Styrene (vinyl benzene) is a colorless or yellowish liquid. Styrene is one of the most important organic chemicals. Styrene is an aromatic hydrocarbon.

**Usage**

Commercial styrene was first produced in the 1920s and 1930s. During World War II, styrene was important in the manufacture of synthetic rubber. Over 90% of styrene is produced by the dehydrogenation of ethylbenzene. Annual US production exceeds 11 billion lb, with production of styrene polymers exceeding 9 billion lb. NIOSH estimates that over 330,000 workers are potentially exposed to styrene.

The great reactivity of the double vinyl-bond makes styrene easy to polymerize and copolymerize, even at room temperature, but more rapidly at high temperatures: thanks to this feature, it is a commercially important chemical widely used in the manufacturing of synthetic rubber, resins, polyesters, and plastics [1].

It is used as a monomer or copolymer for polystyrenes, for acrylonitrile-butadiene-styrene (ABS) resins, styrene-butadiene rubber (SBR), styrene-butadiene copolymer latexes, and styrene-acrylonitrile (SAN) resins [2].

Styrene is commonly used in the manufacturing of polyester laminates, polymers, and copolymers in the yacht industry.

Considerable quantities of styrene are used in spraying and hand rolling styrene-modified polyester plastics with fiberglass reinforcement in the manufacture of boats, swimming pools, and containers of various size [3].

The highest exposure to styrene have been measured in occupational settings, especially in fabrication of reinforced plastic products [Bonanni].

**Routes of exposure:** inhalation, dermal, ingestion

Styrene may be absorbed via inhalation, ingestion, and transdermal routes of exposure. The main route of uptake is through the lungs. The uptake has been reported to be between 59% and 89%. Styrene is soluble in blood and is distributed to other tissues. Percutaneous absorption is not significant. Dermal absorption is
important when styrene comes into direct contact with skin. Increased solvent absorption can occur when solvent is trapped between wet clothing and skin. The ingestion of styrene in clinically significant amounts occurs very infrequently in the occupational setting.

**Metabolism**

Absorbed styrene is metabolized to styrene oxide. Styrene and styrene oxide are further metabolized hepatically as well as by kidney, intestines, lungs, and skin. Styrene oxide is metabolized to styrene glycol and subsequently to mandelic acid, phenylglyoxylic acid, and finally to hippuric acid. The major metabolite of styrene found in the urine is mandelic acid \[4\].

**Target organs:** CNS

**Health effects**

**Acute exposure**

The predominant effect of styrene is on the CNS. Styrene has an irritant effect on mucous membranes (eyes, nose, throat, airways) and skin.

The early signs of acute exposure consist of feelings of euphoria, and disinhibition. Acute high exposure may result in pre-narcotic symptoms such as dizziness, lightheadedness, impaired judgment, nausea and vomiting, incoordination, paresthesias, increased salivation, and tachycardia. These symptoms are mostly transitory, and resolve quickly once exposure ceases. High levels of exposure may cause coma or seizures and even death in severe cases.

**Chronic exposure**

Chronic neurotoxic effects have been reported with repeated exposure to relatively high levels.

Repeated exposure may result in the gradual development of persistent symptoms: headache, fatigue, irritability, memory impairment, depression, emotional instability, sleep disturbance, alcohol intolerance. Further exposure can lead to chronic toxic encephalopathy.

Electroencephalographic changes, performance test abnormalities, and slowing of peripheral nerve conduction velocities have been reported \[5\].

Long-term occupational exposure to environmental levels of styrene that are equal, or slightly above, the ACGIH limits can induce a clinical form of peripheral neuropathy and a subclinical impairment of color vision \[6\].
A study by Campagna, et al. showed that there is a positive relation between styrene exposure and early color and contrast vision dysfunction [7].

Bonanni RC et al determine that chronic exposure, particularly in low doses, has been associated with central and peripheral nervous system disorders, slow reaction time, mood disorders, and impairment in hearing’ olfactory, and color vision abilities. Dermatitis is more likely to appear with prolonged and repeated skin contact, as commonly occurs among workers who use solvents for cleaning and degreasing, or who wash their hands with solvents to remove glue, plastics, or other material from their skin [Xiao].

