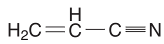
Acrylonitrile

CAS No. 107-13-1

Reasonably anticipated to be a human carcinogen

First listed in the *Second Annual Report on Carcinogens* (1981)



Carcinogenicity

Acrylonitrile is *reasonably anticipated to be a human carcinogen* based on sufficient evidence of carcinogenicity from studies in experimental animals.

Cancer Studies in Experimental Animals

Acrylonitrile caused tumors at several different tissue sites in rats. Exposure to acrylonitrile in drinking water or by inhalation caused cancer of the central nervous system (microglioma or glioma) and Zymbal gland (carcinoma) and benign tumors of the forestomach (squamous-cell papilloma or acanthoma) in both sexes (IARC 1979).

Since acrylonitrile was listed in the *Second Annual Report on Carcinogens,* additional studies in rodents have been identified. Oral exposure to acrylonitrile caused cancer of the forestomach (squamous-cell carcinoma) and increased the combined incidence of benign and malignant Harderian-gland tumors (adenoma and carcinoma) in mice of both sexes. Benign and malignant tumors of the ovary (granulosa-cell tumors) and lung (alveolar/bronchiolar adenoma and carcinoma) in female mice also may have been related to acrylonitrile exposure (NTP 2001). In rats, prenatal exposure followed by postnatal inhalation exposure to acrylonitrile caused brain tumors (glial-cell tumors) in both sexes. In females, it also caused cancer of the mammary gland and the blood vessels (angiosarcoma); in males, it caused cancer of the Zymbal gland and increased the combined incidence of benign and malignant liver tumors (hepatocellular adenoma and carcinoma) (IARC 1999).

Cancer Studies in Humans

The data available from epidemiological studies are inadequate to evaluate the relationship between human cancer and exposure specifically to acrylonitrile. An increased risk of cancer of the lung and colon was reported in U.S. textile plant workers exposed to acrylonitrile and observed for 20 years or more (IARC 1979).

Since acrylonitrile was listed in the *Second Annual Report on Carcinogens,* additional epidemiological studies have been identified. In studies of workers exposed to acrylonitrile (including textile workers and rubber workers) published in the 1980s and 1990s, including several meta-analyses, the risk of cancer was increased only for lung cancer among workers with the highest cumulative exposure levels in a large National Cancer Institute cohort study (IARC 1999). An update of a U.S. textile-worker cohort followed for five decades found no association betweeen acrylonitrile exposure and cancer at any tissue site (Symons *et al.* 2008). A large international case-control study of lung cancer found a significant smoking-adjusted risk of lung cancer with increasing acrylonitrile exposure (Scélo *et al.* 2004), and a meta-analysis of lung-cancer findings found increased risk with acrylonitrile exposure after adjusting for a healthy-worker effect (Sponsiello-Wang *et al.* 2006). A small cohort study (Czeizel *et al.* 2004) found no excesses of lung or other cancer among workers possibly exposed to acrylonitrile; however, the study's statistical power to detect effects was limited. In an update of a cohort study in the Netherlands, excesses of brain cancer were found in some exposure categories (Swaen *et al.* 2004).

Properties

Acrylonitrile exists at room temperature as a volatile, flammable colorless liquid with a sweet characteristic odor. It is soluble in water and isopropyl alcohol and miscible with ethanol, carbon tetrachloride, ethyl acetate, ethylene cyanohydrin, xylene, toluene, petroleum ether, and liquid carbon dioxide. Acrylonitrile is stable under normal shipping and handling conditions but may undergo explosive polymerization if not inhibited (Akron 2009). Physical and chemical properties of acrylonitrile are listed in the following table.

Property	Information
Molecular weight	53.1
Specific gravity	0.8004 at 25°C/4°C
Melting point	–82°C
Boiling point	77.3°C at 760 mm Hg
Log K_{ow}	0.25
Water solubility	74.5 g/L at 25°C
Vapor pressure	109 mm Hg at 25°C
Vapor density relative to air	1.8

Source: HSDB 2009.

