Summary of Initial Risk Assessment Report

Styrene CAS No : 100-42-5

PRTR No of Japan: 177

This substance is assessed based on Guideline for Initial Risk Assessment Version 2.0

1. General Information

1.1 Physico-chemical properties

Appearance	Colorless or pale yellow liquid
Melting point	-30.6 degC
Boiling point	145-146 degC
Water solubility	310 mg/L (25 degC)
Henry's constant	279 Pa*m^3/mol ($2.75*10^{-3}$ atm*m^3/mol) (25degC, measured)
Octanol/water partition coefficient (log Kow)	2.95 (measured), 2.89 (estimated)
Soil adsorption coefficient	Koc = 270-550 (measured)

1.2 Environmental fate

Bioaccumulation	Low bioaccumulative Bioconcentration factor (BCF) : 13.5 (*carassius auratus*,measured) 37 (calculated using logKow of 2.95)
Biodegradation	Styrene is expected to be readily biodegradable in aerobic conditions. It is also expected to be biodegradable under anaerobic conditions, though the process is more slowly than under aerobic conditions.
Stability in the environment	(In air) Reaction with OH radical: Reaction rate constant is $5.8*10^{-11}$ cm^3/molecule-sec.(25 degC, measured) The half-life is 4-7 hours, given OH radical concentration of $5*10^5$-$1*10^6$ molecule/cm^3. Reaction with ozone: Reaction rate constant is $2.2*10^{-17}$ cm^3/molecule-sec.(25 degC, measured) The half-life is calculated to be 10 hours, given ozone concentration of $7*10^{11}$ molecule/cm^3. Reaction with nitrate radical: Reaction rate constant is $1.5*10^{-13}$ cm^3/molecule-sec. (25 degC, measured) The half-life is 0.6-6 hours, given nitrate radical concentration of $2.4*10^8$-$2.4*10^9$ molecule/cm^3 (10-100 ppt). (In water) Styrene is not expected to be hydrolyzed in water.
Environmental fate	When released to water, styrene is expected to be removed from water by volatilization and by biodegradation. Styrene bound to soil particles is expected to be transferred to sediments. Styrene may be removed by biodegradation under aerobic conditions.

2. Sources of release to the environment

2.1 Annual production, import, export and domestic supply in 2003 (ton/year)

Production	Import	Export	Domestic supply	Remarks
3,201,024	17,428	1,204,517	2,013,935	

2.2 Uses

Raw material: polystyrene resins (60.9%), ABS resins (13.9%), synthetic rubbers (7.5%), unsaturated polyester resins (3.8%), others (paint resins, ion exchange resins, raw material for cosmetics) (13.9%)

2.3 Release from the industries within the scope of PRTR system (in 2003)

Release sources		Air (ton)	Waters (ton)	Soil (ton)	Remarks
Listed industries	Reported release	3,802	4	5	Release to rivers: 0.6 ton
	Release outside notification	324	< 0.5	< 0.5	
Release outside notification from non listed industry		81	0	0	
Households		--	--	--	
Mobile sources		2,511	0	0	
Total		6,719	5	6	

2.4 Releases from other sources

It has been reported that if unreacted styrene monomers remain in products such as heat insulating materials or bath units, which are made of polystyrene resin or ABS resin, styrene may vaporize from those products to indoor air. Another possible release source of styrene is polystyrene food containers. The Food Sanitation Act in Japan established codes and standards for styrene monomer content in polystyrene food containers.

2.5 Main release route

Styrene is expected to be released to air mainly by plastic product manufacturing industries during production of synthetic resins and from exhaust from mobile sources. Styrene monomers may remain in polystyrene resins and ABS resins in which styrene is used as a raw material. Styrene may be released to indoor air from various products using those resins.

3. Exposure Assessment

3.1 Measured environmental concentration

Media	No. of points detected / No. of points measured	No. of samples detected / No. of samples measured	Detection range	95th percentile	Detection limit	Year of investigation, Institution
Air (microg/m^3) (indoor)	8/8	16/16	0.273-61.9	21	0.077	1999 Sendai City Institute of Public Health
River water (microg/L)	0/256	--	nd	--	0.1	1998 Ministry of Construction
Drinking water (microg/L)	0/42 (1999) 0/3 (2000) 0/4 (2001) 0/8 (2002)	-- -- -- --	nd nd nd nd	-- -- -- --	0.01	1999 - 2002 Japan Water Research Center
Food (microg/g)	1/9	1/45	nd-0.01	0.005	0.01	1997 Japan Food Research Laboratories

nd: Not detected

For calculation of the 95th percentile, data less than the detection limit are replaced with a value of one half of the detection limit.

