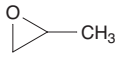
Propylene Oxide

CAS No. 75-56-9

Reasonably anticipated to be a human carcinogen

First listed in the *Sixth Annual Report on Carcinogens* (1991)

Also known as 2-methyloxirane



Carcinogenicity

Propylene oxide is *reasonably anticipated to be a human carcinogen* based on sufficient evidence of carcinogenicity from studies in experimental animals.

Cancer Studies in Experimental Animals

Propylene oxide caused tumors in two rodent species, at several different tissue sites, and by several different routes of exposure. Exposure to propylene oxide by inhalation caused (1) benign and malignant blood-vessel tumors (hemangioma and hemangiosarcoma) in the nasal cavity of mice of both sexes, (2) benign nasal-cavity tumors (papillary adenoma) in rats of both sexes, and (3) benign adrenal-gland tumors (pheochromocytoma) and tumors of the abdominal cavity (mesothelioma) in weanling male rats. Administration of propylene oxide by stomach tube caused forestomach cancer (primarily squamous-cell carcinoma) in female rats, and subcutaneous injection caused cancer at the injection site (fibrosarcoma or pleomorphic sarcoma) in female mice (NTP 1985, IARC 1985, 1987).

Since propylene oxide was listed in the *Sixth Annual Report on Carcinogens,* an additional study in rats has been identified, in which inhalation exposure to propylene oxide caused benign and malignant mammary-gland tumors (fibroadenoma and adenocarcinoma) in females (IARC 1994).

Cancer Studies in Humans

The data available from epidemiological studies are inadequate to evaluate the relationship between human cancer and exposure specifically to propylene oxide. In a cohort study of 602 workers potentially exposed to propylene oxide as well as to ethylene oxide, benzene, ethylene chlorohydrin, and other chemicals, no significant associations were found between exposure and cancer at specific tissue sites; however, the results were considered to be inconclusive with respect to propylene oxide (IARC 1985, 1987).

Since propylene oxide was listed in the *Sixth Annual Report on Carcinogens,* additional epidemiological studies have been identified. The International Agency for Research on Cancer (IARC 1994) reviewed several cohort studies of mixed exposures that included propylene oxide, including studies of chemical workers (Hogstedt *et al.* 1986, Hogstedt 1988, Gardner *et al.* 1989), and one case-control study of specific types of lymphohematopoietic cancer that evaluated exposure specifically to propylene oxide (Ott *et al.* 1989). The cohort studies were not informative because they could not distinguish the specific effects of propylene oxide, and IARC concluded that the case-control study was not informative because of limitations in exposure assessment and potential confounding by other risk factors.

Properties

Propylene oxide is an epoxide compound that exists at room temperature as a volatile colorless liquid with an ethereal benzene-like odor (IPCS 1985). It is soluble in water and ethanol and miscible with acetone, benzene, carbon tetrachloride, methanol, and ether. Propylene oxide is very flammable, but it is stable under normal storage conditions (Akron 2009). It is very reactive, particularly with chlorine, ammonia, strong oxidants, and acids. It may polymerize explosively when heated or involved in a fire (IARC 1994, HSDB 2009). Physical and chemical properties of propylene oxide are listed in the following table.

Property	Information
Molecular weight	58.1
Specific gravity	0.8304 at 20/20°C
Melting point	–112.13°C
Boiling point	34.23°C
Log K_{ow}	0.03
Water solubility	590 g/L at 25°C
Vapor pressure	538 mm Hg at 25°C
Vapor density relative to air	2

Source: HSDB 2009.

Use

Propylene oxide is used primarily as a chemical intermediate in the production of other compounds (HSDB 2009). In the United States in 1993, propylene oxide was used to produce the following compounds: polyurethane polyols (58%), propylene glycols (22%), glycol ethers (5.5%), di- and tri-propylene glycols (3.5%), and miscellaneous compounds (polyalkylene glycols, allyl alcohol, and isopropanolamines) (11%) (CMR 2001). Polyurethane polyols are used to make polyurethane foams, and propylene glycols are used primarily to make unsaturated polyester resins for the textile and construction industries. Propylene oxide is also used in the preparation of lubricants, surfactants, and oil demulsifiers. It is approved for use as a direct and indirect food additive. In addition, propylene oxide has been used as a fumigant for soil and in chambers for the sterilization of packaged foods. It is used as an herbicide, microbicide, insecticide, fungicide, and miticide (HSDB 2009). It is also used as a reactive diluent in preparations for embedding tissues for transmission electron microscopy, in detergent manufacture, and as a component of brake fluids (IARC 1994, HSDB 2009).

