5. PRODUCTION, IMPORT/EXPORT, USE, AND DISPOSAL

5.1 PRODUCTION

In the United States, styrene is produced principally by the catalytic dehydrogenation of ethylbenzene. Hence, ethylbenzene is a common contaminant. Styrene is also produced by oxidation of ethylbenzene to ethylbenzene hydroperoxide, which is then reacted with propylene to produce propylene oxide and α-methylphenyl carbinol. The carbinol is then further dehydrated to produce styrene (Dickson et al. 1973; HSDB 2007; IARC 1979). The first route of manufacture (dehydrogenation of ethylbenzene) represents 90% of styrene production. The other described method is the second most commonly used route of styrene synthesis. Other methods of styrene production are rarely used.

Styrene has been manufactured in the United States since 1938, with production increasing dramatically over the last 30 years. Since 1977, U.S. total styrene production has more than doubled. Production increased 16% in the decade between 1977 and 1987, but production increased >32% between 1987 and 1999, and rose again by another 28% between the years 1999 and 2006 (HSDB 2007; SRI 2006). Specifically, U.S. production of styrene in 1978 was 6.8 billion pounds, and then in 1987, production was approximately 8 billion pounds (USITC 1987, 1988). In 1999, U.S. styrene production was over 10 billion pounds, and in 2006, the United States produced >13 billion pounds (HSDB 2007; SRI 2006).

Information regarding the locations of the numerous styrene production facilities and the amounts of styrene that may be present on-site is presented in Table 5-1. Current domestic producers of styrene include Chevron Phillips Chemical Company LP (Aromatics and Styrenics Business Unit), St. James, Louisiana; Cos-Mar Company, Carville, Louisiana; the Dow Chemical Company, Freeport, Texas; INEOS Americas, LLC, Texas City, Texas; Lyondell Chemical Company, Channelview, Texas; NOVA Chemicals Corp, Bayport, Texas; Sterling Chemicals, Inc., Texas City, Texas; and Westlake Styrene Corporation, Sulphur, Louisiana (SRI 2006). The production of styrene at these facilities is directed primarily for captive processes (on-site conversion to other materials) or for merchant sales to other entities (these include export). The information presented in Table 5-1 reflects the locations of these production plants, where it can be noted that the greatest production capacity occurs primarily in Texas and Louisiana.

Table 5-1. Facilities that Produce, Process, or Use Styrene

State[a]	Number of facilities	Minimum amount on site in pounds[b]	Maximum amount on site in pounds[b]	Activities and uses[c]
AL	84	0	49,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
AR	57	100	49,999,999	1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14
AZ	54	0	999,999	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12
CA	186	0	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
CO	24	100	9,999,999	2, 3, 6, 7, 8, 9, 11, 12, 13
CT	24	0	49,999,999	3, 5, 6, 7, 8, 9, 11, 12
DE	21	100	999,999	1, 2, 3, 4, 6, 7, 8, 11, 12, 14
FL	160	0	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
GA	100	0	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
GU	1	100	999	9
HI	3	100	9,999	2, 3, 6, 7, 8, 10, 11
IA	48	0	49,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
ID	15	0	99,999	1, 2, 3, 6, 7, 8, 11, 12
IL	106	0	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
IN	163	0	99,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
KS	52	0	99,999,999	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
KY	66	0	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
LA	119	0	10,000,000,000	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
MA	34	0	499,999,999	2, 3, 4, 6, 7, 8, 9, 12, 13
MD	39	100	9,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
ME	15	100	99,999	2, 3, 6, 7, 8, 10
MI	99	0	99,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
MN	72	100	9,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
MO	81	0	49,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
MS	45	0	99,999,999	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12
MT	9	100	9,999,999	3, 6, 7, 8, 9, 10, 13
NC	110	0	49,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
ND	17	1,000	499,999,999	2, 3, 6, 7, 8, 9, 10, 11, 13
NE	38	0	999,999	1, 2, 3, 6, 7, 8, 10, 11, 12, 13
NH	26	100	499,999,999	2, 3, 5, 6, 7, 8, 10, 11, 12
NJ	52	100	99,999,999	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
NM	19	100	49,999,999	1, 2, 3, 6, 7, 8, 9, 11, 12
NV	11	1,000	99,999,999	2, 3, 6, 7, 8, 10, 11
NY	56	0	49,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
OH	198	0	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
OK	55	100	49,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
OR	55	100	49,999,999	1, 2, 3, 6, 7, 8, 9, 10, 11, 12
PA	123	0	99,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
PR	29	0	9,999,999	1, 2, 3, 6, 7, 8, 10, 11, 12

