m for 2 hours, lowest LC
Dermal	Rat	600 mg/kg, LD50
	Rabbit	1,025 mg/kg, LD50

Chronic Toxicity

In chronic feeding tests over a 6 month period, 800 ppm in the daily diet of guinea pigs and rats caused no significant change in the weight curve, urine, blood, mortality or tissue pathology. No indications of toxicity have been observed in monkeys when fed toxaphene at a rate corresponding to 10 ppm of their dietary intake. Approximately 60 ppm resulted in toxic symptoms in monkeys after the second week of feeding (ACGIH, 1980).

Toxaphene is readily distributed throughout the body with highest residues found in fat tissue. Elimination is relatively rapid in mammals with a half-life in 1 to 3 days indicated in rats receiving a single oral dose (U.S. EPA, WQC, 1980).

AQUATIC AND TERRESTRIAL TOXICITY

Aquatic Toxicity

Aquatic toxicity rating: TLm 96 is below 1 ppm (RTECS, 1980).

The U.S. EPA Water Quality Criteria for protection of aquatic life are given below:

> For toxaphene the criterion to protect freshwater aquatic life as derived using the Guidelines is 0.013 µg/l as a 24-hour average, and the concentration should not exceed 1.6 µg/l at any time.
>
> For saltwater aquatic life, the concentration of toxaphene should not exceed 0.070 µg/l at any time.

Bioaccumulation: A concentration factor of 52,000 is reported for fat-head minnows (U.S. EPA, WQC, 1980).

Biodegradation in aquatic species: The results of several studies indicate that toxaphene will be reduced in eutropic, anerobic environments, but that different toxaphene components and even different chlorinated sites within molecular structures will be reduced at different rates (Callahan, 1979).

Phytotoxicity

Some polychloroterphenes are quite phytotoxic, presumably because of the facile release of chlorine and the evolution of HCl (Melnikov, 1971). Toxaphene would not be expected to degrade so readily and thus display a much reduced toxicity to plants.

A single test on a freshwater algae showed an effective concentration (50 percent) at 0.38 ug/l. Saltwater algae have been found to vary greatly in sensitivity to toxaphene, with inhibition of growth observed at levels as low as 0.15 µg/l for the dinoflagellate Monochrysis lutheri (U.S. EPA, WQC, 1980).

ENVIRONMENTAL DATA

Air

Toxaphene is a prevalent air contaminant in areas of its use. A survey of nine cities in 1967-78 detected toxaphene in three cities, the highest concentration reported was 2.5 µg/cu m in Orlando, Florida. Toxaphene has also been detected at levels of 0.53 ng/cu m over the Atlantic Ocean (U.S. EPA, WQC, 1980). Weekly air samples were taken in a primary cottongrowing area during 1972-74. Average monthly atmospheric levels of toxaphene were found to range from 0 to 0.5 µg/cu m, with maximum levels occurring during the later summer months and minimal levels in winter (IARC, 1979).

Toxaphene is resistant to photolysis and oxidative degradation in the air, and wide dispersion and significant accumulation can be expected in areas of use. The photolytic half-life of toxaphene is estimated to be greater than 10 years (Callahan, 1979).

Water

In several surveys of drinking water and surface water, toxaphene has not been found to be a contaminant. Toxaphene has been found in watersheds draining agricultural land in concentrations as high as 1.92 µg/l (U.S. EPA, WQC, 1980). It has been found in two U.S. rivers and in lakes. It was detected in 5 of 8 samples of rainwater at levels ranging from 44 to 280 ng/l (IARC, 1979).

Hydrolysis and oxidation of toxaphene in water are probably negligible, and the substance may last several years in natural water systems (Callahan, 1979). The absence of significant degradation and slow removal by biota and sediments can be expected to result in accumulation.

Soil

Degradation of toxaphene has been observed in anerobic sediments. Sorption onto sediments, however, is an important removal process from water (Callahan, 1979) which can result in significant accumulation in this medium. Toxaphene has a half-life of approximately 20 years in some soils (IARC, 1979); forty-five percent of toxaphene applied to sandy loam in 1951 remained 20 years later.

Toxaphene has been detected in many food items at concentrations as high as 0.4 mg/kg. EPA tolerances for toxaphene residues in various agricultural products are shown in Table 1. Fat samples from cattle show a consistent but low percentage of samples with toxaphene levels in excess of 7.0 mg/kg (U.S. EAP, WQC, 1980).

Toxaphene was measured in 96 percent of samples of 50 catfish taken from commercial ponds in the spring of 1970 at an average concentration of 1.98 mg/kg. It has been detected in quail, rabbits, deer, pelicans, and bats.

Toxaphene has also been found in tobacco plants and in aquatic plants, although it is not known to occur as a natural product (IARC, 1979).

Table 1.

Tolerances for Toxaphene Residues in Various Agricultural Products

Residue level (mg/kg)	Product	Reference
7	Fat of meat from cattles, goats, and sheep	22 FR 4615
	Fat of meat from hogs	24 FR 4727
	Fat of meat from horses	27 FR 7492
	Cranberries, hazelnuts, hickory nuts, horseradish, parsnips, pecans, peppers, pimentos, rutabagas, walnuts	22 FR 4615
	Collards, kale, spinach	27 FR 7492
6	Crude soybean oil	31 FR 12435
5	Barley, oats, rice, rye, and wheat	23 FR 477
	Sorghum grain	25 FR 5335
	Cottonseed	26 FR 11799
3	Pineapple and bananas*	27 FR 4913
2	Soybeans, dry form	31 FR 9453
0.1	Sunflower seeds	U.S. EPA, 1977

* Of which not more than 0.3 mg/kg shall be in pulp after the peel is removed and discarded.

Table is reproduced from the U.S. EPA Water Quality Criteria Document (1980).

INDUSTRIAL DATA

Production

No production in North Carolina is reported in the Toxic Substances Control Act (TSCA) Chemical Substances Inventory (U.S. EPA, TSCA, 1980).

Estimated U.S. production for 1975 was 27 million kilograms (30,000 tons); in 1976, three U.S. companies produced a total of 19 million kilograms (21,000 tons) (IARC, 1979).

Consumption and Use

Estimated U.S. Consumption:

The only commercial use of toxaphene is as a pesticide. In 1969, there were 163 registered pesticide uses in the United States, but no quantitative data are available on the distribution or consumption (Metcalf, 1976).

Reported uses of toxaphene and the corresponding Standard Industrial Classification (SIC) codes are listed below:

Insecticide for the control of grasshoppers, army worms, cutworms, cotton pests, livestock pest	01, 02, 287

(IARC, 1979)

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air

No guidelines for air have been established.

Workroom Air

ACGIH — The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH)

for workroom air is 0.5 mg/cu m as a time-weighted average. The recommended Short Term Exposure Limit (STEL) is 1.0 mg/cu m. The importance of skin exposure is noted.

OSHA — The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 0.5 mg/cu m as a time-weighted average.

Water

Addressed by National Interim Primary Drinking Water Regulations set by the U.S. Environmental Protection Agency. The level of toxaphene not to be exceeded is 0.005 mg/l (Code of Federal Regulations, Title 40, Part 141).

Addressed by Ambient Water Quality Criteria set by the U.S. Environmental Protection Agency.

Designated a toxic pollutant by the U.S. Environmental Protection Agency.

Designated a hazardous substance by the U.S. Environmental Protection Agency. Spills in excess of 1 pound must be reported.

Other

Regulated as a hazardous material by the U.S. Department of Transportation.

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Addressed by the Rebuttable Presumption Against Registration (RPAR) through the U.S. Environmental Protection Agency.

Subject of tolerances set by the U.S. Food and Drug Administration to limit residues in agricultural products (See Table 1).

Agencies Concerned with this Chemical

Designated a candidate substance by the Occupational Safety and Health Administration.

Subject of a Risk Assessment Document prepared by the Carcinogen Assessment Group (CAG) of the U.S. Environmental Protection Agency.

Subject of a monograph prepared by the International Agency for Research on Cancer (IARC).

Under toxicological evaluation through the National Toxicology Program to determine mutagenicity. (National Toxicology Program, Fiscal Year 1981 Annual Plan, NTP-80-62, 1980).

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Callahan, M. A., et al. Water-Related Fate of 129 Priority Pollutants. U.S. EPA Office of Water Planning and Standards, Washington, DC, EPA 440/4-79-029 (December 1979).

International Agency for Research on Cancer (IARC). IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon, France, Volume 20. A World Health Organization Publication (WHO), Geneva (1979).

Melkinov, N. N. The Chemistry of Pesticides. Residue Reviews, Vol. 36. Springer-Verlag, NY (1971).

Metcalf, R. and McKelvey, J. J., eds. The Future of Insecticides. Needs and Prospects. John Wiley and Sons, NY (1976).

National Institute for Occupational Safety and Health/Occupational Safety and Health Administration (NIOSH/OSHA). NIOSH/OSHA Pocket Guide to Chemical Hazards. DHEW (NIOSH) Publication No. 78-210 (September 1978).

National Toxicology Program. Fiscal Year 1981 Annual Plan. NTP 80-62 (1980).

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfiche Issue, R. J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 80-111-4 (1980).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA PB-80-155-153 (1980).

U.S. Environmental Protection Agency, Office of Water Planning and Standards. Ambient Water Quality Criteria for Toxaphene. PB81-117863 (October 1980).

TRICHLOROETHANES

Executive Summary

CAS NUMBER: 00071-55-6
1,1,1-Trichloroethane CAS NUMBER 00079-00-5
1,1,2-Trichloroethane CAS NUMBER 25323-89-1
Mixed isomers

The trichloroethanes are colorless, nonflammable liquids used as solvents, chemical intermediates, and components of adhesives, lacquers, and other products. Estimated U.S. production of 1,1,1-trichloroethane in 1976 was 316,000 tons. 1,1,2-trichloroethane is produced in smaller volumes, an estimated 2,000 tons in 1978. North Carolina requires the reporting of all spills if they occur near water.

Health Effects

ACUTE. 1,1,1-Trichloroethane is an anesthetic and is capable of causing death when inhaled at concentrations in excess of 14,000-15,000 ppm. Hepatic effects include liver function abnormalities and cellular damage. Cardiovascular effects are reported, including drop in blood pressure, decreased heart rate, cardiac arrhythmias, and blood clotting changes. Skin contact causes redness and scaling but the skin is not believed to be a significant exposure route.

1,1,2-Trichloroethane, on the other hand, is reported to be readily absorbed through the skin. Its toxicological properties are believed to resemble those of symmetric tetrachloroethane and chloroform. Concentrations on the order of 13,600 ppm produce deep narcosis and death during a two -hour exposure. Narcotic concentrations result in irritation of the eyes and nose.

CARCINOGENICITY. There is limited evidence that 1,1,2-trichloroethane is carcinogenic in mice. NIOSH recommends that it would be prudent to handle the compound in the workplace as if it were a human carcinogen. The available data are insufficient to permit an evaluation of the carcinogenicity of 1,1,1-trichloroethane.

MUTAGENICITY. 1,1,1-Trichloroethane was found to be mutagenic in Salmonella typhimurium but 1,1,2-trichloroethane was not.

TERATOGENICITY & EMBRYOTOXICITY. 1,1,1-Trichloroethane did not produce teratogenic effects in rats or mice exposed 7 hours per day to 875 ppm during the period of organogenesis.

CHRONIC. In diabetic individuals, trichloroethanes may cause a significant increase in SGPT activity (17-fold increase in diabetic rats).

1,1,2-trichloroethane is readily absorbed through the intact skin.

Occupational Health

The American Conference of Governmental Industrial Hygienists has established a Threshold Limit Value (time-weighted average concentration under which it is believed that all workers may be repeatedly exposed day after day without adverse effect) of 350 ppm (1.9 mg/cu m) for the 1,1,1-isomer, and 10 ppm (.045 gm/cu m) for the 1,1,2-isomer. The Short Term Exposure Limit (maximum concentration to which workers may be exposed for a period up to 15 minutes) is 450 ppm (2.5 gm/cu m) for the 1,1,1-isomer, and 20 ppm (.09 gm/cu m) for the 1,1,2-isomer.

Routes of Human Exposure

OCCUPATIONAL. In 1974, the uses of 1,1,1-trichloroethane in the U.S. were the following: cold cleaning of metals, 37 percent; vapor degreasing, 34 percent; chemical intermediate for vinylidene chloride, 23 percent; and other applications, 6 percent.

The National Occupational Health Survey (1974) indicated that workers primarily exposed to 1,1,2-trichloroethane were those in the blast furnace and steel mill, telephone communication, engineering and scientific instrument manufacturing industries.

AMBIENT. Rural air concentrations of 1,1,1-trichloroethane have been reported ranging up to 0.45 ppb (2.5 mg/cu m). Urban levels as high as 14 ppb (76 mg/cu m) have been observed during an inversion. The 1,1,1-isomer has been identified in air samples from many locations (data were not reported for the 1,1,2-isomer).

Both 1,1,1- and 1,1,2-trichloroethane have been detected in raw water and finished drinking water at levels ranging from 0.1 - 8.5 mg/l. 1,1,1-Trichloroethane was detected in drinking water samples from Durham, North Carolina, but no concentrations were reported.

The 1,1,1-isomer has been detected in soil and sediment samples taken near trichloroethylene plants at levels as high as 100 ppb (100 µg/kg). Several marine organisms have been found to have small concentrations of
the same isomer (usually reported together with carbon tetrachloride). Neither isomer is known to occur as a natural product.

CONSUMER. 1,1,1-Trichloroethane has been detected in many food products including meat, oils, fats, tea, fruits, and vegetables at levels ranging from 1-10 mg/kg. It is used in aerosol and other consumer products, such as insecticides and spot cleaners.

Both 1,1,1- and 1,1,2-trichloroethane were approved by the U.S. Food and Drug Administration as constituents of adhesives used as components of food packaging or containers.

Environmental Significance

Estimated atmospheric residence time is reported as 970 days for 1,1,1-trichloroethane and 3 years as an upper limit for 1,1,2-trichloroethane. Estimated half-life in water is 17-23 minutes for the 1,1,1-isomer and 21 minutes for the 1,1,2-isomer.

Freshwater data indicate that acute toxicity occurs at concentrations as low as 18 g/l for the two trichloroethanes; chronic toxicity occurs at concentrations as low as 9.4 g/l. Acute toxicity to saltwater fish and invertebrate species occurs at concentrations as low as 31.2 g/l for 1,1,1-trichloroethane.

