Vinyl Chloride

75-01-4

Hazard Summary

Most vinyl chloride is used to make polyvinyl chloride (PVC) plastic and vinyl products. Acute (short-term) exposure to high levels of vinyl chloride in air has resulted in central nervous system (CNS) effects, such as dizziness, drowsiness, and headaches in humans. Chronic (long-term) exposure to vinyl chloride through inhalation and oral exposure in humans has resulted in CNS effects and liver damage. Animal studies have reported effects on the liver, kidney, and CNS from chronic exposure to vinyl chloride. Vinyl chloride exposure, via inhalation, has been shown to increase the risk of a rare form of liver cancer, angiosarcoma of the liver, in humans. EPA has concluded that vinyl chloride is carcinogenic to humans by the inhalation and oral routes of exposure, and highly likely to be carcinogenic by the dermal route of exposure.

Please Note: The main sources of information for this fact sheet are the U.S. Environmental Protection Agency's (EPA's) Integrated Risk Information System and the Agency for Toxic Substances and Disease Registry's (ATSDR's) Toxicological Profile for Vinyl Chloride. (1,2)

Uses

- Most of the vinyl chloride produced is used to make polyvinyl chloride (PVC), a material widely used in automotive parts, packaging products, pipes, construction materials, furniture, and a variety of other products. (2)
- Smaller amounts of vinyl chloride are used as a chemical intermediate and a solvent. (2,4)

Sources and Potential Exposure

- Ambient air concentrations of vinyl chloride are generally quite low, with exposure occurring from the discharge of exhaust gases from factories that manufacture or process vinyl chloride, or evaporation from areas where chemical wastes are stored. (2,3)
- Vinyl chloride may enter finished drinking water from the flow of water through older PVC piping made before 1977, but a more recent study suggests that the extraction of vinyl chloride may diminish over time. Since 1977, product standards (NSF/ANSI 14 and 61) have controlled the release of vinyl chloride from PVC pipes. (5,6)
- Occupational exposure to vinyl chloride may occur in those workers concerned with the production, use, transport, storage, and disposal of the chemical. (2,3)
- Vinyl chloride has been detected in tobacco smoke. (2)

Assessing Personal Exposure

• Vinyl chloride can be measured in urine, body tissue, and exhaled air but the tests are not reliable indicators of total exposure. (2)

Health Hazard Information

Acute Effects:

- Acute exposure of humans to high levels of vinyl chloride via inhalation has resulted in effects on the CNS, such as dizziness, drowsiness, headaches, and giddiness. (2,3)
- Acute exposure to high levels of vinyl chloride in animals has resulted in effects on the CNS, liver, kidney, and lungs. (2)
- Tests involving acute exposure of mice have shown vinyl chloride to have high acute toxicity from inhalation exposure. (2,3)

Chronic Effects (Noncancer):

- Liver damage may result in humans from chronic exposure to vinyl chloride through both inhalation and oral exposure. (2,3)
- A small percentage of individuals occupationally exposed to high levels of vinyl chloride in air have developed a set of symptoms termed "vinyl chloride disease," which is characterized by Raynaud's phenomenon (fingers blanch and numbness and discomfort are experienced upon exposure to the cold), changes in the bones at the end of the fingers, joint and muscle pain, and scleroderma-like skin changes (thickening of the skin, decreased elasticity, and slight edema). (2,3)
- CNS effects (including dizziness, drowsiness, fatigue, headache, visual and/or hearing disturbances, memory loss, and sleep disturbances) as well as peripheral nervous system symptoms (peripheral neuropathy, tingling, numbness, weakness, and pain in fingers) have also been reported in workers exposed to vinyl chloride. (2)
- Animal studies have reported effects on the liver, kidney, and CNS from chronic exposure to vinyl chloride. (2,3)
- EPA has established a Reference Concentration (RfC) of 0.1 milligrams per cubic meter (0.1 mg/m³) based on effects on the liver in rats. The RfC is an estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation to the human population (including sensitive subgroups) that is likely to be without appreciable risk of deleterious noncancer effects during a lifetime. It is not an estimator of risk but rather a reference point to gauge the potential for effects. At exposures increasingly greater than the RfC, the potential for adverse health effects increases.

Lifetime exposure above the RfC does not imply that an adverse effect would necessarily occur. (1)

• EPA has established a Reference Dose (RfD) for vinyl chloride is 0.003 milligrams per kilogram body weight per day (mg/kg/d) based on liver toxicity in rats. (1)

Reproductive/Developmental Effects:

- Several epidemiological studies have reported an association between vinyl chloride exposure in pregnant women and an increased incidence of birth defects; however, other studies have not supported these findings. (2,3)
- Several case reports involving worker exposures suggest that male sexual performance may be affected by vinyl chloride; however, these reports are limited by possible co-exposure to other chemicals and lack of exposure estimates. (2)
- Testicular damage and decreased male fertility have been reported in rats exposed to vinyl chloride. (2)
- Animal studies have reported decreased fetal weight and birth defects in the offspring of rats exposed to vinyl chloride through inhalation at levels that are also toxic to maternal animals. (2)

