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**GLOBAL EPOXY**

**RESIN MARKET**

**FORECAST & OPPORTUNITIES, 2030**

**PUBLISHED: September 2021**

**MARKET INTELLIGENCE. CONSULTING**

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**Executive Summary**

**1. Brief insight about the company and project:**

****

**Established - 1973 Turnover (Consolidated) - INR 5,39,238 Crore (FY Year 2020-21)**

* 1. **Overview of the Company:**
* Reliance Industries Limited is Indian based, one of the well-known brands involved in manufacturing and sales of diverse range of products including polymers, aromatics, elastomers etc. globally.
* The company caters customers and various industries viz., healthcare, automotive, packaging etc across over 70 countries worldwide.
* The company’s total production capacity of PE, PP and PVC is 2.3, 2.9 and 0.7 million MT per annum as of 2019.
* The company exported 1.1 million MT of polymers globally in 2019.
* The company has 6 state-of-the-art manufacturing facilities to produce polymers.

**1.2 Brief Profile of Board of Directors:**

**Mukesh Ambani:** Mr. Mukesh D. Ambani is a Chemical Engineer from the Institute of Chemical Technology, Mumbai (erstwhile the University Department of Chemical Technology, University of Mumbai). He pursued an MBA from Stanford University in the US. He has been on the Board of Reliance since 1977.

**Nita M. Ambani:** Mrs. Nita M. Ambani (DIN 03115198) is a Commerce Graduate from Mumbai University and a diploma holder in Early Childhood Education.

**Hital R. Meswani:** Mr. Hital R. Meswani (DIN 00001623) is a Management & Technology graduate from the University of Pennsylvania (UPenn) in the USA.

**Nikhil R. Meswani:** Nikhil Meswani is an Executive Director on the Board of Reliance. A chemical engineer from the University Institute of Chemical Technology (UICT) Mumbai, he joined Reliance in 1986.

**P.M.S. Prasad:** PMS Prasad is an Executive Director at Reliance and one of the longest serving members on the Board and the company.

**P.K. Kapil:** PK Kapil is an Executive Director on the Board of Reliance. With experience spanning four decades, he is a driving force in the HSE, Technology, Reliability and Operations of all manufacturing sites.

**R.A. Mashelkar:** RA Mashelkar is an independent Director on the Board of Reliance. An eminent scientist and champion of the Innovation Movement in India, he is the Chairman of Reliance Innovation Council.

**Adil Zainulbhai:** Adil Zainulbhai is an independent Director on the Board of Reliance. One of the world’s foremost consultants, he is a mechanical engineering graduate from IIT and holds an MBA from Harvard University.

**Mansingh L. Bhakta:** Mansingh Bhakta is an independent Director on the Board of Reliance. An advocate par excellence, he has almost six decades of experience.

**Dipak C. Jain:** Dipak Jain is an independent Director on the Board of Reliance. One of the world’s top educationalists, he is a former Dean of Kellogg School of Management and INSEAD.

**Dharam Vir Kapur:** Dharam Vir Kapur is an independent Director on the Board of Reliance. A technology, industrial development and project implementation expert, he has a long and illustrious career in the Indian government.

**Mahesh P. Modi:** Mahesh Modi is an independent Director on the Board of Reliance. He has in-depth management experience in the petrochemical, telecommunications, energy and insurance industries.

**Yogendra P. Trivedi:** Yogendra Trivedi is an independent Director on the Board of Reliance. He is an expert in the fields of economics, politics, education, sports, and social and professional services.

**Ashok Misra:** Ashok Misra is an independent Director on the Board of Reliance. An IIT Director from 2000-2008, Misra was the driving force behind its transformation into leading research and development institute.

* 1. **Brief Project summary**

The project is a greenfield project and for manufacturing of various types of epoxy resins such as Bisphenol-A and Bisphenol-F epoxy resin, cycloaliphatic epoxy resins, dimer acid modified epoxy resin and multifunctional epoxy resins (Epoxy-phenol Novolac resins and Epoxy-cresol Novolac resins). It falls under Category 5 (f) B, thereby the Environmental Clearance must be obtained from SEAC, Gujarat.

**1.4. Key Highlights of the Project**

Considering the growing market scenario, Reliance Industries Limited proposes to enter epoxy resin business. With the increasing demand (within India and across the globe), there is urgent need to world class epoxy resin manufacturing unit in India. The market of this product has gained pace tremendously and there are greater opportunities in the indigenous as well as export markets. Due to increasing demand of this product and to reduce the gap between demand and supply, the company proposes to manufacture various grade of epoxy resins.

Epoxy Resin (base liquid and blend), though produced indigenously, is also imported in substantial quantities into India. Moreover, the technology is totally proven and safe in all aspects. The project will help in bridging demand-supply gap. Various formulated resins based on liquid epoxy resin have export potential too.

Success for the project includes:

* Ease of Availability of skilled and non-skilled workers
* Cost Competitiveness
* Availability of well-developed infrastructure facility
* Positive impact on the socio-economic condition of the area in terms of direct and indirect employment due to the proposed project during construction / operation phase.
* India being the Top 10 preference for FDI Inflows in the country.
* India being the 4th largest producer of Chemicals & Petrochemical in Asia Pacific region.
* India is 3rd largest consumer of polymers globally.
* Development of Industrial Corridors across the country.
* “AatmaNirbhar Bharat” and “Make in India” policies are pushing domestic manufacturer to come up with green field capacity.