A concentration factor of 9 was observed for the 1,1,1-isomer in the bluegill, and a concentration factor of 11.5 was calculated for the 1,1,2-isomer based on the octanol/water partition coefficient.

Toxicity to algae was observed for 1,1,2-trichloroethane at concentrations as low as 443 mg/l. The aquatic toxicity rating is 10-100 (TLm 96) for both isomers.

Recommended Reviews

Chemical Hazard Information Profile, U.S. Environmental Protection Agency, EPA-560/11-80-011 (1980).

Ambient Water Quality Criteria for Chlorinated Ethanes, U.S. Environmental Protection Agency, EPA/440-5-80-029 (1980).

FIRST AID AND EMERGENCY RESPONSE INFORMATION

TRICHLOROETHANES

First Aid (NIOSH/OSHA Pocket Guide to Chemical Hazards)

Eyes:	Wash with large amounts of water immediately. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING TRICHLOROETHANE.
Skin:	Wash the contaminated skin promptly with soap or mild detergent and water. Remove clothing if contaminated and wash skin.
Inhalation:	Move to fresh air at once. Perform artificial respiration if necessary. Seek immediate medical attention.
Ingestion:	Induce vomiting by finger or by giving syrup of ipecac. Seek medical attention.

Procedures for Spills and Leaks (U.S. DOT Emergency Response Guidebook, 1980)

Isolate hazard are and deny entry. Stay upwind and keep out of low areas. Wear positive pressure breathing apparatus and special protective clothing. Do not touch spilled material. Stop leak if it can be done without risk. Use water spray to reduce vapors.

SMALL SPILLS:	Take up with sand, or other noncombustible absorbent material, then flush area with water.
SMALL DRY SPILLS:	Shovel into dry containers and cover, move containers, then flush area with water.
LARGE SPILLS:	Dike far ahead of spill for later disposal.

Fire and Explosion Information

GENERAL: Non-flammable

Reactivity

MATERIALS TO AVOID: Reacts violently with acetone, nitrites, oxygen, sodium and sodium hydroxide. Corrosive to aluminum.

CONDITIONS TO AVOID: Hot metals or ultraviolet radiation will decompose 1,1,2-trichloroethane to form irritating and poisonous gases.

Protective Measures

HANDLING AND STORAGE: Store in a cool, dark, dry place. Do not store in aluminum containers.

ENGINEERING CONTROLS: Provide adequate ventilation. Sinks, showers and eyewash stations should be readily available.

PROTECTIVE CLOTHING (Should not be substituted for proper handling and engineering controls): Gloves and apron of polyvinyl alcohol, neoprene (Do not use natural rubber) or leather, and splash proof goggles should be worn if contact with trichloroethane is likely.

PROTECTIVE EQUIPMENT: For exposure up to 500 ppm use a supplied-air, or self-contained breathing apparatus with face shield. For escape from a contaminated area use a gas mask with organic vapor canister, or self-contained breathing apparatus.

TRICHLOROETHANES

Profile

CHEMICAL IDENTIFICATION

Alternative Names:

Aerothene II
Chloroethene
Chloroform, Methyl-
Chlorten
Ethane, 1,1,1-trichloro-
Methyl chloroform
Solvent 111
Alpha-trichloroethane

Chemical Abstract Services (CAS) Registry Number: 00071-55-6

Registry of Toxic Effects of Chemical Substances (RTECS) Number: KJ 2975000

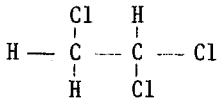
Hazardous Materials Table Identification Number: UN 2831

RCRA Identification Number: U 226

Molecular Weight: 133.42

Molecular Formula: $C_2H_3Cl_3$

Structure:



Classification: Chlorinated aliphatic hydrocarbon

Description: A colorless, nonflammable liquid

Uses: As a solvent and chemical intermediate

Chemical/Physical Data

Boiling point: 74.1°C
Melting point: -32.6°C
Vapor pressure: 100 mm Hg at 20°C; 155 mm at 30°C
Vapor density: 4.63 (Air = 1.0)
Solubility in water: 4,400 mg/l at 20°C
Specific gravity: 1.34

Name: 1,1,2-Trichloroethane

Alternative Names:

Ethane trichloride
Beta-T
Beta-trichloroethane
1,1,2-Trichlorethane
Vinyltrichloride

Chemical Abstract Services (CAS) Registry Number: 00079-00-5

Registry of Toxic Effects of Chemical Substances (RTECS) Number: KJ 3150000

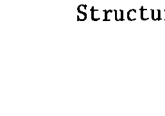
Hazardous Materials Table Identification Number: Not listed.

RCRA Identification Number: U 227

Molecular Weight: 133.42

Molecular Formula: $C_2H_3Cl_3$

Structure:



Classification: Chlorinated aliphatic hydrocarbon

Description: A colorless, nonflammable liquid with a pleasant odor

Uses: As a solvent and chemical intermediate

Chemical/Physical Data

Boiling point: 113.8°C
Melting point: -36.5°C
Vapor pressure: 19 mm Hg at 20°C; 32 mm at 30°C; 40 mm at 35°C
Vapor density: 4 (Air = 1.0)
Solubility in water: 4,500 mg/l at 20°C
Specific gravity: 1.44

HUMAN TOXICITY

1,1,1-Trichloroethane may affect a variety of human organs or systems including hematologic, cardiovascular, gastrointestinal, hepatic biliary, neurologic, dermatologic, opthalmologic, and others. Specific adverse neurological effects include central nervous system depression, incoordination, inebriation, headache, dizziness, unconsciousness, generalized weakness, sleepiness, mental confusion and other effects. Hepatic effects include liver function abnormalities and cellular damage. Cardiovascular effects such as drop in blood pressure, decrease in heart rate, and cardiac arrhythmias are reported. Blood clotting changes are also noted (NIOSH, 1978).

Adverse human effects of the 1,1,2-isomer are not reported (NIOSH, 1978).

While comparatively low in systemic toxicity, 1,1,1-trichloroethane is an anesthetic and is capable of causing death when inhaled at concentrations in excess of 14,000-15,000 ppm. Beginning anesthetic effects occur at concentrations approaching 500 ppm. It is reported that "repetitive vapor exposure to...350 ppm produced on untoward subjective or objective health response..." (ACGIH, 1980).

Skin contact with the 1,1,1-isomer causes redness and scaling. Although absorption through the skin can occur, this is not believed to be a significant exposure route (ACGIH, 1980). The 1,1,2-isomer is reported to be readily absorbed through the skin (U.S. EPA, CHIP, 1980).

The 1,1,2-isomer is believed to resemble symmetric tetrachloroethane and chloroform in its toxicological properties (ACGIH, 1980).

The maximum level at which one could escape within 30 minutes without any escape-impairing symptoms or irreversible effects is suggested to be 500 ppm for 1,1,2-trichloroethane (NIOSH/OSHA, 1978).

Carcinogenicity

U.S. EPA, WQC 1980	The U.S. EPA Carcinogen Assessment Group (CAG) has determined 1,1,2-trichloroethane is carcinogenic in animals and therefore poses a risk to man. Water Quality Criteria for the 1,1,2-isomer are based on incremental increase of cancer with increasing exposures, assuming nonthreshold behavior.
IARC, 1979	The available data do not permit an evaluation of the carcinogenicity of 1,1,1-trichloroethane to be made. There is limited evidence that 1,1,2-trichloroethane is carcinogenic in mice.
NIOSH, 1978	NIOSH recommends that it would be prudent to handle 1,1,2-trichloroethane in the workplace as if it were a human carcinogen. This recommendation is based primarily on National Cancer Institute (NCI) data indicating that laboratory animals administered the compound experienced a statistically significant excess of cancer as compared to control animals.
OSHA, 1980	1,1,2-Trichloroethane was found to be carcinogenic in male and female mice at two dose levels (390 and 190 mg/kg-day, 5 days/week for up to 78 weeks).

Mutagenicity

IARC, 1979	1,1,1-Trichloroethane is mutagenic in Salmonella typhimurium; but 1,1,2-trichloroethane was not.

Teratogenicity & Embryotoxicity

1,1,1-Trichloroethane did not produce teratogenic effects in rats or mice exposed 7 hours per day to 875 ppm during the period of organogenesis (ACGIH, 1980).

ANIMAL TOXICITY

All of the chloroethane compounds are known to cause central nervous system depression, usually expressed as abnormal weakness, intoxication, restlessness, irregular respiration, muscle incoordination, and unconsciousness. Chloroethanes are irritating to the eyes and skin (NIOSH, 1978).

The 1,1,1-isomer has been studied extensively in several species. Less data are available for the 1,1,2-isomer. Reported effects differ for the two isomers.

Acute Toxicity

Results of lethal studies in several species as reported in the RTECS, 1980 are listed below:

Route	Species	Lethal Dose or Lethal Concentration
1,1,1-		
Oral	Rat	10.3 gm/kg, LD50
	Mouse	11.2 gm/kg, LD50
	Dog	.75 gm/kg, LD50
	Rabbit	5.6 gm/kg, LD50
	Guinea pig	9.4 gm/kg, LD50
1,1,2-	Rat	1.1 gm/kg, LD50
	Dog	.5 gm/kg, Lowest lethal dose
1,1,1-		
Inhalation	Rat	1,000 ppm (5.4 gm/cu m) for 24 hours, lowest LC
1,1,2-	Rat	500 ppm (2.7 gm/cu m) for 8 hours, lowest LC
	Cat	2,426 ppm (13 gm/cu m) for 4.5 hours, lowest LC

Chronic Toxicity

Liver and kidney injury have resulted in dogs and guinea pigs exposed to 1,1,2-trichloroethane (NIOSH, 1978).

Aquatic Toxicity

Aquatic toxicity rating: TLm 96 is 10-100 ppm for both 1,1,1- and 1,1,2-trichloroethane (RTECS, 1980).

The U.S. Water Quality Criteria for the protection of aquatic life are given below:

> The available freshwater data for chlorinated ethanes indicate that toxicity increases greatly with increasing chlorination and that acute toxicity occurs at concentrations as low as 18 mg/l for two trichloroethanes. Chronic toxicity occurs at concentrations as low as 9.4 mg/l for 1,1,2-

trichloroethane. Acute and chronic toxicity would occur at lower concentrations among species that are more sensitive than those tested.

The available saltwater data for chlorinated ethanes indicate that toxicity increases greatly with increasing chlorination and that acute toxicity to fish and invertebrate species occurs at concentrations as low as 31 mg/l for 1,1,1-trichloroethane. Acute and chronic toxicity would occur at lower concentrations among species that are more sensitive than those tested.

Bioaccumulation: A concentration factor of 9 was observed for the 1,1,1-isomer in the bluegill exposed, and a concentration factor of 11.5 was calculated for the 1,1,2-isomer based on the octanol/water partition coefficient (U.S. EPA, WQC, 1980).

Biodegradation in aquatic species: No data are available.

Phytotoxicity

Toxicity to algae was observed for 1,1,1-trichloroethane at concentrations as low as 443 mg/l (U.S. EPA, WQC, 1980).

ENVIRONMENTAL DATA

Air

Rural levels of 1,1,1-trichloroethane have been reported ranging from below the detection limit to 0.45 ppb (2.5 ug/cu m). Urban levels as high as 14 ppm (76 ug/cu m) have been observed during an inversion (Lillian, 1975; Lillian, 1976; U.S. EPA, ETS, 1977). The 1,1,1-isomer has been identified in air samples from many locations, data are not reported for the 1,1,2-isomer (IARC, 1979).

The 1,1,2-isomer has an estimated atmospheric residence time of 3 years (as an upper limit) (Callahan, 1979). The 1,1,1-isomer has an estimated atmospheric residence time of 970 days (Cupitt, 1980) and an estimated oxidative half-life in air of 1.1 - 8 years (Callahan, 1979). The high volatility of these substances results in substantial atmospheric loading, but degradation is rapid. Release rates and accumulation are lower than for other chlorinated compounds such as tetrachloroethylene.

Water

Both 1,1,1- and 1,1,2-trichloroethane have been detected in raw water and municipal drinking water at levels ranging from 0.1 - 8.5 ug/l (IARC, 1979). 1,1,1,-Trichloroethane was detected in drinking water samples from Durham, North Carolina but no concentrations were reported (Shackelford, 1977).

The 1,1,1-isomer has an estimated half-life in water of 17-23 minutes (Verschueren, 1977) based on evaporation, and degrades via hydrolysis (experimental half-life of 6 months; Callahan, 1979). The 1,1,2-isomer has similar properties. Although somewhat resistant to hydrolysis and oxidation, rapid volatilization to the atmosphere is expected. Low levels may be quite stable and widely dispersed in this medium.

Soil

Limited data suggest some preferential adorption onto organic sediments (Callahan, 1979). Volatilization is probably more important as a removal process than degradation. Some accumulation can be expected.

Biota

There is no evidence to suggest significant bioaccumulation in this medium. There is some evidence for resistance to microbial degradation (Callahan, 1979 and U.S. EPA, WQC, 1980), but no magnification is expected.

1,1,1-Trichloroethane has been detected in many food products, including meat, oils, fats, tea, fruits, and vegetables at levels ranging from 1010 ug/kg (IARC, 1979). It has also been detected in soil and sediment samples taken near trichloroethylene plants at levels as high as 100 ppb (199 ug/kg) (U.S. EPA, OTS, 1977). Several marine organisms have been found to have small concentrations of the 1,1,1-isomer (usually reported together with carbon tetrachloride). Neither isomer is known to occur as a natural product (IARC, 1979).

INDUSTRIAL DATA

Production

No production in North Carolina was reported in the Toxic Substances Control Act (TSCA) Chemical Substances Inventory (U.S. EPA, TSCA, 1980).

The estimated U.S. production for the 1,1,1-isomer in 1976 was 316,000 tons (IARC, 1979). The estimated U.S. production for the 1,1,2-isomer in 1978 was 2,000 tons (U.S. EPA, CHIP, 1980).

