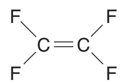
Tetrafluoroethylene

CAS No. 116-14-3

Reasonably anticipated to be a human carcinogen

First listed in the *Ninth Report on Carcinogens* (2000)



Carcinogenicity

Tetrafluoroethylene is *reasonably anticipated to be a human carcinogen* based on sufficient evidence of carcinogenicity from studies in experimental animals (NTP 1997).

Cancer Studies in Experimental Animals

Exposure to tetrafluoroethylene by inhalation caused tumors at several different tissue sites in mice and rats. It caused benign and malignant liver tumors (hepatocellular adenoma and carcinoma) in mice and rats of both sexes and blood-vessel tumors (hemangioma and hemangiosarcoma) in the liver of mice of both sexes and female rats. Tetrafluoroethylene also increased the combined incidence of benign and malignant kidney tumors (renal-tubule adenoma and carcinoma) in rats of both sexes and caused mononuclear-cell leukemia in female rats. In addition, it caused cancer of the immune system (histiocytic sarcoma) in numerous organs and tissues in mice of both sexes (NTP 1997).

Cancer Studies in Humans

No epidemiological studies were identified that evaluated the relationship between human cancer and exposure specifically to tetrafluoroethylene.

Studies on Mechanisms of Carcinogenesis

Tetrafluoroethylene did not cause gene mutations in *Salmonella typhimurium* with or without mammalian metabolic activation (NTP 1997, HSDB 2009). It also did not cause gene mutations in Chinese hamster ovary cells or micronucleus formation in peripheral-blood erythrocytes in mice exposed *in vivo* (NTP 1997). In tetrafluoroethylene-induced hepatocellular tumors from $B6C3F_1$ mice, mutations in codon 61 of the H-*ras* oncogene occurred at a significantly lower frequency (15%) than in spontaneous liver tumors (56% to 59%), suggesting that tetrafluoroethylene causes liver tumors via a *ras*-independent pathway (NTP 1997).

The kidney-specific toxicity and carcinogenicity of tetrafluoroethylene most likely are related to the selective uptake and subsequent processing of tetrafluoroethylene-glutathione conjugates by renal β-lyase (Anders *et al.* 1988, Miller and Surh 1994). In rats, a tetrafluoroethylene-cysteine conjugate is bioactivated in the kidney to a difluorothionacetyl fluoride, the putative reactive metabolite for tetrafluoroethylene-induced nephrotoxicity (NTP 1997). There is no evidence to suggest that mechanisms by which tetrafluoroethylene causes tumors in experimental animals would not also operate in humans.

Properties

Tetrafluoroethylene is a halogenated olefin that occurs as a colorless, odorless gas at room temperature. It is practically insoluble in water. Tetrafluoroethylene is very flammable and may present a fire hazard. At high pressures, it may polymerize easily without an inhibitor, especially if heated or in the presence of oxygen (IARC 1979, NTP 1997). Physical and chemical properties of tetrafluoroethylene are listed in the following table.

Property	Information
Molecular weight	100.0[a]
Density	1.519 g/cm^3 at –76°C[a]
Melting point	–142.5°C[a]
Boiling point	–75.9°C[a]
Log K_{ow}	1.21[b]
Water solubility	0.16 g/L at 25°C[a]
Vapor pressure	2.45 × 10^4 mm Hg at 25°C[b]
Vapor density relative to air	3.87[a]

Sources: [a]HSDB 2009, [b]ChemIDplus 2009.

Use

Tetrafluoroethylene is used primarily in the synthesis of fluoropolymers, particularly the homopolymer polytetrafluoroethylene (PTFE, or Teflon) (IARC 1979, HSDB 2009). Tetrafluoroethylene is also used as a copolymer to make fluorinated ethylene-propylene resins with hexafluoropropylene as a copolymer, perfluoroalkoxy resins with perfluoropropyl vinyl ether as the copolymer, and ethylene-tetrafluoroethylene resins. Tetrafluoroethylene is used in the production of low-molecular-mass compounds and intermediates, such as iodoperfluoroalkanes, and it reacts with perfluoronitrosoalkanes to produce nitroso rubbers (HSDB 2009). Tetrafluoroethylene was also used in the past in food-product aerosols.

Production

Tetrafluoroethylene is produced primarily by the pyrolysis of chlorodifluoromethane or trifluoromethane (NTP 1997). It was first produced commercially in the United States in 1960 (IARC 1979). In 2009, tetrafluoroethylene was produced by three manufacturers in China (SRI 2009) and was available from six suppliers, including two U.S. suppliers (ChemSources 2009). Reports filed under the U.S. Environmental Protection Agency's Toxic Substances Control Act Inventory Update Rule indicated that U.S. production plus imports of tetrafluoroethylene totaled 10 million to 50 million pounds from 1986 to 1994, increasing to between 50 million and 100 million pounds from 1998 to 2006 (EPA 2004, 2009).

Exposure

Inhalation is the primary route of exposure to tetrafluoroethylene; however, exposure from ingestion and dermal contact are also possible. Although human exposure to tetrafluoroethylene is mainly occupational, it may also occur through release of tetrafluoroethylene to the environment. Tetrafluoroethylene may be released to the environment during its production and use in the production of fluoropolymers, nitroso rubbers, and low-molecular-mass compounds and intermediates (HSDB 2009). However, reporting of releases of tetrafluoroethylene is not required under EPA's Toxics Release Inventory system. Tetrafluoroethylene has been reported, along with several other low-molecular-mass halogenated compounds, in volcanic emissions (Gribble 1994). If released to air, tetrafluoroethylene will exist in the vapor phase and react with photochemically produced hydroxyl radicals and ozone. If released to water or soil, it is not expected to bind to soil or sediment. It is expected to volatilize rapidly from water surfaces, with a half-life of 2.9 hours in a river model and 4 days in a lake model. Tetrafluoroethylene has a low potential for bioconcentration, and it does not biodegrade or hydrolyze rapidly.

Occupational exposure to tetrafluoroethylene may occur among workers involved in the production of polymers and copolymers of products containing the chemical (HSDB 2009). Tetrafluoroethylene is produced and maintained in closed-capture systems, so exposure would occur primarily through leakage from these systems or from pyrolysis of Teflon or other polymers (NTP 1997). The National Occupational Exposure Survey (conducted from 1981 to 1983) estimated that 14,963 employees (in 870 facilities in the Paper and Allied Products, Printing and Publishing, and Transportation Equipment industries), including 325 women, potentially were exposed to tetrafluoroethylene (NIOSH 1990).

Regulations

Department of Transportation (DOT)

Tetrafluoroethylene 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

Prevention of Accidental Release: Threshold quantity (TQ) = 10,000 lb.

Emergency Planning and Community Right-To-Know Act

Toxics Release Inventory: Listed substance subject to reporting requirements.

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

Considered a highly hazardous chemical: Threshold quantity (TQ) = 5,000 lb.

Guidelines

American Conference of Governmental Industrial Hygienists (ACGIH)

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

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