**India Competitiveness for Setting Up Epoxy Resin Manufacturing Market**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Region / Country** | **Raw Material Sourcing** | **Product Demand** | **Capital Cost** | **Operating Cost** | **Project Implementation** | **Overall Attractiveness** |
| **Middle East** |  |  |  |  |  |  |
| **US** |  |  | Icon, bubble chart  Description automatically generated |  |  |  |
| **Europe** |  |  |  |  |  |  |
| **India** |  |  |  |  |  |  |
| **China** |  |  |  |  |  |  |

*Source: TechSci Research*



Highly Attractive

Unattractive

**Real GDP Growth Forecast for Major Economies**

|  |  |  |  |
| --- | --- | --- | --- |
| **Country** | **2023** | **2025** | **2030** |
| **India** | **7.95%** | **7.52%** | **7.24%** |
| China | 5.75% | 5.60% | 5.28% |
| France | 2.32% | 1.76% | 2.05% |
| United Kingdom | 1.94% | 1.67% | 1.92% |
| Germany | 1.87 | 1.22% | 1.44% |
| United States | 2.35% | 1.86% | 2.05% |
| Russia | 2.15% | 1.85% | 2.10% |
| Japan | 1.26% | 0.72% | 1.25% |
| World | 3.84% | 3.56% | 3.78% |

*Source: OECD, World bank*

**2. Product Profile**

**2.1. Product Overview (Introduction and Characteristics):**

Epoxy resins have a set of unique combinations of properties and performance characteristics. These are thermosetting polymer, which crosslink & polymerize when mixed with the catalytic agent or “Hardener”.

Epoxy resin is classified into standard epoxy resin and specialized epoxy resins.

**Standard epoxy resins:** The standard epoxy resin also known as commodity epoxy resin includes only Bisphenol A and F based epoxy resin which constituted around 80% of the market in 2020.

* **Bisphenol-A Type Epoxy Resin:** The most common epoxy resins are produced by reacting Epichlorohydrin (ECH) with Bisphenol A (BPA). This reaction produces BADGE or DGEBA (Bisphenol A Diglycidyl Ether), which represents the smallest unit of a typical Epoxy Resin. Bisphenol A liquid epoxy resins are used in broad applications including coatings, civil engineering, adhesives, electrical insulating materials, and reactive intermediates.
* **Bisphenol-F Epoxy Resin:** This can be manufactured from Bisphenol F by similar methods to those used for bisphenol A and epichlorohydrin with a catalyst such as NaOH. These resins have lower viscosities than the equivalent DGEBA. EEW (Epoxy Equivalent Weight) value of Bisphenol F resin lies between 158-175 & viscosity 5000-7000 CPS (Centipoise) at 25°C.

**Specialized epoxy resins:** The specialized epoxy resin include cycloaliphatic epoxy resins, dimer acid modified epoxy resins and multifunctional epoxy resins (Epoxy phenol Novolac resins, Epoxy cresol Novolac resins, Diamino diphenyl methane-based epoxy resin, Para-aminophenol based epoxy resin, triglycidylether epoxy resin etc).

* **Multi-functional Epoxy Resins (Epoxy Phenol / Cresol Novolac Resins):** Epoxy phenol/cresol novolac (EPN) resins contain more than two epoxy groups per molecule and are therefore described as multifunctional epoxy resins. EPN resins are recommended in formulations for high-performance applications requiring excellent chemical resistance, solvent resistance, and high temperature resistance than the standard bisphenol-based epoxy resin. These EPN resins are also used in blends with Bisphenol-A and F epoxy resins to improve the performance. Novolac resins, which are the reaction products from formaldehyde and excess phenol under acidic catalysis, when co-cured with high molecular weight solid bis-A epoxy resins result in coatings with excellent adhesion, film strength, flexibility, and chemical resistance. They are especially useful in powder coatings applications for corrosion resistant pipe reinforcing bars (rebars) and with brominated epoxy resins for FR3 electrical laminate production.

* **Cycloaliphatic Epoxy Resins:** Cycloaliphatic epoxy resins are characterized by non-aromatic saturated rings in their molecular structures. These resins are ideally suited for applications where inherently low viscosity, and excellent weathering electrical performance are required. In India, Cycloaliphatic epoxy resins are mainly used in weather resistant solvent-based coatings for outdoor applications.
* **Brominated Epoxy Resins:** Brominated epoxy resins are produced when tetrabrominated bisphenol A is added to the formulation. Fluorinated epoxy resins are used in high performance applications. Generally, it has been observed halogenated epoxy resins are used to cater to demand of flame retardant and other end uses. Brominated epoxy resins are widely used globally in flame retardant in electrical applications.
* **Glycidyl amine Epoxy Resins** are another specialized epoxy resins are heavily used in aerospace composite applications uses. They provide outstanding thermal stability and good adhesion strength making them ideal for high performance composites, adhesives, and coatings. These resins are higher functionality epoxies based on reaction between aromatic amines and epichlorohydrin resulting in cross-linking which invoke specific properties in the resins. Because of their low to medium viscosity at room temperatures, these are easier to process than standard epoxies. These have unique combination of properties making them highly end-use specific. Triglycidyl para-aminophenol (TGPAP) is one of the most widely used glycidyl amine epoxy resins around the world.
* **Solvent Cut Epoxy Resins-** These resins are mainly dissolved in various organic solvents which are primarily used in coating applications. Various solvents used in the production of different epoxy resins are xylene, MEK (methyl ethyl ketone), cyclohexane, butyl cellosolve, cyclohexanone, MIBK (methyl isobutyl ketone), n-butanol, PGM- Ac (propylene glycol mono-methyl ether acetate), toluene etc.
* **Semi Solid Epoxy Resin:** The epoxy industry has adopted a common nomenclature to describe the Solid Epoxy Resins (SERs). They are called type “1,” “2” up to type “10” resins, which correspond to the increased values of n, the degree of polymerization\* , EEW, MW, and viscosity Value. The degree of polymerization is dictated by the ratio of LER to bisphenol A. The semisolid resins are used in advanced composites and adhesives where toughness, hot-wet strength, and resistance to high temperature oxidation are required. Their purity, formulated stability, fast reactivity, and retention of electrical properties over a broad temperature range make the solid resins suitable for use in the semiconductor molding powders industry.

Epoxy resin can be also marketed as pure epoxy resin which is typically just a resin and a hardener. It cures at a slower rate than the other product classes (polyesters and epoxy acrylates) and, as a result offers less shrinkage, excellent adhesion, and high strength performance.