Table 5-1. Facilities that Produce, Process, or Use Styrene

State[a]	Number of facilities	Minimum amount on site in pounds[b]	Maximum amount on site in pounds[b]	Activities and uses[c]
RI	29	100	999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
SC	84	100	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14
SD	7	1,000	99,999	1, 2, 3, 6, 7, 8, 11
TN	103	0	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
TX	259	0	10,000,000,000	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
UT	42	0	99,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
VA	63	0	49,999,999	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12
VT	5	1,000	99,999	6, 7, 8
WA	89	0	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
WI	92	0	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14
WV	40	100	999,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
WY	2	1,000	9,999	6, 8, 9

[a]Post office state abbreviations used
[b]Amounts on site reported by facilities in each state
[c]Activities/Uses:

1. Produce
2. Import
3. Onsite use/processing
4. Sale/Distribution
5. Byproduct
6. Impurity
7. Reactant
8. Formulation Component
9. Article Component
10. Repackaging
11. Chemical Processing Aid
12. Manufacturing Aid
13. Ancillary/Other Uses
14. Process Impurity

Source: TRI05 2007 (Data are from 2005)

5.2 IMPORT/EXPORT

Imports of styrene have generally been <1% of U.S. domestic production volumes, with imported styrene amounts decreasing over the last decades, and exported amounts increasing during the same time period. Styrene imports were reported to be 26.4 million pounds for 1976, 320 million pounds in 1986 (Dickson et al. 1973; IARC 1979), but only 1 million pounds in 1999 (HSDB 2007). These trends indicate a higher capacity for domestic producers to meet industry needs. Styrene exports were <1 billion pounds in 1978, but had exceeded 1 billion pounds by 1983. Exports have slowly increased such that recent export data indicate that the U.S. exports >2 billion pounds of styrene annually (HSDB 2007), also indicating that domestic production is more than capable to serve domestic needs.

5.3 USE

Styrene is used predominantly (65% of total product) in the production of polystyrene plastics and resins (James and Castor 2005). In addition, fiberglass products used for boats are also made from polyester resins dissolved in styrene. Styrene is also used as an intermediate in the synthesis of materials used for ion exchange resins and to produce copolymers such as styrene-acrylonitrile (SAN) and acrylonitrile-butadiene-styrene (ABS), both representing approximately 9% of styrene use, and styrene-butadiene rubber (SBR), representing approximately 6% of styrene use. SBR is used for such products as car tires, hoses used for industrial applications, and shoes. A related polymer, styrene-butadiene latex (approximately 7%), is used in making carpet, coatings for paper, and as part of latex paints. SAN and ABS are used for materials such as piping, automotive components, refrigerator liners, plastic drinking glasses, and car battery enclosures. An additional 7% of styrene is formulated with unsaturated polyester resins in such things as boat hulls (fiberglass reinforcement materials). The remaining amounts of styrene produced are used for several types of applications, including less common thermoplastics and even for laboratory and water purification uses (ion-exchange resins) and glues and adhesives (James and Castor 2005). Styrene copolymers are also frequently used in liquid toner for photocopiers and printers (HSDB 2007).

The Food and Drug Administration (FDA) permits styrene to be used as a direct additive for synthetic flavoring and an indirect additive in polyester resins, ion-exchange membranes, and in rubber articles (5% by weight maximum) intended for use with foods (HSDB 2007; IARC 1979; NIOSH 1983).

5.4 DISPOSAL

Typical means of styrene disposal include absorption on vermiculite or similar material, followed by disposal in an EPA-permitted landfill. Incineration is also a useful disposal method, but this must be carefully controlled since pure styrene is highly flammable (HSDB 2007). No data were located regarding the quantities of styrene disposed by these means on a national level, but the state of Massachusetts reported that most styrene disposal occurred via incineration (95.5%), followed by smaller amounts being disposed of in landfills (0.5%), a slightly greater amount being subjected to solvent recovery (0.7%), and slightly more being transferred to waste/energy brokers (3.3%) (Keenan and Harriman 1993). The total amounts represented were ~250,000 pounds. Whether the data reported for Massachusetts are representative of the proportions disposed of by these means in other states is not known.