

## 4. PRODUCTION, IMPORT/EXPORT, USE, AND DISPOSAL

### 4.1 PRODUCTION

Isocyanates are produced almost exclusively by the reaction of amines with phosgene ( $\text{COCl}_2$ ), with the specific reaction conditions varying particularly for aromatic and aliphatic isocyanates (Chadwick and Cleveland 1981; Codd et al. 1972; Ulrich 1989). Aliphatic diisocyanates are produced by reaction of phosgene with either a slurry of the carbamate salts obtained in the reaction of the aliphatic diamines with carbon dioxide, or with a slurry of the amine hydrochloride (Ulrich 1989). Hexamethylene diisocyanate (HDI) is produced by the reaction of phosgene with the amine salt (Chadwick and Cleveland 1981). The trimeric HDI biuret (HDI-BT), which has a low monomer content and is widely used in the formulation of exceptionally high quality polymer coatings, is produced by controlled reaction of HDI with water, a water generator, or an amine (Chadwick and Cleveland 1981).

Current U.S. producers of HDI are Arco Chemical Company, Lake Charles, Louisiana and Bayer Corporation, Baytown, Texas (formerly, Mobay Corporation and Miles Incorporated) (Chemical Manufacturers Association 1997). Data on U.S. production volumes of HDI could not be located in the available literature.

No information is available in the Toxics Release Inventory database for facilities that produce HDI because this compound is not included under SARA, Title III and, therefore, is not among the chemicals that facilities are required to report (EPA 1995).

### 4.2 IMPORT/EXPORT

Rhone-Poulenc, Inc. imports HDI (Chemical Manufacturers Association 1997); however, no information on import volume was found in the available literature. No information on export volumes of HDI was found in the available literature.

### 4.3 USE

HDI is one of the most commercially important isocyanate compounds currently used in the United States, HDI, toluene diisocyanate (TDI) and 4,4'-diphenylmethane diisocyanate (MDI) are widely used in the

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production of polyurethane foams, elastomers, and coatings, which account for more than 90% of the commercial use of isocyanates (Kennedy and Brown 1992). Specific products include plastics, synthetic rubber, adhesives and glues, cable and wire insulations, anti-corrosive agents, varnishes, lacquers, and paints (Codd et al. 1972; Parmeggiani 1983; Plunkett 1987). One of the primary uses of HDI is as a polymerizing agent in polyurethane spray paint formulations (Butcher et al. 1993) and in other light-stable polyurethane coatings (Ulich 1989). Other uses of HDI are as solid rocket fuel binder or as paint thickener (Chemical Manufacturers Association 1997). Because of the potentially high exposures to HDI resulting from its high vapor pressure (see Table 3-3), a prepolymeric form of HDI, which has a much lower vapor pressure, is finding increasing use in industrial applications (Chadwick and Cleveland 1981; Dalene et al. 1994a). For example, HDI-biuret (HDI-BT), a trimeric condensation product of HDI, is widely used as a hardener in automobile and airplane paints. Automobile paint hardeners typically contain 0.5-1.0% monomeric HDI (Alexandersson et al. 1987). Consequently, use of these spray paints is one of the most significant sources of exposure to monomeric HDI and its prepolymers (e.g., HDI-BT) (Butcher et al. 1993).

#### 4.4 DISPOSAL

There are no regulations specifically governing the treatment and disposal of wastes containing HDI. Toluene diisocyanate is, however, regulated under the Resource Conservation and Recovery Act (RCRA) (EPA 1989). The recommended technology-based standards for treatment of waste containing TDI are carbon adsorption or incineration for waste waters, and fuel substitution or incineration for non-waste waters (EPA 1989). Toxic fumes of nitrogen oxides are emitted when HDI is heated to decomposition (Lewis 1992). Because oxides of nitrogen are criteria pollutants, the potential for their release to the atmosphere must be controlled during heating or incineration of HDI or waste containing HDI. Bicarbonate-catalyzed hydrolysis of HDI to 1,6-hexamethylene diamine (HDA) has been suggested as a possible treatment method in scrubbers used to purify HDI-contaminated atmospheres (Berode et al. 1991). No data were found in the available literature on the amount of HDI disposed of in the United States.