**Epoxy resin can be further classified based on liquid, solid and semi-solid type.**

* **Liquid epoxy resins** have minimum two epoxy groups in a molecule and are liquid at temperature of 20°C. Liquid epoxy is the standard type of epoxy resin which is highly versatile. These resins can be cured and modified and can deliver unique combination of properties. They find their applications in coatings, castings, constructions, adhesives, electrical and electronics and other end-user industries.
* **Solid epoxy resins** conventionally have more than three epoxy groups in a molecule and are at solid at temperature of 40°C. These are ideal for composites, industrial coatings, and preparation of epoxy ester resins because of their high flexibility, good abrasion resistance and good corrosion resistance.
* **Semi-Solid epoxy resins** have dual nature as they are in solid state at temperature of 20°C, while liquid at 40°C. They bridge the processing gap between liquid and solid epoxy resins by offering pourability at slightly high temperatures and having intermediate time-to-hardness during the curing process. These properties make semi-solid epoxy resins suitable for adhesives and coatings with varying level of tack and improved flow and levelling.

**2.2. Production Routes and Related Details**

Epoxy resin is usually synthesized by bulk polymerization. The material is available commercially at 98% purity & are colourless. Many commercial liquid resins consist essentially of low molecular weight diglycidyl ether of Bisphenol A together with small quantity of higher molecular weight polymer. In general, production of bisphenol A epoxy resin is divided into one step method & two-step process method.

In one-step method, Bisphenol A reacts directly with epichlorohydrin in order to prepare epoxy resin, which commonly used for the synthesis of low to medium molecular weight (MW) epoxy resins.

**Mass Balance**

|  |  |  |  |
| --- | --- | --- | --- |
| **Input** | **T/T** | **Output** | **T/T** |
| BPA | 0.7 | Product | 1 |
| NaOH | 0.04 | Salt | 0.336 |
| ECH | 0.56 | Solid Waste (Waste Polymer) | 0.096 |
| 48% NaOH | 0.46 | Reaction Water | 0.33 |
| **Total** | **1.76** | **Total** | **1.76** |

The two-step method require continuation the reaction of low molecular weight resin with bisphenol A (BPA). High molecular weight (MW) epoxy resins can be synthesized via one step or in a two-step process.

**One Step Process (BADGE):** The one-step process proceeds via polycondensation reaction of epichlorohydrin (ECH) with bisphenol A (BPA).

**Two Step Process:** The two-step process is the reaction of bisphenol A (BPA) and epichlorohydrin (ECH) in presence of a catalyst (such as a quaternary ammonium salt). The first step is an addition reaction to form a diphenol-propane chlorohydrin ether as an intermediate. This closed loop reaction produces an epoxy resin.

**Production process of Solid Bisphenol- A Epoxy Resin:**

**Taffy Process:** In Taffy Process, bisphenol A is reacted at 85–95°C in a controlled excess of epichlorohydrin in the presence of caustic soda and an inert solvent. This reaction is used to produce lower molecular weight (LMW) epoxides. *Source of information, refer Annexure-I.*

**Description of Taffy Process:** A mixture of bisphenol A and 10% aqueous sodium hydroxide solution is introduced in a reactor equipped with high-speed powerful agitator. The mixture is heated up to 45°C and epichlorohydrin is added rapidly with agitation, giving off heat. The temperature is allowed to rise to 95°C, where it is maintained for approx. 80-85 minutes for the completion of reaction. Then agitation is stopped, and the mixture gets separate in two layers. The heavier aqueous layer is drawn off from bottom and the molten, taffy-like product is washed with hot water until the wash water gets a neutral pH. The taffy-like product is dried at 135°C to give a solid resin with softening point of 70-75°C and an EEW value of 500. Alternatively, epichlorohydrin is removed by vacuum distillation at temperatures up to 180°C approx. The crude resin is then dissolved in a secondary solvent (Toluene or Xylene) to facilitate water washing and salt removal. This secondary solvent is then recovered via vacuum distillation to obtain the resin product.

**Advancement Process:** For manufacturing of higher molecular weight epoxy resins, liquid epoxy resin is reacted with calculated amount of bisphenol A. Further, catalyst solution is added to boost the reaction and the temperature is maintained at approx. 160°C. This process is known as Advancement process. High molecular weight epoxides are manufactured by Advancement process using Benzyl trimethyl ammonium hydroxide as a catalyst. It is widely practiced by coating producers to facilitate the handling of the high molecular weight, highly viscous epoxy resins used in many paint & coating formulations. The degree of polymerization is calculated by ratio of liquid epoxy resin (formed from BADGE Process) to bisphenol A, an excess of the former provides epoxy terminal groups. The actual molecular weight obtained depends on purity of the starting materials, solvents & catalyst used. Reactive mono-functional groups are used as chain terminators to control the molecular weight and viscosity build.

In the advancement process, bisphenol A and a liquid BADGE resin (170–180 EEW) are heated in the presence of a catalyst and reacted (i.e., advanced) to form a high MW resin. This process is exothermic and proceeds rapidly to completion. In the cases of higher MW resins, exotherm temperature can reach >190-205°C. Reaction catalysts facilitate the rapid preparation of medium to high MW linear resins, also control side reactions inherent with epoxy resin preparations, e.g, chain branching is done by addition of the epoxy group generated through chain-lengthening process with alcohol group. Nuclear Magnetic Resonance (NMR) spectroscopy method can be used to determine the extent of branching.

**2.3 Applications and Properties**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Paints and Coatings (Coating Ingredients/ Ink Ingredients)** | **Electrical and Electronics (Impregnation/ Lamination/ FRP Molding)** | **Construction (Floor Coating Materials/ Linings/ Civil Engineering Repair Materials)** | **Adhesives/ Adhesive Ingredients** | **Composites** |
| Bisphenol A Liquid Epoxy Resin | \* |  | \* | \* |  |
| Bisphenol A Solid Epoxy Resin | \* |  | \* | \* |  |
| Bisphenol F Liquid Epoxy Resin | \* | \* | \* | \* |  |
| Brominated (Flame Retardant Types) |  | \* |  | \* |  |
| Cresol Novolac Epoxy Resin |  | \* |  | \* |  |
| Phenol/Modified Novolac Epoxy Resin | \* | \* |  | \* | \* |
| Cycloaliphatic Epoxy Resin |  | \* |  | \* |  |
| Dimer Acid modified epoxy resin |  |  |  | \* |  |
| Diamino diphenyl methane-based epoxy resin | \* |  |  | \* |  |
| Para-aminophenol based epoxy resin | \* |  |  | \* | \* |