Consumption and Use

Quantitative consumption pattern data are available for 1,1,1-trichloroethane only. These data are given below:

Cold cleaning of metal	37 percent
Vapor degreasing	34 percent
Chemical intermediate for vinylidine chloride	23 percent
Miscellaneous	6 percent

(IARC, 1979)

Reported uses of trichloroethanes and their corresponding SIC codes are listed below:

1,1,1-Trichloroethane

Cold cleaning solvent for electric motors, generators, electronic apparatus	35
High purity cleaning of missile parts, semiconductors, and high vacuum equipment	376, 3674, 36
Vapor degreasing	-
In adhesives and as a resin solvent	2891, 282
Lubricant carrier	-
Coolant for drilling and tapping stainless steel	34
Solvent for drain cleaners, shoe polishes, spot remover, insecticides, and printing inks	2869, 721, 2879, 2893

(IARC, 1979)

1,1,2-Trichloroethane

Chemical intermediate for production of vinylidene chloride (use reportedly terminated in 1978)	2869
Solvent for fats, waxes, and natural resins	28
Production of Teflon tubing	282
In adhesives, lacquers, and coating formulations	2891, 285

(U.S. EPA, CHIP, 1980)

Manufacture of 1,1,-dichloroethane 2869
(U.S. EPA, WQC, 1980)

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air
Under evaluation for possible designation as a Hazardous Air Pollutant by the U.S. Environmental Protection Agency.

Workroom Air

ACGIH The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air is 350 ppm (1.9 gm/cu m) as a time-weighted average for 1,1,1-trichloroethane. The recommended Short Term Exposure Limit (STEL) for the 1,1,1-isomer is 450 ppm (2.5 gm/cu m). The time-weighted average for the 1,1,2-isomer is 10 ppm (0.45 gm/cu m) and the STEL is 20 ppm (.09 gm/cu m).

NIOSH The National Institute of Occupational Safety and Health (NIOSH) recommends a standard of 350 ppm (1.9 gm/cu m) as a ceiling limit for 1,1,1-trichloroethane. NIOSH has recommended the handling of 1,1,2-trichloroethane as if it were a human carcinogen. Exposure should be limited to as few employees as possible while minimizing workplace exposure levels with engineering and work practice controls.

OHSA The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 350 ppm (1.9 gm/cu m) for 1,1,1-trichloroethane and 10 ppm for 1,1,2-trichloroethane as a time-weighted average.

Water
Addressed by Ambient Water Quality Criteria set by the U.S. Environmental Protection Agency.

Designated a toxic pollutant by the U.S. Environmental Protection Agency.

Designated a hazardous substance by the U.S. Environmental Protection Agency.

Other
Regulated as a hazardous material by the U.S. Departmnet of Transportation.

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Agencies Concerned with this Chemical

Chemical Hazard Information Profile (CHIP) compiled by the Office of Testing and Evaluation, U.S. Environmental Protection Agency.

Designated a candidate substance by the Occupational Safety and Health Administration.

Subject of a monograph prepared by the International Agency for Research on Cancer (IARC).

Subject of a Risk Assessment (1,1,2-trichloroethane) prepared by U.S. EPA's Carcinogen Assessment Group (CAG) for the Office of Water Planning and Standards.

Appears on the Priority List of the Interagency Testing Committee (ITC).

Subject to a proposed rule by the U.S. Environmental Protection Agency (EPA) under the Toxic Substances Control Act, Section 4(a) that would require manufacturers and processors to test the chemical according to standards EPA had adopted. Proposed testing includes: structural teratogenicity; aquatic vertebrates--acure and chronic toxicity, aquatic invertebrates-chronic toxicity; birds--chronic toxicity; terrestrial plants--early seedling growth; seed germination, root elongation; bioconcentration--plant uptake/translocation; and soil adsorption (U.S. EPA, Federal Register, Vol. 46, No. 108, June 5, 1981).

Subject to a proposed rule under the Toxic Substances Control Act that would require all chemical manufacturers to report production and exposurerelated data to the U.S. environmental Protection Agency (Federal Register, Vol. 45, No. 42, 1980).

Addressed by a development plan prepared by the Interagency Regulatory Liaison Group (IRLG).

Under toxicological evaluation through the National Toxicology Program to determine carcinogenicity of 1,1,1-trichloroethane. Testing of rats and mice by gavage is in testing phase (FY 1980) (National Toxicology Program, Fiscal Year 1981 Annual Plan, NTP-80-62, 1980).

Approved (both isomers) by the U.S. Food and Drug Administration as a constituent of adhesives used as component of articles intended for use in packaging, transporting, or holding food.

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Callahan, M. A., et al. Water-Related Fate of 129 Priority Pollutants. U.S. EPA Office of Water Planning and Standards, Washington, DC, EPA 440/4-79-029 (December 1979).

Cupitt, L. T. Fate of Toxic and Hazardous Materials in the Air Environment. EPA-600/3-80-084, NTIS PB 80-221948 (September 1980).

International Agency for Research on Cancer (IARC). IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon France, Volume 20. A World Health Orgnaization Publication (WHO), Geneva (1979).

Lillian, D., H. B. Singh, and A. Appleby. Gas Chromatographic Analysis of Ambient Halogenated Compounds. Journal of the Air Pollution Control Association, Vol. 26, No. 2 (1976).

Lillian, D. Atmospheric Fates of Halogenated Compounds. Environmental Science and Technology, Volume 9, No. 12 (1975).

Merck Index: An Encyclopedia of Chemicals and Drugs, Ninth Edition, M. Windholz, Ed. Merck and Co., Rahway, NJ (1976).

National Institute for Occupational Safety and Health (NIOSH). NIOSH Current Intelligence Bulletin No. 27. Chloroethanes: Review of Toxicology. U.S. Department of Health, Education and Welfare. DHEW (NIOSH) Publication No. 78-181 (1978).

National Institute for Occupational Safety and Health (NIOSH). Criteria for a Recommended Standard...Occupational Exposure to 1,1,1-Trichloroethane (Methyl Chloroform). U.S. Department of Health, Education and Welfare (DHEW/NIOSH) Publication No. 76-184 (1976).

National Institute for Occupational Safety and Health/Occupational Safety and Health Administration (NIOSH/OSHA). NIOSH/OSHA Pocket Guide to Chemical Hazards. DHEW (NIOSH) Publication No. 78-210 (September 1978).

National Toxicology Program. Fiscal Year 1981 Annual Plan. NTP 80-62 (1980).

Occupational Safety and Health Administration (OSHA). Candidate Substance Data Summary Sheet. Chemical: Ethane, 1,1,2-trichloro. (1980).

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfiche Issue, R. J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco Inc., Rockville MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 80-111-4 (1980).

Shackelford, W. M., and L. H. Keith. Frequency of Organic Compounds Identified in Water. U.S. Environmental Protection Agency, EPA600/476062 (December 1976).

U.S. Environmental Protection Agency. Dichloromethane, Nitrobenzene, and 1,1,1-Trichloroethane: Proposed Test Rule. Federal Register, Vol. 46, No. 108 (June 5, 1981).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Chemical Hazard Information Profiles (CHIPs). EPA-560/11-80-011 (1890).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA PB-80-155-153 (1980).

U.S. Environmental Protection Agency, Office of Toxic Substances. Environmental Monitoring Near Industrial Sites: Trichloroethylene. Available from the National Technical Information Service, Springfield, VA, PB 273-203 (1977).

U.S. Environmental Protection Agency, Office of Water Planning and Standards. Ambient Water Quality Criteria for Chlorinated Ethanes. EPA-440/5-80-029 (October 1980).

Verschueren, Karel. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York, NY (1977).

TRICHLOROETHENE

Executive Summary

CAS NUMBER: 00079-01-6

Trichloroethene is a colorless, nonflammable liquid with a chloroform-like odor. It is currently used for degreasing, dry cleaning and as a solvent. In the past, trichloroethene was used as an extractant in foodprocessing and as an anesthetic, but both these applications have been discontinued as a result of the substance's toxic and possible carcinogenic effects. Trichloroethene is prepared by the chlorination and dehydrochlorination of 1,2-dichloroethene. Production of trichloroethene in the U.S. in 1977 was 132 million kg, output has been decreasing since 1970 primarily because of legislation restricting use and emissions of this product. Numerous fatalities resulting from anesthesia and industrial intoxication have been compiled. Federal regulations require the reporting of spills in excess of 1000 pounds. North Carolina requires the reporting of all spills if they occur near water.

Health Effects

ACUTE. The predominant physiological response to acute trichloroethene exposure is central nervous system depression - vital disturbances, mental confusion, fatigue, nausea and vomiting. Prolonged skin contact may cause local irritation, blister formation and in some cases, temporary paralysis of the fingers. Other biological effects resulting from acute exposure to trichloroethene include necrosis of the liver and kidney, arrhythmias of the heart and anemia.

CARCINOGENICITY. There is limited evidence that trichloroethene is carcinogenic in animals. Epidemiological studies on humans are considered inadequate to evaluate carcinogenicity.

MUTAGENICITY. Mutagenic activity has been associated with trichloroethene, although the results were partially attributable to mutagenic contaminants of the samples tested.

TERATOGENICITY AND EMBRYOTOXICITY. No evidence was found to indicate that trichloroethene causes birth defects or is embryotoxic. Trichloroethene as an anesthetic is contraindicated for pregnant women, however, because it diffuses rapidly across the placenta.

CHRONIC. Deliberate inhalation of moderate concentrations of trichloroethene induces a state of euphoria which has led to addiction.

Occupational Health Regulations

ACGIH: The Threshold Limit Value (TLV) for workroom air is 50 ppm (270 mg/cu m) as a time-weighted average. The recommended Short Term Exposure Limit (STEL) is 150 ppm (805 mg/cu m).

NIOSH: The time-weighted average limit for workroom air is 100 ppm (535 mg/cu m). The ceiling limit is 150 ppm (805 mg/cu m) for 10 minutes.

OSHA: The time-weighted average is 100 ppm with a ceiling limit of 200 ppm.

Routes of Human Exposure

OCCUPATIONAL. Major occupational exposure to trichloroethene occurs during the vapor degreasing of prefabricated metal parts. Exposure also occurs during dry cleaning operations and some textile manufacturing operations.

AMBIENT. Background ambient air concentrations range from 27-80 mg/cu m (5-15 parts per trillion). Concentrations of trichloroethene in ambient water are about 0.6 mg/l. This substance can be expected to accumulate in some sediments.

CONSUMER. Trichloroethene has been observed in meats, fruits, vegetables and beverages at concentrations of 5-10 ug/kg. It is also found in tea and coffee as a result of extraction procedures using trichloroethene.

Environmental Significance

The Aquatic Toxicity Rating (TLm 96) for trichloroethene is 100-1000 ppm. Biodegradation in aquatic species is presumed to be rapid, and the half-life of trichloroethene in tissue is less than one day. Trichloroethene is not expected to accumulate significantly in the environment, although low levels may be quite stable and widely dispersed.

Recommended Reviews

Axelson, O. et al. (1978). A cohort study on trichloroethene exposure and cancer mortality. J. Occup. Med., 20, 194-196.

Browning, G. (1965). Toxicity and Metabolism of Industrial Solvents, Amsterdam, Elsevier, pp. 189-212.

FIRST AID AND EMERGENCY RESPONSE INFORMATION

TRICHLOROETHENE

First Aid

Inhalation: Get to fresh air. Give artificial respiration or oxygen, if necessary. Keep person warm and at rest. Seek medical attention as soon as possible.

Skin: Take off clothing soaked with liquid. Flush skin with plenty of water. Seek medical attention immediately.

Eyes: Flush eyes with water for 15 minutes, occasionally lifting upper and lower lids. Seek medical attention immediately. CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH TRICHLOROETHENE.

Ingestion: Seek medical attention. Induce vomiting with syrup of ipecac or by having victim touch the back of his throat with his finger.

Note to Physician: Expired air analysis and urinary metabolites have been used to monitor exposure.

Procedures for Spills and Leaks (U.S. DOT Emergency Response Guidebook, 1980)

Isolate hazard area and deny entry. Stay upwind and keep out of low areas. Wear positive pressure breathing apparatus and special protective clothing. Do not touch spilled material. Stop leak if it can be done without risk. Use water spray to reduce vapors.

SMALL SPILLS: Take up with sand, or other noncombustible absorbent material, then flush area with water.

SMALL DRY SPILLS: Shovel into dry containers and cover; move containers; then flush area with water.

LARGE SPILLS: Dike far ahead of spill for later disposal.

Fire and Explosion Information

GENERAL: Not flammable or explosive at room temperatures. Ignites at 770°F (410°C), moderately flammable at high temperatures.

EXPLOSIVE LIMITS: Upper 41%, lower 11%.

EXTINGUISHER: Carbon dioxide, dry chemical or foam.

Reactivity

CONDITIONS TO AVOID: Contact with open flames or ultraviolet radiation can form poisonous or explosive products.

MATERIALS TO AVOID: Contact with certain hot metals (e.g., aluminum and magnesium) and strong alkalies can form highly poisonous or explosive products.

Protective Measures

STORAGE AND HANDLING: Store in sealed steel or plastic cans or dark glass bottles.

ENGINEERING CONTROLS: Use in well ventilated areas with no cross drafts. Sinks, eye wash stations and showers should be available.

PROTECTIVE CLOTHING (Should not be substituted for proper handling and engineering controls): If direct contact is likely , wear overalls, polyvinyl boots and gloves, and goggles or a faceshield.

PROTECTIVE EQUIPMENT: At exposures above 500 ppm, wear a chemical cartridge respirator with an organic vapor cartridge, supplied-air respirator or self-contained breathing apparatus. At exposures above 1000 ppm wear any respirator appropriate for 500 ppm exposure with a full facepiece or a gas mask with an organic vapor canister.

TRICHLOROETHENE

Profile

Chemical Identification

Alternative Names:

Acetylene Trichloride	Ethylene Trichloride
Algylen	Fleck-Flip
Anamenth	Flock Flip
Benzinol	Fluate
Biacosolv	Gemalgen
Cecolene	Lanadin
Chlorilen	Lethurin
1,-Chloro-	Narcogen
2,2-Dichloroethylene	Narkosoid
Chlorylea	Nialk
Chlorylen	Perm-a-chlor
Dow-Tri	TLE
Dukeron	Tri-Clene
Ethinyl Trichloride	Trichloroethylene

Chemical Abstract Services (CAS) Registry Number: 00079-01-6

Registry of Toxic Effects of Chemical Substances (RTECS) Number: KX 4550000

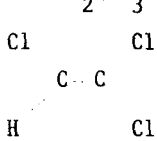
Hazardous Materials Table Identification Number: UN 1710

RCRA Identification Number: U 228

Molecular Weight: 131.38

Molecular Formula: C_2HCl_3

Structure:



Classification: Unsaturated alkyl halides

Description: A colorless, heavy, mobile liquid; chloroformlike odor

Uses: Industrial solvent, degreasing, dry cleaning, manufacturing of organic chemicals

Chemical/Physical Data

Boiling point: 86.7°C
Melting point: -73°C
Vapor pressure: 100 mm Hg at 32°C
Vapor density: 4.54 (air = 1.0)
Solubility in water: 1,000 ug/ml
Solubility (other): Soluble in chloroform, acetone, alcohol, ether
Estimated half-life in air: 5 hours to 6 weeks
Estimated atmospheric residence time: 5.2 days (Cupitt, 1980)
Estimated oxidative half-life in air: 35 hours (Radding, 1977)
Estimated half-life in water (hydrolysis): 2.5 years
Hydrolysis rate: Not hydrolized by water under normal conditions
Log octanol/water partition coefficient: 2.29 (Radding, 1977)
Bioaccumulation in aquatic organisms: A concentration factor of 17 was measured in the bluegill (U.S. EPA, WQC, 1980)
Odor threshold in air: 116-580 mg/cu m (21.4 - 100 ppm) (Verschueren, 1977)
Odor threshold in water: 10 mg/l (Verschueren, 1977)

HUMAN TOXICITY

The predominant physiological response to acute trichlorethene exposure is central nervous system depression. Visual disturbances, mental confusion, fatigue, and sometimes nausea and vomiting have been observed. Dangers of acute exposure are accentuated by visual disturbances and incoordination which in turn, may lead to unsafe mechanical operation in the workplace (NIOSH, 1978).

