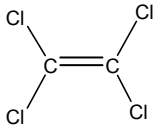
TETRACHLOROETHYLENE (PERCHLOROETHYLENE)
CAS No. 127-18-4
First Listed in the *Fifth Annual Report on Carcinogen*



CARCINOGENICITY

Tetrachloroethylene (perchloroethylene) is *reasonably anticipated to be a human carcinogen* based on sufficient evidence of carcinogenicity in experimental animals (NTP 1986, IARC 1979, 1987, 1995). When administered by inhalation, tetrachloroethylene increased the incidences of hepatocellular adenomas and carcinomas in male mice and hepatocellular carcinomas in female mice. By the same route of administration, the compound increased the incidences of mononuclear cell leukemia in rats of both sexes and rare renal tubular cell neoplasms in male rats. When administered by gavage, tetrachloroethylene increased the incidence of hepatocellular carcinomas in mice of both sexes.

There is limited evidence for the carcinogenicity of tetrachloroethylene in humans (IARC 1987, 1995). Tetrachloroethylene has been studied by observing laundry and dry-cleaning workers, who may also have been exposed to other solvents, especially trichloroethylene, but also petroleum solvents. In several cohort and proportionate mortality studies, excesses have been reported of lymphosarcomas, leukemias, and cancers of the skin, colon, lung, and urogenital tract. Some excess of lymphomas and of cancers of the larynx and urinary bladder was seen in a large cohort of dry cleaners. A familial cluster of chronic lymphocytic leukemia has also been related to dry cleaning. Although these studies suggest a possible association between long-term occupational exposure to tetrachloroethylene and increased lymphatic malignancies and urogenital cancers, the evidence must be regarded as inconclusive because workers were exposed to petroleum solvents and other dry cleaning agents as well as tetrachloroethylene. When all studies are considered, there is evidence for consistent positive associations between tetrachloroethylene exposure and esophageal and cervical cancer and non-Hodgkin's lymphoma. While these associations appear unlikely to be due to chance, confounding cannot be excluded; further, the total numbers in the cohort studies combined are relatively small (IARC 1995).

PROPERTIES

Tetrachloroethylene is a colorless, volatile liquid with an ether-like odor. It is slightly soluble in water and miscible with alcohol, ether, chloroform, hexane, and benzene (IARC 1995, ATSDR 1997). In water, tetrachloroethylene slowly decomposes to form trichloroacetic and hydrochloric acids (IARC 1979). Tetrachloroethylene is nonflammable; however, containers may explode when heated in a fire. Phosgene, a highly toxic gas, may form when tetrachloroethylene vapors are exposed to sunlight or flames. This chemical is incompatible with chemically active metals (e.g., barium, lithium, and beryllium), caustic soda, sodium hydroxide, potash, and strong oxidizers (IARC 1995, HSDB 2001).

USE

Tetrachloroethylene is used primarily as a cleaning solvent and as a chemical precursor for fluorocarbons. In the 1970s, domestic use patterns were as follows: 58% for dry cleaning and textile processing, 18% for metal cleaning, 12% for chemical intermediates, and 12% for all other uses (IARC 1995). By the mid 1990s, dry cleaning, metal cleaning, chemical intermediates, and other uses accounted for 55%, 11%, 29%, and 5%, respectively (Chemexpo 1997). During the 1990s, tetrachlorethylene use in the dry cleaning industry declined by 60% in order to meet stringent government regulations for workplace exposure. In 2000, 50% was used for chemical intermediates and 21% was used in dry cleaning (Chemexpo 2000). Tetrachloroethylene is also used as an insulating fluid and cooling gas in electrical transformers, in paint removers, printing inks, adhesive formulations, paper coatings, and leather treatments, in aerosol formulations such as water repellants, automotive cleaners, silicone lubricants, and spot removers, as an extractant for pharmaceuticals, and as an anthelmintic agent (IARC 1995, ATSDR 1997).

PRODUCTION

Tetrachloroethylene was first prepared in 1821 and commercial production in the U.S. began in 1925. Several commercial grades are available that differ in the amount and type of added stabilizers (e.g., amines, phenols, and epoxides). Annual production rose rapidly in the U.S. from 5,000 metric tons (1.1 million lb) in 1941 to a peak of 347,000 metric tons (763 million lb) in 1980. Between 1980 and 1993, annual production declined by more than 60% (IARC 1995, ATSDR 1997). In recent years, U.S. demand (domestic production plus imports) has increased slightly from 280 million lb in 1996 to 318 million lb in 1999. The projected demand for 2003 is 340 million lb. There are currently three U.S. producers with a combined capacity of 355 million lb (Chemexpo 1997, 2000). Chem Sources (2001) listed 37 current U.S. suppliers.