Production

Propylene oxide was first prepared in 1860, but commercial production did not begin until the early 1900s (IARC 1985, 1994). Annual combined production and imports of propylene oxide were reported to total over a billion pounds between 1988 and 2006, and fell in the range of 1 billion to 5 billion pounds in 2015 (EPA 2016). These volumes are consistent with production volumes reported by other sources for time periods since 1977 (CMR 2001, HSDB 2009). U.S. imports of propylene oxide were consistently high (between 25 million and 50 million pounds) in the 1970s and 1980s, but have since fluctuated widely; no imports were reported in 2017. U.S. exports of polypropylene oxide ranged between 99 million and 526 million pounds from the 1970s through 2006 and totaled 428.5 million pounds in 2017 (HSDB 2009, USITC 2009, 2018). In 2009, propylene oxide was available from 49 suppliers worldwide, including 17 U.S. suppliers (ChemSources 2009).

Exposure

The routes of exposure to propylene oxide are inhalation, ingestion, and incidental dermal exposure. Consumers may be exposed through ingestion of propylene oxide residues in foods resulting from its use as an indirect food additive or by contact with consumer products containing propylene oxide. The U.S. Environmental Protection Agency (EPA) has established tolerance limits for propylene oxide based on residues from fumigation of cocoa beans, nutmeats, herbs and spices, and some fruits (e.g., figs, prunes, and raisins) (EPA 2006).

Consumer products with the highest concentrations of propylene oxide include automotive and paint products. One automotive product lists propylene oxide as an ingredient at a concentration of 0.1% to 0.5% (HPD 2009).

According to EPA's Toxics Release Inventory, environmental releases of propylene oxide declined from a high of 4.9 million pounds in 1988 to a low of 374,000 lb in 2001. In 2007, 97 facilities produced, processed, or otherwise used propylene oxide, and 84 facilities released a total of 436,321 lb; 97% of releases were to air (TRI 2009).

The primary route of occupational exposure to propylene oxide is inhalation, during its use in the production of polyurethane polyols and propylene glycol or as a fumigant (IARC 1994, HSDB 2009). For almond and walnut fumigation, the daily time-weighted-average exposure concentration was 0.71 ppm (geometric mean) for combined non-specific exposure and exposure during chamber unloading (adjusted for exposure duration) (EPA 2006). The National Occupational Hazard Survey (conducted from 1972 to 1974) estimated that 268,433 workers potentially were exposed to propylene oxide (NIOSH 1976), and the National Occupational Exposure Survey (conducted from 1981 to 1983) estimated that about 420,000 workers, including 317,000 women, potentially were exposed (NIOSH 1990).

Regulations

Coast Guard (Dept. of Homeland Security)

Minimum requirements have been established for safe transport of propylene oxide on ships and barges, and requirements for Notices of Arrival and Notice of Hazardous Conditions have been established.

Department of Transportation (DOT)

Propylene oxide is considered a hazardous material and special requirements have been set for marking, labeling, and transporting this material.

Environmental Protection Agency (EPA)

Clean Air Act

National Emission Standards for Hazardous Air Pollutants: Listed as a hazardous air pollutant.
New Source Performance Standards: Manufacture of propylene oxide is subject to certain provisions for the control of volatile organic compound emissions.
Prevention of Accidental Release: Threshold quantity (TQ) = 10,000 lb.

Clean Water Act

Designated a hazardous substance.

Comprehensive Environmental Response, Compensation, and Liability Act

Reportable quantity (RQ) = 100 lb.

Emergency Planning and Community Right-To-Know Act

Reportable quantity (RQ) = 100 lb.
Threshold planning quantity (TPQ) = 10,000 lb.
Toxics Release Inventory: Listed substance subject to reporting requirements.

Federal Insecticide, Fungicide, and Rodenticide Act

Tolerances for residues of propylene oxide when used as a postharvest fumigant: = 300 ppm for dried garlic, dried herbs and spices, tree nuts, dried onion; = 200 ppm for cacao bean and cocoa powder; = 3 ppm for fig; = 2 ppm for plum, prune; = 1 ppm for grape, raisin.

Food and Drug Administration (FDA, an HHS agency)

Limitations on propylene oxide use in food additives permitted for direct addition to food for human consumption and in food contact materials are prescribed in 21 CFR 172, 173, 175, 176, and 178.

Occupational Safety and Health Administration (OSHA, Dept. of Labor)

While this section accurately identifies OSHA's legally enforceable PELs for this substance in 2018, specific PELs may not reflect the more current studies and may not adequately protect workers.
Permissible exposure limit (PEL) = 100 ppm (240 mg/m^3).

Guidelines

American Conference of Governmental Industrial Hygienists (ACGIH)

Threshold limit value – time-weighted average (TLV-TWA) = 2 ppm.

National Institute for Occupational Safety and Health (NIOSH, CDC, HHS)

Immediately dangerous to life and health (IDLH) limit = 400 ppm.
Listed as a potential occupational carcinogen.

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