Contact allergy to styrene has been reported.

It is considered that styrene is an ototoxic chemical agent [8].

The study in rats showed that styrene is ototoxic: morphologic examination determined a corresponding loss of outer hair cells of the rat cochlear. In human studies the association between occupational exposure to solvents and hearing impairment has been suggested. Combined exposure to solvents and noise leads to a higher degree of hearing loss than could be expected from noise exposure alone [9].

A study in Poland evaluated styrene-related hearing loss in humans. This study provides the epidemiological evidence that occupational exposure to styrene is related to a significant increase in the odds of developing hearing loss. Moreover, this study indicates that combined exposures to two or more ototoxic agents, such as styrene and noise, or styrene, toluene, and noise, are more ototoxic than an exposure to noise alone [10].

Styrene also has been found to increase the risk of acute ischemic heart disease mortality among the most highly exposed workers at a synthetic rubber plant [LaDou, 2014]

In Denmark the relationship between occupational styrene exposure and male fecundity was examined. It is unlikely that styrene exposure has a strong effect on male fecundity [11].

Styrene may be embryotoxic or fetotoxic in animals. Human reproductive studies (spontaneous abortions, congenital malformations, low birth weight, or reduced fertility) have been inconsistent [La Dou, 2014].

Congenital effects in children whose mothers had been occupationally exposed to styrene were reported. Styrene may cross the placenta, and it has been demonstrated in umbilical-cord blood [Zenz].

Carcinogenicity
The metabolic transformation of styrene is characterized by its conversion to styrene-7,8-oxide (SO) by the mixed function oxidases and the cytochrome P-450 enzyme complex. SO binds covalently to DNA and shows activity in various in-vitro and in-vivo assays for genetic effects. The genetic and related effects of styrene are therefore associated with its oxidation, which also occurs, e.g. in human whole blood cultures, where styrene induces dose-related responses of chromosomal damage at low concentrations. Styrene-7,8-oxide is detected in blood of workers exposed to styrene.

Styrene-7,8-oxide is mutagenic in several prokaryotic and eukaryotic systems. Chromosome aberrations and sister chromosome exchanges were reported to be significantly increased in several studies of styrene-exposed workers [Xiao].

A Texas study investigated 12 toxicants that are released into the environment by industry (carbon tetrachloride, formaldehyde, methylene chloride, styrene, tetrachloroethylene, trichloroethylene, arsenic, cadmium, chromium, cobalt, copper, and nickel) with breast cancer incidence in Texas. Styrene was the most important toxicant positively associated with invasive breast cancer incidence in Texas. Styrene may be an important breast carcinogen due to its widespread use for food storage and preparation, and its release from building materials, tobacco smoke, and industry [12].

The last evaluation of carcinogenicity of styrene has been done at 2002. Retrospective cohort studies of styrene have been conducted. The risk of lymphatic and hematopoietic neoplasms was increased among exposed workers after more than 20 years since their first exposure to styrene, and increased with increasing intensity of exposure but not with increasing cumulative exposure to styrene. An excess of leukemia was observed among workers employed before 1971 (the period with the highest styrene exposures). There was also a significant increase in the incidence of leukemia when attention was restricted to the follow-up period after 10 years since first exposure to styrene, but only among workers with very short employment (less than 1 year). There have also been reports of increased risks of rectal, pancreatic and nervous system cancers in some of the cohort and case–control studies. The numbers of cases were quite small in these studies, and most of the larger cohort studies have not yielded similar findings. The increased risks for lymphatic and hematopoietic neoplasms observed in some of the studies are generally small, statistically unstable and often based on subgroup analyses. There is limited evidence in humans for the carcinogenicity of styrene.

Styrene-7,8-oxide (SO) is probably carcinogenic to humans (Group 2A).

Styrene is possibly carcinogenic to humans (Group 2B) [13].
References