Use

Acrylonitrile is an important industrial chemical used extensively in the manufacture of synthetic fibers, resins, plastics, elastomers, and rubber for a variety of consumer goods, such as textiles, drinking cups, automotive parts, and appliances (Brazdil 2010). It is also used as a monomer for acrylic and modacrylic fibers, in plastics, in surface coatings, as a chemical intermediate, in organic synthesis, in home furnishings, in nitrile rubbers, and as a modifier for natural polymers (HSDB 2009). Of total acrylonitrile production, reported uses were 38% for the production of adiponitrile, 22% for acrylonitrile-butadiene-styrene and styrene-acrylonitrile resins, 17% for acrylic fibers, 11% for acrylamide, 3% for nitrile elastomers, and 9% for miscellaneous uses, including polymers, polyols, barrier resins, and carbon fibers (CEN 2009). Acrylonitrile is used in the manufacture of carbon fibers used to reinforce composites for high-performance applications in the aircraft, defense, and aerospace industries. Other specialty applications include the production of fatty amines, ion-exchange resins, and fatty amine amides used in cosmetics, adhesives, corrosion inhibitors, and water-treatment resins (IARC 1999). Acrylonitrile was formerly used as a fumigant; however, almost all pesticide registrations for acrylonitrile were canceled in 1978 (ATSDR 1990).

Production

Acrylonitrile has been produced in the United States since 1940 (IARC 1979). In 2009, acrylonitrile was available from 16 U.S. suppliers (ChemSources 2009). In 2015, combined U.S. production and imports of acrylonitrile were in the range of 1 billion to 5 billion pounds (EPA 2016), similar to the production volumes of 2.2 billion to 3.4 billion pounds reported from 1985 through 2008 (IARC 1996, CEN 2009). U.S. exports of acrylonitrile have greatly decreased since the early 2000s, when they ranged from 1.5 billion to 3 billion pounds (USITC 2009), but have continued to substantially exceed imports (as shown in the following table).

Category	Year	Quantity (lb)
Production + imports[a]	2015	1 to 5 billion
U.S. imports[b]	2017	13.4 million
U.S. exports[b]	2017	717.7 million

Sources: [a]EPA 2016. [b]USITC 2018.

Exposure

The potential routes of human exposure to acrylonitrile are inhalation, ingestion, and dermal contact. Exposure is greater in occupational settings than in the general population. The general population may be exposed through the use of consumer products made with polymers of acrylonitrile, such as acrylic carpeting or polyacrylonitrile-resin-based food packaging. However, exposure from these sources is very low, because little of the monomer migrates from such products into air or food (ATSDR 1990). The U.S. Consumer Product Safety Commission in 1978 estimated concentrations of acrylonitrile as less than 1 ppm in acrylic and modacrylic fibers, 30 to 50 ppm in acetonitrile-butadiene-styrene copolymers, 15 ppm in styrene-acrylonitrile copolymers, and 0 to 750 ppm in nitrile rubber and latex goods (as cited in IPCS 1983). Foods most likely to contain measureable acrylonitrile are high-fat or highly acidic items, such as luncheon meat, peanut butter, margarine, vegetable oil, or fruit juice. In 1984, typical concentrations of acrylonitrile in margarine were reported to be 25 μg/kg (ATSDR 1990). However, the U.S. Food and Drug Administration's Total Diet Study found no acrylonitrile residue in any of the foods tested from 1991 to 2004 (FDA 2006).

Acrylonitrile has been measured in the vapor phase of mainstream tobacco smoke at a concentration of 18.5 μg per cigarette (Laugesen and Fowles 2005). Indoor air concentrations of acrylonitrile in the residences of smokers (to which nonsmokers were exposed) were estimated at 0.5 to 1.2 $μg/m^3$ (Nazaroff and Singer 2004). Acrylonitrile-hemoglobin adducts are a reliable marker of smoking behavior and correlate with the number of cigarettes smoked per day (Bergmark 1997, Fennell *et al.* 2000). The adducts may also be present in infants born to mothers who smoke (Tavares *et al.* 1996, Schettgen *et al.* 2004).

