SAFETY DATA SHEET

Updated on 26/09/2024

1. Material Identification

Product Name : Styrene
Catalog Number : io-3027
CAS Number : 100-42-5
Identified uses : Laboratory chemicals, manufacture of chemical compounds
Company : Ionz

>> R&D Use only

2. Hazards Identification

GHS Classification:

Flammable liquid (category 2)
Acute toxicity, oral (Category 3)
Acute toxicity, dermal (Category 3)
Acute toxicity, inhalation (Category 3)
Specific target organ toxicity, single exposure (Category 1)

Note

>> Pictograms displayed are for > 99.9% (6092 of 6095) of reports that indicate hazard statements. This chemical does not meet GHS hazard criteria for < 0.1% (3 of 6095) of reports.

Pictogram(s)

GHS Hazard Statements

>> H226 (> 99.9%): Flammable liquid and vapor [Warning Flammable liquids]

>> H304 (50.4%): May be fatal if swallowed and enters airways [Danger Aspiration hazard]

>> H315 (> 99.9%): Causes skin irritation [Warning Skin corrosion/irritation]

>> H319 (99.9%): Causes serious eye irritation [Warning Serious eye damage/eye irritation]

>> H332 (97.9%): Harmful if inhaled [Warning Acute toxicity, inhalation]

>> H335 (51.9%): May cause respiratory irritation [Warning Specific target organ toxicity, single exposure; Respiratory tract irritation]

>> H361 (34.9%): Suspected of damaging fertility or the unborn child [Warning Reproductive toxicity]

>> H372 (73.7%): Causes damage to organs through prolonged or repeated exposure [Danger Specific target organ toxicity, repeated exposure]

>> H412 (48.8%): Harmful to aquatic life with long lasting effects [Hazardous to the aquatic environment, long-term hazard]

Precautionary Statement Codes

>> P203, P210, P233, P240, P241, P242, P243, P260, P261, P264, P264+P265, P270, P271, P273, P280, P301+P316, P302+P352, P303+P361+P353, P304+P340, P305+P351+P338, P317, P318, P319, P321, P331, P332+P317, P337+P317, P362+P364, P370+P378, P403+P233, P403+P235, P405, and P501

NFPA 704 Diamond

NFPA Health Rating

>> 2 - Materials that, under emergency conditions, can cause temporary incapacitation or residual injury.

NFPA Fire Rating

>> 3 - Liquids and solids that can be ignited under almost all ambient temperature conditions. Materials produce hazardous atmospheres with air under almost all ambient temperatures or, though unaffected by ambient temperatures, are readily ignited under almost all conditions.

NFPA Instability Rating

>> 2 - Materials that readily undergo violent chemical changes at elevated temperatures and pressures.

NFPA Specific Notice

>> W - No water: Materials that react violently or explosively with water.

Health Hazards:

>> Excerpt from ERG Guide 171 [Substances (Low to Moderate Hazard)]:

>> Inhalation of material may be harmful. Contact may cause burns to skin and eyes. Inhalation of Asbestos dust may have a damaging effect on the lungs. Fire may produce irritating, corrosive and/or toxic gases. Some liquids produce vapors that may cause dizziness or asphyxiation. Runoff from fire control or dilution water may cause environmental contamination. (ERG, 2024)

>> Excerpt from ERG Guide 171 [Substances (Low to Moderate Hazard)]:

>> Some may burn but none ignite readily. Containers may explode when heated. Some may be transported hot. For UN3508, Capacitor, asymmetric, be aware of possible short circuiting as this product is transported in a charged state. Polymeric beads, expandable (UN2211) may evolve flammable vapours. (ERG, 2024)

>> Flammable. Gives off irritating or toxic fumes (or gases) in a fire. Above 31 °C explosive vapour/air mixtures may be formed.

3. Composition/Information On Ingredients

Chemical name : Styrene
CAS Number : 100-42-5
Molecular Formula : C8H8
Molecular Weight : 104.1500 g/mol

4. First Aid Measures

First Aid:

>> EYES: First check the victim for contact lenses and remove if present. Flush victim's eyes with water or normal saline solution for 20 to 30 minutes while simultaneously calling a hospital or poison control center. Do not put any ointments, oils, or medication in the victim's eyes without specific instructions from a physician. IMMEDIATELY transport the victim after flushing eyes to a hospital even if no symptoms (such as redness or irritation) develop.

>> SKIN: IMMEDIATELY flood affected skin with water while removing and isolating all contaminated clothing. Gently wash all affected skin areas thoroughly with soap and water. If symptoms such as redness or irritation develop, IMMEDIATELY call a physician and be prepared to transport the victim to a hospital for treatment.

>> INHALATION: IMMEDIATELY leave the contaminated area; take deep breaths of fresh air. If symptoms (such as wheezing, coughing, shortness of breath, or burning in the mouth, throat, or chest) develop, call a physician and be prepared to transport the victim to a hospital. Provide proper respiratory protection to rescuers entering an unknown atmosphere. Whenever possible, Self-Contained Breathing Apparatus (SCBA) should be used; if not available, use a level of protection greater than or equal to that advised under Protective Clothing.

