TotalEnergies Petrochemicals & Refining USA, Inc.

Product Summary: Styrene
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Product Overview

Styrene is a building block, or monomer, for the manufacture of a broad range of materials used in thousands of plastics products throughout the world.

The most recognizable styrene-based material is probably polystyrene, often encountered as expanded polystyrene foam (EPS). Other styrene-based materials include impact polystyrene (polystyrene-polybutadiene-copolymer), acrylonitrile-butadiene styrene (ABS), styrene-acrylonitrile (SAN), styrene-butadiene rubber (SBR), and unsaturated polyester resin (UPR), which is better known as fiberglass.

Chemical Identity

Name: Styrene
Also known as: Ethenylbenzene; Phenylethylene; Vinylbenzene CAS[1] Registry Number: 100-42-5

Uses

Styrene-based materials add convenience, value, and quality to daily life. Some examples of these uses include:

- Packaging, including food packaging
- Toys/Recreational Equipment
- Consumer Electronics
- Construction
- Transportation
- Medical Supplies

Benefits of styrene-based materials

Styrene-based materials offer unique characteristics of toughness, high performance, versatile design and simplicity of production. They provide excellent hygiene, sanitary, and safety benefits. Styrene-based products offer superior insulation qualities for use in building construction and lightweight components resulting in energy use reduction. They can be recycled where collection systems are available. In many cases, styrene helps create products for which there are few, if any, substitutes.

Physical/chemical properties

Styrene Property	Value
Specific Gravity:	0.91
Appearance:	clear liquid
Freezing Point	-31°C (-24°F)

[1] CAS Registry Number is a Registered Trademark of the American Chemical Society.

Boiling Point:	145°C (293°F)
Flash Point:	31°C (88°F)
Auto ignition Temperature	490°C (914°F)
Explosive limits, vol % in air	0.9 – 6.8%
Vapor Pressure:	4.3 – 5.0 mm Hg @ 20°C
Relative vapor density @ 20 °C	3.6 (Air = 1)
Solubility in water:	310 - 320 mg/L at 25°C.
Log Kow	3.0
Molecular weight:	104 Daltons (g/mol)
Molecular Formula:	C_8H_8
Odor Threshold:	0.01 - 0.1 ppm

Physical Hazards

Flammability

Styrene is classified as a Flammable Liquid, Category 3, under Occupational Safety and Health Administration (OSHA) Hazard Communication regulations. It is also classified as a Flammable Liquid by the United States Department of Transportation (USDOT) and other transportation authorities throughout the world.

Hazardous Polymerization

Under certain conditions, styrene can spontaneously polymerize, producing heat and high pressures inside its container, which may lead to an explosion.

To prevent auto-polymerization, routinely monitor for percent polymer and inhibitor. Add inhibitor as needed. The most commonly used inhibitor is tertiary-butylcatechol (TBC) in the 10-15 ppm concentration range. Higher concentrations may be needed. Inhibitor needs greater than 15 ppm dissolved oxygen (O2) to prevent polymerization. Do NOT blanket with nitrogen without providing means for keeping and checking a minimum of 15 ppm of oxygen (O2) dissolved in liquid phase. Inhibitor depletion and risk of polymerization will increase if product is stored under high temperatures, in the presence of moisture, rust, or other impurities, or for extended periods.

Store below 84°F (29°C) in a dry, well-ventilated area. Storage temperature should be continuously monitored. If the temperature rises 1°C/day, it may be an early indication of spontaneous polymerization and the temperature should be monitored closely. Re-circulation of the material may stop or decrease the rate of temperature rise. A 2-3°C/day temperature increase is a typical indication of the onset of a runaway polymerization.

Conditions to avoid

- Elevated temperatures
- Contact with copper, copper alloys, peroxides, and rust
- Static Electricity

Storage

Storage tanks should be engineered to prevent contact with water resources, as this material could contaminate the water resources. Surface spills can reach groundwater through porous soil or cracked surfaces. The storage tanks should be monitored regularly for leaks. Facilities which store these products should have a comprehensive response plan for spills or leaks.

For additional information on the safe use and handling of styrene, refer to the CEFIC Styrene Monomer: Environmental, Health, Safety, Transport and Storage guidelines located on the Internet (Styrene Monomer: Environmental, Health, Safety, Transport and Storage guidelines).

