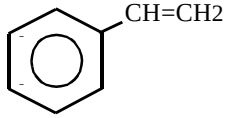
STYRENE

Styrene is a federal hazardous air pollutant and was identified as a toxic air contaminant in April 1993 under AB 2728.

CAS Registry Number: 100-42-5

Molecular Formula: C_8H_8



Styrene is a colorless to yellowish, refractive, oily liquid with an aromatic odor. It is insoluble in water and soluble in alcohol, ether, methanol, acetone, and carbon disulfide. Styrene readily undergoes polymerization when heated or exposed to light or as a peroxide catalyst. This polymerization releases heat and may become explosive (Sax, 1987).

Physical Properties of Styrene

Synonyms: vinylbenzene; phenylethylene; cinnamene; ethenylbenzene; styrol; styrolene; cinnamol; vinylbenzol

Molecular Weight:	104.16
Boiling Point:	145-146 ^oC
Melting Point:	-30.63 ^oC
Flash Point:	31 ^oC (closed cup)
Vapor Density:	3.6 (air = 1)
Density/Specific Gravity:	0.9074 at 20/4 ^oC (water = 1)
Vapor Pressure:	6.6 mm Hg at 25 ^oC (extrapolated)
Log Octanol/Water Partition Coefficient:	2.95
Conversion Factor:	1 ppm = 4.26 mg/m^3

(Howard, 1990; Merck, 1989; Sax, 1987; Sax, 1989)

SOURCES AND EMISSIONS

A. Sources

Styrene is used in polymer manufacturing. It has also been detected in oxy-acetylene flames, cigarette smoke, gases emitted by pyrolysis of brake linings, and stack emissions from waste incineration (Howard, 1990).

The primary stationary sources that have reported emissions of styrene in California are plastics manufacturers, manufacturers of synthetics, and ship and boat building and repairing

(ARB, 1997b). Styrene has also been detected but not quantified in motor vehicle exhaust by the Air Resources Board (ARB) (ARB, 1995e).

B. Emissions

The total emissions of styrene and styrene oxide from stationary sources in California are estimated to be at least 2.5 million pounds per year, based on data reported under the Air Toxics "Hot Spots" Program (AB 2588) (ARB, 1997b).

C. Natural Occurrence

Steele et al. (1994) found styrene to be present in 8 of 12 common agricultural commodities. The samples were collected in a manner that avoided contact with styrene or any type of plastic. The results indicate that styrene may be a natural component of many foods.

AMBIENT CONCENTRATIONS

Styrene is routinely monitored at the statewide ARB air toxics network. The network's mean concentration of styrene from January 1996 through December 1996 is estimated to be 0.30 micrograms per cubic meter ($\mu g/m^3$) or 0.07 parts per billion (ppb) (ARB, 1997c).

The United States Environmental Protection Agency (U.S. EPA) has also compiled ambient concentration data from three study areas throughout the United States from 1989-91. Information from this data reported an overall mean concentration of 0.55 $\mu g/m^3$ (0.13 ppb) (U.S. EPA, 1993a).

INDOOR SOURCES AND CONCENTRATIONS

Styrene is ubiquitous in indoor air samples. The major indoor sources include carpets, office machines, and environmental tobacco smoke (Hodgson et al., 1992; Hetes et al., 1995; Daisy et al., 1994).

Styrene concentrations in public buildings have been obtained from studies conducted outside of California. Results indicate that the range of styrene concentrations in public buildings is similar to, yet slightly higher than, the residential range. Limited data obtained from public buildings and offices indicate that typical styrene levels in such buildings may range from 1.24 to 3.8 $\mu g/m^3$ or 0.29 to 0.89 ppb (U.S. EPA, 1988).

Surveys measuring residential styrene concentrations have been conducted in three communities in California (Los Angeles, Contra Costa County, and Woodland) during the winter and summer of 1984, 1987, and 1990. The 24-hour median styrene concentrations ranged from 0.72 to 2.14 $\mu g/m^3$ or 0.17 to 0.60 ppb.