Prolonged skin contact may cause local irritation and blister formation and, under industrial conditions, repeated immersion of the hands in trichloroethene has caused paralysis of the fingers. While trichloroethene penetrates intact skin, it is considered unlikely that absorption of toxic quantities would occur by this route. Trichloroethene is readily absorbed from the gastrointestinal tract, leading to respiratory failure or cardiac arrest. Depending on the dose, signs and symptoms may be delayed for several hours (NIOSH, 1978).

Other biological effects resulting from acute exposure to trichloroethene include necrosis of the liver and kidney, tachypnea of the lungs, arrhythmias of the heart and anemia (ACGIH, 1980).

The following inhalation exposures produced toxic, central nervous system and systemic effects in humans: 160 ppm (812 mg/kg) for 83 minutes. The LCLo for humans is 2,900 ppm, and the probable oral lethal dose is 50-500 mg/kg (between 1 teaspoon and one ounce) for a 70 kg (150 lb.) person.

Trichloroethene (as an anesthetic) is not advocated for children, and is contraindicated in the presence of anemia, toxemia of pregnancy and disease of the heart, lungs, kidneys and liver. Trichloroethene, when inhaled by pregnant women, diffuses rapidly across the placenta (NIOSH 1978).

Deliberate inhalation of moderate concentrations of trichloroethene induces a state of euphoria which has led to addiction. Liver and kidney injuries attributed to overexposure to trichloroethene, while rare, have been reported (NIOSH, 1978).

Carcinogenicity

U.S. EPA, CAG, 1980 There is limited evidence that trichloroethene is carcinogenic in mice.

IARC, 1979 Trichloroethane has been classified as a positive animal carcinogen.

Trichloroethene was tested in one experiment in mice and one in rats by oral administration. In mice, it produced hepatocellular carcinomas and lung tumors in both males and females. The experiment with rats was considered inadequate. Epidemiological studies on humans were also considered inadequate, and no assessment of carcinogenicity could be made.

Mutagenicity

U.S. EPA, CAG, 1980 Mutagenic activity associated with trichloroethene was partially attributable to mutagenic contaminants of the samples tested.

Teratogenicity and Embryotoxicity

No evidence was found to indicate that trichloroethene causes birth defects or is embryotoxic.

ANIMAL TOXICITY

Death in laboratory animals from acute exposure to trichloroethene vapor is caused by liver injury, respiratory failure or cardiac arrest. Trichloroethene is reported to have caused anemia in rabbits and brain damage in rats. An apparent difference in metabolism has been observed among humans, rabbits and rats exposed to trichloroethene -- rats metabolized the substance most rapidly, and humans the most slowly (ACGIH, 1980).

Acute Toxicity

Results of lethal studies in several species as reported in the RTECS, 1980 are listed below:

Route	Species	Lethal Dose or Lethal Concentration
Oral	Rat	4,920 mg/kg, LD50
	Rabbit	7,330 mg/kg, LDLo
	Dog	5,860 mg/kg, LDLo
	Cat	5,864 mg/kg, LDLo
Inhalation	Rat	8,000 ppm for 4 hours, LCLo
	Guinea Pig	37,200 ppm for 40 minutes, LCLo
	Mouse	3,000 ppm for 2 hours, LCLo
	Cat	32,500 mg/cu m for 2 hours, LCLo

Chronic Toxicity

Route	Species	Dose	Effect
Oral	Mice	912 mg/kg for 78 wks	Carcinogenic
Dermal	Rabbit	500 mg/24 hours	Severe Skin Irritant
Ocular	Rabbit	20 mg/24 hours	Severe eye Irritant

Aquatic Toxicity

Aquatic Toxicity Rating: TLm 96 is 100-1000 ppm

The U.S. EPA Water Quality Criteria for the protection of aquatic life is given below:

> The available data for trichloroethene indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 45,000 ug/l. No data are available concerning the chronic toxicity of trichloroethene to sensitive freshwater aquatic life but adverse behavioral effects occur to one species at concentrations as low as 21.9 mg/l.
>
> The available data for trichloroethene indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 2.0 mg/l. No data are available concerning the chronic toxicity of trichloroethene to sensitive saltwater aquatic life.

The saltwater alga, Phaedactylum tricornutum showed a 50 percent decrease in carbon (by 14C technique) uptake at a concentration of 8.0 mg/l of trichloroethene. Bioaccumulation: a bioconcentration factor of 17 was measured in bluegills.

Biodegradation in aquatic species is presumed to be rapid. Half-life in tissue is less than one day.

Phytotoxicity

No plant data was found for toxic effects from trichloroethene.

ENVIRONMENTAL DATA

Air

Background ambient air concentrations of trichloroethene range from 27-80 ng/cu m (5-15 parts per trillion). The U.S. EPA has estimated that approximately 60% of the total annual world production of trichloroethene is released to the environment, with annual emissions of about 540 million kg to the atmosphere and 9.1 million kg to the ocean. Dispersive uses of trichloroethene such as metal cleaning and solvent applications

result in estimated annual emissions of 192 million kg. in the U.S. (IARC, 1979). Trichloroethene has an estimated half-life in air of 5 hours to 6 weeks (Callahan, 1979). It degrades rapidly in vapor atmosphere, but elevated levels do not occur due largely to its high volatility (IARC, 1979).

Water

Concentrations of trichloroethene in ambient water are about 0.6 mg/l. It has been detected in lake and river waters, in raw sewage, in chemical plant effluent, and in ground and surface water and urban tap water (IARC, 1979). Trichloroethene is resistance to hydrolysis and oxidation, but volatilizes rapidly to the atmosphere (Callahan, 1979). Low levels may be quite stable and widely dispersed.

Soil

Concentrations of trichloroethene in soil and sediments near production and user sites in the U.S. ranged from 0-100 ug/kg (IARC, 1979). Limited data suggest some preferential absorption onto organic sediments (Callahan, 1979) Volatilization is probably more significant than degradation, resulting in some sedimentary accumulation.

Biota

Trichloroethene has been detected in fish, mollusc and human tissue (IARC, 1979).

Other

Trichloroethene has been observed in meats, fruits, vegetables, and beverages at concentrations of 5-10 ug/kg. Tea contained 60 ug/kg. Foods using trichloroethene in the extraction procedure have maximum allowable residue requirements. These limitations are listed below:

Instant coffee	10 mg/kg
Ground coffee	25 mg/kg
Spice extracts	30 mg/kg

INDUSTRIAL DATA

Production

No production in North Carolina reported in the Toxic Substances Control Act (TSCA) Chemical Substance Inventory (U.S. EPA, TSCA, 1980).

U.S. production in 1977 was 132 million kg (145,500 tons).

Consumption and Use

Estimated U.S. Consumption:

Vapor degeasing of fabricated metal parts	82 percent
Miscellaneous applications	3 percent
Export	15 percent

Reported uses of trichloroethene and the corresponding SIC codes are listed below:

Vapor degreasing of fabricated metal parts	34
Solvent in textile industry	22
Solvent for adhesives and lubricant	2821
Low temperature heat transfer fluid	-
Solvent in consumer cleaning fluids	721
Pharmaceutical uses as anesthetic and disinfectant	283
Food and drug extraction	
Fur cleaning agent	
Motion picture film cleaner	
Formulation in paint remover	

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air

Under evaluation for possible designation as a Hazardous Air Pollutant by the U.S. Environmental Protection Agency.

Workroom Air

ACGIH — The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air is 50 ppm (270 mg/cu m) as a time-weighted average.

NIOSH — The National Institute of Occupational Safety and Health (NIOSH) recommends a standard of 100 ppm (535 mg/cu m) as a time-weighted average and a ceiling limit of 150 ppm (805 mg/cu m).

Water

Addressed by Ambient Water Quality Criteria set by the U.S. Environmental Protection Agency.

Designated a toxic pollutant by the U.S. Environmental Protection Agency.

Designated a hazardous substance by the U.S. Environmental Protection Agency. Spills in excess of 1,000 pounds must be reported.

Other

Regulated as a hazardous material by the U.S. Department of Transportation. The regulations pertain to the identification and transportation of hazardous materials in commerce (Code of Federal Regulations, Title 49, Part 172.101). Trichloroethene is classified as a ORM-A. There is no special label required in shipping.

Regulated as a hazardous waste under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Agencies Concerned with this Chemical

Designated a candidate substance by the Occupational Safety and Health Administration.

Subject of a Risk Assessment Document prepared by the Carcinogen Assessment Group (CAG) of the U.S. Environmental Protection Agency.

Subject of a monograph prepared by the International Agency for Research on Cancer (IARC).

Addressed by a development plan for Chloroform and Chlorinated Solvents prepared by the Interagency Regulatory Liaison Group (IRLG).

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Callahan, M. A., et al. Water-Related Fate of 129 Priority Pollutants. U.S. EPA Office of Water Planning and Standards, Washington, DC, EPA 440/4-79-029 (December 1979).

Cupitt, L. T. Fate of Toxic and Hazardous Materials in the Air Environment. EPA-600/3-80-084, NTIS PB 80-221948 (September 1980).

International Agency for Research on Cancer (IARC). IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon France, Volume 19. A World Health Organization Publication (WHO), Geneva (1979).

Merck Index: An Encyclopedia of Chemicals and Drugs, Ninth Edition, M. Windholz, Ed. Merck and Co., Rahway, NJ (1976).

National Institute for Occupational Safety and Health/Occupational Safety and Health Administration (NIOSH/OSHA). NIOSH/OSHA Pocket Guide to Chemical Hazards. DHEW (NIOSH) Publication No. 78-210 (September 1978).

National Institute for Occupational Safety and Health. National Occupational Hazard Survey. Available from Division of Technical Services. Cincinnati, OH, DHEW 74-127, 77-123, and 78-114 (1980).

National Toxicology Program. Classification of 102 NTP Compounds for FY 81 by the Chemical Nomination and Selection Committee. U.S. Department of Health, Education and Welfare, Jefferson, Arkansas (March 1980).

National Toxicology Program. Executive Summaries of Nine Compounds Nominated for FY 81 Testing. U.S. Department of Health, Education and Welfare, Jefferson, Arkansas (January 1980).

National Toxicology Program. Executive Sumaries of Twenty-Five Compounds Nominted for FT-80 Testing. U.S. Department of Health, Education, and Welfare, Jefferson, Arkansas (January 1980).

National Toxicology Program. Fiscal Year 1981 Annual Plan. NTP 80-62 (1980).

National Toxicology Program. Review of Current DHEW Research Related Toxicology Fiscal Year 1980. Department of Health, Education and Welfare, Public Health Service (1980).

National Toxicology Program. NTP Executive Summaries. Prepared by the National Center for Toxicological Research, Office of Scientific Intelligence, Jefferson, Arkansas (March 1979).

National Toxicology Program, NTP Technical Bulletin, Department of Health and Human Services, Vol. 1, Issue 3 (December 1980).

Radding, S., et al. Review of the Environmental Fate of Selected Chemicals. Prepared by the U.S. Environmental Protection Agency. Available from the National Technical Information Service, Springfield, VA. PB 267-121 (1977).

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfiche Issues, R. J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville , MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 80-111-4 (1980).

Shepard, T. H. Catalog of Teratogenic Agents. The John Hopkins University Press, Baltimore, MD (1973).

Shackelford, W. M., and L. H. Keith. Frequency of Organic Compounds Identified in Water. U.S. Environmental Protection Agency. EPA-600/4-76/062 (December 1980).

Sittig, M., Ed. Priority Toxic Pollutants. Noyes Data Corporation, Park Ridge, NJ (1980).

Stahl, Q. R. Preliminary Air Pollution Survey of Aldehydes. Prepared by Litton Systems, Inc., under Contract No. PH 22-68-25 for National Air Pollution Control Administration. Available from Clearinghouse for Federal Scientific and Technical Information, Springfield, VA APTD 69-24 (1969).

U.S. Environmental Protection Agency, Carcinogen Assessment Group (CAG). Carcinogen Assessment Group's Preliminary Risk Assessment on Trichloroethene, Washington, DC (February 11, 1980).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Chemical Hazard Information Profiles (CHIPs). EPA-560/11-80-011 (1980).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA PB-80-155-153 (1980).

U.S. Environmental Protection Agency, Office of Water Planning and Standards. Ambient Water Quality Criteria for Trichloroethenes. EPA-440/5-80-077 (October 1980).

Verschueren, Karel. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold, Co., New York, NY (1977).

1,1,2-TRICHLOROFLUOROETHANE

Executive Summary

CAS NUMBER 00076-13-1

1,1,2-Trichlorotrifluoroethane is a colorless, noncombustible liquid with a sweet odor. It has been used primarily as a dry-cleaning solvent, as an aerosol propellant and as a refrigerant. Total U.S. production in 1974 exceeded 29 million kilograms. Nonessential aerosol uses have been banned in a joint action by EPA and FDA to prevent depletion of the stratospheric ozone layer. 1,1,2-Trichlorotrifluoroethane continues to be used as a refrigerant, industrial solvent, and as a pharmaceutical rotary tablet-press lubricant. North Carolina requires the reporting of all spills if they occur near water.

Health Effects

ACUTE. 1,1,2-Trichlorotrifluoroethane has been tested in human volunteers. The threshold concentration for impairment of psychomotor performance (ability to concentrate, mild lethargy) was about 2,500 ppm.

