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STYRENE

Part I - Environment

CAS No: 100-42-5

EINECS No: 202-851-5

Summary Risk Assessment Report

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SUMMARY RISK ASSESSMENT REPORT

Final report, 2002

United Kingdom

This document has been prepared by the UK rapporteur on behalf of the European Union. The scientific work on the environmental part was prepared by the Building Research Establishment (BRE), by order of the rapporteur.

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Review of report by MS Technical Experts finalised:	**1999**
Final report:	**2002**

(The last full literature survey for the environmental part was carried out in 1995 - targeted searches for plant toxicity information were carried out subsequently in December 2001).

PREFACE

This report provides a summary, with conclusions, of the risk assessment report of the substance styrene that has been prepared by the United Kingdom in the context of Council Regulation (EEC) No. 793/93 on the evaluation and control of existing substances.

For detailed information on the risk assessment principles and procedures followed, the underlying data and the literature references the reader is referred to the comprehensive Final Risk Assessment Report (Final RAR) that can be obtained from the European Chemicals Bureau[1]. The Final RAR should be used for citation purposes rather than this present Summary Report.

[1] European Chemicals Bureau – Existing Chemicals – http://ecb.jrc.it

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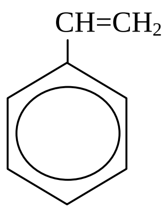
TABLES

1 GENERAL SUBSTANCE INFORMATION

1.1 IDENTIFICATION OF THE SUBSTANCE

CAS-No.:	100-42-5
EINECS-No.:	202-851-5
IUPAC name:	Styrene
Synonyms:	Cinnamene, ethenyl benzene, phenylethene, phenylethylene, vinyl benzene
Molecular formula:	C_8H_8
Molecular weight	104.15
Structure:	



1.2 PURITY, IMPURITIES AND ADDITIVES

The purity of the commercial product ranges from 99.7 to >99.9%. Impurities indicated by the manufacturers include ethylbenzene, cumene, xylenes and water. A polymerisation inhibitor may be added at <0.006 - 0.01% w/w.

1.3 PHYSICO-CHEMICAL PROPERTIES

Styrene is a liquid at room temperature. The commercial material is colourless to slightly yellow, volatile, with a sweet and pungent odour. Styrene polymerises at room temperature in the presence of oxygen, and oxidises in the presence of light and air. The physico-chemical properties of styrene are summarised in **Table 1.1**.

Table 1.1 Physico-chemical properties of styrene

Property	Value
Physical state	liquid
Boiling point (at 1 atmosphere)	145 - 146°C
Melting point	-30.6°C
Vapour pressure	5 mmHg (667 Pa) at 20°C
Water solubility	300 mg/l at 20°C
Octanol-water partition coefficient	3.02 (log value)
Density	0.906 g/cm^3 at 20°C
Vapour density (air = 1)	3.6
Flash point (closed cup)	31°C
Autoflammability	490°C
Conversion factors	1 mg/m^3 = 0.23 ppm: 1 ppm = 4.33 mg/m^3

Note: values are from individual determinations, with the exception of the octanol-water partition coefficient, which is the geometric mean of three separate valid determinations.

1.4 CLASSIFICATION

Styrene is classified as a dangerous substance within the meaning of Directive 67/548/EEC and is listed in Annex 1 of this directive, being assigned risk and safety phrases:

R10: Flammable
R20: Harmful by inhalation
R36/38: Irritating to eyes and skin
S2: Keep out of reach of children
S23: Do not breathe gas/fumes/vapour/spray.

The proposal based on the data in the risk assessment is that styrene should not be classified as dangerous to the environment. The Commission working group on the Classification and Labelling of Dangerous Substances at their meeting on 15-17 September 1999, agreed not to classify styrene for environmental effects.

2 GENERAL INFORMATION ON EXPOSURE

2.1 PRODUCTION

Nine companies produce or import styrene into the EU in quantities of over 1,000 tonnes per year. The total quantity of styrene used in the EU is estimated as 3,743,000 tonnes (for 1993). Styrene is produced from ethylbenzene by two routes, either direct dehydrogenation or via oxidation and reaction with propylene (this second process also produces propylene oxide).

2.2 USE

Styrene is largely processed in closed systems as a monomer in the chemical industry. It is used to make polystyrene (general purpose, GP-PS; high impact, HI; and expanded, EPS) and in copolymer systems (acrylonitrile-butadiene-styrene, ABS; styrene-acrylonitrile, SAN; methyl methacrylate-butadiene-styrene, MBS; and others) and in the production of styrene-butadiene rubber (SBR) and related latices (SB latex for example). It is also used as a component of unsaturated polyester (UPE) resins.

A breakdown of styrene usage is given in **Table 2.1**, together with descriptions of the areas in which the end products made from styrene are used.