*\* Represent use of epoxy resin in the mapped application.*

|  |  |  |
| --- | --- | --- |
| Grades | Features | Applications |
| Bisphenol A Liquid Epoxy Resin | Viscosity range - 450 to 26000 mPa-s | Paints and Coatings (Coating Ingredients/ Ink Ingredients), Construction (Floor Coating Materials/ Linings/ Civil Engineering Repair Materials), Adhesives/ Adhesive Ingredients |
| High heat distortion temperature |
| Bisphenol A Solid Epoxy Resin | Viscosity range between 160 to 10,000 mPa.s | Paints and Coatings (Coating Ingredients/ Ink Ingredients), Construction (Floor Coating Materials/ Linings/ Civil Engineering Repair Materials), Adhesives/ Adhesive Ingredients |
| Bisphenol F Liquid Epoxy Resin | low viscosity | Paints and Coatings (Coating Ingredients/ Ink Ingredients), Construction (Floor Coating Materials/ Linings/ Civil Engineering Repair Materials), Adhesives/ Adhesive Ingredients, Electrical and Electronics (Impregnation/ Lamination/ FRP Molding) |
| low crystallization tendency |
| Brominated (Flame Retardant Types) Epoxy Resin | High bromine type, solid content 60% toluene solution | Electrical and Electronics (Impregnation/ Lamination/ FRP Molding), Adhesives/ Adhesive Ingredients |
| Cresol Novolac Epoxy Resin | High viscosity | Electrical and Electronics (Impregnation/ Lamination/ FRP Molding), Adhesives/ Adhesive Ingredients |
| High epoxy index |
| Phenol/Modified Novolac Epoxy Resin | Viscosity at 52°C (126°F): 600-50,000 cP.  Epoxide equivalent weight (EEW): 160 – 270 g/eq. | Paints and Coatings (Coating Ingredients/ Ink Ingredients), Electrical and Electronics (Impregnation/ Lamination/ FRP Molding), Adhesives/ Adhesive Ingredients, Composites |
| Cycloaliphatic Epoxy Resin | Low-viscosity liquid epoxy, Low viscosity Cycloaliphatic Glycidyl Ether of Hydrogenated Bisphenol-A. Viscosity at 25 degree C Cp - 1800-2500 | Electrical and Electronics (Impregnation/ Lamination/ FRP Molding), Adhesives/ Adhesive Ingredients |
| Dimer Acid modified epoxy resin | Viscosity -50000 cps@52 degree Celsius,  EEW (g/eq) – 660 | Adhesives/ Adhesive Ingredients |
| Diamino diphenyl methane-based epoxy resin | N/A | Paints and Coatings (Coating Ingredients/ Ink Ingredients), Adhesives/ Adhesive Ingredients |
| Para-aminophenol based epoxy resin | low viscosity | Paints and Coatings (Coating Ingredients/ Ink Ingredients), Adhesives/ Adhesive Ingredients, Composites |
| high temperature |
| high mechanical strength |
|  |

***Bisphenol A Liquid:*** *- Liquid Bisphenol A have standard undiluted liquid epoxy resin having good reactivity and resistance properties with high heat distortion temperature used in multiple application. Viscosity range between 450 to 26,000 mPa-s depending on the application and grade.*

***Bisphenol A Solid:*** *- Solid bisphenol-A-based epoxy resins are a reaction product of lower molecular weight-based bisphenol-A-based epoxy resins. Therefore, solid bisphenol-A-based epoxy resins are mostly used as a part of two-component systems to create epoxy coatings. Viscosity range between 160 to 10,000 mPa.s depending on application.*

***Bisphenol F Liquid: -*** *Bisphenol F liquid is based diglycidyl ether (BFDGE), a stabilizing compound, used alone or as a modifier to improves solvent resistance. The product is known for low viscosity, low crystallization tendency and have better chemical resistance.*

***Brominated (Flame Retardant Types)****: - Brominated (flame retardant type) have higher heat resistance compared to other products. Due to its strong durability, binding properties and strong resistance properties, the product is used in electronic application and adhesive industry*

***Cresol Novolac****: - The product is used for high temperature adhesives, electrical and laminating product areas. These products have higher viscosity and epoxy index to achieve higher thermal and chemical resistance.*

***Cycloaliphatic Epoxy based Resin****: - These products have low-viscosity liquid epoxy. The major application is in outdoor electrical, casting applications and filament winding applications. Low-viscosity cycloaliphatic epoxy recommended for use in the manufacture of medium and high-voltage electrical insulating components.*

***Dimer Acid modified epoxy resin: -*** *Dimer acid modified epoxy resin is an adduct of a DGEBA resin and a dimer fatty acid. At room temperature, it is a semi-solid which requires mild heating to assist flow or pumping.*

***Phenol/Modified Novolac Epoxy Resin:*** *- An epoxy phenol novolac (EPN) is an epoxy resin where the epoxide functional group is attached to the phenolic oxygen of a phenolic novolac. In industrial settings, EPN resins are used for the epoxy coating of tanks, pipes, floors, automotive parts, electronic parts, etc. High chemical, solvent, and temperature resistance of EPNs are especially useful for high-performance applications and corrosion resistance.*

***Diamino diphenyl methane-based epoxy resin:*** *- These epoxies comprise of four functional amine epoxy resins which have been successfully used for carbon fiber reinforced polymers (CFRPs) for primary aircraft structure resins. They are mainly used for CFRPs, heat resistant paints, heat resistant adhesives. This epoxy comes in different grades with different viscosity.*

***Para-aminophenol based epoxy resin: -*** *This is a very reactive polyfunctional specialty epoxy resin based on p-aminophenol. This resin is suitable for high performance fiber reinforced composites, adhesives and coatings. It serves various benefits like high performance, low viscosity, high Tg, high temperature and chemical resistance and high mechanical strength.*

***Paints and coatings*** *–*

*Paints and coatings have major application in automotive and other sectors which require high heat resistance and medium viscosity ranges. Therefore, the most suitable epoxy resins for the application in paints and coatings are Bisphenol A Liquid, Bisphenol A Solid, Bisphenol F Liquid, and Phenol/Novolac Epoxy Resin. The viscosity range of Bisphenol A liquid Epoxy resin is from 450 to 26,000 mPa.s.*