3.2 Estimated environmental concentration

Media	Estimated concentration	Description
Air (microg/m^3)	4.4	-Calculated by mathematical model / Atmospheric Dispersion Model for Exposure and Risk Assessment ver.1.5 (AIST-ADMER) -Maximum of annual average concentration.
River water (microg/L)	0.40	Calculated by mathematical model / Initial Assessment System for the PRTR chemicals (IAS)

3.3 Estimated environmental concentration in water (EEC)

EEC(microg/L)	0.40
	Estimated river concentration was used for EEC since Styrene was not detected in any samples in the survey 1998.[1)]

3.4 Estimated human intake

Intake route		Concentration used for estimation of intake	Estimated intake (microg/ person/ day)	Estimated intake (microg/ kg-Bodyweight (BW)/ day)
Inhalation	Air	21 (microg/m^3)	420	8.4
		As a result of comparing measured concentration in indoor air and estimated concentration, the larger value (the ninety-fifth percentile (21 microg/m^3) of measured concentrations) was used[1)] for the risk assessment.		
Oral	Drinking water	0.005 (microg/L)	0.01	0.0002
		The value (0.005 microg/L) equal to 1/2 of the detection limit was used, since styrene was not detected in drikintg water in the measurements from 1999 to 2002.		
	Food	0.005 (microg/g)	10	0.2
		The ninety-fifth percentile (0.005 microg/g) of the survey by the Japan Food Research Laboratories in 1997 was used for the risk assessment.		
	Subtotal	--	10	0.20
Total route		--	430	8.6

1) This substance is assessed based on the Guideline for Initial Risk Assessment Version2.0. Under Version 2.0, a measured concentration and an estimated concentration (calculated by mathematical model) are compared and the larger of two concentrations is used for risk assessment.

4. Hazard assessment

4.1 Effects on organisms in the environment

	Acute or Chronic	Species	Endpoint	Concentration
Algae	Chronic	*Selenastrum capricornutum*	96 hours EC_{10} Growth inhibition (growth rate)	0.28 (mg/L)
Crustacea	Acute	*Daphnia magna*	48 hours EC_{50} Immobilization	4.7 (mg/L)
Fish	Acute	*Pimephales promelas*	96 hours LC_{50}	4.02 (mg/L)
Key study		The data of algae (*selenastrum capricornutum*) was chosen for the key study because effects were observed at the lowest concentration in the hazard assessment.		

4.2 Human health toxicity

Toxicity	Exposure route	Species	Duration / Dose method	Toxic effects (Key study is underlined)	NOAEL or LOAEL
Repeated dose toxicity	Inhalation	Rat	8 weeks	Enhanced nasal mucosal secretion, vacuolation, desquamation and nuclear condensation of tracheal mucosal epithelium	(respiratory system) LOAEL: 30 ppm (130 mg/m^3) (equivalent to 16 mg/kg/day)
		Rat	3 months	Effects on nervous system	(nervous system) NOAEL: 90 ppm (390 mg/m^3) (equivalent to 290 mg/kg/day)
	Oral	Rat	60 days	Decreased epididymal spermatozoa count, increased activities of testicular sorbitol dehydrogenase and acid phosphatase, decreased activities of lactate dehydrogenase, beta-glucuronidase, G-6P dehydrogenase, and gamma-GTP	NOAEL: 100 mg/kg/day (equivalent to 86 mg/kg/day)
	Dermal	--	--	--	--
Reproductive and developmental toxicity	Oral	Rat	2 years (3 generations) (drinking water)	Fertility, the number of offspring born, viability index, sex ratio and body weight of neonates	NOAEL: 250 ppm (equivalent to 21 mg/kg/day)
Carcinogenicity	Evaluation by IARC : Group 2B (possibly carcinogenic to humans)				
Genotoxicity	Considered to be genotoxic				

5. Risk Assessment

5.1 Environmental organisms

	EEC (microg/L)	NOEC * (mg/L)	MOE (NOEC * /EEC)	Product of uncertainty factors	Conclusion
Risk characterization	0.40	EC_{10}: 0.28	700	100	No immediate concern
	Product of uncertainty factors (UF): Extrapolation from laboratory test (10) * Toxicity data on one nutritional stage (10) = 100				
Recommendation : The substance is considered to be of no immediate concern for the moment, and a low priority for further work.					

NOEC* means NOEC, LOEC, EC_{50}, etc.

5.2 Human health

5.2.1 Repeated dose toxicity

Exposure route	Intake (microg/kgBW/day)	NOAEL (mg/kgBW/day)	Risk characterization		
			MOE	Product of uncertainty factors	Conclusion
Inhalation	8.4	(respiratory system) LOAEL: 16	1,900	10,000	Substance of concern
		(nervous system) 290	35,000	500	
Oral	0.20	86	430,000	1,000	No immediate concern
Total	--	--	--	--	--
Product of uncertainty factors (UF): Inhalation (respiratory system): Interspecies (10) * Intraspecies (10) * Using of LOAEL (10) * Duration of test (10) = 10,000 Inhalation (nervous system): Interspecies (10) * Intraspecies (10) * Duration of test (5) = 500 Oral: Interspecies (10) * Intraspecies (10) * Duration of test (10) = 1,000					

5.2.2 Reproductive and developmental toxicity

Since NOAEL of reproductive and developmental toxicity is larger than NOAEL of repeated dose toxicity, risk characterization of reproductive and developmental toxicity was not carried out.

5.2.3 Carcinogenicity

Risk characterization of carcinogenicity of the substance was not carried out in this assessment.

5.2.4. Recommendation for Human Health

The substance is considered to be of concern in terms of risk to human health. Further investigation, analysis and assessment are necessary.

Since styrene is expected to be emitted from indoor release sources, risk assessment methods for indoor exposures need to be examined. In addition, collecting data on exposures from building materials and consumer products is necessary.

6. Supplement

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