CARCINOGENICITY. No carcinogenic studies have been reported.

MUTAGENICITY. 1,1,2-Trichlorotrifluoroethane was negative in the Ames bacterial mutagen test.

TERATOGENICITY & EMBRYOTOXICITY. No evidence has been reported which suggests that 1,1,2-trichlorotrifluoroethane causes birth defects or embryotoxicity.

CHRONIC. Fluorocarbons may be concentrated in human lipids, but adverse effects of cardiac sensitization due to this storage are not expected.

Occupational Health

Workers exposed to a median concentration of 435 ppm for an average of 2 years showed no evidence of adverse effects. The American Conference of Governmental Industrial Hygienists has established a Threshold Limit Value in air (time-weighted average concentration under which it is believed that all workers may be repeatedly exposed day after day without adverse effect) of 1,000 ppm (7.6 gm/cu m). The recommende d Short Term Exposure Limit (maximum concentration to which workers may be exposed for a period up to 15 minutes) is 1,250 ppm (9.5 gm/cu m).

Routes of Human Exposure

OCCUPATIONAL. Workers servicing air conditioners, refrigerators, and freezers are likely to be exposed. Workers are also exposed to it as a solvent in specialized industrial uses.

AMBIENT. Urban atmospheric concentrations as high as 38 ppb have been reported during smog episodes. Concentrations as high as 30 ug/l have been found in U.S. rivers flowing through industrialized areas.

CONSUMER. No information available.

Environmental Significance

Continued release of chlorofluorocarbons is believed to lead to depletion of the stratospheric ozone layer. Because the ozone layer helps shield the earth's surface from harmful ultraviolet radiation, the reduction in stratospheric ozone may lead to an increase in the rate of skin cancer.

No data on the aquatic toxicity or phytotoxicity of 1,1,2-trichlorotrifluoroethane are available.

North Carolina Production and Users

Production: None reported
Users: No information available

Recommended Reviews

Protection Against Depletion of Stratospheric Ozone by Chlorofluorocarbons, National Academy of Sciences (1979).

FIRST AID AND EMERGENCY RESPONSE INFORMATION

1,2-TRICHLOROFLUOROETHANE

First Aid (NIOSH/OSHA Pocket Guide to Chemical Hazards)

Eyes:	Immediately wash the eyes with large amounts of water. CONTACT LENS SHOULD NOT BE WORN WHEN WORKING WITH 1,1,2-TRICHLOROTRIFLUOROETHANE.
Skin:	Promptly wash the skin with soap or mild detergent and water. Remove clothing if contaminated and wash skin.
Inhalation:	Move the exposed person to fresh air at once. Perform artificial respiration if necessary. Get medical attention as soon as possible.
Ingestion:	Induce vomiting by using finger or by giving syrup of ipecac. Seek medical attention immediately.
Note to Physician:	Epinephrine or isoproterenol is contraindicated. Monitor arterial blood gases.

Procedures for Spills and Leaks (U.S. DOT Emergency Response Guidebook, 1980)

Evacuate all personnel from spill area. Provide adequate ventilation and allow the liquid to evaporate.

Fire and Explosion Information

At normal temperatures, 1,1,2-trichlorotrifluoroethane is considered nonflammable. It will burn at 1256°F (680°C).

Reactivity

CONDITIONS TO AVOID: Extreme high temperatures; 1,1,2-trichlorotrifluoroethane will break down into toxic gases at high temperatures.

MATERIALS TO AVOID: Reacts violently with sodium, calcium, powdered aluminum, zinc, magnesium, beryllium and other reactive metals.

Protective Measures

STORAGE AND HANDLING: Protect container from physical damage.

ENGINEERING CONTROLS: Use in a well ventilated area. Sinks, showers and eyewash stations should be readily available.

PROTECTIVE CLOTHING (Should not be substituted for proper handling and engineering controls): If contact is likely, wear rubber gloves and safety glasses.

PROTECTIVE EQUIPMENT: For levels up to 4,500 ppm, use a supplied-air respirator or a self-contained breathing apparatus. For escape from a contaminated area use a gas mask with an organic vapor canister or a self-contained breathing apparatus.

1,2-TRICHLOROFLUOROETHANE

Profile

Chemical Identification

Trade Names:

Arklane P
FC 113
Fluorocarbon 113
Freon TF
Freon 113
Frigen 113TR-T
Genetron 113
R-113
1,1,2-Trichloro-1,2,2-Trifluoroethane
1,1,2-Trifluoro-1,2,2-trichloroethane
UCON Fluorocarbon 113
UCON 113

Chemical Abstract Services (CAS) Registry Number: 00076-13-1

Registry of Toxic Effects of Chemical Substances (RTECS) Number: KJ 4000000

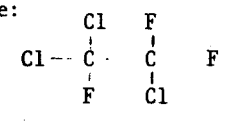
Hazardous Materials Table Identification Number: None

RCRA Identification Number: None

Molecular Weight: 187.37

Molecular Formula: $C_2Cl_3F_3$

Structure:



Classification: Halogenated aliphatic hydrocarbon; a chlorofluorocarbon

Description: A colorless, noncombustible liquid with a sweet odor

Uses: As a dry-cleaning solvent, refrigerant, aerosal propellant and in fire extinguishers.

Chemical/Physical Data

Boiling point: 47.7°C
Melting point: -36.4°C
Vapor pressure: 284 mm Hg at 20°C; 400 mm at 30°C
Vapor density: 6.47 (Air = 1.0)
Solubility in water: Insoluble, quantitative data not reported
Specific gravity: 1.56 at 25°C

HUMAN TOXICITY

1,1,2-Trichlorotrifluoroethane has been tested in human volunteers. The threshold concentration for impairment of psychomotor performance (loss of ability to concentrate, mild lethargy) is about 2,500 ppm (ACGIH, 1980). Workers exposed for an average of 2 years at a median concentration of 435 ppm showed no evidence of adverse effects (ACGIH, 1980).

It is recognized that fluorocarbons may concentrate in lipids, where they are concentrated and slowly released into the blood at concentrations that should not cause any risk of cardiac sensitization (TDB, 1981).

Carcinogenicity

No reports of carcinogenic studies were found (ACGIH, 1980).

Mutagenicity

An Ames bacterial mutagen test was negative (ACGIH, 1980).

Teratogenicity and Embryotoxicity

No evidence was found to indicate that 1,1,2-trichlorotrifluoroethane causes birth defects or embryotoxicity. At doses below those causing maternal toxicity, 1,1,2-trichlorotrifluoroethane caused no changes in offspring from pregnant rabbits exposed either orally or by inhalation (nine daily 2 hour exposures at levels up to 20,000 ppm) (ACGIH, 1980).

ANIMAL TOXICITY

1,1,2-Trichlorotrifluoroethane is a weak narcotic, and has a relatively strong cardiac sensitization potential. Subacute reversible effects in exposed animals have been observed. Acute toxicity by inhalation is low. Irritation of the respiratory tract occurs with very high concentrations, and liver cell enlargement is reported (ACGIH, 1980). Mild effects were observed after administration of 500 mg to the skin of rabbits (RTECS, 1980). The undiluted chemical produced no significant irritation in rabbit eyes (ACGIH, 1980).

Acute Toxicity

Results of lethal studies in several species are listed below:

Route	Species	Lethal Dose or Lethal Concentration
Oral	Rat	43 gm/kg, LD50 (Multiple doses were required.) (ACGIH, 1980).
Inhalation	Rat	52,000-68,000 ppm for 4 hours, LC50 (ACGIH, 1980)
	Mouse	25 percent by volume in air for 1.5 minutes, lowest LC (RTECS, 1980)
	Guinea pig	50,000 ppm for 1 hour, lowest LC (RTECS, 1980)

Occluded contact (5 g/kg) with rabbit skin for 5 days produced necrosis and sloughing; enlargement of liver cells was also observed. Single applications at slightly higher dosages produced no liver changes (ACGIH, 1980).

Chronic Toxicity

Applications to uncovered skin of rabbits for 20 weeks produced no effect.

After 19 seven-hour exposures at 5,000 ppm, some rats showed very slight liver changes. Prolonged or repeated exposures of several species at levels ranging from 2,000 ppm to 25,000 ppm produced no adverse effects (ACGIH, 1980).

AQUATIC AND TERRESTRIAL TOXICITY

No data on the aquatic toxicity or terrestrial phytotoxicity of 1,1,2-trichlorotrifluoroethane are available.

ENVIRONMENTAL DATA

AIR

Rural background concentrations have been reported as 0.02 ppb (0.15 µg/cu m) in one study (Singh, 1977) and less than the detection limit of 0.01 ppb (0.077 µg/cu m) in another (Lilian, 1975). Urban levels as high as 38 ppb (290 µg/cu m) have been reported during smog episodes (Lilian, 1975). Chlorofluorocarbons accumulate in the lower atmosphere. Upon migration to the upper atmosphere, they react with ozone causing the release of free chlorine and subsequent depletion of the ozone layer. The accumulation and dispersion of trichlorotrifluoroethane in the air and its migration to the upper atmosphere are, therefore, of primary environmental importance. 1,1,2-Trichlorotrifluoroethane is somewhat less reactive in the air than other chlorofluorocarbons.

Water

In a survey of U.S. rivers flowing through industrialized areas, trichlorotrifluoroethane (isomer not specified) was found in 8 samples at estimated levels as high as 30 µg/l (Ewing, 1977). The environmental fate of 1,1,2-trichlorotrifluoroethane in water is difficult to assess because of limited data regarding its half-life (in water) and hydrolysis rate. Elevated concentrations found in river water suggest that it most probably accumulates, and should therefore be regarded as persistent in this medium.

SOILS

There are insufficient data to comment on the persistence of 1,1,2-trichlorotrifluoroethane in ambient soil.

BIOTA

Very few quantitative data are available regarding the presence or accumulation of 1,1,2-trichlorotrifluoroethane in biota. This substance has a half-life of 15 minutes after exposure by inhalation by humans, and there is some evidence that it may accumulate in lipids. (MEDLARS, 1981)

INDUSTRIAL DATA

Production

No production in North Carolina has been reported in the Toxic Substances Control Act (TSCA) Chemical Substances Inventory (U.S. EPA, TSCA, 1980).

Consumption and Use

Total U.S. production in 1974 exceeded 29 million kilograms (MEDLARS, 1980).

Nonessential aerosol uses of 1,1,2-trichlorotrifluoroethane and other fully halogenated chlorofluorocarbons (CFCs) have been banned in a joint action by the U.S. Environmental Protection Agency and the U.S. Food and Drug Administration (IRLG, 1980). Nonaerosol uses for CFCs and their corresponding SICs are given below.

	Standard Industrial Classification
Refrigerant in air conditioners, refrigerators, freezers	3632, 3585, 3629
Industrial solvent in cleaning, drying, and solder flux removal (No practical replacement is known for many of the highly specialized cleaning procedures in which it is used (NAS, 1979)	34
Blowing agent for foams used in insulation, packaging, bedding, carpet (EPA, 1980)	282, 2515, 2271
Special use exemptions have been granted for aerosol use as: Pharmaceutical rotary tablet-press lubricant	283
Aerosol propellant for insecticides used for long-term tobacco storage	21
Inkless finger printing equipment	

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air

Guidelines for 1,1,2-trichlorotrifluoroethane in air have not been established.

Workroom Air

ACGIH — The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air is 1,000 ppm (7.6 gm/cu m) as a time-weighted average. The recommended Short Term Exposure Limit (STEL) is 1,250 ppm (9.5 gm/cu m).

OSHA — The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 1,000 ppm (7.6 gm/cu m) as a time-weighted average.

Water
Guidelines for 1,1,2-trichlorotrifluoroethane in water have not been established.

Organizations Concerned with this Chemical

Chlorofluorocarbons are the subject of a development plan prepared by the Interagency Regulatory Liaison Group (IRLG).

Chlorofluorocarbons are the subject of a proposed rule under the Toxic Substances Control Act that would restrict production. Federal Register, Vol. 45, No. 196, 1980.

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Ewing, B., E. Chian, and J. Cook. Monitoring to Detect Previously Unrecognized Pollutants in Surface Waters: Organic Analysis Data. U.S. Environmental Protection Agency. Available from the National Technical Information Service, Springfield, VA, PB-274-349 (1977).

Interagency Regulatory Liaison Group (IRLG). Regulatory Reporter, Volume II, Issue 1 (1980).

Lilian, D. Atmospheric Fates of Halogenated Compounds. Environmental Science and Technology, 9(12): 1042-1048 (1975).

MEDLARS II Toxicology Data Bank Record. Available through the National Library of Medicine, Betheseda, MD (May 1980).

National Academy of Sciences. Protection Against Depletion of Stratospheric Ozone by Chlorofluorocarbons. Washington, DC (1979).

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfiche Issue, R. J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville, MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 80-111-4 (1980).

Singh, H. B. et al. Urban-Nonurban Relationships of Halocarbons: SF6, N20 and Other Atmospheric Trace Constituents. Atmospheric Environment 12: 865-875 (1978).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA PB-80-155-153 (1980).

U.S. Environmental Protection Agency. Ozone Depleting Chlorofluorocarbons; Proposed Production Restriction. Federal Register, Vol. 45, No. 196 (October 7, 1980).

Verschueren, Karel. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York, NY (1977).

VINYL ACETATE

Executive Summary

CAS NUMBER: 00108-05-4

Vinyl acetate is a volatile liquid which polymerizes in light to a colorless, transparent mass. It is soluble in water at 20 g/l at 20°C. It is used primarily in the manufacture of polyvinyl acetate homopolymer and polyvinyl alcohol. Federal regulations require the reporting of spills if they exceed 5000 pounds (2270 kilograms) or 130 gallons (492 liters) and North Carolina requires the reporting of all spills if they occur near water.

Health Effects

ACUTE. Slight irritation causing cough and hoarseness is observed when vinyl acetate is inhaled at 22 ppm. It is usually detectable by odor at levels less than 5 ppm. The chemical is moderately hazardous (LD50 for rats; 2.9 gm/kg) when ingested. Vinyl acetate appears to be rapidly detoxified by esterases present in mammalian blood. Several investigators have reported that vinyl acetate caused dermal and ocular irritation.

CARCINOGENICITY. No tumors were reported to have occurred in a study using rats, but early mortality was high.

MUTAGENICITY. No mutagenic effect in Salmonella typhimurium was observed.

TERATOGENICITY & EMBRYOTOXICITY. No data were found indicating vinyl acetate causes birth defects or is embryotoxic.