>> INGESTION: DO NOT INDUCE VOMITING. If the victim is conscious and not convulsing, give 1 or 2 glasses of water to dilute the chemical and IMMEDIATELY call a hospital or poison control center. Be prepared to transport the victim to a hospital if advised by a physician. If the victim is convulsing or unconscious, do not give anything by mouth, ensure that the victim's airway is open and lay the victim on his/her side with the head lower than the body. DO NOT INDUCE VOMITING. IMMEDIATELY transport the victim to a hospital.

>> OTHER: Since this chemical is a known or suspected carcinogen you should contact a physician for advice regarding the possible long term health effects and potential recommendation for medical monitoring. Recommendations from the physician will depend upon the specific compound, the exposure level and the route of exposure. (NTP, 1992)

First Aid Measures

Inhalation First Aid

>> Fresh air, rest. Refer for medical attention.

Skin First Aid

>> Remove contaminated clothes. Rinse and then wash skin with water and soap.

Eye First Aid

>> First rinse with plenty of water for several minutes (remove contact lenses if easily possible), then refer for medical attention.

Ingestion First Aid

>> Rinse mouth. Do NOT induce vomiting. Give one or two glasses of water to drink. Rest.

5. Fire Fighting Measures

>> Electrical ignition hazard: May be ignited by static discharge.

>> Excerpt from ERG Guide 171 [Substances (Low to Moderate Hazard)]:

>> CAUTION: Fire involving Safety devices (UN3268) and Fire suppressant dispersing devices (UN3559) may have a delayed activation and a risk of hazardous projectiles. Extinguish the fire at a safe distance.

>> SMALL FIRE: Dry chemical, CO2, water spray or regular foam.

>> LARGE FIRE: Water spray, fog or regular foam. Do not scatter spilled material with high-pressure water streams. If it can be done safely, move undamaged containers away from the area around the fire. Dike runoff from fire control for later disposal.

>> FIRE INVOLVING TANKS: Cool containers with flooding quantities of water until well after fire is out. Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank. ALWAYS stay away from tanks in direct contact with flames. (ERG, 2024)

>> Excerpt from ERG Guide 128 [Flammable Liquids (Water-Immiscible); polymerization hazard]:

>> CAUTION: The majority of these products have a very low flash point. Use of water spray when fighting fire may be inefficient. CAUTION: For mixtures containing alcohol or polar solvent, alcohol-resistant foam may be more effective.

>> SMALL FIRE: Dry chemical, CO2, water spray or regular foam. If regular foam is ineffective or unavailable, use alcohol-resistant foam.

>> LARGE FIRE: Water spray, fog or regular foam. If regular foam is ineffective or unavailable, use alcohol-resistant foam. Avoid aiming straight or solid streams directly onto the product. If it can be done safely, move undamaged containers away from the area around the fire.

>> FIRE INVOLVING TANKS, RAIL TANK CARS OR HIGHWAY TANKS: Fight fire from maximum distance or use unmanned master stream devices or monitor nozzles. Cool containers with flooding quantities of water until well after fire is out. For petroleum crude oil, do not spray water directly into a breached tank car. This can lead to a dangerous boil over. Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank. ALWAYS stay away from tanks in direct contact with flames. For massive fire, use unmanned master stream devices or monitor nozzles; if this is impossible, withdraw from area and let fire burn. (ERG, 2024)

>> Use dry powder. Use foam. Use carbon dioxide. In case of fire: keep drums, etc., cool by spraying with water.

6. Accidental Release Measures

Isolation and Evacuation:

Isolation and evacuation measures to take when a large amount of this chemical is accidentally released in an emergency.

>> Excerpt from ERG Guide 171 [Substances (Low to Moderate Hazard)]:

>> IMMEDIATE PRECAUTIONARY MEASURE: Isolate spill or leak area in all directions for at least 50 meters (150 feet) for liquids and at least 25 meters (75 feet) for solids.

>> SPILL: Increase the immediate precautionary measure distance, in the downwind direction, as necessary.

>> FIRE: If tank, rail tank car or highway tank is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions. (ERG, 2024)

Spillage Disposal:

Methods for containment and safety measures to protect workers dealing with a spillage of this chemical.

>> Personal protection: chemical protection suit including self-contained breathing apparatus. Remove all ignition sources. Do NOT let this chemical enter the environment. Do NOT wash away into sewer. Collect leaking and spilled liquid in covered containers as far as possible. Absorb remaining liquid in sand or inert absorbent. Then store and dispose of according to local regulations.

7. Handling And Storage

Safe Storage:

>> Fireproof. Separated from incompatible materials. See Chemical Dangers. Cool. Keep in the dark. Store only if stabilized. Store in an area without drain or sewer access.

Storage Conditions:

>> Fireproof. Separated from incompatible materials. See Chemical Dangers. Cool. Keep in the dark. Store only if stabilized. Store in an area without drain or sewer access.

