ACETALDEHYDE
CAS No. 75-07-0
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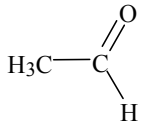

CARCINOGENICITY

Acetaldehyde is *reasonably anticipated to be a human carcinogen* based on sufficient evidence of carcinogenicity in experimental animals (IARC 1985, 1987, 1999). When administered by inhalation, acetaldehyde increased the incidence of squamous cell carcinomas and adenocarcinomas in the nasal mucosa in rats of both sexes and laryngeal carcinomas in hamsters of both sexes. In another inhalation study using a lower exposure level and in an intratracheal instillation study, no increased incidence of tumors in hamsters was observed. When administered by inhalation, acetaldehyde enhanced the incidence of respiratory tract tumors as induced by intratracheal instillation of benzo[*a*]pyrene in hamsters of both sexes.

There is inadequate evidence for the carcinogenicity of acetaldehyde in humans (IARC 1985, 1987, 1999). A single study of workers in an aldehyde plant reported nine cases of cancer, including five cases of bronchial tumors and two cases of carcinomas of the oral cavity. This study was considered to be inadequate for evaluation because of mixed exposure, the small number of cases, and the poorly defined population. Three case control studies investigated the risk of oral, throat, and esophageal cancers following heavy alcohol intake. These studies consistently showed an increased risk of these cancers in people with genetic polymorphisms; these polymorphisms resulted in higher blood acetaldehyde concentrations after drinking alcohol (IARC 1999).

PROPERTIES

Acetaldehyde occurs as a volatile, flammable, colorless liquid. It has a pungent, suffocating odor, but at dilute concentrations it emits a pleasant, fruity odor. The vapor pressure of acetaldehyde is 755 mm Hg at 200°C and the vapor density is 1.5. It has a melting point of -123.5°C, and it boils at 20.2 to 20.8°C with a flash point of -38°C (closed cup). It decomposes above 400°C to form principally methane and carbon monoxide. Acetaldehyde is miscible in water, alcohol, ether, benzene, gasoline, solvent naphtha, toluene, xylene, turpentine, acetone, and other common organic solvents. It is a highly reactive compound that undergoes numerous condensation, addition, and polymerization reactions. Acetaldehyde is dangerous when exposed to heat or flame; it can react vigorously with oxidizing material. Acetaldehyde is also incompatible with acids, bases, alcohol, ammonia, amines, phenols, ketones, and hydrogen cyanide. It oxidizes readily to form corrosive acetic acid. It will polymerize readily in the presence of trace metals (iron). Acetaldehyde can form unstable/explosive peroxides with exposure to air. It may polymerize under influence of air and heat, acids, or bases with potential of fire or explosion. Acetaldehyde is polymerized violently by concentrated sulfuric acid. Rubber products decompose on contact with acetaldehyde, but it is not corrosive to most metals (IARC 1999).

USE

Acetaldehyde is used primarily as a chemical intermediate, principally for the production of acetic acid, pyridine and pyridine bases, peracetic acid, pentaerythritol, butylene glycol, and chloral. It is used in the production of esters, particularly ethyl acetate and isobutyl acetate (IARC 1985, 1999, Chem. Prod. 1985). It is also used in the synthesis of crotonaldehyde, as well as flavor and fragrance acetals, acetaldehyde 1,1-dimethylhydrazone, acetaldehyde cyanohydrin, acetaldehyde oxime, and various acetic esters, paraldehyde, metaldehyde (a molluscicide widely used to kill slugs and snails), polymers, and various halogenated derivatives (IARC 1985). Acetaldehyde has been used in the manufacture of aniline dyes and synthetic rubber, to silver mirrors, and to harden gelatin fibers (Merck 1989). It has been used in the production of polyvinyl acetal resins, in fuel compositions, and to inhibit mold growth on leather (IARC 1985). Acetaldehyde is also used in the manufacture of disinfectants, drugs, perfumes, explosives, lacquers and varnishes, photographic chemicals, phenolic and urea resins, rubber accelerators and antioxidants, and room air deodorizers; acetaldehyde is a pesticide intermediate (Sittig 1985, Gosselin *et al.* 1984).

