

Chemical Products Synopsis (CPS)

by Mannsville Chemical Products

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CHEMICAL PRODUCTS SYNOPSIS is an on-going reporting service which provides accurate, in-depth, cost effective commercial research on 220 individual chemical commodities (see reverse side for a detailed list of chemical products covered). The unique format of these SYNOPSIS reports puts the detailed and useful market information you need at your finger tips in a convenient, easy to use format. Each report is a 1,800+ word, two-page market overview, providing clear, concise, useful market information.

Each SYNOPSIS provides information on a particular chemical, focusing on US markets (which are mostly similar to world markets). Each report has the following sections:

- Focus** (brief overview)
- Availability** (producer/site capacity for most products)
- Outlook**
- End uses**
- Pricing**
- Manufacturing** (description of technology/process)
- Supply & demand**
- Environmental aspects**

The information contained in the CHEMICAL PRODUCTS SYNOPSIS reports is obtained from a wide range of resources including interviews with producers and other industry participants, government and trade association reports and studies, other published information sources, and analysis of overall business and economic trends.

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Chemical Products Synopsis

August 2006
Previous Report - March 2003

A Reporting Service of:
Mannsville Chemical Products
Spring, TX

EPOXY RESINS

FOCUS. Epoxy resins are a family of high performance synthetic thermoset polymers. Most epoxy resins are made from bisphenol A (BPA) and epichlorohydrin. Liquid epoxy resins are the foundation of the industry since most epoxy resins are initially produced as liquid and can then be modified into solid epoxy resins or solutions through the addition of incremental BPA or solvents. In the US, only three companies produce unmodified liquid epoxy resins, but many companies produce and market modified epoxies made from purchased unmodified liquid resin. Epoxy resins are generally combined with other chemical additives to create inert, chemically stable, or "cured" products. Once cured, epoxy resins have attractive attributes such as outstanding adhesion, corrosion and chemicals resistance, high strength and toughness, temperature stability, electrical insulation and easy processability. Epoxy resins are used in coatings, electrical and electronic applications including printed circuit boards, construction, adhesives, and composites for use in a variety of industries. The protective coating industry consumes over 50% of annual US epoxy demand.

Demand for epoxy resins is highly influenced by overall economic conditions. Typically, epoxy resin demand growth has slightly exceeded GDP growth. In the US, epoxy resin demand growth has been unsteady since demand reached a peak in 2000. The economic recession in 2001 resulted in a sharp reduction in epoxy demand and the market has not yet been able to return to the 2000 level, although US sales and captive use approached this level in 2004, aided in part by a 20% increase in export volumes. In 2003, the epoxy resin market experienced a difficult year. Demand was down, in large part due to weak industrial production and weak business investment, and margins faced severe pressure from rising raw material and energy costs. Traditionally high growth markets including powder coatings, electrical laminating, and industrial maintenance markets remained depressed. Demand improved considerably in 2004, with US sales and captive use rising by 12%, as US economic growth accelerated. As demand improved, price increases were also implemented to improve the profitability of the business. In 2004, all major applications continued to grow. Demand reportedly remained relatively healthy in 2005, although apparent US consumption is believed to have declined somewhat after the large jump in 2004. Lower sales volumes of basic epoxy resins in the coatings, construction, and adhesives markets, as well as reduced volumes of electronic laminates products, were reported in 2005.

OUTLOOK. Assuming continued steady economic growth, US epoxy resin demand growth is forecast to be in the range of 3% per year over the next several years. With principal end use markets in building and construction, transportation, machinery, and electrical and electronics markets, demand will remain highly dependent on general economic growth.

Globally, epoxy resin demand growth has been projected at 4.6% per year, fueled by strong growth in Asia, particularly China. Overall growth in the range of 1.5 times GDP growth will be driven by above average growth in electronics and electrical laminates, composites where growth will be spurred by material substitution and increased use in the energy sector, and in the flooring and aggregates market. The largest market, the protective coatings segment, is expected to show growth at or slightly above GDP levels.

PRICING. Prices for unmodified liquid epoxy resins are influenced by typical supply/demand factors and raw material cost pressures (benzene for bisphenol A and propylene and chlorine for epichlorohydrin). Actual sales values are negotiated, but actual pricing data for merchant sales are not available. There are a wide variety of modified and specialty epoxy products with differing price levels, some as high as \$3.00/pound or more for specialty resins.