8. Exposure Control/ Personal Protection

REL-TWA (Time Weighted Average)

>> 50 ppm (215 mg/m³)

REL-STEL (Short Term Exposure Limit)

>> 100 ppm (425 mg/m³)

>> TWA 50 ppm (215 mg/m3) ST 100 ppm (425 mg/m3)

>> 100.0 [ppm], Ceiling(OSHA) = 200 ppm(600 ppm is 5-min. peak in any 3 hrs.)

PEL-TWA (8-Hour Time Weighted Average)

>> 100 ppm

PEL-C (Ceiling)

>> 200 ppm; 600 ppm (Peak) for a single time period up to 5 min in any 3 hours

>> 10.0 [ppm]

TLV-STEL

>> 20.0 [ppm]

>> 10 ppm as TWA; 20 ppm as STEL; (OTO); A3 (confirmed animal carcinogen with unknown relevance to humans); BEI issued.

TLV-TWA (Time Weighted Average)

>> 10 ppm [2020]

TLV-STEL (Short Term Exposure Limit)

>> 20 ppm [2020]

MAK (Maximale Arbeitsplatz Konzentration)

>> 86 mg/m

>> ERPG-1: 50 ppm - one hour exposure limit: 1 = mild transient health effects or objectionable odor [AIHA]

>> ERPG-2: 250 ppm - one hour exposure limit: 2 = impaired ability to take protective action [AIHA]

>> ERPG-3: 1,000 ppm - one hour exposure limit: 3 = life threatening health effects [AIHA]

Inhalation Risk:

>> A harmful contamination of the air will be reached rather slowly on evaporation of this substance at 20 °C.

Effects of Short Term Exposure:

>> The substance is irritating to the eyes, skin and respiratory tract. If this liquid is swallowed, aspiration into the lungs may result in chemical pneumonitis. The substance may cause effects on the central nervous system. Exposure at high levels could cause unconsciousness.

Effects of Long Term Exposure:

>> The substance defats the skin, which may cause dryness or cracking. The substance may have effects on the central nervous system. Exposure to the substance may increase noise-induced hearing loss. This substance is possibly carcinogenic to humans.

Acceptable Daily Intakes:

An estimate of the amount of a chemical in food or drinking water that can be consumed daily over a lifetime without presenting an appreciable risk to health. It is usually expressed as milligrams of the substance per kilogram of body weight per day and applies to chemicals such as food additives, pesticide residues and veterinary drugs.

>> An ADI of 0.133 mg/kg/day was calculated on the basis of the available chronic toxicity data /for rats/.

Fire Prevention

>> NO open flames, NO sparks and NO smoking. Above 31 °C use a closed system, ventilation and explosion-proof electrical equipment.

Exposure Prevention

>> STRICT HYGIENE!

Inhalation Prevention

>> Use ventilation, local exhaust or breathing protection.

Skin Prevention

>> Protective clothing. Protective gloves.

Eye Prevention

>> Wear safety goggles or eye protection in combination with breathing protection.

Ingestion Prevention

>> Do not eat, drink, or smoke during work.

Exposure Control and Personal Protection

Exposure Summary

>> Biological Exposure Indices (BEI) [ACGIH] - Mandelic acid plus phenylglyoxylic acid in urine = 150 mg/g creatinine at end of shift; Styrene in urine = 20 ug/L at end of shift; [TLVs and BEIs]

RD50 (Exposure concentration producing a 50% respiratory rate decrease)

>> 980.0 [mmHg]

Maximum Allowable Concentration (MAK)

>> 20.0 [ppm] (styrene monomer)[German Research Foundation (DFG)]

9. Physical And Chemical Properties

Molecular Weight:

>> 104.15

Exact Mass:

>> 104.062600255

Physical Description:

>> Insoluble in water and less dense than water. Contact may cause irritate skin, eyes, and mucous membranes. May be toxic by ingestion.

>> COLOURLESS-TO-YELLOW OILY LIQUID.

Color/Form:

>> Colorless to yellowish, oily liquid

Odor:

>> Characteristic, sweet, balsamic, almost floral odor that is extremely penetrating

Boiling Point:

>> 293 to 295 °F at 760 mmHg (NTP, 1992)

>> 145 °C

Melting Point:

>> 464 °F (NTP, 1992)

>> -30.6 °C

Flash Point:

>> 88 °F (NTP, 1992)

>> 31 °C c.c.

Solubility:

>> less than 1 mg/mL at 66 °F (NTP, 1992)

>> Solubility in water, g/100ml at 20 °C: 0.03

Density:

>> 1.04 to 1.65 at 68 °F (NTP, 1992)

>> Relative density (water = 1): 0.91

Vapor Density:

>> 3.6 (Air = 1)

>> Relative vapor density (air = 1): 3.6

Vapor Pressure:

>> 4.3 mmHg at 59 °F ; 9.5 mmHg at 86 °F; 10 mmHg at 95 °F (NTP, 1992)

>> Vapor pressure, kPa at 20 °C: 0.67

LogP:

>> log Kow = 2.95

>> 3.0

Stability/Shelf Life:

>> Stable under recommended storage conditions. Test for peroxide formation before distillation or evaporation. Test for peroxide formation or discard after 1 year.