Acetaldehyde, an alcohol denaturant, is a GRAS (generally recognized as safe) compound for the intended use as a flavoring agent and adjuvant (Furia and Bellanca 1975, HSDB 2000). It is an important component of food flavorings and is added to milk products, baked goods, fruit juices, candy, desserts, and soft drinks; the concentration of acetaldehyde in food is generally up to 0.047%. In 1976, approximately 19,000 lb of acetaldehyde were used as food additives. It is an especially useful synthetic flavoring ingredient to impart orange, apple, and butter flavors. It is used in the manufacture of vinegar and yeast and as a fruit and fish preservative. Acetaldehyde is approved for use in phenolic resins in molded containers for contact with nonacidic foods. Acetaldehyde is exempted from a residue tolerance when it is used as a fumigant for storage of apples and strawberries (IARC 1985).

PRODUCTION

Acetaldehyde was first produced commercially in the United States in 1916. Production in 1940 was 127 million lb and 816 million lb in 1960. U.S. production of acetaldehyde reached its peak in 1969 at approximately 1.65 billion lb (IARC 1985). U.S. production reportedly decreased to 740 million lb in 1989 (EPA 1994). The overall decline in the demand for acetaldehyde has been attributed to more economical starting materials for principal derivatives and a lower demand for some acetal derivatives (Chem. Prod. 1985). USITC has reported two to three manufacturers for each year from 1985 to 1994; production figures, however, were not made available (USITC 1986-1991, 1993-1995). The 1997 *Directory of Chemical Producers* listed one producer for acetaldehyde and two producers for natural acetaldehyde; no production volumes were disclosed (SRI 1997). The 1998 *Chemical Buyers Directory* named six U.S. suppliers of acetaldehyde and two suppliers for natural acetaldehyde (Tilton 1997). *Chemcyclopedia 98* named five such companies (Rodnan 1997). In 2001, Chem Sources (2001) listed 23 suppliers for acetaldehyde.

U.S. imports of acetaldehyde totaled 1,350 lb in 1985 (HSDB 2000). Imports for 1987 were reported to be 10,000 lb (USDOC Imports 1988). In 2000, imports increased to 120 million lb (ITA 2001). In 1985, estimated U.S. exports of acetaldehyde were 1.2 billion lb (Chemical Prod. 1985). Exports for 2000 decreased to 20 million lb (ITA 2001).

EXPOSURE

The potential for exposure of the general population and workers to acetaldehyde is great. Acetaldehyde is the product of most hydrocarbon oxidation reactions and is a normal intermediate in the respiration of most higher plants; it is found in trace amounts in all ripe fruits and may form in wine and other alcoholic beverages after exposure to air. It is a major metabolite of ethyl alcohol (Kirk-Othmer 1978). It is found in leaf tobacco and in tobacco smoke and in automobile and diesel exhaust. Therefore, many individuals are exposed to acetaldehyde by breathing ambient air.

Acetaldehyde has a widespread natural occurrence. It is a product of alcohol fermentation and is a metabolic intermediate in higher plants. It is a volatile component of cotton leaves and blossoms. Acetaldehyde occurs in oak and tobacco leaves and is a natural component of apples, broccoli, coffee, grapefruit, grapes, lemons, mushrooms, onions, oranges, peaches, pears, pineapples, raspberries, and strawberries. It has been detected in the essential oils of alfalfa, rosemary, balm, clary sage, daffodil, bitter orange, camphor, angelica, fennel, mustard, and peppermint (IARC 1985). Consumers may be exposed to acetaldehyde in cheese, heated milk, cooked beef, cooked chicken, and rum. It is a synthetic flavoring ingredient in processed foods, especially margarine. Acetaldehyde is also tolerated as a fumigant residue on apples and strawberries after storage. It has been detected in mother's milk. Consumers may have been exposed to acetaldehyde in room air deodorizers (Gosselin *et a*l. 1984, DPIM 1989). Acetaldehyde is a component of smoke of marijuana cigarettes (1,220 µg/cigarette) and tobacco cigarettes (980 µg/cigarette to 1.37 mg/cigarette). In addition to potential exposure from food and cigarette sources, consumers risk exposure in the home environment from pyrolysis products. Burning wood produces approximately 0.7 g acetaldehyde/kg wood; fireplace emissions range from 0.083 to 0.20 g/kg wood burned. An estimated total annual emission from residential burning in the United States is approximately 99 million lb. It is a combustion product of some plastics (e.g., polycarbonate) and some hard and soft polyurethane foams. Acetaldehyde also occurs in gasoline exhaust (1.4 to 8.8 mg/m^3) and diesel exhaust (0.05 to 6.4 mg/m^3) (IARC 1985).