Although precise market prices are not available, prices have been on the upswing for several years. While higher raw material values have been the principal force behind increases, a tightened market balance and the need to improve margins for future reinvestment in the epoxy chain have also supported higher prices. Because of volatile feedstock costs, producers have moved away from quarterly price protection mechanisms. Little relief is expected in feedstock costs, and further price increase attempts will likely be made in 2006/2007.

TRADE LIST	AVERAGE PRICE RANGE - EPOXY RESIN (Unmodified) LIQUID											
	Dollars Per Pound Bulk Tanker Delivered											
	1980	1985	1990	1995	2000	2001	2002	2003	2004	2005	2006	2008
	1.07	1.31	1.31	1.41	1.41	1.41	1.40	1.40	1.40	1.60E	1.80E	1.90

List prices are year end published prices. Current list prices are in the range of \$1.40 - \$1.90 per pound. The published list price has not changed for several years. Actual sales values are negotiated.

SUPPLY AND DEMAND - Millions of Pounds...Estimated...Domestic US

	HISTORICAL											PROJECTED	
	1980	1985	1990	1995	2000	2001	2002	2003	2004	2005	2006	2008	
Production	315	400	430	603	611	656	576	645	615E				
Imports	6	12	18	41	133	104	107	97	103	116			
Exports	35	42	84	158	150	158	159	171	208	210E			
Demand	386	355	433	815	876	537	573	504	542	521E			
Sales/Captive Use	454	620	669	597	620	637	658	na			540	575	

Production, export, and sales & captive use data through 1998 are from Society of the Plastics Industry reports. Data since 1999 are from reports of the APC Plastics Industry Producers' Statistics Group, as compiled by Association Survey Resource, LLC. Sales and captive use data include export sales. Imports are from Census Bureau reports. Census Bureau export figures are believed to include large volumes of modified resin and are therefore considered overstated.

AVAILABILITY. The US and global epoxy resin markets have been characterized as balanced with periods of tightness in recent years. A variety of factors have caused this situation including improved demand, limited investment in new capacity, and tightness in the supply of the raw materials epichlorohydrin and particularly bisphenol A. A balanced to tight market is expected to persist for the next few years unless demand falters. Raw material (bisphenol A) markets are also expected to remain tight which could affect epoxy resin markets. Additionally, short term shortages may develop if demand spikes upward because producers have reportedly been attempting to limit inventory levels for economic reasons. With above average growth forecast for China, Asia will likely be the region where a large share of new capacity will be constructed in the future.

PRODUCERS AND CAPACITIES - EPOXY RESINS MILLIONS OF POUNDS

PRODUCER	LOCATION	2006 CAPACITY*
Dow Chemical	Fresport, TX; Torrance, CA	355
Hexion Specialty Chemicals	Deer Park, TX	340
Huntsman Advanced Materials	Montreal, AL	215
TOTAL		910

Based on announced capacities and trade estimates. * Capacities include total capacity to make the various forms of epoxies, including unmodified liquid resins. Dow Chemical, Hexion and Huntsman are the dominant global producers of unmodified liquid epoxy resins. Hexion Specialty Chemicals was formed in 2005 when Apollo Management merged Borden Chemical, Resolution Performance Products, and Resolution Specialty Materials. The epoxy resin business of Hexion had formerly operated under Resolution Performance Products, which was formed in 2000 when Apollo Management acquired the business from Shell Chemical. Hexion had filed a registration statement for a proposed initial public offering of its common stock in 2006, but in mid-2006 suspended those plans. Huntsman Corporation indirectly owns 50.3% of Huntsman Advanced Materials LLC. Both Dow Chemical and Hexion are back integrated to raw materials epichlorohydrin and bisphenol A. In 2004, Dow announced the closing of its epoxy resin plant at Sarnia, ON, Canada which produced solid epoxy resins and epoxy vinyl ester resins.

END USES. Epoxy resins provide toughness, corrosion resistance, adhesion and electrical insulation, among other properties. These resins are inherently brittle and require modifiers to reduce brittleness. Epoxy resins are used for a variety of high-end coating applications which require the superior strength and durability of epoxy. Epoxy resins are also the fundamental building blocks of many types of material, such as formulated composite resins and structural adhesives. Epoxy resins also have significant use in laminating printed circuit boards and for encapsulating electrical devices. Epoxy resins are available as liquid, solution, or solid material. Curing agents commonly used to convert epoxies to thermosets include anhydrides, aliphatic amines, polyamides, Lewis acids, and others.

