Styrene-7,8-oxide
CAS No. 96-09-3

Reasonably anticipated to be a human carcinogen
Also known as 1,2-epoxyethylbenzene

Carcinogenicity
Styrene-7,8-oxide is reasonably anticipated to be a human carcino-
gen based on sufficient evidence of carcinogenicity from studies in
experimental animals.

Cancer Studies in Experimental Animals
Oral exposure to styrene-7,8-oxide caused tumors in two rodent
species and at two different tissue sites. Styrene-7,8-oxide (styrene
oxide) administered by stomach tube caused cancer of the forestom-
ach (squamous-cell carcinoma) in both sexes of mice (one strain) and
rats (three strains) (IARC 1994). It also caused liver tumors (hepato-
cellular tumors) in male mice (Lijinsky 1986).

Cancer Studies in Humans
No epidemiological studies were identified that evaluated the rela-
tionship between human cancer and exposure specifically to styrene-
7,8-oxide.

Studies on Mechanisms of Carcinogenesis
Styrene oxide given orally to rabbits, rats, and mice is absorbed and
broken down rapidly in the acid environment of the stomach and
excreted almost completely in the urine. Styrene oxide can be me-
tabolized by epoxide hydrolase to form the glycol or by glutathione
S-transferase to glutathione conjugates. Styrene glycol is further me-
tabolized to mandelic, phenylglyoxylic, and hippuric acids, which are
excreted in urine (IARC 1976, 1994). Workers exposed to styrene ox-
ide vapors excreted large amounts of mandelic acid and phenylgly-
oxylic acid in their urine. (Fustinoni et al. 1998).

Styrene oxide caused mutations in bacteria, yeast, insects, and
cultured mammalian cells, including mutations at the hprt locus in
Chinese hamster V79 cells and human T lymphocytes. It caused chro-
mosomal aberrations or sister chromatid exchange in Chinese ham-
ster V79 cells, Chinese hamster ovary cells, mouse bone marrow
cells in vivo, and cultured human lymphocytes. It also caused DNA
strand breaks in cultured primary animal hepatocytes, human em-
bryonal cells, human lymphocytes, mouse lymphocytes, and mouse
liver and kidney cells (IARC 1994).

Styrene oxide–DNA adducts were observed at low levels in the
forestomachs of male rats given styrene oxide orally (Lutz et al. 1993).
DNA adducts that formed at very low levels in the livers of mice ad-
ministered styrene orally were attributed to styrene oxide, as styrene
was presumed to have been almost completely metabolized to styrene
oxide (Cantoreggi and Lutz 1993). A study of workers in a boat-
making facility where styrene concentrations ranged from 1 to 235 mg/m³
(mean = 65.6 mg/m³, or 13.3 ppm) found elevated levels of styrene ox-
ide–DNA adducts in mononuclear cells (Huff 1984, McConnell and
Swenberg 1993). Styrene oxide–DNA and styrene oxide–albumin ad-
ducts were found in the blood of plastics workers exposed to styrene
oxide (Fustinoni et al. 1998). Styrene oxide–DNA adducts in rodents
and humans appear to be similar. There is no evidence to suggest that
mechanisms by which styrene oxide causes genotoxic effects and
tumors in experimental animals would not also operate in humans.

Properties
Styrene-7,8-oxide is an epoxide of styrene that exists at room tem-
perature as a colorless to pale yellow liquid with a pleasant sweet
odor. It is soluble in alcohol, ether, benzene, acetone, methanol, car-
bon tetrachloride, and heptane, and miscible with most other or-
ganic solvents. It is only slightly soluble in water. Styrene-7,8-oxide
polymerizes exothermally and reacts vigorously in the presence of
catalysts with compounds with available hydrogen ions (IARC 1994).
Physical and chemical properties of styrene-7,8-oxide are listed in
the following table.