Autoignition Temperature:

>> 800 °F (NTP, 1992)

>> 490 °C

Decomposition:

>> Hazardous decomposition products formed under fire conditions - Carbon oxides.

Viscosity:

>> 0.696 cP at 25 °C

Corrosivity:

The ability of a chemical to damage or destroy other substances when it comes into contact.

>> Styrene will corrode copper and copper alloys

Heat of Combustion:

>> -4,395.63 kJ/mol at 25 °C

Heat of Vaporization:

>> 10.50 kcal/mol at 25 °C

Surface Tension:

>> 32.3 dynes/cm at 20 °C

Ionization Potential:

>> 8.40 eV

Polymerization:

Polymerization is a process of reacting monomer molecules together in a chemical reaction to form polymer chains or three-dimensional networks.

>> Polymerizes slowly at room temperature and readily at temp > 65 °C.

Odor Threshold:

>> Odor Threshold Low: 0.01 [mmHg]

>> Odor Threshold High: 1.9 [mmHg]

>> Detection odor threshold from AIHA (mean = 0.14 ppm)

Refractive Index:

>> Index of refraction: 1.5440 at 25 °C

10. Stability And Reactivity

>> Flammable. Insoluble in water.

>> Highly Flammable

Peroxide Forming Chemical:

Peroxide-forming chemicals (PFCs) are chemicals that can "auto-oxidize" with atmospheric oxygen under ambient conditions to form organic peroxides (contains an -O-O- bond). Peroxide formation can be initiated by exposure to air, self-polymerization, or solvent impurities. Once formed, organic peroxides are sensitive to thermal or mechanical shock and can be violently explosive in concentrated solutions or as solids.

Chemical

>> Styrene

Class (* = UMN Designation)

>> C: Compounds that autopolymerize due to peroxide formation if inhibitors are depleated or not present

Reference(s)

>> Kelly

11. Toxicological Information

Toxicity Summary:

>> IDENTIFICATION AND USE: Styrene is a colorless to yellowish, oily liquid. It is used in the manufacture of plastics, synthetic rubber, and resins, and as an insulator. It is also used as a flavoring agent for ice cream and candy. HUMAN STUDIES: Humans acutely exposed to styrene by inhalation to 800 ppm (3.4 mg/L) for 3 hr experience immediate eye

and throat irritation, increased nasal mucous secretion, metallic taste, drowsiness, and vertigo. After test termination, slight muscular weakness, accompanied by inertia and depression were noted. Long-term contact with styrene results in blistering of the skin and development of dermatitis, which is thought to result from defatting of the skin. Effects on the liver (e.g., increased serum bile acid and enhanced activity of plasma enzymes) and reproductive system (e.g., decreased frequency of births and increased frequency of spontaneous abortions in female workers) have been reported. Epidemiologic studies found styrene workers had increased mortality or incidences of lymphohematopoietic cancers (leukaemia or lymphoma or all), with suggestive evidence for pancreatic and esophageal tumors. No adequate human studies are available for styrene-7,8-oxide although this is the primary and active epoxide metabolite of styrene. Both are genotoxic and form DNA adducts in humans. Products having high irritancy to the human eye are formed when styrene is photo-oxidized with ozone and nitrogen dioxide as in formation of smog. Also, a potent lacrimator has been formed when styrene wastes became mixed with bromine or chlorine wastes and reacted under the influence of sunlight. ANIMAL STUDIES: Acute exposure of animals to styrene causes irritation of the skin and respiratory tract, and central nervous system effects. Liquid styrene is a skin irritant which, on direct contact, causes erythema. Styrene in the rabbit eye caused moderate conjunctival irritation and slight, transient corneal injury. Nystagmus was demonstrated in rabbits, and during styrene exposure the directions of the rotatory nystagmus reversed. Rats and guinea pigs that inhaled 10,000 ppm styrene became comatose within minutes and died after 30 to 60 minutes of exposure. Animals exposed at 2500 ppm showed weakness and stupor, followed by incoordination, tremor, and coma; death followed within 8 hours. A 50% reduction in respiratory rate occurred in mice that inhaled 160 ppm for 3 minutes; mice that inhaled 250 ppm for two 6-hr periods or 500 ppm for a single 6-hr period developed severe centrilobular hepatic necrosis. Mice inhaling 125 ppm styrene, 6 hrs/day for 4 days developed increased liver weight. When rats were given 0, 125, or 250 ppm commercial grade styrene in their drinking water for three generations, no treatment-related changes in reproduction could be detected. Long-term chemical carcinogenesis bioassays showed that styrene caused lung cancers in several strains of mice and mammary cancers in rats and styrene-7,8-oxide caused tumors of the forestomach in rats and mice and of the liver in mice. Styrene induced reverse mutations in Salmonella typhimurium TA1535 and TA100 in presence of metabolic activation. It was not mutagenic to TA1537, TA1538 or TA98. Styrene was not mutagenic in spot test with various strains of Salmonella typhimurium without metabolic activation. It did not induce forward mutations in Schizosaccharomyces pombe, even with metabolic activation. In host-mediated assay using male mice, 1000 mg/kg styrene increased gene conversion frequency in Saccharomyces cerevisiae strain D4. The endocrine disruptor activity of styrene in humans and other vertebrates appears to be negligible. ECOTOXICITY STUDIES: Offspring numbers were reduced in Ceriodaphnia dubia bred in polystyrene cups. The swimming activity of the amphipod, Pontoporeia affinis, was stimulated by styrene at concentrations between 2.3 and 23 mg/L. Higher styrene levels (35 and 46 mg/L) caused amphipods to cease swimming for several days, then resume greater than normal activity.