Table 2.1 Breakdown of styrene usage in the EU

Use	Europe 1993		Industrial and consumer applications
	(tonnes)	%	
GP-, HI-PS	1,879,000	50.2	General packaging, furniture, electrical equipment (e.g. audio-visual cassettes), industrial mouldings (e.g. dental, medical)
EPS	696,000	18.6	Packaging, thermal insulation of refrigeration equipment and buildings
ABS/SAN	397,000	10.6	Interior and exterior automobile parts, drains, ventilation pipes, air conditioning, hobby equipment, casings etc.
SB latex	389,000	10.6	Tyres, radiators and heater hoses, belts and seals, wire insulation
SB rubber	209,000	5.6	Paper coatings, carpet backings, floor tile adhesives
UPE resin	172,000	4.6	Building panels, marine products, household consumer goods, trucks

3 ENVIRONMENT

3.1 EXPOSURE ASSESSMENT

3.1.1 Environmental releases

The assessment considers releases from the production of styrene based on specific information from the producers. It also considers releases from the production of polymers, latices and resins, and from the use of these materials to make products.

Emissions of residual styrene from products during their lifetime are also estimated, as are potential emissions from disposal. Two indirect sources of styrene, automobile exhausts and cigarettes, are also considered.

The estimated emissions on local, regional and continental scales are summarised in **Table 3.1**.

Table 3.1 Estimated emissions of styrene

Source	Local		Regional		Continental	
	Air	Water	Air	Water	Air	Water
Production	130	250	130	250	357	686
Polymers						
GP-, HI-PS	128	0.02	} 263	0.08	} 2,364	0.73
EPS	61	0.38		0.45		4.0
Copolymer ABS	38.3	0.23	} 40.5	} 0.25	} 364	} 2.3
Copolymer SAN	15.3	0.1				
UPE	24	0.59	34	0.84	310	7.6
SBR	41	0.25	} 61	} 0.38	} 549	} 3.4
SB latex	34	0.21				
Polymer processin						
PS (HI,GP)	0.11		13.2		118	
EPS	0.84		20.9		188	
ABS/SAN	0.04		5.6		50	
SB latex	0.05		8		72	
XSBR latex	0.17		29		262	
SB rubber	0.25		42		378	
UPE	78		1,376		12,384	
Plastics in use						
EPS			21		189	
Others			12		105	
Disposal						
Incineration			22.5		203	
Landfill			30	30	270	270
Others						
Exhausts			506		4,554	
Cigarettes			0.62		5.6	
TOTAL			2,615	282	22,722	974

3.1.2 Environmental fate

Styrene reacts readily in the atmosphere with hydroxyl radicals and with ozone, with an estimated half-life of 4 hours. It has a low potential for the generation of low-level ozone. Styrene is readily biodegradable under aerobic conditions. Due to its high vapour pressure and low to moderate solubility, volatilisation from water is likely to be an important distribution process. From its Kow value, styrene is predicted to be moderately mobile in soils. The Kow value also indicates a potential for bioaccumulation, but by analogy with substances such as toluene, xylene and ethylbenzene it does not appear likely that styrene will accumulate in aquatic organisms.

3.1.3 Environmental concentrations

Predicted environmental concentrations (PECs) have been calculated for specific production and/or processing sites. A generic calculation for production was also carried out; as the specific information covers 93% of production then this is considered to be more reliable than the generic calculations. For the various processing steps, a combination of some specific information and default values from the Technical Guidance Document (TGD) has been used to calculate the PECs. The methods from the TGD together with the EUSES program have been used. The resulting PECs are in **Table 3.2**.

Table 3.2 PECs for styrene

	Water (µg/l)	Sediment (µg/kg)	Air (µg/m^3)	Soil (µg/kg)
Site-specific (production and/or processing)	0.025-20	0.21-169	0.1-85	0.38-35.2
Generic production	12	99	99	26,300
Processing: GP-, HI-PS	0.23	1.95	97	8.4
EPS	4.6	38.7	47	43
ABS	2.9	24.3	29	27
SAN	1.2	10.1	12	11
SB rubber	3.1	26.0	31	29
SB latex	2.5	21.1	26	24
UPE resin production	7.1	60.2	18	63
UPE resin use			59	4.2
Regional	0.052	0.37	0.03	0.002

Note: PECs for processing of polymers etc not shown (for air, all below 1 µg/m^3, for soil all below 0.1 µg/kg, for water and sediment same as for regional). Generic production values included for information only, not used in risk characterisation.

3.2 EFFECTS ASSESSMENT

Styrene is volatile and there are therefore difficulties in maintaining exposure concentrations in aqueous tests. The reports of the available tests have been examined carefully, with preference given to flow through studies, studies where concentrations were monitored and studies where precautions were taken to minimise volatilisation. The results for aquatic toxicity considered valid are in **Table 3.3**.