<table>
<thead>
<tr>
<th>Property</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Molecular weight</td>
<td>120.2 g/mol</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>1.0523 at 16°C/4°C</td>
</tr>
<tr>
<td>Melting point</td>
<td>−35.6°C</td>
</tr>
<tr>
<td>Boiling point</td>
<td>194.1°C</td>
</tr>
<tr>
<td>Log Kow</td>
<td>1.61</td>
</tr>
<tr>
<td>Water solubility</td>
<td>3.00 g/L at 20°C</td>
</tr>
<tr>
<td>Vapor pressure</td>
<td>0.3 mm Hg at 20°C</td>
</tr>
<tr>
<td>Vapor density relative to air</td>
<td>4.3</td>
</tr>
</tbody>
</table>


Use
Styrene oxide is used as a chemical intermediate in the production
of styrene glycol and its derivatives, cosmetics, surface coatings,
and agricultural and biological chemicals. It also is used as a reactive
diluent for epoxy resins and in cross-linked polyesters and polyurethanes.
Styrene oxide has been used as a raw material for the production of
2-phenylethanol (oil of roses) used in perfumes and in the treatment
of fibers and textiles. Small quantities are used to improve the stabil-
ity of hydraulic fluids, chlorinated cleaning compositions, petroleum
distillates, dielectric fluids, and acid-sensitive polymers and copoly-

Production
Styrene oxide was listed by the U.S. Environmental Protection Agency
as a high-production-volume chemical in 1990, indicating that an-
ual production exceeded 1 million pounds (EPA 2006). In 2009, one
U.S. manufacturer of styrene oxide was identified (HSDB 2009). Re-
ports filed under EPA’s Toxic Substances Control Act Inventory Up-
date Rule indicated that U.S. production plus imports of styrene oxide
totaled over 1 million to 10 million pounds in 1990 and 10,000 to

Exposure
The general population may be exposed to styrene oxide by contact
with contaminated air or water; however, according to EPA’s Toxics
Release Inventory, annual environmental releases of styrene oxide
from industrial facilities were less than 100 lb until 2006. In 2006 and
2007, larger quantities (246 lb and 380 lb, respectively) were sent to
off-site hazardous-waste landfills (TRI 2009). No quantitative expo-
sure data were found.

In a study in the United Kingdom, various plastics and resins were
analyzed to determine whether styrene oxide could migrate to food.
Styrene oxide was found in items that came into contact with food,
including 9 base resins and 16 samples of polystyrene articles. Con-
centrations of styrene oxide in typical polystyrene materials were low,
ranging from undetectable (< 0.5 mg/kg) to 3 mg/kg. Assuming that
styrene oxide migrates in the same pattern as the styrene monomer,
estimated concentrations in food resulting from migration ranged from 0.002 to 0.15 μg/kg (Philo et al. 1997).

Occupational exposure to styrene oxide occurs most often in the fabricated rubber products, paints, and allied products industry (HSDB 2009). Occupational exposure to styrene oxide is primarily indirect via exposure to styrene. Styrene oxide can form in air at low levels (< 1 mg/m³, or < 203 ppb) when styrene reacts with oxygen or hydroperoxides (used to initiate the curing of reinforced plastics) (Yeowell-O’Connell et al. 1997). The National Occupational Exposure Survey (conducted from 1981 to 1983) estimated that 333,212 workers, including 86,902 women, potentially were exposed to styrene, and that 458 workers potentially were exposed to styrene oxide (NIOSH 1990).

In personal exposure air samples for 19 workers at a U.S. boat manufacturing company who were heavily exposed to styrene by inhalation (at a mean concentration of 64 mg/m³), the average concentration of styrene oxide was 0.14 mg/m³ (28.5 ppb) (IARC 1994). Nylander-French et al. (1999) studied levels of styrene oxide exposure and factors contributing to exposure in workers who manufactured reinforced plastics. From laboratory experiments, they hypothesized that styrene oxide formed by (1) breakdown of polymeric styrene peroxide radicals resulting from the copolymerization of styrene and oxygen, (2) epoxidation of the styrene monomer, or (3) reaction of styrene with volatile organic peroxides used in curing reinforced plastics. However, no measurements in manufacturing plants have confirmed these hypotheses. Among workers, styrene oxide exposure increased with increasing styrene exposure, but this correlation was statistically significant only among hand laminators, who were exposed to the highest levels of styrene and styrene oxide. Resin use also was an important factor in predicting styrene oxide exposure, regardless of the quantity of resin used. It was concluded that styrene oxide exposure was affected by factors other than styrene exposure.

Regulations

Environmental Protection Agency (EPA)

Clean Air Act

National Emission Standards for Hazardous Air Pollutants: Listed as a hazardous air pollutant.

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.

References