CHRONIC. A report of 15 years' industrial experience with 21 vinyl acetate chemical operators revealed no evidence of chronic effects from concentrations of 10 ppm.

Occupational Health

The American Conference of Governmental Industrial Hygienists has established a Threshold Limit Value (time-weighted average concentration under which it is believed that all workers may be repeatedly exposed day after day without adverse effect) of 10 ppm (30 mg/cu m) and a Short Term Exposure Limit (the maximum concentration to which workers may be exposed for a period up to 15 minutes) of 20 ppm (60 mg/cu m).

Routes of Human Exposure

OCCUPATIONAL. In 1976, 310 million kilograms of vinyl acetate were used in the U.S. for the production of polyvinyl acetate emusions and resins. It has been detected in the air of production plants at levels of 17.5-35 mg/cu m (5-10 ppm).

AMBIENT. Vinyl acetate has been detected in waste waters from a polyvinyl acetate plant in concentrations of 50 mg/liter and air samples in Texas City, Texas at concentrations ranging from 0.07-0.57 ppm.

CONSUMER. No information available.

Environmental Significance

No information on persistence in air or water has been reported. Vinyl acetate is not expected to bioaccumulate. The aquatic toxicity is 10-100 (TLm 96). This is supported by data for fathead, bluegill, goldfish, and guppie. Cell division in aquatic algae is inhibited at 35 ppm but no data were found regarding effects of vinyl acetate vapor on terrestrial vegetation.

North Carolina Production and Users

Production: Reichold Chemical Company, Charlotte, reported an annual production of 5,000-25,000 tons.

Users: No information available.

Recommended Reviews

Criteria for a Recommended Standard: Occupational Exposure to Vinyl Acetate, DHEW Publication No. 78-205 (1978), National Institute for Occupational Safety and Health.

FIRST AID AND EMERGENCY RESPONSE INFORMATION

VINYL ACETATE

First Aid (NIOSH/OSHA Pocket Guide to Chemical Hazards)

Not listed: Suggested treatment:

Eyes: Flush with water promptly.

Skin: Flush with water promptly.

Inhalation: Remove to fresh air promptly.

Procedures for Spills and Leaks (U.S. DOT Emergency Response Guidebook, 1980)

Isolate hazard area and deny entry. Stay upwind and keep out of low areas. No flares, smoking or flames in hazard area. Stop leak if it can be done without risk. Use water spray to reduce vapors. Wear self-contained breathing apparatus and full protective clothing. Isolate for one-half mile in all directions if tank or tankcar is involved in fire.

SMALL SPILLS: Take up with sand, or other noncombustible absorbent material, then flush area with water.

LARGE SPILLS: Dike far ahead of spill for later disposal.

Fire and Explosion Information

GENERAL: Flammable. Ignites at -6°C (21°F)

EXPLOSIVE LIMITS: Upper - 13.6%, lower - 2.2%.

EXTINGUISHER: Foam, carbon dioxide, or dry chemical.

Reactivity

CONDITIONS TO AVOID: Heat, sparks and open flame are fire hazards. Light may induce violent, heat generating polymerization. May give off acrid fumes in both cases.

MATERIALS TO AVOID: Reacts violently with peroxides, aldehydes, 2-aminoethanol, chlorosulfonic acid, ethylene diamine, ethylene amine, strong mineral acids such as sulfuric and strong oxidizers such as chlorine and permangantes.

Protective Measures

STORAGE AND HANDLING: Outdoor or detached storage preferred. Keep in a cool, well ventilated place away from fire hazards and out of direct sunlight.

ENGINEERING CONTROLS: Provide adequate ventilation or process enclosure Sinks, showers and eyewash stations should be easily available.

PROTECTIVE CLOTHING (Should not be substituted for proper handling and engineering controls): Chemical safety goggles or face shield with goggles should be worn. Use gloves, apron, suit and boots to prevent skin contact.

PROTECTIVE EQUIPMENT: For levels up to 40 ppm use a Type-C supplied-air respirator with a half-mask facepiece in a pressure demand mode. For levels up to 400 ppm use a gas mask with any type of organic vapor canister; a Type-C supplied-air respirator with full facepiece in a positive pressure mode; or a self-contained breathing apparatus with full facepiece in a positive pressure mode. For levels up to 4000 ppm use a Type-C supplied-air respirator with half-mask or full facepiece in a positive pressure mode, or a Type-C supplied-air respirator with hood helmet or suit, operated in continuous flow mode. For levels above 4000 ppm use a self-contained breathing apparatus with full facepiece operated in a positive pressure mode or a combination Type-C supplied-air respirator with full facepiece in pressure-demand mode with an auxiliary self-contained air supply. For emergency (entry into unknown concentration), use a self-contained breathing apparatus with full facepiece operated in a positive pressure mode.

The North Carolina Toxic Substances Management Guide

VINYL ACETATE

Profile

Chemical Identification

Alternative Names:

Acetic acid, ethenyl ester
Acetic acid, vinyl ester
1-Acetoxyethylene
Ethylenyl Acetate
Ethenylethanoate
VAC
Vinyl Acetate H.Q.
Vinyl A Monomer
VyAc
Zeset T

Chemical Abstract Services (CAS) Registry Number: 00108-05-4

Registry of Toxic Effects of Chemical Substances (RTECS) Number: AK 0875000

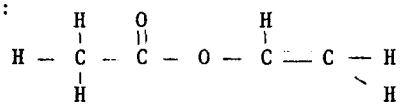
Hazardous Materials Table Identification Number: UN 1301

RCRA Identification Number: None

Molecular Weight: 86.10

Molecular Formula: $C_4H_6O_2$

Structure:



Classification: An unsaturated aliphatic ester of acetic acid

Description: A volatile liquid which polymerizes in light to a colorless, transparent mass.

Uses: In the preparation of vinyl polymers, paints, paper coating, and textile finishes.

Chemical/Physical Data

Boiling point: 72.2-73.3°C
Melting point: -93.2°C
Vapor pressure: 100 mg Hg at 23.3°C
Vapor density: 3.0 (air = 1.0)
Solubility in water: 1 g in 50 ml at 20°C
Specific gravity: 0.9317

HUMAN TOXICITY

Vinyl acetate is not a significant upper respiratory tract irritant at 10 ppm. Slight irritation causing cough and hoarseness is observed at 22 ppm. At levels of less than 5 ppm, vinyl acetate is detectable by odor by most individuals. Olfactory fatigue may occur in a matter of a few minutes at 20 ppm, but recovery is rapid (ACGIH, 1980).

In workers exposed to vinyl acetate for about 15 years, no chronic effects were found, although skin effects and eye, nose and throat irritation were reported (NIOSH, 1978).

Vinyl acetate appears to be rapidly detoxified by esterases present in mammalian blood (NIOSH, 1978).

Carcinogenicity

IARC, 1979 — A group of 96 Sprague-Dawley rats (sex not specified) were exposed for 4 hours/day for 5 days/week for 52 weeks to the maximum tolerated concentration, 2,500 ppm (8.8 g/cu m) in air. No tumors were reported to have occurred during 135 weeks. Early mortality was high: forty-nine animals survived for 26 or more weeks. (The Working Group noted that the time of death of animals that lived longer than 26 weeks was not indicated.)

Mutagenicity

IARC, 1979 — Exposure of Salmonella typhimurium to vapors of vinyl acetate caused no mutagenic effect.

Teratogenicity & Embryotoxicity

IARC, 1979 — No evidence was found to indicate that vinyl acetate causes birth defects or is embryotoxic.

ANIMAL TOXICITY

The oral rat LD50 for vinyl acetate is reported to be 2.9 gm/kg (RTECS, 1980) indicating that the chemical is moderately hazardous when ingested. The LD50 in rabbits by skin application was more than 5 ml/kg body weight. Severe irritation to rabbit eyes resulted from 0.5 ml applied topically to the eyes (ARC, 1979).

Results of inhalation studies in several species are tabulated below (ACGIH, 1980).

Acute Toxicity

Species	Level*/duration	Effect
Rat	4,000 ppm, 4 hours	LC50
Rabbit	2,500 ppm, 4 hours	LC50
Mouse	1,550 ppm, 4 hours	LC50
Dog	106 ppm, 4 hours	Eye irritation, but no other observable effects
Rat	106 ppm, 6 hr/day for 15 days	Normal growth and behavior

* 1 ppm = 3.58 mg/cu m.

Results of Inhalation (Continued)

Rat	265 ppm, 6 hr/day for 15 days	Retarded growth in females, but no hematologic or pathologic abnormalities
Rat	100 ppm, repeated exposures	No effects
Dog	91 to 186 ppm, 6 hr/day for approx imately 11 weeks	Eye irritation with lacrimation

Aquatic Toxicity

Aquatic toxicity rating: TLm is 10-100 ppm (RTECS, 1980). This rating is supported by data for fathead, bluegill, goldfish, and guppie (Verschueren, 1977).

No data are available regarding bioaccumulation or biodegradation in aquatic species.

Phytotoxicity

No data were found regarding effects of vinyl acetate vapor on terrestrial vegetation.

Cell division in aquatic algae is inhibited at 35 ppm (Verschueren, 1977).

ENVIRONMENTAL DATA

Air

Vinyl acetate has been detected in air samples in the Texas City, Texas area at concentrations ranging from 0.07-0.57 ppm (0.25-2.0 mg/cu m) (NIOSH, 1978). Although there is no reported atmospheric residence time, vinyl acetate is chemically reactive and degradation would probably prevent accumulation. Vinyl acetate is also removed from the air by rainfall (hydrolysis). Wide dispersion is not expected in this medium.

Water

Vinyl acetate was detected in wastewaters from a polyvinyl acetate plant in concentrations of 50 mg/l (IARC, 1979). This compound is highly volatile and rapid degradation is expected in water. There are no estimates of half-life in water, and no quantitative data regarding a hydrolysis rate (hydrolysis is rapid in blood) (NIOSH, 1978).

Soil

High volatility prevents this compound from accumulating significantly in the soil. Vinyl acetate is also removed from this medium by hydrolysis.

Biota

Vinyl acetate is not persistent in biota. It degrades rapidly due to hydrolysis and no bioaccumulation or magnification is expected.

Wide dispersion of this product is not expected. Vinyl acetate is not known to occur naturally.

INDUSTRIAL DATA

Production

Production in North Carolina was reported by one company in the Toxic Substances Control Act (TSCA) Chemical Substance Inventory:

Reichold Chemical, Charlotte: 5,000-25,000 tons/year.

U.S. annual production was estimated at 673 million kg (740,000 tons) for 1977 (IARC, 1979).

Consumption and Use

Estimated U.S. Consumption in 1976:

Manufacture of polyvinyl acetate homopolymer emulsions and resins	61 percent
Manufacture of polyvinyl alcohol	22 percent
Manufacture of polyvinyl butyral	6 percent
Manufacture of vinyl chloride-vinyl acetate copolymers	5 percent
Manufacture of ethylene-vinyl acetate resins and emulsions	5 percent

(IARC, 1979)

Reported uses of vinyl acetate and the corresponding SIC codes are listed below:

Manufacture of polyvinyl acetate homopolymer emulsions and resins	2821
Manufacture of polyvinyl alcohol and polyvinyl butyral	2869
Manufacture of vinyl chloride--vinyl acetate resins and emulsions	2821
Uses for polyvinyl acetate:	
Adhesives	2981
Paints	2851
Paper coatings	2641
Textile treatment	22
Uses for polyvinyl alcohol:	
Textile warp sizing and finishing agent	226
Adhesives	2891
Polymerization aid	282
Paper sizing and coating	2841

(IARC, 1979)

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air

No guidelines for air have been established.

Workroom Air

ACGIH The Threshold Limit Value (TLV) established by the American Conference of Governmental Industrial Hygienists

(ACGIH) for workroom air is 10 ppm (30 mg/cu m) as a time-weighted average. The recommended Short Term Exposure Limit (STEL) is 20 ppm (60 mg/cu m).

NIOSH — The National Institute of Occupational Safety and Health (NIOSH) recommends a standard of 4 ppm (15 mg/cu m) as a ceiling limit measured in a 15-minute sample.

Water

Designated a hazardous substance by the U.S. Environmental Protection Agency. The hazardous substance designation and the proposed reporting regulations are to limit the discharge of toxic and hazardous substances to the nation's water. Spills in excess of 1,000 pounds must be reported (Code of Federal Regulations, Title 40, Part 116).

Other

Regulated as a hazardous material by the U.S. Department of Transportation. The regulations pertain to the identification and transportation of hazardous materials in commerce. Vinyl acetate is classified as a "Flammable Liquid" and shipments must carry this label (Code of Federal Regulations, Title 49, Part 172.101).

Organizations Concerned with this Chemical

Vinyl acetate and vinyl acetate polymers are addressed in monographs prepared by the International Agency for Research on Cancer (IARC).

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

International Agency for Research on Cancer (IARC). IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon, France, Volume 19. A World Health Organization Publication (WHO), Geneva (1979).

Merck Index: An Encyclopedia of Chemicals and Drugs, Ninth Edition, M. Windholz, Ed. Merck and Co., Rahway, NJ (1976).

National Institute for Occupational Safety and Health (NIOSH). Criteria for a Recommended Standard...Occupational Exposure to Vinyl Acetate. U.S. Department of Health, Education, and Welfare. DHEW (NIOSH) Publication No. 78-205 (1978).

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfiche Issue, R. J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville, MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 80-111-4 (1980).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA. PB-80-155-153 (1980).

Verschueren, Karel. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York, NY (1977).

VINYL CHLORIDE

Executive Summary

CAS NUMBER: 00075-01-4

Vinyl chloride is a colorless liquid or gas that polymerizes in light or in the presence of a catalyst. Combustion products are hydrogen chloride, carbon monoxide, carbon dioxide, and traces of carbonyl chloride (phosgene). It is usually handled as a liquid under pressure; phenol is used as a polymerization inhibitor. First synthesized in 1835, vinyl chloride has been produced commercially for over 50 years. It is not known to occur as a natural product. About 96 percent of the 2,274 million kg vinyl chloride used in the U.S. in 1976 was for the production of vinyl chloride homopolymer and copolymer resins. North Carolina requires the reporting of all spills if they occur near water.

Health Effects

ACUTE. Effects observed among workers exposed to very high concentrations of vinyl chloride include hepatitis, nervous disorders (including euphoria, incoordination, and dizziness) and narcosis. A wide variety of neurologic, gastrointestinal, hepatic, respiratory, hematologic and dermatologic effects have been reported.