Cancer Risk:

- Inhaled vinyl chloride has been shown to increase the risk of a rare form of liver cancer (angiosarcoma of the liver) in humans. (1,2,3)
- Animal studies have shown that vinyl chloride, via inhalation, increases the incidence of angiosarcoma of the liver and cancer of the liver. (1,2,3)
- Several rat studies show a pronounced early-life susceptibility to the carcinogenic effect of vinyl chloride, i.e., early exposures are associated with higher liver cancer incidence than similar or much longer exposures that occur after maturity. (2)
- EPA has classified vinyl chloride as a known human carcinogen by the inhalation route of exposure. (1)
- EPA uses mathematical models, based on animal studies, to estimate the probability of a person developing cancer from breathing air containing a specified concentration of a chemical. EPA has calculated inhalation unit risk estimates of $4.4 \times 10^{-6} (\mu g/m^3)^{-1}$ for exposure to vinyl chloride during adulthood and $8.8 \times 10^{-6} (\mu g/m^3)^{-1}$ for lifetime exposure. EPA estimates that, if an individual were to continuously breathe air containing vinyl chloride at an average of $0.11 \text{ ug/m}^3 (1.1 \times 10^{-4} \text{ mg/m}^3)$ over his or her entire lifetime, that person would theoretically have no more than a one-in-a-million increased chance of developing cancer as a direct result of breathing air containing $1.1 \mu g/m^3 (1.1 \times 10^{-3} \text{ mg/m}^3)$ would result in not greater than a one-in-a-hundred thousand increased chance of developing cancer, and air containing $11 \mu g/m^3 (1.1 \times 10^{-2} \text{ mg/m}^3)$ would result in not greater than a one-in-a-hundred thousand increased chance of developing cancer, and air containing $1.1 \mu g/m^3 (1.1 \times 10^{-2} \text{ mg/m}^3)$ would result in not greater than a one-in-gillion increased chance of developing cancer. For a detailed discussion of confidence in the potency estimates, please see IRIS. (1)

• EPA has calculated an oral cancer slope factor of 7.2 x 10⁻¹(mg/kg-day) for oral exposure to vinyl chloride during adulthood and an oral cancer slope factor of 1.4 (mg/kg-day) for lifetime exposure. (1)

Physical Properties

- Vinyl chloride is a colorless, flammable gas with a mild, sweet odor. (4)
- The odor threshold for vinyl chloride ranges from 260 ppm to 4,000 ppm. (4)
- The chemical formula for vinyl chloride is C₂H₃Cl and the molecular weight is 62.5 g/mol.
 (4)
- The vapor pressure for vinyl chloride is 2,600 mm Hg at 25 °C, and it has a log octanol/water partition coefficient (log K_{ow}) of 1.36. (2)

Conversion Factors:

To convert concentrations in air (at 25 °C) from ppm to mg/m^3 : $mg/m^3 = (ppm) \times (molecular weight of the compound)/(24.45)$. For vinyl chloride: 1 ppm = 2.6 mg/m^3 .



Health Data from Inhalation Exposure

ACGIH TLV--American Conference of Governmental and Industrial Hygienists' threshold limit value expressed as a time-weighted average; the concentration of a substance to which most workers can be exposed without adverse effects.

AIHA ERPG - American Industrial Hygiene Association's emergency response planning guidelines. ERPG 1 is the maximum airborne concentration below which it is believed nearly all individuals could be exposed up to one hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined objectionable odor; ERPG 2 is the maximum airborne concentration below which it is believed nearly all individuals could be exposed up to one hour without experiencing irreversible or other serious health effects that could impair their abilities to take protective action.

ATSDR MRL – An inhalation MRL is an estimate of the amount of a chemical a person can breathe each day without a detectable risk to health. MRLs are developed for health effects other than cancer. MRLs can be calculated for 3 different time periods of exposure to the chemical: acute (about 1 to 14 days), intermediate (from 15-364 days), and chronic (exposure for more than 364 days).

CalEPA Acute REL – California EPA Office of Environmental and Human Health Assessment (OEHHA) acute reference exposure level is the concentration at or below which no adverse health effects are anticipated for a specified exposure duration.

OSHA PEL--Occupational Safety and Health Administration's permissible exposure limit expressed as a time-weighted average: the concentration of a substance to which most workers can be exposed without adverse effect averaged over a normal 8-h workday or a 40-h workweek.

OSHA PEL Ceiling -- Occupational Safety and Health Administration's permissible exposure limit expressed as a short-term exposure limit that should not be exceeded in a 15-minute time period.

RBC—Risk-based concentration.

- ^a Toxicity, Health, and Risk numbers are toxicological values from animal testing or risk assessment values developed by EPA.
- ^b Regulatory numbers are values that have been incorporated in Government regulations, while advisory numbers are nonregulatory values provided by the Government or other groups as advice. OSHA numbers are regulatory, whereas ACGIH, NIOSH, and AIHA numbers are advisory.

Summary updated in March 2020

References

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