USGS Health-Based Screening Levels for Evaluating Water-Quality:

This section provides the USGS Health-Based Screening Levels for Evaluating Water-Quality data.

Chemical

>> Styrene

USGS Parameter Code

>> 77128

MCL (Maximum Contaminant Levels)[µg/L]

>> 100

Reference

>> Smith, C.D. and Nowell, L.H., 2024. Health-Based Screening Levels for evaluating water-quality data (3rd ed.). DOI:10.5066/F71C1TWP

Evidence for Carcinogenicity:

Evidence that this chemical does or may cause cancer. The information here is collected from various sources by the Hazardous Substances Data Bank (HSDB).

>> Styrene is reasonably anticipated to be a human carcinogen based on limited evidence of carcinogenicity from studies in humans, sufficient evidence of carcinogenicity from studies in experimental animals, and supporting data on mechanisms of carcinogenesis.

Carcinogen Classification:

This section provides the International Agency for Research on Cancer (IARC) Carcinogenic Classification and related monograph links. In the IARC Carcinogenic classification, chemicals are categorized into four groups: Group 1 (carcinogenic to humans), Group 2A (probably carcinogenic to humans), Group 2B (possibly carcinogenic to humans), and Group 3 (not classifiable as to its carcinogenicity to humans).

IARC Carcinogenic Agent

>> Styrene

IARC Carcinogenic Classes

>> Group 2A: Probably carcinogenic to humans

IARC Monographs

>> Volume 60: (1994) Some Industrial Chemicals

>> Volume 82: (2002) Some Traditional Herbal Medicines, Some Mycotoxins, Naphthalene and Styrene

>> Volume 121: (2019) Styrene, Styrene-7,8-oxide, and Quinoline

>> 2B, possibly carcinogenic to humans. (L135)

Health Effects:

>> Styrene causes nervous system depression and may be carcinogenic. Animals studies have also shown that hearing loss and liver damage may occur. (L1831, L1832)

Exposure Routes:

>> The substance can be absorbed into the body by inhalation of its vapour.

>> inhalation, skin absorption, ingestion, skin and/or eye contact

Inhalation Exposure

>> Dizziness. Drowsiness. Headache. Nausea. Vomiting. Weakness. Unconsciousness.

Skin Exposure

>> Redness. Pain.

Eye Exposure

>> Redness. Pain.

Ingestion Exposure

>> Nausea. Vomiting.

>> irritation eyes, nose, respiratory system; headache, lassitude (weakness, exhaustion), dizziness, confusion, malaise (vague feeling of discomfort), drowsiness, unsteady gait; narcosis; defatting dermatitis; possible liver injury; reproductive effects

Target Organs:

Organs that are affected by exposure to this chemical. Information in this section reflects human data unless otherwise noted.

>> Cancer, Neurological (Nervous System)

>> Hematologic

>> Hepatic

>> Nervous

Adverse Effects:

An adverse effect is an undesired harmful effect resulting from a medical treatment or other intervention.

>> Neurotoxin - Acute solvent syndrome

>> Occupational hepatotoxin - Secondary hepatotoxins: the potential for toxic effect in the occupational setting is based on cases of poisoning by human ingestion or animal experimentation.

>> Dermatotoxin - Skin burns.

>> Asthma - Reversible bronchoconstriction (narrowing of bronchioles) initiated by the inhalation of irritating or allergenic agents.

>> IARC Carcinogen - Class 2: International Agency for Research on Cancer classifies chemicals as probable (2a), or possible (2b) human carcinogens.

>> NTP Carcinogen - Reasonably anticipated to be a human carcinogen.

>> ACGIH Carcinogen - Confirmed Animal.

Toxicity Data:

>> LC50 (rat) = 12,000 mg/m3/4H

Minimum Risk Level:

The minimal risk level (MRL) is an estimate of the amount of a chemical a person can eat, drink, or breathe each day without a detectable risk to health

>> Acute Inhalation: 2 ppm (L134) Chronic Inhalation: 0.2 ppm (L134) Acute Oral: 0.1 mg/kg/day (L134)

Treatment:

Treatment when exposed to toxin

>> Treatment is mainly symptomatic and supportive. Respiratory assistance may be needed. (L1832)

Interactions:

>> Risk assessment for exposure to mixtures of drugs and pollutants relies heavily on in vitro characterization of their bioactivation and/or metabolism individually and extrapolation to mixtures assuming no interaction. Herein, we demonstrated that in vitro CYP2E1 metabolic activation of acetaminophen and styrene mixtures could not be explained through the Michaelis-Menten mechanism or any models relying on that premise. As a baseline for mixture studies with styrene, steady-state analysis of acetaminophen oxidation revealed a biphasic kinetic profile that was best described by negative cooperativity (Hill coefficient=0.72). The best-fit mechanism for this relationship involved two binding sites with differing affinities (Ks=830 uM and Kss=32 mM). Introduction of styrene inhibited that reaction less than predicted by simple competition and thus provided evidence for a cooperative mechanism within the mixture. Likewise, acetaminophen acted through a mixed-type inhibition mechanism to impact styrene epoxidation. In this case, acetaminophen competed with styrene for CYP2E1 (Ki=830 uM and Ksi=180 uM for catalytic and effector sites, respectively) and resulted in cooperative impacts on binding and catalysis. Based on modeling of in vivo clearance, cooperative interactions between acetaminophen and styrene resulted in profoundly increased styrene activation at low styrene exposure levels and therapeutic acetaminophen levels. Current Michaelis-Menten based toxicological models for mixtures such as styrene and acetaminophen would fail to detect this concentration-dependent relationship. Hence, future studies must assess the role of alternate CYP2E1 mechanisms in bioactivation of compounds to improve the accuracy of interpretations and predictions of toxicity.

Antidote and Emergency Treatment:

>> Immediate first aid: Ensure that adequate decontamination has been carried out. If patient is not breathing, start artificial respiration, preferably with a demand-valve resuscitator, bag-valve-mask device, or pocket mask, as trained. Perform CPR if necessary. Immediately flush contaminated eyes with gently flowing water. Do not induce vomiting. If vomiting occurs, lean patient forward or place on left side (head-down position, if possible) to maintain an open airway and prevent aspiration. Keep patient quiet and maintain normal body temperature. Obtain medical attention. /Aromatic hydrocarbons and related compounds/

Human Toxicity Excerpts:

>> /HUMAN EXPOSURE STUDIES/ ... Nine human volunteers /were exposed/ to styrene vapor at concentrations of 50, 100, 216, and 376 ppm for varying periods up to 7 hrs. None of the volunteers exposed at 50 ppm for 1 hr experienced any subjective symptoms or abnormal objective clinical findings. Vapor exposure at 100 ppm, however, produced mild, untoward, but transient subjective responses in half of those exposed. At 376 ppm, the majority of test subjects experienced unpleasant, subjective symptoms and definite signs of neurologic impairment.

Non-Human Toxicity Excerpts:

>> /LABORATORY ANIMALS: Acute Exposure/ Administration of a single high dose of styrene (878 mg/kg, ip in corn oil) to young male rats produced significant elevations in the activities of serum transaminase: 230, 209, and 71% increases in the activity of serum glutamic-oxaloacetic transaminase (SGOT) and 163, 437, and 227% of serum glutamic-pyruvic transaminase (SGPT) at 2, 6, and 24 hr, respectively. These results demonstrated that styrene could produce acute hepatic injury in young rats. Urinary nonprotein sulfhydryl contents and mandelic acid, phenylglyoxylic acid, and hippuric acid were all increased. ... /Srp: toxicity due to unreacted styrene/

Non-Human Toxicity Values:

>> LC50 Mouse 4940 ppm/2 hr

National Toxicology Program Studies:

Reports from the National Toxicology Program, an interagency program supported by three government agencies (NIH, FDA, and CDC) within the Department of Health and Human Services. This program plays a critical role in generating, interpreting, and sharing toxicological information about chemicals of public health concerns.

>> A bioassay for the possible carcinogenicity of styrene was conducted using Fischer 344 rats and B6C3F1 mice. Styrene was admin by gavage to groups of 50 male and 50 female animals of each species. Forty rats of each sex and twenty mice of each sex were placed on test as vehicle controls. The high, medium, and low dosages of styrene admin to rats were, respectively, 2,000, 1,000, and 500 mg/kg. The high and low dosages admin to mice were 300 and 150 mg/kg, respectively. The cmpd was admin for 78 wk to high and medium dose rats, for 103 wk to low dose rats, and for 78 wk to mice. The period of cmpd admin was followed by an observation period of 27 wk for high and medium dose rats, 1 wk for low dose rats, and 13 wk for mice. Mortality among male and female high dose rats was significantly higher than that among their respective vehicle controls. In response to this elevated and early mortality, an additional dosed group of each sex was included in the chronic bioassay. No significant positive association was apparent between dosage and mortality among any other dosed rat groups. For mice, there was a significant positive association between mortality and the dosages of styrene administered to males, but not to females. Adequate numbers of animals in all groups,

except for the high dose male and female rats, survived sufficiently long to be at risk from late developing tumors. ... It is concluded that, under the conditions of this bioassay, no convincing evidence for the carcinogenicity of the compound was obtained in Fischer 344 rats or B6C3F1 mice of either sex.