CARCINOGENICITY. Vinyl chloride has produced liver angiosarcoma, a very rare form of cancer, as well as other cancers and serious liver damage in occupationally exposed populations. Vinyl chloride monomer causes lung tumors, mammary carcinomas and angiosarcomas in mice following exposure by inhalation.

MUTAGENICITY. Vinyl chloride has induced mutations in a variety of test systems. Mutagenic responses are higher with activation. The mutagenicity of several possible metabolites has also been established.

TERATOGENICITY & EMBRYOTOXICITY. A significant excess of fetal deaths was reported in women whose husbands were exposed to vinyl chloride. It was postulated that the fetal loss might be due to germ cell damage in the father. Increased fetal mortality is reported in rats exposed to 1,500 ppm during pregnancy. NIOSH recommends that no woman who is pregnant or expects to become pregnant should be employed in vinyl chloride operations.

CHRONIC. Vinyl chloride produced acute liver injury in rats exposed to 130 mg/cu m (50,000 ppm) for 6 hours. Exposure of guinea pigs to 260 mg/cu m of vinyl chloride for 2 hours/day for 3 months resulted in marked growth disturbance and lesions in the liver, kidney, spleen and lungs.

Occupational Health

The American Conference of Governmental INdustrial Hygienists has recommended a Threshold Limit Value for workroom air (time-weighted average concentration under which it is believed that all workers may be repeatedly exposed day after day without adverse effect) of 5 ppm (10 mg/cu m). The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 1 ppm (2 mg/cu m) as a time-weighted average and 5 ppm (10 mg/cu m) as a 15-minute ceiling. The National Institute of Occupational Safety and Health (NIOSH) recommends a standard of 1 ppm (2 mg/cu m) as a 15-minute ceiling.

Routes of Human Exposure

OCCUPATIONAL. Air concentrations of vinyl chloride in working areas of polyvinyl chloride-producing factories have been reported to range between 100-800 mg/cu m (40-312 ppm). Vinyl chloride monomer may be present in polyvinyl chloride leaving the manufacturing plant and in the products fabricated from polyvinyl chloride. Major uses for polyvinyl chloride include the production of plastic piping and conduit, floor coverings, electrical equipment, and consumer goods. In 1974 it was estimated that 20,000 U.S. workers, past and present, had been exposed to vinyl chloride.

AMBIENT. Vinyl chloride has been measured in ambient air near production areas at concentrations ranging from 3.1-1,250 ppb (8 to 3,200 mg/cum) (IARC, 1979). Prior to 1975, vinyl chloride emissions to the atmosphere are estimated at 110 million kg/yr.

Vinyl chloride has been identified in municipal drinking water in concentrations as high as 10 ug/l.

CONSUMER. Levels of vinyl chloride identified in food and other items include the following:

Alcoholic beverages	0-2.1 ppm and as high as 20 ppm
Vinegars	0-9.4 ppm
Edible oils	0.05-14.8 ppm
Butter and margarine	0.05 ppm
New car interiors	0.4-1.2 ppm
Tobacco products	5.6-27 ng/cigarette
Marijuana cigarette	5.4 ng/cigarette

Limited quantities of vinyl chloride were used in the U.S. as an aerosol propellant, but in 1974 it was banned from use in pesticide aerosol products, in self-pressurized household containers and as an ingredient of drug and cosmetic products. A branch of the U.S. Treasury Department in 1973 banned the use of polyvinyl chloride for the packaging of alcoholic beverages. Industrial grade polyvinyl chloride coated films used for food were found to contain 5-71 ug/kg (ppb) of monomer and plastic bottles up to 7.9 mg/kg (ppm).

Environmental Significance

Estimated half-life in air is a few hours; vinyl chloride is removed by photochemical oxidation. In water, the estimated half-life is 26 minutes, based on evaporation from a 1 ppm solution at 25°C. Bioaccumulation is not expected.

No freshwater or saltwater organisms have been tested with vinyl chloride and no statement can be made concerning acute or chronic toxicity. TLM 96 is over 1,000 ppm.

No information on phytotoxicity was found. Effects in aquatic plants or algae are not reported.

North Carolina Production and Users

Production: No known producers.

Users: No information available.

Recommended Reviews

Environmental Health Perspectives: Vinyl Chloride Related Compounds, Volume 21, NIEHS, December 1977.

NIOSH Recommended Standard for Occupational Exposure to Vinyl Chloride, National Institute for Occupational Safety and Health, 1979.

Vinyl Chloride: A Review, C.H. Binns. Journal of the Society of Occupational Medicine 29 (4): 134 (1979).

FIRST AID AND EMERGENCY RESPONSE INFORMATION

VINYL CHLORIDE

First Aid (DOT Emergency Response Guidebook, 1980)

Move victim to fresh air.

Seek immediate medical attention.

If not breathing, give artificial respiration.

Keep victim quiet and maintain normal body temperature.

Procedures for Spills and Leaks (U.S. DOT Emergency Response Guidebook, 1980)

Isolate hazard area and deny entry. Stay upwind and keep out of low areas. Wear self-contained breathing apparatus and full protective clothing. Isolate for ½ mile in all directions if tank or tankcar is involved in fire. No flares, smoking or flames in hazard area. Stop leak if it can be done without risk. Use water spray to reduce vapors. Isoalte area until gas has dispersed.

Fire and Explosion Information

GENERAL: Flammable. Fumes may travel long distances and flash back. Ignites at -108°F (-78°C).

EXPLOSIVE LIMITS: Upper - 33%, lower - 3%.

EXTINGUISHER: Stop flow of gas. Use water to keep fire-exposed containers cool.

Reactivity

CONDITIONS TO AVOID: High temperatures may cause breakdown to phosgene and hydrochlorid acid. Avoid sources of ignition.

MATERIALS TO AVOID: Long contact with air may result in formation of unstable peroxides which are explosive. Corrosive to iron at high temperatures in the presence of water.

Protective Measures

STORAGE AND HANDLING: Protect against physical damage. Outside or detached storage preferred. Indoors, store in a cool, dry, well-ventilated areas away from sources of ignition.

ENGINEERING CONTROLS: Provide ventilation or process enclosures. Sinks, showers and eye-wash stations should be readily available.

PROTECTIVE CLOTHING (Should not be substituted for proper handling and engineering controls): Goggles, gloves and impervious clothing should not be worn if contact with vinyl chloride is possible.

PROTECTIVE EQUIPMENT: For levels up to 10 ppm use a combination Type C supplied-air respirator, demand type, with auxiliary self-contained air supply and half facepeice, or a Type C supplied-air respirator, providing a service life of at least 1 hour at 20 ppm. For levels up to 25 ppm use a powered air-purifying respirator with hood, helmet, full or half facepiece, and canister providing 4 hour service life at 25 ppm, or a gas mask with chest or back mounted canister with a similar service life. For levels up to 100 ppm, use a Type C supplied-air respirator with an auxiliary air-supply and full facepiece, or open-circuit self-contained breathing apparatus with full facepiece in demand mode. For levels up to 1,000 ppm, use a combination Type C supplied-air respirator in continuous flow mode, full or half facepiece and auxiliary self-contained air supply, or Type C supplied-air respirator, full or half facepiece, helmet or hood in continous flow mode. For levels up to 3,600 ppm, use a combination Type C supplied-air respirator, demand type, with full or half facepiece and auxiliary self-contained air supply. At unknown levels or above 3,600 ppm use an open circuit, self-contained breathing apparatus, pressure demand type, with full facepiece.

The North Carolina Toxic Substances Management Guide

VINYL C"LORIDE

Profile

CHEMICAL IDENTIFICATION

Alternative Names:

Chloroethane
Chloroethylene
Monochloroethylene
VC
VCM
Vinyl C. monomer

Chemical Abstract Services (CAS) Registry Number: 00075-01-4

Registry of Toxic Effects of Chemical Substances (RTECS) Number: KU 9625000

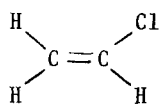
Hazardous Materials Table Identification Number: UN 1086

RCRA Identification Number: U 043

Molecular Weight: 62.50

Molecular Formula: C_2H_3Cl

Structure:



Classification: Unsaturated alkyl halide; chlorinated hydrocarbon

Description: A colorless liquid or gas that polymerizes in light or in the presence of a catalyst. Combustion products are hydrogen chloride, carbon monoxide, carbon dioxide, and traces of carbonyl chloride (phosgene). It is usually handled as a liquid under pressure with phenol being used as a polymerization inhibitor (IARC, 1979).

Uses: In the manufacturing of homopolymer and copolymer resins.

Chemical/Physical Data

Boiling point: -13.37°C
Melting point: -158.8°C
Vapor pressure: 2,660 mm Hg at 25°C
Vapor density: 2.2 (air = 1.0)
Solubility in water: Slightly soluble; 1.1 g/l at 25°C
Specific gravity: 0.9106
Flashpoint: -78°C (closed cup)

HUMAN TOXICITY

Effects observed among workers exposed to very high concentrations of vinyl chloride include hepatitis, nervous disorders (including euphoria, incoordination, and dizziness) and narcosis (ACGIH, 1980). A summary (NIOSH/ OSHA, 1978) of adverse effects other than carcinogenesis is presented below. Specific exposure levels associated with the effects are not well documented.

System	Adverse Effect
neurologic	dizziness, lightheadedness, dulling vision and hearing, drowsiness, headache, loss of memory, euphoria, nervousness, numbness or tingling in fingers or toes
gastrointestinal	nausea, loss of appetite, abdominal distress, varices of esophagus or stomach, black stools, bloody vomitus
cardiovascular	increased blood pressure, Raynaud's Syndrome
hepatic	liver enlargement, liver function abnormalities, increased sulphbromophthalein retention, liver damage, serum enzyme abnormalities
respiratory	coughing and sneezing, bronchial rales, emphyzema, pulmonary fibrosis, decreased respiratory function, lung function disturbances
hematologic	anemia, reticulocytosis, leukopenia, thrombocytopenia, splenomegaly
dermatologic	contact dermatitis, sclerodermalike skin changes
musculoskeletal	calf and joint pain, acroosteolysis
other	increased perspiration, cold sensation in fingers and hands, fatigue, weight loss, weakness, impotency

Carcinogenicity

U.S. EPA CAG, 1980	The U.S. EPA Carcinogen Assessment Group (CAS) has determined that vinyl chloride is a human and animal carcinogen. Vinyl chloride has produced liver angiosarcoma, a vary rare form of cancer, as well as other cancers and serious liver damage in occupationally exposed populations.

IARC, 1979	Vinyl chloride is a human carcinogen. Its target organs are the liver, brain, lung, and hemo-lymphopoietic system. Similar carcinogenic effects were first demonstrated in rats and were later confirmed in mice and hamsters. Although evidence of a carcinogenic effect of vinyl chloride in humans has come from occupational groups exposed to high doses of vinyl chloride, there is no evidence that there is an exposure level below which no increased risk of cancer would occur in humans.
NIOSH/OSHA, 1978	Vinyl chloride is known to cause angioscarcoma of the liver and cancers of other sites in laboratory animals and in humans. Vinyl chloride is regulated by OSHA as a demonstrated carcinogen in humans.
U.S. EPA, WQC, 1980	Water quality criteria are based on incremental increase of cancer risk with increasing exposures. Nonthreshold behavior is assumed.

Mutagenicity

IARC, 1979	Vinyl chloride vapor has induced mutations in a variety of test systems. Mutagenic responses are higher with activation. The mutagenicity of several possible metabolites has also been established.

Teratogenicity & Embryotoxicity

A significant excess of fetal deaths was reported in women whose husbands were exposed to vinyl chloride (IARC, 1979). It was postulated that the fetal loss might be due to germ cell damage in the father. Increased fetal mortality is reported in rats exposed to 1,500 ppm during pregnancy (Shepard, 1980).

ANIMAL TOXICITY

Acute inhalation toxicity of vinyl chloride is very low although cardiac irregularities in dogs have been reported (ACGIH, 1980). It is rapidly absorbed through the lungs and enters the bloodstream. Detoxification of vinyl chloride takes place primarily in the liver. It has been shown to be metabolized extensively in rats in vivo. The primary metabolic pathway appears to be saturated by exposures exceeding 220 to 250 ppm. At higher concentrations, a secondary pathway is postulated (U.S. EPA, WQC, 1980).

Acute Toxicity

Results of acute inhalation studies as summarized by the ACGIH (1980) are listed below:

NUMBER OF DEATHS IN DIFFERENT GROUPS OF FIVE MICE, RATS AND GUINEA PIGS EXPOSED FOR THIRTY MINUTES TO VARYING CONCENTRATIONS OF VINYL CHLORIDE IN AIR

Vinyl Chloride concentration (percent by volume in air)	Laboratory animal			
	Mice	Rats	Guinea pigs	TOTAL
10	0/5	0/5	0/5	0/15
20	1/5	0/5	0/5	1/15
30	5/5	5/5	1/5*	11/15
40	-	-	2/5*	2/5*

* A delayed death occurred within 24 hours following exposure.

Chronic Toxicity

Chronic studies in animals have produced effects to the liver including angiosarcomas as well as tumors in other organs.

Aquatic Toxicity

Aquatic toxicity rating: TLm 96 is over 1,000 ppm (RTECS, 1980).

The U.S. EPA Water Quality Criteria for the protection of aquatic life are given below:

> No freshwater organisms have been tested with vinyl chloride and no statement can be made concerning acute or chronic toxicity (U.S. EPA WQC, 1980).
>
> No saltwater organisms have been tested with vinyl chloride and no statement can be made concerning acute or chronic toxicity.

Bioaccumulation: No data are available on the bioaccumulation or biodegradation of vinyl chloride. Because of its volatility, vinyl chloride is expected to be readily removed from the aquatic environment.

Phytotoxicity

No information on phytotoxicity was found.

Effects in aquatic plants or algae are not reported.

ENVIRONMENTAL DATA

Air

Vinyl chloride has been measured in ambient air near production areas at concentrations ranging

from 3.1-1,250 ppb (8 to 3,200 ug/cu m). Prior to 1975, vinyl chloride emissions to the atmosphere are estimated at 110 million kg/yr (IARC, 1979). Vinyl chloride has an estimated half-life in air of several hours, and is removed rapidly by photochemical oxidation (Callahan, 1979). Although it is not expected to accumulate, high ambient levels have been detected near industrial sources (U.S. EPA, WQC, 1980).

