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

5.1 PRODUCTION

1,3-Butadiene was discovered in the nineteenth century and its use in the development of rubber-like polymers was explored during the early 1900s (Grub and Loser 2005; Sun and Wristers 2002). Large volume production of 1,3-butadiene in the United States began during World War II as a result of the nation's synthetic rubber program (American Chemical Society 2007; Dolnick and Potash 1948). U.S. production rose to 2.7 billion pounds in 1965 as new plants were started to meet the increasing butadiene-rubber demand of the auto industry (Chemical Market Reporter 2006; Grub and Loser 2005; Kirshenbaum 1978). Production reached 3.7 billion pounds (1,674 metric tons) by 1974 and then fluctuated through the 1980s as a response to market pressures (Grub and Loser 2005; Kirshenbaum 1978; Sun and Wristers 2002). Production growth resumed during the 1990s, reaching 4.5 billion pounds (2,020 metric tons) in 1998 (Grub and Loser 2005). Actual production volumes of 1,3-butadiene manufactured in the United States during more recent years are not available; however, the annual U.S. production capacity was reported to be 6 billion pounds (2,800 metric tons) during 2008 (Chemical Week 2008; SRI 2008).

The 1,3-butadiene market is heavily dependent on the synthetic rubber demand of the auto industry, which accounts for approximately 60% of the total consumption of this substance (Chemical Market Reporter 2006). Also, since most 1,3-butadiene is produced through steam cracking, the supply of this chemical has been largely influenced by the demand for ethylene, the primary product from steam cracking (Sun and Wristers 2002).

The companies that produced 1,3-butadiene in the United States, their production sites, and their annual capacities during 2008 (the most recent year for which figures are available) are shown in Table 5-1 (SRI 2008). Table 5-2 summarizes the number of facilities in each state that manufactured or processed 1,3-butadiene in 2007, the ranges of maximum amounts on site, if reported, and the activities and uses as reported in the Toxics Release Inventory (TRI) (TRI09 2011). The data listed in this table should be used with caution since only certain types of facilities are required to report. This is not an exhaustive list.

Except for a small amount of 1,3-butadiene produced by the oxydehydrogenation of n-butene, all the 1,3-butadiene produced in the United States is a co-product of ethylene manufacture (Chemical Market Reporter 2006; Sun and Wristers 2002). In this process, feed streams ranging from light hydrocarbons to heavy gas oils are cracked in the presence of steam at 700–900 °C (Grub and Loser 2005; Kirshenbaum

Table 5-1. Companies that Produce 1,3-Butadiene in the United States and Annual Capacities During 2008

Company	Location	Capacity (million pounds/year)	Capacity (metric tons)
Equistar Chemicals, LP	Alvin, Texas	150	68,060
	Channelview, Texas	865	392,500
	Corpus Christi, Texas	200	90,740
ExxonMobil Chemical Company	Baton Rouge, Louisiana	385	
	Baytown, Texas	325	147,500
INEOS Americas, LLC			
INEOS Olefins & Polymers USA	Alvin, Texas	235	106,600
Sabina Petrochemicals LLC	Port Arthur, Texas	900	
Shell Chemical LP	Deer Park, Texas	360	163,300
	Norco, Louisiana	575	260,900
Texas Petrochemicals, Inc.	Houston, Texas	1,080	490,000
	Port Neches, Texas	925	419,700
Total		6,000	2,722,000

Source: SRI 2008

Table 5-2. Facilities that Produce, Process, or Use 1,3-Butadiene

State[a]	Number of facilities	Minimum amount on site in pounds[b]	Maximum amount on site in pounds[b]	Activities and uses[c]
AL	8	0	9,999,999	1, 3, 5, 6, 8, 13, 14
AR	6	1,000	999,999	1, 2, 3, 6, 9, 12
AZ	1	10,000	99,999	9
CA	73	0	999,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14
CO	13	0	9,999,999	1, 3, 5, 6, 8, 12, 13
CT	3	1,000,000	9,999,999	2, 3, 6
DE	11	1,000	9,999,999	1, 2, 3, 5, 6, 7, 9, 12, 13
GA	4	100,000	9,999,999	1, 5, 6
HI	7	1,000	99,999	1, 3, 5, 6, 13, 14
IA	5	100,000	9,999,999	1, 3, 4, 5, 6
IL	39	0	49,999,999	1, 2, 3, 5, 6, 7, 8, 9, 11, 12, 13, 14
IN	24	0	9,999,999	1, 3, 4, 5, 6, 7, 8, 12, 13, 14
KS	11	0	499,999,999	1, 3, 6, 10, 13
KY	16	10,000	9,999,999	1, 3, 4, 5, 6, 7, 9, 12, 13
LA	106	0	10,000,000,000	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14
MI	28	0	49,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13
MN	10	0	9,999,999	1, 2, 3, 5, 6, 7, 12, 13
MO	6	0	9,999	1, 5, 7, 12, 14
MS	12	1,000	499,999,999	1, 2, 3, 4, 5, 6, 7, 9, 13, 14
MT	19	100	999,999	1, 3, 5, 6, 8, 12, 13, 14
NC	9	0	49,999,999	2, 3, 6, 7, 8, 10
ND	4	0	9,999	1, 2, 3, 4, 6
NE	2	0	9,999	3, 8, 11, 12
NH	1	1,000	9,999	6
NJ	16	0	99,999	1, 3, 4, 5, 6, 7, 12, 13
NM	2	0	9,999	1, 3, 5, 7, 11
NY	7	10,000	999,999	2, 3, 4, 6, 8, 11
OH	33	0	49,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 12, 13, 14
OK	21	0	9,999,999	1, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13
PA	20	0	9,999,999	1, 2, 3, 5, 6, 7, 8, 12, 13, 14
PR	1	10,000,000	49,999,999	1, 5, 7
SC	3	0	99,999	1, 5, 6, 13, 14
TN	21	0	9,999,999	1, 2, 3, 5, 6, 7, 8, 9, 10, 12, 13, 14
TX	234	0	10,000,000,000	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
UT	15	100	999,999	1, 3, 4, 5, 6, 7, 8, 9, 12
VA	7	0	9,999	1, 3, 4, 5, 6, 13
VI	5	100	99,999	1, 2, 3, 6, 13
WA	27	0	9,999,999	1, 2, 3, 4, 5, 6, 7, 11, 12, 13, 14