TSCA Test Submissions:

Under the Toxic Substances Control Act (TSCA), EPA has broad authority to issue regulations designed to require manufacturers (including importers) or processors to test chemical substances and mixtures for health and environmental effects. This section provides information on test reports submitted for this chemical under TSCA.

>> Chronic toxicity and oncogenicity were evaluated in groups of male and female Sprague-Dawley rats (96/sex/group) receiving whole body exposures to monomeric styrene vapor at nominal concentrations of 0, 600 or 1200ppm (due to overt toxicity, concentration changed to 1000ppm) in a dynamic air flow chamber. At each concentration, groups of male and female rats (7-8 weeks of age) were exposed for 6 hours per day, 5 days per week, for 18.3 months (males) and 20.7 months (females). A high incidence of chronic murine pneumonia was evident in the controls and high dose males, which complicated mortality analysis for male rats. No statistically significant differences were evident between treated females and controls for mortality. Mean body weights of all treated males and high dose females were lower throughout part or all the study period. At six and twelve month sacrifices, statistically significant decreases were evident for absolute kidney weights and absolute liver weights in treated males. At the six month sacrifice and at termination of the study, high dose females showed a significant increase in mean absolute liver weights. Histopathologic examination of the lung of high dose females in the later part of the study revealed a significant increase in the incidence of alveolar histiocytosis. The incidences of leukemia-lymphosarcoma are as follows: control males -1/85, control females -1/85, 600ppm males -5/86, 600ppm females -6/85, 1000ppm males -1/84 and 1000ppm females -6/85.

Populations at Special Risk:

>> ... Effects on the liver (eg, increased serum bile acid and enhanced activity of plasma enzymes) and reproductive system (eg, decreased frequency of births and increased frequency of spontaneous abortions in female workers) have been reported.

12. Ecological Information

Resident Soil (mg/kg)

>> 6.00e+03

Industrial Soil (mg/kg)

>> 3.50e+04

Resident Air (ug/m3)

>> 1.00e+03

Industrial Air (ug/m3)

>> 4.40e+03

Tapwater (ug/L)

>> 1.20e+03

MCL (ug/L)

>> 1.00e+02

Risk-based SSL (mg/kg)

>> 1.30e+00

MCL-based SSL (mg/kg)

>> 1.10e-01

Chronic Oral Reference Dose (mg/kg-day)

>> 2.00e-01

Chronic Inhalation Reference Concentration (mg/m3)

>> 1.00e+00

Volatile

>> Volatile

Mutagen

>> Mutagen

Fraction of Contaminant Absorbed in Gastrointestinal Tract

>> 1

Soil Saturation Concentration (mg/kg)

>> 8.67e+02

ICSC Environmental Data:

>> The substance is toxic to aquatic organisms. It is strongly advised not to let the chemical enter into the environment.

Sediment/Soil Concentrations:

Concentrations of this compound in sediment/soil.

>> SEDIMENTS: Water/sediment sample from lower Tennessee river contained 4.2 ppb of styrene(1). Styrene was detected, not quantified, in sediments from Lake Tobin, Saskatchewan Canada(2).

Fish/Seafood Concentrations:

Concentrations of this compound in fish or seafood.

>> The concentration of styrene in Korean salt-fermented fish and shrimp pastes were as follows: anchovy, 69.0 ng/g; big eyed herring, 223 ng/g; shrimp, 180 ng/g(1). The concentration of styrene in crabs (Charybdis feriatus) were 4.4 ug/kg dry wt for leg meat, 7.3 ug/kg dry wt for body meat, and 27.0 ug/kg for carapace meat(2).

Average Daily Intake:

The average amount of the compound taken into the body through eating, drinking, or breathing.

>> Worst-case exposure estimates for styrene of 0-0.5 ug/day from drinking water, 30 ug/day from food, and 65 mg/day from air were calculated by EPA(1); these estimates are based on the highest levels estimated or monitored and, therefore, reflect the highest potential exposure rather than typical exposure for the general population(1). The following nominal daily respiratory intakes of styrene have been estimated(1): worker in reinforced plastics industry, 2 g; worker in styrene polymerization, 100 mg; living within 1 km of a production unit, 600 ug; breathing polluted urban air, 400 ug; breathing typical urban air, 6 ug; breathing indoor air, 6-1000 ug; drinking polluted water, 2 ug; cigarette smoke (20 cigarettes per day), 400-960 ug(2). In a Boston Exposure Assessment in Microenvironments, time weighted average intake of styrene from air for 55 people living and working in the Boston area averaged 0.64 ug/cu m(3).

13. Disposal Considerations

Spillage Disposal

>> Personal protection: chemical protection suit including self-contained breathing apparatus. Remove all ignition sources. Do NOT let this chemical enter the environment. Do NOT wash away into sewer. Collect leaking and spilled liquid in covered containers as far as possible. Absorb remaining liquid in sand or inert absorbent. Then store and dispose of according to local regulations.

Disposal Methods

>> SRP: Recycle any unused portion of the material for its approved use or return it to the manufacturer or supplier. Ultimate disposal of the chemical must consider: the material's impact on air quality; potential migration in air, soil or water; effects on animal, aquatic and plant life; and conformance with environmental and public health regulations. If it is possible or reasonable use an alternative chemical product with less inherent propensity for occupational harm/injury/toxicity or environmental contamination.