According to the U.S. Environmental Protection Agency's Toxics Release Inventory, the volume of environmental releases of acrylonitrile has remained high since 2001, when 11.5 million pounds was released, and most releases since 2000 have been to underground injection wells. In 2007, 94 facilities released a total of about 7 million pounds of acrylonitrile, most of which (6.6 million pounds) was released by two facilities to on-site hazardous waste underground injection wells (TRI 2009).

Occupational exposure to acrylonitrile may occur during its manufacture and production and in factories where it is used as a monomer; exposure levels are highest where acrylonitrile is manufactured. Typical workplace air concentrations were reported to range from 0.1 to 4 mg/m^3 (ATSDR 1990). The National Occupational Exposure Survey (conducted from 1981 to 1983) estimated that 51,153 workers, including 25,320 women, potentially were exposed to acrylonitrile. Occupations with potential for exposure included acrylic resin, rubber, synthetic fiber, and textile maker; synthetic organic chemist; and pesticide worker (NIOSH 1990).

Regulations

Coast Guard (Dept. of Homeland Security)

Minimum requirements have been established for safe transport of acrylonitrile on ships and barges.

Department of Transportation (DOT)

Acrylonitrile 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

National Emission Standards for Hazardous Air Pollutants: Listed as a hazardous air pollutant.
New Source Performance Standards: Manufacture of acrylonitrile is subject to certain provisions for the control of volatile organic compound emissions.
Prevention of Accidental Release: Threshold quantity (TQ) = 20,000 lb.
Urban Air Toxics Strategy: Identified as one of 33 hazardous air pollutants that present the greatest threat to public health in urban areas.

Clean Water Act

Designated a hazardous substance.
Effluent Guidelines: Listed as a toxic pollutant.
Water Quality Criteria: Based on fish or shellfish and water consumption = 0.061 μg/L; based on fish or shellfish consumption only = 7.0 μg/L.

Comprehensive Environmental Response, Compensation, and Liability Act

Reportable quantity (RQ) = 100 lb.

Emergency Planning and Community Right-To-Know Act

Toxics Release Inventory: Listed substance subject to reporting requirements.
Reportable quantity (RQ) = 100 lb.
Threshold planning quantity (TPQ) = 10,000 lb.

Resource Conservation and Recovery Act

Listed Hazardous Waste: Waste codes for which the listing is based wholly or partly on the presence of acrylonitrile = U009, K011, K013.
Listed as a hazardous constituent of waste.

Food and Drug Administration (FDA, an HHS agency)

Acrylonitrile copolymers and resins may be used in materials that are intended for use in producing, manufacturing, processing, preparing, treating, packaging, transporting, or holding food, as prescribed in 21 CFR parts 173, 175, 176, 177, 178, 179, 180, 181.

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

While this section accurately identifies OSHA's legally enforceable PELs for this substance in 2018, specific PELs may not reflect the more current studies and may not adequately protect workers.
Ceiling concentration = 10 ppm (15-min exposure).
Permissible exposure limit (PEL) = 2 ppm.
Potential for dermal absorption.
Comprehensive standards for occupational exposure to acrylonitrile have been developed.

Guidelines

American Conference of Governmental Industrial Hygienists (ACGIH)

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

National Institute for Occupational Safety and Health (NIOSH, CDC, HHS)

Ceiling recommended exposure limit = 10 ppm (15-min exposure).
Recommended exposure limit (time-weighted-average workday) = 1 ppm.
Immediately dangerous to life and health (IDLH) limit = 60 ppm.
Potential for dermal absorption.
Listed as a potential occupational carcinogen.

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