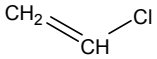
VINYL CHLORIDE
CAS No. 75-01-4
First Listed in the *First Annual Report on Carcinogens*



CARCINOGENICITY

Vinyl chloride is *known to be a human carcinogen* based on sufficient evidence of carcinogenicity in humans (IARC 1987). Vinyl chloride has been associated with tumors of the liver, brain, lung, and hematolymphopoietic system. A large number of epidemiological studies and case reports have substantiated the causal association between vinyl chloride and angiosarcoma of the liver. Several studies also confirm that exposure to vinyl chloride causes other forms of cancer, i.e., hepatocellular carcinoma, brain tumors, lung tumors, and malignancies of the lymphatic and hematopoietic system. Exposure to poly(vinyl chloride) dust was associated with an increased incidence of lung tumors in one study; the authors suggested that trapped vinyl chloride monomer was responsible. Melanoma occurred in excess in one study, but it has not been mentioned in others. Slightly elevated risks for gastric and gastrointestinal cancer (other than liver cancer) were indicated in some studies, but these were not confirmed in others.

An IARC Working Group reported that there is sufficient evidence of carcinogenicity of vinyl chloride in experimental animals (IARC 1979, 1982, 1987). When administered by inhalation, vinyl chloride induced pulmonary adenomas and adenocarcinomas, mammary adenocarcinomas, liver angiosarcomas, and angiosarcomas and adenocarcinomas at other sites in mice of both sexes. Inhalation of vinyl chloride induced Zymbal gland carcinomas, nephroblastomas, and liver angiosarcomas in rats of both sexes and mammary tumors and hepatocellular carcinomas in female rats. When administered by inhalation, vinyl chloride induced skin tumors in male hamsters and angiosarcomas (liver, spleen, or skin), mammary carcinomas, skin carcinomas, and stomach adenomas in female hamsters. Newborn rats developed angiosarcomas and hepatomas when exposed to vinyl chloride by inhalation. A combination of oral administration of ethanol and inhalation of vinyl chloride resulted in more liver tumors (including angiosarcomas) than after treatment with vinyl chloride alone.

PROPERTIES

Vinyl chloride is a colorless, flammable gas with a faintly sweet odor. It is slightly soluble in water, soluble in ethanol, and very soluble in ether, carbon tetrachloride, and benzene. Vinyl chloride is extremely flammable and is easily ignited by heat, sparks, or flames. Explosive mixtures will form with air, and it tends to self-polymerize explosively if peroxidation occurs. It reacts vigorously with oxidizers and, in the presence of moisture, corrodes iron and steel. Fires may release irritating and toxic gases including carbon dioxide, carbon monoxide, hydrogen chloride, and traces of phosgene. Technical-grade vinyl chloride is commercially supplied as 99.9% pure liquid under pressure (HSDB 2001).

USE

Vinyl chloride was first produced commercially in the 1920s and is now one of the highest volume chemicals produced in the U.S. (Kielhorn *et al.* 2000, HSDB 2001). It is used almost exclusively by the plastics industry to produce polyvinyl chloride (PVC) and copolymers. Some vinyl chloride is used in organic synthesis. PVC is a plastic resin used in numerous consumer and industrial products, including automotive parts and accessories, furniture, medical supplies, containers, wrapping film, battery cell separators, electrical insulation, water distribution systems, flooring, windows, videodiscs, irrigation systems, and credit cards. More than 95% of vinyl chloride monomer production is used to make PVC and its various polymers, with the remaining used for organic synthesis and miscellaneous applications (Keilhorn *et al.* 2000, HSDB 2001). Vinyl chloride-vinyl acetate copolymers are used extensively to produce films and resins (IARC 1974, 1979, NCI 1978, ATSDR 1997). It was once used as a refrigerant, extraction solvent, and in aerosol propellants. These uses were banned in 1974 because of its carcinogenic effects (HSDB 2001).

PRODUCTION

Vinyl chloride has been identified in *Chemical and Engineering News*' top 50 list of high-volume chemicals produced in the U.S. for the past several years. Production steadily increased from approximately 6 to 9 billion lb per year in the late 1970s through the 1980s to approximately 15 billion lb per year in the mid 1990s (Chem. Eng. News 1996, USITC 1996, HSDB 2001). The projected demand for 2001 was 16.8 billion lb (HSDB 2001). There are at least 11 current chemical suppliers of vinyl chloride in the U.S. (Chem Sources 2001).

U.S. imports reached a peak of 302 million lb in 1989. In 2000, the U.S. imported more than 231 million lb compared to 29 million lb in 1994 and 164 million lb in 1991 (ATSDR 1997, ITA 2001). Exports fluctuated from approximately 685 million lb per year to 2.2 billion lb per year from the late 1970s to the mid 1990s (ATSDR 1997, HSDB 2001). In 2000, U.S. exports were approximately 1.03 billion lb (ITA 2001).