Table 5-2. Facilities that Produce, Process, or Use 1,3-Butadiene

State[a]	Number of facilities	Minimum amount on site in pounds[b]	Maximum amount on site in pounds[b]	Activities and uses[c]
WI	2	100,000	9,999,999	6
WV	10	0	99,999,999	1, 5, 6, 7, 8, 12
WY	5	0	99,999	1, 3, 4, 6

[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: TRI09 2011 (Data are from 2009)

1978; Sun and Wristers 2002). The fraction of 1,3-butadiene produced by this process varies widely with the type of feedstock used and is lowest with low-boiling input streams (Grub and Loser 2005; Kirshenbaum 1978).

Purification of the crude C4 stream resulting from the steam cracking process cannot be achieved by a simple distillation due to the close boiling point of the various products and the fact that 1,3-butadiene forms an azeotrope with butane (Grub and Loser 2005; Kirshenbaum 1978). 1,3-Butadiene can be removed from the hydrocarbon stream by liquid-liquid extraction or extractive distillation. The selective solvents used in these processes include aqueous cupric ammonium acetate, acetonitrile, furfural, dimethylformamide, N,N-dimethylacetamide, and N-methylpyrrolidinone (Grub and Loser 2005; Sun and Wristers 2002).

The oxidative dehydrogenation of n-butene, used in the production of 1,3-butadiene, is a highly selective, irreversible process that involves heating the starting material, air, and a suitable catalyst together at 400–450 °C (Grub and Loser 2005; Kirshenbaum 1978; Sun and Wristers 2002). The hydrogen released in the dehydrogenation step combines with oxygen, producing large amounts of heat, which makes this process energy-efficient (Grub and Loser 2005; Kirshenbaum 1978; Sun and Wristers 2002). As indicated above, oxidative dehydrogenation of n-butene has not been competitive with the steam cracking process for manufacture of 1,3-butadiene (Chemical Market Reporter 2006; Grub and Loser 2005). Rather, this method has been used on a campaign basis when there is a large enough differential between feedstock and 1,3-butadiene prices (Grub and Loser 2005).

5.2 IMPORT/EXPORT

Large amounts of 1,3-butadiene are imported into the United States as consumption typically exceeds production (Chemical Market Reporter 2006; Chemical Week 2008; Sun and Wristers 2002). U.S. imports of 1,3-butadiene in 2005 were approximately 600 million pounds (Chemical Market Reporter 2006). More recent import data are not available. U.S. Exports of 1,3-butadiene are considered to be negligible (Chemical Market Reporter 2006).

5.3 USE

1,3-Butadiene is used as a monomer in the production of rubber and plastics; approximately 60% of the 1,3-butadiene consumed in the United States is used in the production of synthetic rubbers (Chemical Market Reporter 2006). 1,3-Butadiene uses can be broken down into the following categories: synthetic rubber, 61% (styrene butadiene rubber [SBR], 30%; polybutadiene elastomer, 25%; polychloroprene elastomer, 4%; nitrile elastomer, 2%) adiponitrile/hexamethylene diamine (HMDA), 11%; styrene-butadiene latex, 12%; ABS resins, 5%; and other uses, 11% (Chemical Market Reporter 2006). Automobile tires are the major end-use product (Chemical Market Reporter 2006). Both styrene butadiene rubber and polybutadiene are used heavily for this purpose. 1,3-Butadiene is also used for other automotive applications such as high-impact polystyrene and ABS resin plastics (Chemical Market Reporter 2006). 1,3-Butadiene is a precursor in the production of adiponitrile (used to make nylon) and chloroprene (used to make neoprene) (Chemical Market Reporter 2006).

5.4 DISPOSAL

The recommended method of disposal of 1,3-butadiene is by incineration within a suitable combustion chamber or in a safe area (HSDB 2009). Gaseous 1,3-butadiene can be burned directly; however, liquefied 1,3-butadiene (in a compressed cylinder) must be atomized before burning (HSDB 2009). Kennedy et al. (2009) report that burning off 1,3-butadiene, also referred to as flaring, is commonly practiced at facilities where excess amounts of this substance need to be destroyed (Kennedy et al. 2009).