Water
Vinyl chloride has been identified in municipal drinking water in concentrations as high as 10.0 µg/l (IARC, 1979). It has short half-life of 26 minutes based on volatility (Verschueren, 1977), and is not known to accumulate to significant levels in this medium. Degradation via hydrolysis is very slow (half-life based on hydrolysis is less than 10 years, Callahan, 1979).

Soil
Vinyl chloride's high volatility and slight solubility indicate removal to air and water (Callahan, 1979). Adsorption is expected to be low, and significant accumulation is unlikely.

Biota
There are no data on bacterial degradation or degradation by aquatic organisms, although there is evidence of metabolism by rats. Slight bioaccumulations was observed in a model ecosystem. A low partition coefficient indicates that accumulation will not be significant in this medium. Biomagnification is not likely.

Vinyl chloride is not known to occur as a natural product (IARC, 1979).

Levels identified in foods and other items packaged in vinyl chloride include the following:

Alcoholic beverages: 0-2.1 ppm and as high as 20 ppm (use banned in 1973).
Vinegars: 0-9.4 ppm
Edible oils: 0.05-14.8 ppm
Butter and margarine: 0.05 ppm
New car interiors: 0.4-1.2 ppm
Tobacco products: 5.6-27 ng/cigarette
Marijuana cigarette: 5.4 ng/cigarette
(IARC, 1979)

INDUSTRIAL DATA

Production

No production in North Carolina is reported in the Toxic Substances Control Act (TSCA) Chemical Substances Inventory (U.S. EPA, TSCA, 1980).

Estimated U.S. production in 1976 was 2,580 million kilograms (2.8 million tons) (IARC, 1979).

Consumption and Use

Estimated U.S. Consumption:

Production of vinyl chloride homopolymer and copolymer resins	96 percent
Production of methyl chloroform and as a comonomer with vinylidene chloride	4 percent

(IARC, 1979)

Reported uses of vinyl chloride and the corresponding SIC codes are listed below:

Production of polyvinyl chloride resins	282
Polyvinyl chloride (PVC) used in:	
plastic pipes and conduit	307, 2821
floor coverings	3996, 1752
electrical insulation	30
construction materials	15
bottles, plastic film	307
upholstery and seat covers for cars	3799
Production of methyl chloroform	2865
Production of vinylidene chloride resins used mainly for acrylic fibers	282

(IARC, 1979)

RESEARCH AND REGULATORY DATA

Existing Guidelines and Standards

Ambient Air
Designated a hazardous air pollutant by the U.S. Environmental Protection Agency.

Workroom Air

ACGIH — The Threshold Limit Value (TLV) recommended in the notice of intended changes by the American Conference of Governmental Industrial Hygienists (ACGIH) for workroom air is 5 ppm (10 mg/cu m) as a time-weighted average. Vinyl chloride is designated a human carcinogen.

NIOSH — The National Institute of Occupational Safety and Health (NIOSH) recommends a standard of 1 ppm (2 mg/cu m). This level reflects demonstrated carcinogenicity.

OSHA — The Occupational Safety and Health Administration's (OSHA) standard for workroom air is 1 ppm (2 mg/cu m) as a time-weighted average and 5 ppm (10 mg/cu m) as a 15-minute ceiling. Vinyl chloride is regulated as a demonstrated carcinogen.

Water
Addressed by Ambient Water Quality Criteria set by the U.S. Environmental Protection Agency.

Designated a toxic pollutant by the U.S. Environmental Protection Agency.

Other
Regulated as a hazardous material by the U.S. Department of Transportation. The regulations pertain to the identification and transportation of hazardous materials in commerce (Code of Federal Regulations, Title 49, Part 172.101). Vinyl chloride is classified as a "Flammable Gas" and shipments must carry this level.

Regulated as a hazardous wasre under the Hazardous Waste Management System by the U.S. Environmental Protection Agency.

Agencies Concerned with this Chemical

Subject of a Quantitative Risk Assessment Document prepard by the Carcinogen Assessment Group (CAG) of the U.S. Environmental Protection Agency.

Subject of a monograph prepared by the International Agency for Research on Cancer (IARC).

Addressed by a development plan prepared by the Interagency Regulatory Liaison Group (IRLG).

REFERENCES

American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of the Threshold Limit Values, Fourth Edition. Cincinnati, OH (1980).

Callahan, M. A., et al. Water-Related Fate of 129 Priority Pollutants. U.S. EPA Office of Water Planning and Standards, Washington, DC, EPA 440/4-79-029 (December 1979).

International Agency for Research on Cancer (IARC). IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Lyon, France, Volume 19. A World Health Organization Publication (WHO), Geneva (1979).

Merck Index: An Encyclopedia of Chemicals and Drugs, Ninth Edition, M. Windholz, Ed. Merck and Co., Rahway, NJ (1976).

Radding, S., et al. Review of the Environmental Fate of Selected Chemicals. Prepared for the U.S. Environmental Protection Agency. Available from the National Technical Information Service, Springfield, VA, PB 267-121 (May, 1977).

Registry of Toxic Effects of Chemical Substances, October 1980 Quarterly Microfiche Issue, R. J. Lewis, and R. L. Tatkins. Prepared by Tracor Jitco, Inc., Rockville, MD for National Institute for Occupational Safety and Health. DHHS (NIOSH) Publication No. 80-111-4 (1980).

Shepard, T. H. Catalog of Teratogenic Agents, Third Edition. The John Hopkins University Press, Baltimore, MD (1980).

U.S. Environmental Protection Agency, Carcinogen Assessment Group (CAG). Carcinogen Assessment Group's Quantitative Risk Assessment on Vinyl Chloride. Washington, DC (December 5, 1975).

U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. Toxic Substances Control Act (TSCA) Chemical Substances Inventory. Available from the National Technical Information Service, Springfield, VA PB-80-155-153 (1980).

U.S. Environmental Protection Agency, Office of Water Planning and Standards. Ambient Water Quality Criteria for Vinyl Chloride. EPA-440/5-80-078 , PB 81-117889 (October 1980).

Verschueren, Karel. Handbook of Environmental Data on Organic Compounds. Van Nostrand Reinhold Co., New York, NY (1977).

GLOSSARY

ACGIH: American Conference of Governmental Industrial Hygienists. The ACGIH is devoted to the development of administrative and technical aspects of worker health protection. The committees on Industrial Ventilation and Threshold Limit Values are recognized throughout the world for their expertise and contributions to industrial hygiene.

Acute Effect: A reaction to an exposure of short-term duration (acute exposure) which results in immediate or proximate effects.

Adsorption: Adhesion of the molecules of a gas, liquid or dissolved substance to a surface.

Bioaccumulation: Accumulation of a chemical substance in an organism above ambient levels.

Biodegradable: Having the ability to break down or decompose rapidly under normal environmental conditions and processes.

Biological Half-Life: The amount of time required for half the amount of a substance in or introduced into a living system to be eliminated by natural processes.

Biomagnification: Increased bioaccumulation with increasing levels of the food chain.

CAG: Carcinogen Assessment Group. CAG is a small group of scientists who perform an advisory assessment function for EPA's regulatory offices.

Carcinogen: An agent which is capable of causing cancer in a tissue after exposure.

CAS Registry Number: Chemical Abstract Service Registry Number. A numeric designation assigned by the American Chemical Society's Chemical Abstracts Service to uniquely identify a specific chemical compound.

CHIP: Chemical Hazard Information Profile. CHIPs are evaluations of chemical substances prepared by EPA's Office of Testing and Evaluation, Office of Pesticides and Toxic Substances (OPTS). The CHIP provides a brief summary giving the health and environmental effects and exposure potential of a chemical.

Chronic Effect: A reaction to prolonged or repeated exposure over an extended period (chronic exposure) which results in long-term effects.

CIIT: Chemical Industry Institute of Toxicology. CIIT is an independent organization supported by 34 member companies concerned with the scientific study of toxicological problems posed by commodity chemicals.

Hazardous Materials Table Identification Number: The identification number assigned by the U.S. Department of Transportation to identify hazardous materials in commerce. The numbers are set forth in the Hazardous Materials Table included in the Code of Federal Regulations, Title 49, Part 172. The Table was published in the Federal Register, Vol. 45, No. 101, May 22, 1980.

Hazardous Substance: Any substance designated by the U.S. Environmental Protection Agency for the purpose of proposed reporting regulations to limit the discharge of toxic and hazardous substances to the nation's water (Code of Federal Regulations, Title 40, Part 116).

Hazardous Wastes: A solid waste which may cause illness or death or pose a substantial hazard to human health or the environment. They are regulated under the Hazardous Waste Management System by the U.S. Environmental Protection Agency. Persons who generate, transport, store, or dispose of these wastes must comply (Code of Federal Regulations, Title 40, Part 260).

Hydrolysis: A chemical reaction in which a substance reacts with the ions of water to produce a weak acid or weak base, or both.

IARC: International Agency for Research on Cancer. In 1971, IARC initiated a program on the evaluation of the carcinogenic risk of chemicals to humans. In 1980, the program was expanded to include the evaluation of the carcinogenic risk associated with employment in specific occupations.

IRLG: Interagency Regulatory Liaison Group: The IRLG was designed to coordinate the efforts on toxic substance issues of the following four agencies -- Consumer Product Safety Commission, Occupational Safety and Health Adminstration, U. S. Environmental Protection Agency, and the U. S. Food and Drug Administration -- for the purpose of improving public health through sharing of information, avoiding duplication of effort and developing consistent regulatory policy.

ITC: Interagency Testing Committee: The federal committee that makes recommendations to the U.S. Environmental Protection Agency regarding chemical substances or mixtures which should be given priority consideration in the development of requirements for testing for adverse health and environmental effects (Federal Register, Vol. 45, No. 104, 1980).

LC50: The lethal concentration (LC) to 50 percent of a population; the calculated concentration of a substance in either air or water (as separated figures) which will cause the death of 50 percent of an experimental animal population under controlled conditions and time exposure, most often 96 hours for aquatic species. (The 50 may or may not be subscripted.)

LD50: The lethal dose (LD) to 50 percent of a population; the calculated dose of a chemical substance which is expected to cause the death of 50 percent of an entire population of an experimental animal species as determined from exposure to the substance by any route other than inhalation. (The 50 may or may not be subscripted).

MEDLARS: A computerized information retrieval system supported by the National Library of Medicine.

Mutagenic: Resulting in a permanent change in hereditary material involving a physical change in chromosome relations, a fundamental change in the arrangement of genes, or an alteration in the structure of DNA.

NESHPs: National Emissions Standards for Hazardous Air Pollutants. Standards may be established for designated pollutants which increase the risk of cancer or irreversible health effects to the general public when emitted to the ambient air from specific sources (Code of Federal Regulations, Title 40, Part 61).

NIEHS: National Institute of Environmental Health Sciences: One of several of the National Institutes of Health.

NIOSH: National Institute of Occupational Safety and Health. NIOSH serves as the official scientific advisory board of the Occupational Safety and Health Administration. NIOSH is responsible for developing criteria for setting occupational standards designed to protect the health and safety of workers for a 40-hour week over a working lifetime.

OSHA: Occupational Safety and Health Administration. This federal agency has the regulatory authority to protect workers from hazards in the workplace under the Occupational Safety and Health Act. OSHA standards represent allowable concentrations of toxic or hazardous substances to which employees may be exposed without incurring adverse health effects (Code of Federal Regulations, Title 24, Part 1910, Subpart Z).

Octanol/Water Partition Coefficient (also Partition Coefficient): A measure of partitioning of a solute between the nonaqueous and aqueous phases of a two phase system. This coefficient is used as a reference for estimating the probability of the substance accumulating in the fatty tissues of living organisms and of bioaccumulations up the food chain.

Phytotoxicity: Toxicity to plant life.

RCRA: The Resource Conservation and Recovery Act. RCRA provides the legislative guidance for the management of solid wastes.

RCRA Identification Number: Generator of hazardous waste must properly identify and dispose of their waste. The RCRA identification number is used to specify the hazardous substances found in a given waste.

RPAR: Rebuttable Presumption Against Registration through the U.S. Environmental Protection Agency. RPAR prohibits uncontrolled use of pesticides and is issued if the pesticides' ingredients, metabolites, or degradation products represent unreasonable risks to the general public and environment (Code of Federal Regulations, Title 40, Part 162).

RTECS: Registry of Toxic Effects of Chemical Substances. The RTECS is published yearly by the National Institute for Occupational Safety and Health. It contains basic toxicity information and other data, such as chemical identifiers, safety directives, and hazard evaluations for chemical substances. Listings for more than 145,000 chemical substances are currently included.

RTECS Number: A nine position accession number (two letters, seven numbers) assigned to each compound in the RTECS. RTECS

numbers are assigned to correspond directly with the alphabetic sequence of the prime name.

SIC: Standard Industrial Classification. The SIC defines industries in accordance with the composition and structure of the economy and covers the entire field of economic activities.

STEL: Short Term Exposure Limit. The maximum short term exposure level of a contaminant considered safe for workroom atmosphere, as established by ACGIH.

Teratogenic: Inducing structure and/or function deviation in an embryo during its development, resulting in congenital birth defects.

TDB: Toxicology Data Bank. This is an online interactive computer file which contains peer reviewed information on over 3,000 chemical substances. It is available through the National Library of Medicine.

TLV: Threshold Limit Value. Maximum levels of contaminants considered safe for workroom atmosphere, as established by the ACGIH. Ten hours per day or 40 hours per week exposure is assumed.

TLm: Tolerance Limit median (often used interchangeable with aquatic LC50). The concentration of a substance in water which will cause the death of 50 percent of an experimental aquatic animal population under controlled conditions and time of exposure (most often 96 hours).

Toxic Pollutant: Designated by the U.S. Environmental Protection Agency. The EPA must develop water quality criteria and promulgate regulations by which these toxic pollutants will be governed (Code of Federal Regulations, Title 40, Part 401).

TSCA: Toxic Substances Control Act. TSCA is intended to provide protection from substances manufactured, processed, distributed, or used in the United States. A mechanism for screening new substances before they enter the market place and for testing existing substances that are suspected of creating health hazards is required by the Act. Specific regulations for controlling substances found to be detrimental to human health and to the environment may also be promulgated under this Act (Federal Register, Vol. 45, No. 42, 1980).

Volatization: The rapid vaporization/evaporation of a substance into the atmosphere.

WQC: Ambient Water Quality Criteria. The Clean Water Act requires the Environmental Protection Agency to publish and periodically update water quality criteria to reflect the latest scientific knowledge on the effects of pollutants on human health and the environment (Federal Register, Vol. 44, No. 231, 1980).