>> SRP: Wastewater from contaminant suppression, cleaning of protective clothing/equipment, or contaminated sites should be contained and evaluated for subject chemical or decomposition product concentrations. Concentrations shall be lower than applicable environmental discharge or disposal criteria. Alternatively, pretreatment and/or discharge to a permitted wastewater treatment facility is acceptable only after review by the governing authority and assurance that "pass through" violations will not occur. Due consideration shall be given to remediation worker exposure (inhalation, dermal and ingestion) as well as fate during treatment, transfer and disposal. If it is not practicable to manage the chemical in this fashion, it must be evaluated in accordance with EPA 40 CFR Part 261, specifically Subpart B, in order to determine the appropriate local, state and federal requirements for disposal.

>> Product: Burn in a chemical incinerator equipped with an afterburner and scrubber but exert extra care in igniting as this material is highly flammable. Offer surplus and non-recyclable solutions to a licensed disposal company. Contact a licensed professional waste disposal service to dispose of this material; Contaminated packaging: Dispose of as unused product.

>> 1. By absorbing it in vermiculite, dry sand, earth or a similar material and disposing in a secured sanitary landfill. 2. By atomizing in a suitable combustion chamber. Combustion may be improved by mixing with a more flammable liq.

>> For more Disposal Methods (Complete) data for Styrene (15 total), please visit the HSDB record page.

14. Transport Information

DOT

Styrene
3
UN Pack Group: III
Reportable Quantity of 1000 lb or 454 kg

IATA

Styrene
3,
UN Pack Group: III

15. Regulatory Information

Federal Drinking Water Standards:

Federal drinking water standards (e.g. maximum containment level (MCL)) for this chemical. These standards are legally enforceable.

>> Maximum contaminant levels (MCL) for organic contaminants apply to community and non-transient, non-community water systems: styrene, MCL 0.1 mg/L.

Federal Drinking Water Guidelines:

Federal drinking water guidelines (e.g. maximum containment level (MCL)) for this chemical. In general, these guidelines are recommendations and not legally enforceable.

>> Maximum contaminant level goal (MCLG) for organic contaminants: styrene, MCLG 0.1 mg/L.

Clean Water Act Requirements:

The Clean Water Act (CWA) of 1972 establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters. Under CWA, the U.S. Environmental Protection Agency (EPA) developed the Toxic Pollutant List (40 CFR Part 401.15) and the Priority Pollutant List (40 CFR Part 423, Appendix A). These lists are to be used by EPA and States to develop the Effluent Guidelines regulations and ensure water quality criteria and standards.

>> Styrene is designated as a hazardous substance under section 311(b)(2)(A) of the Federal Water Pollution Control Act and further regulated by the Clean Water Act Amendments of 1977 and 1978. These regulations apply to discharges of this substance. This designation includes any isomers and hydrates, as well as any solutions and mixtures containing this substance.

Regulatory Information

The Australian Inventory of Industrial Chemicals

>> Chemical: Benzene, ethenyl-, homopolymer

The Australian Inventory of Industrial Chemicals

>> Chemical: Benzene, ethenyl-

REACH Registered Substance

>> Status: Active Update: 19-05-2023 https://echa.europa.eu/registration-dossier/-/registered-dossier/15565

>> Status: No longer Valid Update: 05-01-2010 https://echa.europa.eu/registration-dossier/-/registered-dossier/1416

>> Status: Cease Manufacture Update: 12-02-2013 https://echa.europa.eu/registration-dossier/-/registered-dossier/1747

>> Status: Active Update: 23-03-2018 https://echa.europa.eu/registration-dossier/-/registered-dossier/23027

New Zealand EPA Inventory of Chemical Status

>> Benzene, ethenyl-: HSNO Approval: HSR001221 Approved with controls

New Zealand EPA Inventory of Chemical Status

>> Benzene-d5, ethenyl-d3-: Does not have an individual approval but may be used under an appropriate group standard

New Zealand EPA Inventory of Chemical Status

>> Benzene, ethenyl-, homopolymer: Does not have an individual approval but may be used under an appropriate group standard

16. Other Information

Toxic Combustion Products:

Toxic products (e.g., gases and vapors) produced from the combustion of this chemical.

>> ... Toxic gases and vapors (such as carbon monoxide) may be released in a fire involving styrene. Styrene fumes are very acrid.

Other Safety Information

Chemical Assessment

>> IMAP assessments - Benzene, ethenyl-: Human health tier II assessment

Chemical Assessment

>> IMAP assessments - Benzene, ethenyl-, homopolymer: Environment tier I assessment

>> IMAP assessments - Benzene, ethenyl-, homopolymer: Human health tier I assessment

"The information provided is believed to be accurate but is not comprehensive and should be used as a reference. It reflects our current knowledge and is intended for safety guidance related to the product. This document does not constitute a warranty of the product's properties. Ionz is not responsible for any damages resulting from handling or contact with the product incorrectly."