Table 3.3 Aquatic toxicity of styrene

Species	Test type/duration	Test result (mg/l)
Fathead minnow *Pimephales promelas* (fish)	96 hr LC_{50} 96 hr LC_{50}	4.02 10
Water flea *Daphnia magna* (invertebrate)	48 hr EC_{50}	4.7
Amphipod *Hyalella azteca* (invertebrate)	96 hr LC_{50}	9.5
Selenastrum capricornutum (algae)	72 hr EC_{50}	4.9

The values of the $L(E)C_{50}$ for all species are very similar. They include data for a further species in addition to the base set requirements. Values predicted from the octanol-water partition coefficient on the basis of a non-polar narcosis mechanism also agree well with the measured values. Therefore an assessment factor of 100 is applied to the lowest LC_{50}, to give a PNEC of 40 µg/l.

There is no information available on the toxicity of styrene to sediment organisms, so the equilibrium partitioning method has been used to estimate a PNEC of 340 mg/kg in sediment. A PNEC for microorganisms in WWTPs of 5 mg/l is derived from a test on activated sludge. One study on the toxicity of styrene to earthworms is available, but this is not sufficient to allow a PNEC to be derived. Instead the equilibrium partitioning method is used to give a PNEC for soil of 255 mg/kg. There are no data on effects of styrene on organisms in the environment through the air. Consideration of analogous substances such as toluene indicates that effects on plants through the air would only be expected at very high concentrations of styrene in air, and a value of 60 mg/m^3 is taken as indicative of the level below which effects are not expected.

3.3 RISK CHARACTERISATION

The risk characterisation involves the comparison of the estimated concentrations (PECs) with the PNEC values. For the aquatic compartment none of the generic scenarios lead to PEC/PNEC ratios greater than 1, and all of the ratios estimated for specific sites are less than 1. The conclusion for the aquatic compartment is therefore no concern.

The PEC/PNEC ratios for microorganisms in wastewater treatment plants are less than 1 for all specific sites having such plants, and for the generic scenarios with the exception of the generic production site. This corresponds to the largest size of styrene production site, discharging its effluent to a default wastewater treatment plant of 2,000 m^3/day volume. The production sites which provided specific information cover 93% of styrene production in the EU and are considered to provide a more realistic estimate of the levels of styrene in wastewater treatment plants receiving production waste. Therefore the conclusion for microorganisms in WWTPs is for no concern.

For the terrestrial compartment, only the generic scenario for production gives a PEC/PNEC ratio greater than 1. This is due to the assumption of a large site discharging to a standard size WWTP, which produces a very large concentration in the waste sludge and hence in soil. The available site-specific information covers 93% of styrene production sites and these are considered more representative. Therefore the conclusion is that there is no need for any further information or testing.

The levels of styrene in the atmosphere are expected to be low, with the possible exception of the vicinity of major sites. The highest estimated concentration in air is 97 $\mu g/m^3$, which is nearly three orders of magnitude below the indicative effect level estimated from analogous substances. Styrene reacts rapidly with hydroxyl radicals and ozone in the atmosphere. It has a low photochemical ozone creation potential, and so is not expected to contribute to low-level photochemical air pollution.

Conclusion (ii) There is at present no need for further information and/or testing and for risk reduction measures beyond those which are being applied already.

This conclusion applies to all steps in the production and use of styrene and the use of styrene-containing products.

4 HUMAN HEALTH

(This section will be added later)

5 RESULTS

5.1 INTRODUCTION

Styrene is produced or imported by nine companies in the EU, with an estimated usage of 3,743,000 tonnes in Europe in 1993. It is used mainly as a monomer in a range of polymers and synthetic rubbers; it is also used in unsaturated polyester resins for reinforced plastics.

5.2 ENVIRONMENT

The environmental risk characterisation considers the production of styrene and its use as a monomer in the production of polymers and synthetic rubbers. It also includes the processing of polymers and rubbers into products, and releases of residual monomer from products in use and on disposal. The formulation and use of UPE resins is considered. Calculations for specific sites are included as well as generic assessments.

For the aquatic compartment, including sediment, the PEC/PNEC ratios for all sites and generic scenarios are less than one. The ratios for microorganisms in wastewater treatment plants and for the terrestrial environment are all less than one with the exception of a generic assessment for production; the site-specific calculations for production are considered to be more representative. Styrene is not expected to contribute to low-level ozone formation.

<u>Result</u>

Conclusion (ii) There is at present no need for further information and/or testing and for risk reduction measures beyond those which are being applied already.

This conclusion applies to all steps in the production and use of styrene and the use of styrene-containing products, for the aquatic compartment (including sediment), to microorganisms in wastewater treatment plants, to the terrestrial compartment and to the air compartment. No assessment of secondary poisoning for predators via the food chain has been carried out.