***Electrical and Electronics –***

*Most of the electrical and electronic products require thermal and electrical resistance. Brominated epoxy resin is therefore used in electronics and electricals due to its flame retardant properties and high electrical insulation. Other epoxy resins that are useful for electronics and electricals include Bisphenol F liquid, Novolac, Phenol, and Cycloaliphatic epoxy resins.*

***Construction –***

*Epoxy resins are used in construction for floor coating materials, linings, and repair materials. Therefore, the material used should have high mechanical strength and medium viscosity range. Hence, the most suitable epoxy resins for construction applications include Bisphenol A liquid, Bisphenol A solid and Bisphenol F liquid. Bisphenol F is known for its low viscosity and chemical resistance hence, it is most preferred for construction applications.*

***Adhesives –***

*Nearly all the epoxy resins possess adhesive properties, therefore all the epoxy resins are suitable for adhesive applications. Depending upon the final application and the required mechanical strength, the materials can be used in different type of adhesive applications. For example: Brominated Epoxy resins have flame retardant properties therefore, they can be used in the adhesive applications where there is a risk of fire such as circuit boards etc.*

***Composites –***

*Phenol/ Modified epoxy resin is the most suitable for composite applications due to the property of high compatibility with other matrix materials such as glass fibre etc. the resin is used in composite materials with the help of dispersion of the matrix material into the resin followed by thermal curing of the material.*

**2.4 End of Life and Sustainability (Health, Safety & Environment (HSE))**

Epoxy resins are classified under different health standard such as Occupational Safety and Health Administration (OSHA)-USA, Workplace Hazardous Material Information System-Canada, EU-OSHA, etc. Health standard hazards are classified and mapped in the table below.

|  |  |
| --- | --- |
| Skin irritation | Category 2 |
| Eye irritation | **Category 2B** |
| Skin sensitisation | **Sub-category 1B** |

Epoxy resins have low potential to volatilize from water to air. Further, the material is toxic to aquatic life.

**End of the life:** Epoxy Resin have shelf life of 24 months when stored in a controlled environment as per guidelines suggested by manufacturers.

**Storage and Handling:** The product need to be stored in a sealed original container in a well-ventilated area. Further, Epoxy resins need to be stored in a cool and dry place and should be protected from direct sunlight. Containers that have been opened must be carefully resealed and to be kept upright to prevent leakage and to preserve the chemical properties of the product.

**Transportation:** Sealed containers need to be kept upright during the transit phase. The transportation guidelines are provided by the manufacturing companies, Further, guidelines vary from region to region and company to company.

**2.5 Environmental Compliance**

Applications and end products consuming epoxies are safe and do not risk to human health. Before application, epoxy resins are typically mixed with a hardener component following which a chemical reaction takes place producing an inert final material. The finished, hardened epoxy resin does not pose any health risk and offers superior performance. However, production of petroleum-derived epoxy resins and the disposal of epoxy containing components pose several risks to the environment.

There should be no National Parks, Wildlife Sanctuaries, Biosphere reserves, Tiger/ Elephant Reserves, Wildlife corridors etc. within 10 km from the project site.

Ways of treating waste generated while epoxy resin production:

**(1)** **Waste Disposal Method-Incineration**

While industrial production of Epoxy Resins, by-products like NaCl and oligomers are also released. NaCl can be removed by washing with water one or more times, depending on the reaction requirement. An aqueous solution of sodium chloride called Brine formed resultantly can be further send to ETP plant for its treatment to decrease its concentration to the optimum level so that it can be disposed to sea or can be sent to Pollution control Board for further use. The resin is separated through filtration while solid polymeric particles (with high K-value) are discarded in a manageable way such as through landfilling. Manufacturers must essentially maintain an adequate ratio of ECH and BPA while Epoxy Resin manufacturing to minimize the waste generated.

**(2)** **Carbon Footprint and Abatement of Epoxy Resin Process**

The manufacturing of Epoxy Resin leads to production of various undesirable gases like CO2, CO, NOx, SOx, in addition to these flue gases it also generates particulate matter of various sizes. These products are harmful to environment and in the long run could harm humans and environment. To reduce waste generation, the company should plan for higher capacity power equipment and explore the use of renewable energy to the maximum extent possible. Installation of energy efficient devices and adoption of modes of alternative eco-friendly sources of energy like solar water heater, solar lighting, wind energy etc. are proposed for energy conservation.

For different gaseous emissions, different types of wet scrubbers are installed by the companies which effectively controls the air pollution by removing particles and gases from industrial exhaust streams. It operates by introducing the dirty gas stream with a scrubbing liquid – typically water.

**Life Cycle Assessment (LCA) data for Epoxy Resin**

|  |  |  |  |
| --- | --- | --- | --- |
| **Material** | **EE (MJ/kg)** | **GWP (kg CO2e/kg)** | **Reference** |
|  |
| Epoxy | 76‐137 | 4.7‐8.1 | Bricout et al. (2017) |  |
| Epoxy | 76 |  | Suzuki and Takahashi (2005) |  |
| Epoxy | 137.1 | 8.1 | Plastics Europe (2005) |  |
| Bisphenol‐A | 80.1 | 2.54 | Plastics Europe (2011) |  |
| Epoxy | 77.4 |  | US DoE (2016) |  |
| Epoxy | 76‐80 |  | Song et al. (2009) |  |
| Epoxy | 137.1 | 5.7 | Rankine (2006) (quoting PE) |  |
| EP Curing Agent‐Ethylenediamine | 124.6 | 6.3 | Eu CIA (2014) |  |
| EP Curing Agent‐Phthalic Anhydride | 78.2 | 2.7 | Eu CIA (2014) |  |
| EP Resin | 135 | 6.8 | Eu CIA (2014) |  |

*Source: EPA, European Commission*

|  |  |
| --- | --- |
| **Greenhouse Gas** | **Global Warming Potential (GWP)** |
| 1. Carbon dioxide (CO2) | 1 |
| 2. Methane (CH4) | 25 |
| 3. Nitrous Oxide (N2O) | 298 |
| 4. Hydrofluorocarbons (HFCs) | 124-14,800 |
| 5. Perfluorocarbons (PFCs) | 7,390 – 12,200 |
| 6. Sulphur hexafluoride (SF6) | 22,800 |
| 7. Nitrogen trifluoride (NF3) | 17,200 |

*Source: EPA, European Commission*

*The “global warming potential” (or “GWP”) of a GHG indicates the amount of warming a gas cause over a given period (normally 100 years). GWP is an index, with CO2 having the index value of 1, and the GWP for all other GHGs is the number of times more warming they cause compared to CO2. E.g., 1kg of methane causes 25 times more warming over a 100-year period compared to 1kg of CO2, and so methane as a GWP of 25.*

**Key Implications**

* As per emission average observed at domestic as well as overseas facility, the production of 1 Kg epoxy resin is estimated to record GWP ranges from 2.54 to 8.1 implying a fair degree of GHG emissions and substantial amount of heat retention.
* As industry experts, different types of wet scrubbers are installed for different GHG emissions.