Health Effects

High levels of exposure to styrene monomer can cause adverse health effects. Regulations require occupational exposures to remain within safe limits by use of appropriate industrial hygiene practices and emission controls.

The GHS health hazard classifications based on OSHA Hazard Communication regulations (29 CFR 1910.1200)[2] for styrene are provided in the table below. For additional information including GHS hazard statements, precautionary statements, and information on specific target organ toxicity (STOT), the safety data sheet for the specific product should be consulted.

OSHA GHS Health Hazard Classifications	Styrene
Acute Toxicity (inhalation:vapor)	Cat. 4
Aspiration hazard	Cat. 1
Skin corrosion/irritation	Cat. 2
Serious eye damage/eye irritation	Cat. 2A
Carcinogenicity	Cat. 2
STOT (Single Exposure) - Narcotic Effects	Cat. 3
STOT (Single Exposure) – Respiratory Irritation	Cat. 3
STOT (Repeated Exposure)	Cat. 2

Short-term exposure to levels of styrene above 100 parts per million can potentially cause central nervous system effects, including headaches, fatigue, weakness, eye irritation, respiratory irritation, and symptoms similar to those of alcohol intoxication, such as dizziness and slight nausea. These symptoms are typically temporary, and recovery usually occurs within 48 hours. Styrene exposure below permissible levels typically does not cause these effects.

If swallowed, styrene is a potential aspiration hazard (inhaling liquid into the lungs). Vomiting increases risk of inflammation of the lung caused by aspirating the substance (chemical pneumonia) or fluid accumulation in the air spaces of the lungs (pulmonary edema) caused by aspiration. This is a serious medical condition which requires immediate and proper medical attention.

Repeated exposure to skin may cause dryness, redness, or cracking.

Based on animal studies, short term and intermediate duration exposure to styrene may cause liver damage. However, there is little evidence of liver damage in humans exposed to styrene.

The nervous system is affected by long term exposure to styrene. Studies have shown that long-term exposure at levels above 30 parts per million has been identified as possibly contributing to hearing loss. Additionally, chronic exposure to styrene may result in impairment of color vision discrimination.

Different governmental and non-governmental agencies rate the cancer-causing potential (carcinogenicity) of chemicals. Some results for Styrene Monomer include:

[2] OSHA does not provide GHS hazard classifications for a chemical. OSHA places the responsibility of GHS hazard classification upon the manufacturers (or importers) of the chemical (see 21 CFR 1910.1200(d)). Therefore, GHS hazard classification in the United States may differ from manufacturer (or importer) to manufacturer (or importer). Additionally, these GHS hazard classifications may differ from other internationally established GHS classifications, such as those in the Europe Union or Japan.
The provided GHS classifications are current as of the date of this document. However, the GHS classifications are subject to change as new information is obtained. The user should always refer to the most recent product SDS to confirm the GHS classifications.

Agency	Carcinogenicity
International Agency for Research on Cancer (IARC)	Probably carcinogenic to humans
National Toxicology Program (NTP)	Reasonably anticipated to be a human carcinogen
American Conference for Governmental Industrial Hygienists (ACGIH)	Not considered to be carcinogenic
Occupational Safety and Health Administration (OSHA)	Not listed

In 2011, the NTP listed styrene in the 12th Report on Carcinogens (RoC) as "Reasonably Anticipated to be a Human Carcinogen". The RoC does not state or conclude that the use of styrene-based products poses a safety risk to consumers who use the products, employees at companies that manufacture or use styrene-based products such as polystyrene, or individuals living in communities where such companies operate.

In 2019, the International Agency for Research on Cancer (IARC) revised its previous classification of styrene from Group 2B "possibly carcinogenic to humans" to Group 2A "probably carcinogenic to humans."[3]

The carcinogenic potential of styrene has been studied in rats and mice, using the inhalation and oral routes of exposure. Lung tumors were evident in the mouse. In the rat, styrene did not exhibit any clear evidence of carcinogenic potential by the inhalation or oral routes of exposure. The relevance of the mouse lung tumors for human health is questionable due to differences in metabolic pathways for styrene in mice and in humans.