Acetaldehyde has been detected in emissions from power plants that burn fossil fuels, wood, or trash. It is a natural product of combustion and photooxidation of hydrocarbons commonly found in the atmosphere. It naturally occurs as emissions from forest fires, volcanoes, and animal wastes (HSDB 2000).

The 1974 National Occupational Hazard Survey estimated that 1,700 workers were exposed to acetaldehyde in the United States in four nonagricultural industries (NIOSH 1980, 1981, IARC 1985). The greatest potential for exposure was found in the organic chemicals industry, with some exposure in fabricated rubber products and biological products industries (IARC 1985). The National Occupational Exposure Survey (1981-1983) estimated that 14,054 total workers, including 2,772 female workers, were exposed to acetaldehyde (NIOSH 1984). The estimate was based on observation of actual use of acetaldehyde (97%) and its use as an ingredient in trade name products (3%). Potential exposure exists for personnel involved in the manufacturing or use of industrial organic chemicals, dyes, fabricated rubber, plastics, urea-formaldehyde foam insulation, fuels, drugs, explosives, lacquers and varnishes, photographic chemicals, pesticides, food additives, leather goods, and mirrors. Acetaldehyde is a potential exposure problem for automobile and diesel mechanics, gas station attendants, and agricultural and food industry personnel, as well as personnel in coffee-roasting operations, lithographic coatings, automobile spray operations, and fat-rendering plants (IARC 1985).

The use of acetaldehyde is widespread in industry, and it may be released into waste water or the air during production, use, transport, and storage (Kirk-Othmer 1978, HSDB 2000). EPA's Toxic Chemical Release Inventory (TRI) estimated that 12,938,427 lb of acetaldehyde were released to the environment from 283 facilities that processed, produced, or used the chemical in the United States in 1998. Of that total, 92.3% was emitted to air. Thirty-three facilities, each emitting >100,000 lb, represented 39.9% of this release. Total releases to water, land, and underground injection were 1.8%, 0.1%, and 5.8%, respectively (TRI99 2001). Acetaldehyde will rapidly volatilize from water or land, and it will leach into the ground where it will biodegrade (HSDB 2000). Acetaldehyde has been detected in 5/10 surveyed water supplies (Sittig 1985). Acetaldehyde is degraded by aerobic and anaerobic microorganisms; it degrades readily in soil, sewage, and natural waters (EPA 1987). In water, concentrations are generally less than 0.1 μg/L; therefore, contribution from drinking water was considered negligible (IPCS 1995).

The main source of human exposure to acetaldehyde is through the metabolism of alcohol. Other sources include food and other beverages, and to a lesser extent, the air (IPCS 1995). Principal human exposure occurs with inhalation of ambient air from urban areas or near sources of combustion (HSDB 2000). Total U.S. acetaldehyde airborne emissions from all sources in 1978 were estimated to be approximately 114 million lb, 86% of which was thought to be from residential wood burning (IARC 1985). The current annual emission from all sources was estimated to be 27 million lb. In ambient air, concentrations of acetaldehyde generally average 5 $\mu g/m^3$ (IPCS 1995).

REGULATIONS

EPA regulates acetaldehyde under the Clean Air Act (CAA), Clean Water Act (CWA), Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Resource Conservation and Recovery Act (RCRA), Superfund Amendments and Reauthorization Act (SARA), and Toxic Substances Control Act (TSCA). EPA has established water quality criteria, effluent guidelines, rules for regulating hazardous spills, general threshold amounts, and requirements for the handling and disposal of acetaldehyde wastes. A reportable quantity (RQ) of 1,000 lb has been established for acetaldehyde under CWA and CERCLA. The compound is regulated as a hazardous constituent of waste under RCRA.

FDA regulates acetaldehyde as a synthetic flavoring substance for food.

ACGIH recommends a ceiling concentration of 25 ppm (45 mg/m^3). NIOSH recommends that occupational exposure to acetaldehyde be limited to the lowest feasible concentration. OSHA set the permissible exposure limit (PEL) to 200 ppm (360 mg/m^3) as the 8-hr time-weighted average (TWA). Acetaldehyde is regulated by OSHA under the Hazard Communication Standard and as a chemical hazard in laboratories. Regulations are summarized in Volume II, Table 1.

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