**(3)** **Re-engineering Epoxy’s Hardening Component**

Usually, specially designed cured epoxy (resin and hardener mixed at the proper ratio and completely solidified) is NOT considered a “hazardous waste” and may be disposed of as non-hazardous solid waste material. One such cured Epoxy Resin is “Recyclamine” which can likely be recycled at any facility like other plastic products.

Recylamines are prepared by mixing bisphenol A diglycidyl ether with curing agents having amine groups that react with the ether’s epoxide groups to result into hard cross-linked molecules. Recyclamine is the only type of completely recyclable epoxy resin adopted in India till date. Aditya Birla Chemicals acquired the use of Recyclamine Technology from Connora Technologies in 2019. The great thing about epoxies with Recyclamine hardeners is that they can be completely recycled without pyrolysis.

**(4) Sicomin and biobased epoxy resins**

Bio based epoxy resins are bio sourced resins which are produced by the epoxidation of renewable feedstocks such as unsaturated vegetable oils, saccharides, lignin, tannins, cardanols, terpenes, rosins etc. The resins are cured with the help of co-reactants called hardeners. The type of hardener depends upon the type of epoxy resin. The hardener itself can also be biobased.

Sicomin is a leading manufacturer and formulator of advanced epoxy systems. The company manufacturers epoxy systems for application in aerospace, defence, marine, renewable energy, sports, and civil engineering. The products manufactured by the company are used in a variety of processes including infusion, RTM, pultrusion, hand layup etc. The company also offers high performance composite solutions with a range of core materials, fabric reinforcements, fillers, and consumables for the composites market. Some of the major products offered by the company include the biobased epoxy resins.

The resin and hardener are chosen on the basis of the end use application and process specification. The important parameters while choosing the resin and hardener are glass transition temperature of the cured epoxy resin and its viscosity.

In case there is requirement of high-end properties in the final resin, the biobased epoxy resins can be blended with each other and with other natural resins as well. For improving the mechanical properties of the resin, materials such as inorganic fillers and glass fibres can be added to the resins. This is also done in order to reduce the cost of the resins.

Some of the biobased epoxy resins available in the market are Greenpoxy, Entropy Resins, Sicomin Epoxy Systems, One Epoxy, Wessex Resins, etc.

The Biobased Epoxy resins are sources from renewable feedstocks and are environmentally friendly in nature hence are increasing in demand exponentially.

**(5) Emissions related to manufacturing of basic liquid epoxy resins**

The production of Liquid Epoxy Resin is associated with the release of harmful Epichlorohydrin and solvent emissions. The emissions take place in the distillation process when the excess Epichlorohydrin is removed before or after the dehydrochlorination step. The emissions are needed to be treated or absorbed in order to ensure an emission free process.

Excess ECH is removed either before or after the dehydrochlorination step. If it is removed before the step of dehydrochlorination, it is distilled off in two stages. After the first distillation, glycerol dichlorohydrin is added to the reaction mixture, after the second distillation, a solvent mixture of MIBK and isopropanol is added to the mixture and the solution is reacted to the 15% caustic soda solution. The solvent is removed by distillation. The Liquid Epoxy resin is filtered to remove any organic salt.

It is in the two distillation processes where ECH emissions occur. Other sources of ECH emissions in the process include resin finishing, steam jet exhausts, vapour contamination from synthesis, storage tanks, wastewater, and equipment leaks. These can be reduced using various equipment such as water scrubber, carbon adsorption, and waste-water treatment, and LDAR.

ECH emissions are harmful in nature as acute (short-term) inhalation exposure to epichlorohydrin in the workplace causes irritation to the eyes, respiratory tract, and skin. At high levels of exposure, nausea, vomiting, cough, labored breathing, inflammation of the lung, pulmonary edema, and renal lesions can also be observed. EPA has classified epichlorohydrin as a Group B2, probable human carcinogen.

**Chapter 3. Market Outlook and Relevance of the Project**

**3.1. Demand Supply Outlook – Global Epoxy Resin Market**

**Global Epoxy Resin Demand, By Volume** **(Thousand Tonnes), 2015–2030F**

*Source: TechSci Research*

**2021-2030**

**CAGR**

**5.19% By Volume**

**2015-2020**

**CAGR**

**3.44% By Volume**

**Global Epoxy Resin Demand-Supply Scenario, 2015-2030F (Thousand Tonnes)**

*Source: TechSci Research*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Parameters** | **2015** | **2020** | **2021E** | **2025F** | **2030F** |
| **Installed Capacity** | 3766 | 4484 | 4534 | 4785 | 4785 |
| **Production** | 2866 | 3246 | 3485 | 3724 | 4119 |
| **Total Demand** | 2754 | 3261 | 3494 | 4400 | 5511 |
| **(Y-O-Y Growth Rate**  *(In Percentage)* | 4.25% | -3.08% | 7.14% | 5.45% | 4.37% |
| **Demand – Supply Gap** |  | | -9 | -676 | -1392 |

**Market Overview (Post Covid)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Demand Scenario** | **2020** | **2021E** | **2024F** | **2028F** | **2030F** |
| **Realistic** | **3261** | **3494** | **4172** | **5055** | **5511** |
| **Optimistic** | **3261** | **3576** | **4580** | **6100** | **6974** |
| **Pessimistic** | **3261** | **3395** | **3718** | **4008** | **4121** |