The U.S. imported 132 million lb, 38 million lb, and 140 million lb of tetrachloroethylene in 1977, 1982, and 1985, respectively (HSDB 2001). Between 1992 and 1996, U.S. imports averaged approximately 80 million lb per year, but declined from 1998 to 2000 with an average of approximately 36 million lb per year (Chemexpo 1997, 2000, ITA 2001). U.S. exports of tetrachloroethylene totaled 64 million lb, 54 million lb, and 22 million lb in 1978, 1983, and 1985, respectively (HSDB 2001). Exports averaged 45 million lb per year from 1992 to 1996, but increased to an average of 59 million lb per year from 1998 to 2001 (Chemexpo 1997, 2000, ITA 2001).

EXPOSURE

Tetrachlorethylene is widely distributed in the environment and is released to the environment from industrial processes and consumer products. The majority of tetrachlorethylene is released to the air. EPA's Toxic Chemical Release Inventory (TRI) listed 462 industrial facilities that reported releasing tetrachloroethylene in 1999. Total releases to the environment declined by 10 fold between 1988 (37.7 million lb) and 1999 (3.7 million lb) (TRI99 2001).

The primary routes of potential human exposure to tetrachloroethylene are inhalation and ingestion of contaminated water or food. Dermal exposure may occur, but is not important for the majority of the population (ATSDR 1997). Numerous studies have detected

tetrachloroethylene in the air in the United States in rural, urban, and industrial areas. Typical concentrations in rural and remote areas were in the low parts per trillion (ppt) range, while concentrations in urban and industrial areas were in the high ppt to low parts per billion (ppb) range. Tetrachloroethylene also may be formed in small quantities during chlorination of water. The EPA estimated that approximately 11.4 million people were exposed to tetrachloroethylene at concentrations ≥0.5 µg/L and approximately 874,000 were exposed to concentrations ≥5 µg/L from municipal water supplies in the United States in 1985 (IARC 1995). Tetrachloroethylene has also been detected in rainwater, sea water, rivers, groundwater, commercial deionized charcoal-filtered water, dairy products, meats, oils and fats, beverages, fruits and vegetables, fresh bread, fish, shellfish, marine mammals, glues, printing inks, lubricants, stain and paint removers, and other consumer products (IARC 1995, ATSDR 1997).

The general population may also be exposed to tetrachloroethylene through use of coin-operated laundromats that contain dry cleaning machines or through freshly dry-cleaned clothing. Studies show elevated concentrations of tetrachloroethylene in laundromats (even months after removing the dry cleaning machines). Tetrachloroethylene concentrations in homes with freshly dry-cleaned clothing stored in the closets may be 2 to 30 times higher than average background levels. In addition, workers in the dry-cleaning industry are a source of exposure to their families. In one study, indoor air concentrations in apartments where dry cleaning workers lived were more than 10-fold higher than in other apartments (ATSDR 1997).

Workers involved in dry cleaning, metal degreasing, and fluorocarbon production are likely to be exposed to tetrachloroethylene. The National Occupational Hazard Survey, conducted by NIOSH from 1972 to 1974, estimated that approximately 1.6 million workers were potentially exposed to tetrachloroethylene in the workplace (NIOSH 1976). NIOSH later reported that nearly 500,000 workers in 1978 and 275,000 workers in 1979 potentially were exposed to tetrachloroethylene (NIOSH 1978, 1979). The National Occupational Exposure Survey (1981-1983) indicated that approximately 566,000 workers in 42,700 facilities were potentially exposed to tetrachloroethylene in the workplace (IARC 1995). A 1994 survey prepared by industry indicated that approximately 450,000 workers were potentially exposed (IARC 1995).

Occupational exposures show a declining trend over the past several decades. Typical tetrachloroethylene concentrations in workplace air at dry cleaning facilities were 350 to 700 mg/m^3 (about 50 to 100 ppm) in the 1970s and 70 to 350 mg/m^3 (about 10 to 50 ppm) in the 1980s (IARC 1995). The highest exposures occur when loading and unloading the dry cleaning machines; however, more recent studies by NIOSH indicated that exposure levels in the dry cleaning industry were less than the recommended occupational exposure guideline of 25 ppm **(**ATSDR 1997).

REGULATIONS

EPA regulates tetrachloroethylene under the Clean Air Act (CAA), Clean Water Act (CWA), Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Food, Drug, and Cosmetic Act (FD&CA), Resource Conservation and Recovery Act (RCRA), and Safe Drinking Water Act (SDWA). EPA has set a reportable quantity (RQ) of 100 lb for tetrachloroethylene under CERCLA.

FDA regulates tetrachloroethylene as an indirect food additive.

The American Conference of Governmental Industrial Hygienists (ACGIH) recommends a threshold limit value (TLV) of 25 ppm (170 mg/m^3) with a ceiling value not to exceed 100 ppm (685 mg/m^3) for tetrachloroethylene. NIOSH has recommended that tetrachloroethylene be regarded as a potential occupational carcinogen. OSHA established a permissible exposure limit (PEL) of 25 ppm as an 8-hr time-weighted average (TWA) with no short-term exposure limit (STEL) or ceiling permitted. OSHA also regulates tetrachloroethylene under the Hazard Communication Standard and as a chemical hazard in laboratories. Regulations are summarized in Volume II, Table 169.

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