EXPOSURE

The primary routes of potential exposure of the general population to vinyl chloride are inhalation of contaminated air, ingestion of contaminated drinking water and foods, and dermal contact with consumer products; however, the exposure levels for the majority of the population are very low (ATSDR 1997, Kielhorn *et al.* 2000, HSDB 2001). Occupational exposure occurs through inhalation and dermal contact at workplaces where vinyl chloride is produced or used.

Vinyl chloride is released into the environment from emissions and effluents from the plastics industries. Segments of the general population living in the vicinity of emission sources are potentially exposed to relatively high concentrations of vinyl chloride (trace levels to >2,600 $\mu g/m^3$) by inhalation of contaminated air. Average daily intake of vinyl chloride by residents living near an emission source ranged from trace amounts to 2,100 µg/day. Ambient air in the U.S., whether in a rural or urban area, typically does not contain detectable levels of vinyl chloride. The majority of the general population is not expected to be exposed to vinyl chloride through ingestion of drinking water. Only 0.74% of 945 water supplies sampled throughout the U.S. contained detectable levels of vinyl chloride. In another study, vinyl chloride was detected in only 12 of 11,202 public water supplies using surface waters as their primary source. The EPA estimated that approximately 0.9% of the U.S. population is exposed to levels in drinking

water of ≥1.0 µg/L, and 0.3% of the population is exposed to levels >5 µg/L. In the past, vinyl chloride was detected in various foods and beverages that were wrapped or contained in PVC packaging materials; however, current FDA regulations have essentially eliminated this exposure pathway. The average daily intake of vinyl chloride from the diet is predicted to be below detection (ATSDR 1997). Vinyl chloride has also been detected in domestic and foreign cigarettes and little cigars at concentrations ranging from 5.6 to 27 ng/cigarette and in a marijuana cigarette at 5.4 ng/cigarette (IARC 1979).

Occupational exposures generally occur after production when the finished monomer is piped to storage or transportation, or during maintenance. There is a high potential for exposure during the polymerization process to form PVC resins or other materials because vinyl chloride monomer may escape into the air (NCI 1978). The National Occupational Exposure Survey (1981-1983) estimated that 81,314 workers were potentially exposed to vinyl chloride (ATSDR 1997). According to EPA's Toxic Release Inventory (TRI99 2001), an estimated 849,000 lb of vinyl chloride (98% of the total environmental releases) were discharged to the air, 106 lb were discharged to surface water, 405 lb were injected underground, and approximately 14,000 lb were released off-site from 49 manufacturing and processing facilities in the U.S. in 1999. Environmental releases declined slowly from approximately 1.4 million lb in 1988 to less than 1 million lb per year in 1998 and 1999 (TRI99 2001).

REGULATIONS

The Consumer Product Safety Commission (CPSC) has banned self-pressurized products intended or suitable for household use that contain vinyl chloride as an ingredient or in the propellant.

Under the Clean Air Act (CAA), National Emission Standards for Hazardous Air Pollutants (NESHAP), EPA addresses vinyl chloride emissions from production and manufacturing facilities. A reportable quantity (RQ) of 1 lb was established for this chemical under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Under the Clean Water Act (CWA), EPA published a water quality criteria document addressing vinyl chloride for the protection of human health. EPA regulates vinyl chloride as a hazardous constituent of waste under the Resource Conservation and Recovery Act (RCRA). Under the Safe Drinking Water Act (SDWA), EPA established a maximum contaminant level (MCL) of 0.002 mg/L for vinyl chloride. Under the Superfund Amendments and Reauthorization Act (SARA) of 1986, EPA sets forth specific requirements for the submission of information relating to the release of vinyl chloride from covered facilities.

FDA, which also set the allowable level for the chemical at 0.002 mg/L in bottled water, regulates vinyl chloride monomer and polymers as food additives. Vinyl chloride as an ingredient in aerosol drug products has been determined to be a new drug; however, any cosmetic aerosol product containing vinyl chloride has been deemed to be adulterated by FDA.

NIOSH recommends occupational exposure to vinyl chloride be limited to the lowest feasible concentration. OSHA has adopted a permissible exposure limit (PEL) of 1 ppm for vinyl chloride as an 8-hr time-weighted average (TWA), with a 5-ppm ceiling for any 15-minute period. OSHA requires medical surveillance, training for workers, use of protective clothing and respirators, warning signs, product labeling, and periodic monitoring for vinyl chloride in the workplace. OSHA, in addition, regulates vinyl chloride under the Hazard Communication Standard and as a chemical hazard in laboratories. Regulations are summarized in Volume II, Table 186.

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