Coatings account for more than one half of epoxy resin demand. Maintenance & marine coatings, powder coatings, container coatings, and automotive primers are the dominant applications. Powder coatings are used for appliances, automotive, pipes, etc. Powder coatings utilize solid epoxy resins. Epoxy resins are also used in electrocoatings for automotive, appliances and general industry, in heavy duty floor coatings, in metal packaging coatings, in ambient cured coatings for marine, large steel structures, and in waterborne coatings. Epoxy resin-based adhesives are the second-largest end use. These adhesives find widespread use in the construction, automotive, aerospace, and electronics industries. Epoxies are also used to repair cracks in concrete and as binders in a variety of applications.

Epoxy resins are used in making fiber reinforced laminates and composites. Composites are used by the aerospace industry and the military in fuselage sections, wing skins and structural panels for satellites. The epoxy resins are generally combined with glass, carbon or aramid fibers and used in filament winding, resin transfer molding, or prepreg applications. Composites are also used by the automotive industry, in sporting goods such as skis and snowboards, in boat construction, wind energy units, and industrial applications. Printed circuit board manufacture is a principal use for epoxy laminates; other electrical laminate uses are also found. Also in the electrical and electronics industry, epoxies find use in electrical casting resins, molding compounds and encapsulation.

In civil engineering, epoxy coatings are used in bridge and canal construction, concrete enhancement, and corrosion protection.

END USE PATTERN - 2005 ESTIMATE

DERIVATIVE	PERCENT
Protective Coatings	52
Adhesives and Bonding	16
Reinforced Laminates/Composites	11
Flooring, Faving, Aggregates	8
Tooting, Castings & Molding Items	4
Miscellaneous	9

MANUFACTURING. The major commercial epoxy resin is obtained using bisphenol A and epichlorohydrin (epi) as the reactants. Other epoxy resins include brominated, phenoxy, cycloaliphatic and novolac epoxy resins. Liquid epoxy resins may be synthesized by a two step reaction of an excess of epi to BPA in the presence of an alkali catalyst. The reaction commences initially in the formation of the dichlorohydrin of BPA and further reaction via dehydrochlorination of the intermediate with a stoichiometric quantity of alkali. The use of a large excess of epi minimizes the formation of higher molecular weight species. The pure diglycidyl ether of BPA is a crystalline solid with a weight per epoxide of 170. The typical commercial unmodified liquid resins are viscous liquids with an epoxy equivalent weight of ca 160.

Two general methods produce higher molecular weight epoxies. In the latter process, bisphenol A reacts directly with epi in the presence of a catalytic amount of caustic. Molecular weight is governed by the ratio of epichlorohydrin to bisphenol A. The latter process is generally employed for only medium molecular weight resins. The polymerization reaction results in a highly viscous product and the condensation reaction becomes very dependent on agitation. At the completion of the reaction, the heterogeneous mixture consists of an alkaline brine solution and a water resin emulsion, and recovery of the product is accomplished by separation of phases, washing of the latter resin with water, and removal of water under vacuum. The other method, known as the advancement process, is generally preferred since it can be used to directly prepare high molecular weight resins. In this process, liquid epoxy resin (crude diglycidyl ether of bisphenol A) is chain reacted in the presence of a catalyst to yield higher molecular weight products.

ENVIRONMENTAL ASPECTS. Epoxy resins, by themselves, are generally considered to be non-hazardous. However, in 1995 the EPA issued final rules limiting emissions of hazardous air pollutants from the epoxy manufacturing processes. These rules were designed to remove as much as 105 million pounds per year of pollutants, mainly epichlorohydrin, from the atmosphere.

To the best of our knowledge, the information contained herein is accurate. However, we do not assume any liability whatsoever.