**Global Epoxy Resin Demand Outlook, Realistic, Optimistic and Pessimistic, 2021E - 2030F (Thousand Tonnes)**

Growing Usage for the construction of wind turbine blades

Increased demand of brominated and waterborne epoxy resin

Import disruption and unavailability of feedstock resulted in lower operating rate in 2020 and H1 2021

Sharp recovery in growth across the primary markets like automotive and aerospace

*Source: TechSci Research*

* Market Leader such as Hexion, Olin, Huntsman and Kukdo are leveraging their market position to benefit from secular growth trends in composite sector. All major companies have integrated epoxy business which produces epoxy resins, modifiers and curing agents for high-performance materials, coatings, and composites. The integrated epoxy business includes upstream liquid epoxy resins and intermediates delivered as semi-solid or solid epoxy resins, as well downstream specialty epoxy resins used in coatings and composites.
* In November 2021, Westlake Chemical has confirmed to have entered into a definitive agreement to acquire the global epoxy business of the Hexion Corporation for USD 1.2 billion. The estimated time of completion of the transaction is during the first half of 2022.
* Wind energy segment will be key drivers for specialized epoxy resin. Global wind energy installation is expected to grow by 8.0 percent range in coming 9 years due to rising awareness in developing countries like India and China.
* Technology enhancement, recovery in housing sector and infrastructure developments are likely to drive future growth.
* Specialty epoxy resin used with carbon composites help in weight reduction, fuel saving and CO2 emission from automobiles. Lightweight material usage in auto sector is anticipated to increase from 28% in 2015 to 47% by 2030.
* The growth of the market is majorly attributed to the reviving economy of the India, China, European Union, GCC Nations and Latin American countries and growing focus on infrastructural development by public and private entities.

**Assumptions:**

1. Forecasting generally assumes overall economic stability and no significant changes in the industry or market.
2. Historical conditions in the past will not carry over into the future.
3. Operating rate for new unit is considered as 60 percent for 1st year and 90 percent later.
4. Crude oil and commodity prices are likely to stabilize from 2nd half of 2022 onwards.
5. Raw material prices likely to stabilize from 2nd half of 2022 onwards.
6. Covid-19 situation is likely to dimmish from 2023 onwards after global roll out of vaccination.
7. Increased investment in infrastructure and construction sector.
8. BRIC nations will have higher growth in comparison to North America and Europe
9. Increased expenditure in research and development will lead to increased usage of superior grades.
10. The basis of the historic data is secondary databases like annual reports of the competitors, import-export and other socio-economic factors. Forecast has been done through forecast model and primary responses of key opinion leaders.

**3.1.1. Capacity By Company & Location**

**Global Epoxy Resin Capacity, By Company (Thousand Tonnes), 2015-2030F**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Company** | **Location** | **Capacity\*** | | | | |
| **2015** | **2020** | **2021E** | **2025F** | **2030F** |
| Olin Corporation | USA | 170 | 170 | 170 | 170 | 170 |
| Germany | 170 | 245 | 245 | 245 | 245 |
| Brazil | 33 | 33 | 33 | 33 | 33 |
| Italy | 20 | 20 | 20 | 20 | 20 |
| China | 41 | 41 | 41 | 41 | 41 |
| Kukdo Chemical Co., Ltd. | China | 80 | 200 | 200 | 200 | 200 |
| South Korea | 160 | 160 | 160 | 160 | 160 |
| India | 0 | 40 | 40 | 40 | 40 |
| Huntsman Corporation20 | China | 64 | 64 | 64 | 64 | 64 |
| USA | 70 | 70 | 70 | 70 | 70 |
| Switzerland | 50 | 120 | 120 | 120 | 120 |
| Brazil | 10 | 10 | 10 | 10 | 10 |
| Hexion Inc. | Netherlands | 70 | 100 | 100 | 100 | 100 |
| USA | 127 | 127 | 127 | 127 | 127 |
| Spain | 10 | 32 | 32 | 32 | 32 |
| Jiangsu Sanmu Group | China | 170 | 220 | 220 | 220 | 220 |
| Nan Ya Plastics Corporation | Taiwan | 210 | 210 | 230 | 230 | 230 |
| China | 247 | 247 | 247 | 247 | 247 |
| The Dow Chemical Company | China | 41 | 41 | 41 | 41 | 41 |
| USA | 60 | 60 | 60 | 60 | 60 |
| South Korea | 30 | 30 | 30 | 30 | 30 |
| Germany | 30 | 30 | 30 | 30 | 30 |
| Japan | 40 | 40 | 40 | 40 | 40 |
| Grasim Industries Limited | India | 44 | 66 | 66 | 90 | 90 |
| Thailand | 38 | 100 | 100 | 100 | 100 |
| Nantong Xincheng Synthetic Material Co Ltd | China | 120 | 130 | 130 | 130 | 130 |
| Nippon Steel Chemical & Material Co., Ltd. | Japan | 100 | 120 | 120 | 120 | 120 |
| NAMA Chemicals | Saudi Arabia | 120 | 120 | 120 | 120 | 120 |
| Zhuhai Hongchang Electronic Material Co Ltd | China | 117 | 117 | 117 | 117 | 117 |
| Chang Chung Plastics Co Ltd | Taiwan | 50 | 100 | 100 | 100 | 100 |
| Jiangsu Yangnong Kumho Chemical Co., Ltd. | China | 75 | 95 | 95 | 95 | 95 |
| Sinopec Baling Petrochemical Co.,Ltd | China | 60 | 80 | 80 | 80 | 80 |
| Kumho P&B Chemicals | South Korea | 70 | 80 | 80 | 90 | 90 |
| Changchun Chemical (Jiangsu) Co., Ltd. | China | 75 | 75 | 75 | 75 | 75 |
| Spolchemie A.S. | Czech Republic | 60 | 60 | 60 | 60 | 60 |
| Alchemie Ltd. | United Kingdom | 60 | 60 | 60 | 60 | 60 |
| Anhui Shanfu New Material Technology Co., Ltd. | China | 58 | 58 | 58 | 58 | 58 |
| Dalian Qihua New Material Co. Ltd. | China | 50 | 50 | 50 | 50 | 50 |
| Atul Limited | India | 30 | 40 | 40 | 50 | 50 |
| Japan Epoxy Resins | Japan | 40 | 40 | 40 | 40 | 40 |
| LEUNA-Harze GmbH | Germany | 40 | 40 | 40 | 40 | 40 |
| Izel Kimya | Turkey | 40 | 40 | 40 | 40 | 40 |
| Ciech Sarzyna | Poland | 30 | 30 | 30 | 30 | 30 |
| SIR Industriale SpA | Italy | 20 | 20 | 20 | 20 | 20 |
| Meghmani Finechem Limited | India | 0 | 0 | 0 | 25 | 25 |
| Changzhou Hongchang Electronics Co | China | 0 | 0 | 0 | 70 | 70 |
| Sinopec Baling Petrochemical Co., Ltd. | China | 60 | 60 | 60 | 100 | 100 |
| Sika AG | Qatar | 0 | 0 | 15 | 15 | 15 |
| Hindusthan Speciality Chemicals Limited (HSCL) | India | 0 | 30 | 30 | 30 | 30 |
| Others | Rest of Global | 506 | 563 | 578 | 650 | 650 |
| Total |  | 3766 | 4484 | 4534 | 4785 | 4785 |