Personal air sampling was also conducted in the California studies. A sampler accompanied individuals during the entire monitoring period to measure the indoor and outdoor exposure while at home, work or school, and while traveling. Median 24-hour personal air concentrations of styrene ranged from 0.77 to 2.55 $\mu g/m^3$ or 0.18 to 0.60 ppb (Pellizzari et al., 1987b, 1989; Sheldon et al., 1988a, 1988b, 1991).

ATMOSPHERIC PERSISTENCE

Styrene exists in the atmosphere in the gas phase. The dominant atmospheric loss processes for styrene are by reaction with the hydroxyl (OH) radical, reaction with the NO_3 radical, and reaction with ozone (O_3) (Atkinson, 1994; Tuazon et al., 1993). The atmospheric half-life and lifetime of styrene due to reaction with the OH radical are estimated to be 4 hours and 6 hours, respectively. The atmospheric half-life and lifetime of styrene due to reaction with O_3 is estimated to be 16 hours and 23 hours, respectively. The OH radical reaction is therefore expected to be dominant during daylight hours. The products of the OH radical and O_3 reactions are formaldehyde and benzaldehyde (Tuazon et al., 1993).

AB 2588 RISK ASSESSMENT INFORMATION

The Office of Environmental Health Hazard Assessment reviews risk assessments submitted under the Air Toxics "Hot Spots" Program (AB 2588). Of the risk assessments reviewed as of April 1996, styrene was the major contributor to the overall cancer risk, based on a unit risk value that has been withdrawn, in 19 of the approximately 550 risk assessments reporting a total cancer risk equal to or greater than 1 in 1 million, and contributed to the total cancer risk in 38 of these risk assessments. Styrene also was the major contributor to the overall cancer risk in 2 of the approximately 130 risk assessments reporting a total cancer risk equal to or greater than 10 in 1 million, and contributed to the total cancer risk in 14 of these risk assessments (OEHHA, 1996a).

For non-cancer health effects, styrene contributed to the total hazard index in 9 of the approximately 89 risk assessments reporting a total chronic hazard index greater than 1. Styrene also contributed to the total hazard index in 2 of the approximately 107 risk assessments reporting a total acute hazard index greater than 1 (OEHHA, 1996b).

HEALTH EFFECTS

Possible routes of human exposure to styrene are inhalation, ingestion, and dermal contact.

Non-Cancer: Styrene vapors can cause irritation of the eyes, nose, throat, and lungs. Styrene is a central nervous system depressant. Central nervous system depressant effects include headache, fatigue, nausea, weakness, and dizziness (U.S. EPA, 1994a).

A non-cancer chronic Reference Exposure Level (REL) of 700 $\mu g/m^3$ is listed for styrene in the California Air Pollution Control Officers Association Air Toxics "Hot Spots" Program, Revised 1992 Risk Assessment Guidelines. The toxicological endpoints considered are the gastrointestinal tract and liver (CAPCOA, 1993). The U.S. EPA Reference Concentration (RfC) for styrene is 1000 $\mu g/m^3$ based upon neurotoxicity in occupationally exposed workers. The U.S. EPA estimates that inhalation of this concentration or less, over a lifetime, would not likely result in the occurrence of chronic, non-cancer effects. The oral reference dose (RfD) for styrene is 0.2 milligrams per kilogram per day based on red blood cell and liver effects in dogs. The U.S. EPA estimates that consumption of this dose or less, over a lifetime, would not likely result in the occurrence of chronic non-cancer effects (U.S. EPA, 1994a).

Cancer: When styrene is absorbed into the body, it is metabolized to styrene oxide. Styrene oxide is a direct-acting mutagen which causes cancer in test animals. In some studies, occupational exposure to styrene has been associated with chromosomal damage.

The U.S. EPA has not completed its cancer assessment for styrene (U.S. EPA, 1994a). On the basis of limited evidence in experimental animals and other supporting evidence, the International Agency for Research on Cancer classifies styrene in Group 2B: Possible human carcinogen (IARC, 1987a).