Sample chemical product synopsis

Chemical Products Synopses

Acetaldehyde	Citric Acid	Magnesium Sulfate	Propylene Glycol
Acetic Acid	Coconut Oil	Maleic Anhydride	Propylene Oxide
Acetic Anhydride	Copper Sulfate	Malic Acid	Salicylic Acid
Acetone	Cresols & Cresylic Acid	Manganese Sulfate	Silicones
Acetylene	Cumene	Melamine	Soda Ash
Acrylamide	Cyclohexane	Menthol	Sodium
Acrylates	Cyclohexanone	Methanol	Sodium Acetate
Acrylic Acid	Decyl Alcohols	Methylamines	Sodium Bicarbonate
Acrylonitrile	Diacetone Alcohol	Methyl Bromide	Sodium Bisulfate
Adipic Acid	Diammonium Phosphate	Methyl t-Butyl Ether	Sodium Bisulfite/Metabisulfite
Alkylamines	Dichlorobenzene	Methyl Chloride	Sodium Chlorate
Alkylaryl Sulfonates	Dicyclopentadiene	Methyl Diphenyl Diisocyanate	Sodium Chloride
Aluminum Chloride (Anhydrous)	Diethylene Glycol	Methyl Ethyl Ketone	Sodium Dichromate
Aluminum Chloride (Hydrous)	Diethyl Phthalate	Methyl Isobutyl Ketone	Sodium Fluoride
Aluminum Sulfate	Dodecyl Alcohols	Methyl Methacrylate	Sodium Hexametaphosphate
Ammonia	Dodecylbenzene	Methylene Chloride	Sodium Hydrosulfide
Ammonium Chloride	Epichlorohydrin	Alpha-Methylstyrene	Sodium Hydrosulfite
Ammonium Nitrate	Epoxy Resins	Monochlorobenzene	Sodium Hypophosphite
Ammonium Sulfate	Ethanol	Monosodium Glutamate	Sodium Propionate (Propionates)
Aniline	Ethanolamines	Morpholine	Sodium Silicate
Antimony Oxide	Ethyl Acetate	Naphthalene	Sodium Sulfate
Argon	Ethylbenzene	Nitric Acid	Sodium Sulfite
Ascorbic Acid	Ethyl Chloride	Nitrobenzene	Sodium Thiosulfate
Barium Carbonate	Ethylene	Nitrogen	Sodium Tripolyphosphate
Benzene	Ethylenediamine	Nonylphenol	Sorbitol
Benzoic Acid	Ethylene Dichloride	Organoperoxides	Soya Oil
Benzyl Alcohol	Ethylene Glycol	Oxygen	Strontium Carbonate
Benzyl Chloride	Ethylene Oxide	Pentachlorophenol	Styrene
Bisphenol A	2-Ethylhexanol	Pentaerythritol	Sulfur
Borax	Ferric Chloride	Perchloroethylene	Sulfur Dioxide
Boric Acid	Ferrous Sulfate	Phenol	Sulfuric Acid
Bromine	Fluorocarbon Solvents	Phosgene	Talc
Butadiene	Fluorocarbons	Phosphoric Acid (Thermal)	Tall Oil
1,4-Butanediol	Formaldehyde	Phosphoric Acid (Wet)	Terephthalic Acid
Butanol	Formic Acid	Phosphorus	Tetrahydrofuran
Butyl Acetate	Fumaric Acid	Phosphorus Oxychloride	Tetrapotassium Pyrophosphate
Calcium Bromide	Furfural	Phosphorus Pentasulfide	Tetrasodium Pyrophosphate
Calcium Carbonate	Glycerine	Phosphorus Trichloride	Titanium Dioxide
Calcium Chloride	Glycol Ethers	Phthalic Anhydride	Toluene
Calcium Hypochlorite	Hexamine	Platinum	Toluene Diisocyanate
Calcium Phosphates	Hydrazine	Polycarbonate Resins	1,1,1-Trichloroethane
Caprolactam	Hydrochloric Acid	Polyethylene (HD)	Trichloroethylene
Carbon Activated	Hydrofluoric Acid	Polyethylene (LLD)	Tricresyl (Triaryl) Phosphate
Carbon Black	Hydrogen	Polyethylene Terephthalate (PET)	Triethylene Glycol
Carbon Dioxide	Hydrogen Cyanide	Polyactic Acid (PLA) 	Trimethylolpropane
Carbon Disulfide	Hydrogen Peroxide	Polypropylene	Urea
Carboxymethylcellulose	Hydroquinone	Polystyrene	Vinyl Acetate
Castor Oil	Iodine	Polyvinyl Alcohol	Vinyl Chloride
Caustic Potash	Iron Oxides	Polyvinyl Chloride	Xanthan
Caustic Soda	Isopropanol	Potassium Carbonate	o-Xylene
Cellulose Acetate Flake	Isopropyl Acetate	Potassium Chloride	p-Xylene
Chlorine	Lactic Acid	Potassium Permanganate	Zinc Oxide
Chloroacetic Acid	Lime	Potassium Sulfate	Zinc Sulfate
Chloroform	Linseed Oil	Propanol	
Chlorosulfonic Acid	Lithium Carbonate	Propionic Acid	
Chromic Acid	Magnesium Oxide	Propylene	