Several cohort and case-control studies covering workers exposed to styrene are available. In large, well-conducted studies, cancer mortality was investigated with relatively high exposure to styrene and no significant exposures to other chemicals. In these studies, there was no clear evidence for a link between specific cancer mortality and exposure to styrene. In the styrene-butadiene rubber industry, several studies have pointed to an increased risk of cancer of the lymphatic and hematopoietic (blood forming) systems. However, detailed analysis of these data, together with the general toxicological picture for styrene and butadiene, suggests that where increases are due to occupational exposure, it is butadiene, not styrene, that is the causative agent. There is no clear and consistent evidence for a link between specific cancer mortality and exposure to styrene.[4]

A review conducted by an expert panel led by Dr. Paolo Boffetta of Mount Sinai School of Medicine and formerly of the International Agency for Research on Cancer is especially noteworthy. The review panel's results, published in 2009 in the Journal of Occupational and Environmental Medicine, concluded that the available data "does not support a causal relationship between styrene exposure and any type of human cancer."[5]

Potential for Exposure

Environmental Exposure

Styrene readily biodegrades and does not present a hazard to organisms in the environment. Measured environmental concentrations of styrene in the air, water and soil are too low to cause effects on mammals, non-mammals, or microorganisms. Styrene is moderately toxic to aquatic organisms, but the compound's properties keep exposure levels below those required for toxicity.

[3] IARC Monographs Volume 121, STYRENE, STYRENE-7,8-OXIDE, AND QUINOLINE https://publications.iarc.fr/582

[4] European Union Risk Assessment Report, Styrene, Draft for Publication, June 2008, and its Annex XV Transitional Dossier https://echa.europa.eu/information-on-chemicals/transitional-measures/annex-xv-transitional-reports.

[5] Boffetta, P., et al., "Epidemiologic Studies of Styrene and Cancer: A Review of the Literature," Journal of Occupational and Environmental Medicine, v. 51, issue 11, pp. 1275- 1287, November 2009. For abstract, see http://journals.lww.com/joem/Abstract/2009/11000/Epidemiologic_Studies_of_Styrene_and_Cancer__A.5.aspx.

Industrial Worker Exposure

Styrene monomer is a recognized hazardous substance with exposure limits. Ventilation and engineering controls must be used in areas where styrene monomer is present in order to keep exposure levels below established standards. Workers should wear respiratory protection, splash goggles or safety glasses, flame retardant clothing covering the entire body, and chemical resistant gloves and boots. If inhalation above industry standards is possible, an appropriate respirator must be worn.

Current occupational exposure limits that have been developed for styrene are provided in the table below.

ACGIH® Threshold Limit Value (TLV®)		**OSHA Permissible Exposure Limits (PEL) OSHA Z-2 Table**			**NIOSH Recommend Exposure Limit (REL)**	
8-hour Time Weighted Average (TWA) 10 ppm	Short Term Exposure Limit (STEL) 15 min 20 ppm	8-hour Time Weighted Average (TWA) 100 ppm	Acceptable Ceiling Concentration 200 ppm	PEAK 5 minute peak in any 3 hours 600 ppm	Up to 10-hour Time Weighted Average (TWA) 50 ppm	Short Term Exposure Limit (STEL) 15 min 100 ppm

The monomer has a distinct odor at a very low threshold of about 0.1 ppm. This allows it to be readily detected in the workplace at concentrations well below exposure limits.

Consumer/General Public Exposure

Foods such as coffee, strawberries and cinnamon naturally contain styrene. Small amounts of styrene are also produced naturally by plants, bacteria, and fungi. Styrene is also present in combustion products such as cigarette smoke and automobile exhaust.

Consumers use polymers containing styrene and are exposed to very small amounts of residual monomer. Safe food contact use is regulated by the US Federal Food and Drug Administration (FDA).

Product Stewardship Contact Information:

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Additional Information

TotalEnergies Petrochemicals & Refining USA, Inc. Material Safety Data Sheet for Styrene Monomer https://corporate.totalenergies.us/product-stewardship

Plastics Europe, Styrene Monomer: Safe Handling Guide: https://plasticseurope.org/knowledge-hub/styrene-monomer-safe-handling-guide/

Agency for Toxic Substances and Disease Registry (ATSDR) summary for styrene https://wwwn.cdc.gov/TSP/substances/ToxSubstance.aspx?toxid=74

Detailed summaries of available toxicity studies for styrene can be found at the Styrene Information Research Center (SIRC) website: https://styrene.org/styrene-and-human-health/

A resource of information on styrene for consumers, employees, and communities: http://youknowstyrene.org/.

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