*Source: TechSci Research*

\**Only firm capacities (green field and brownfield expansion) have been considered during 2021- 2030 period. As of Q3 2021, five companies are going ahead with the expansion plans. Most of the global capacities other than India, and China are speculative only are in announcement phase and have not received financial closure as of now, hence not considered.*

Majority of epoxy resin capacities are strategically located in China. Rising industrialization and urbanization in developing nations such as India and China will influence the Epoxy Resin producers to expand the capacity in this region. Also, favourable government policies for renewables influences major epoxy resin producers to setup capacity in these countries. On the other hand, Capacities located in Western European and North American countries will show a moderate growth in expansion due to the market slowly reaching to its maturity in these regions. Also, government regulation to commercialize capacity is more stringent in these regions compared to Asia Pacific.

**Expected Upcoming Capacities**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Country | Project | Estimated Investment | Planned Capacities (000 Tonnes) | Expected Year of commissioning | References |
| India | Grasim Industries Ltd | USD 15 Million | 24 (Brownfield Expansion) | 2025 | Primary research |
| China | Changzhou Hongchang Electronics Co | USD 94 Million | 140 (Epoxy Resin System | 2024 | Primary Research |
| China | Sinopec Baling Petrochemical Co., Ltd.1 | USD 3 Million | 20 (Solid Epoxy Resin Plant) | 2023 |  |
| Qatar | Sika AG2 | USD 12 million (Epoxy Resin and Admixture) | 15 (Greenfield Expansion) | 2021 | Company Press Releases |
| India | Meghmani Finechem Ltd | USD 55 Million | 25 (Integrated ECH Epoxy Unit) | 2024 | Primary research |
| India | Atul Limited | USD 8 Million | 10 (Brownfield Expansion) | 2024 | Primary research |

1. *<https://www.echemi.com/cms/355037.html>*
2. [*https://www.sika.com/en/media/media-releases/2021/sika-exploits-further-growth-potential-in-qatar.html*](https://www.sika.com/en/media/media-releases/2021/sika-exploits-further-growth-potential-in-qatar.html)

**Global Annual Wind Installation Required Under IEA’s NZE2050, (In GW)**

Under the ambit of ambitious Net Zero Emissions by 2050 (NZE2050) target, several countries have introduced targets to achieve net-zero emissions by 2050. These targets are included and achieved in the sustainable development scenario (SDS). The investment in renewable sector to achieve net zero emissions target would be immense and estimated to be USD120 billion by 2030, with about one-third of that on strengthening and expanding the wind energy sector.

**3.1.2. Production By Company**

**Global Epoxy Resin Production, By Company (Thousand Tonnes), 2015-2030F**

*Source: TechSci Research*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Company | 2015 | 2020 | 2021E | 2025F | 2030F |
| Olin Corporation | 324 | 337 | 368 | 408 | 442 |
| Kukdo Chemical Co., Ltd. | 187 | 238 | 258 | 262 | 291 |
| Huntsman Corporation | 144 | 177 | 179 | 188 | 212 |
| Nan Ya Plastics Corporation | 402 | 408 | 426 | 420 | 470 |
| Hexion Inc. | 160 | 180 | 196 | 210 | 236 |
| Jiangsu Sanmu Group | 137 | 165 | 175 | 172 | 198 |
| The Dow Chemical Company | 149 | 153 | 156 | 162 | 178 |
| Grasim Industries Limited | 57 | 123 | 131 | 165 | 173 |
| Nantong Xincheng Synthetic Material Co Ltd | 99 | 100 | 106 | 101 | 117 |
| Nippon Steel Chemical & Material Co., Ltd. | 82 | 99 | 97 | 106 | 114 |
| NAMA Chemicals | 91 | 90 | 88 | 94 | 106 |
| Zhuhai Hongchang Electronic Material Co Ltd | 102 | 91 | 98 | 99 | 111 |
| Chang Chung Plastics Co Ltd | 37 | 69 | 77 | 80 | 90 |
| Jiangsu Yangnong Kumho Chemical Co., Ltd. | 61 | 71 | 76 | 74 | 86 |
| Sinopec Baling Petrochemical Co.,Ltd | 51 | 67 | 69 | 68 | 76 |
| Kumho P&B Chemicals | 55 | 57 | 61 | 72 | 79 |
| Changchun Chemical (Jiangsu) Co., Ltd. | 64 | 57 | 60 | 59 | 68 |
| Spolchemie A.S. | 44 | 44 | 45 | 48 | 53 |
| Alchemie Ltd. | 44 | 42 | 47 | 49 | 54 |
| Anhui Shanfu New Material Technology Co., Ltd. | 45 | 48 | 50 | 49 | 55 |
| Dalian Qihua New Material Co. Ltd. | 41 | 41 | 40 | 39 | 45 |
| Atul Limited | 19 | 29 | 32 | 44 | 45 |
| Japan Epoxy Resins | 30 | 28 | 29 | 30 | 34 |
| LEUNA-Harze GmbH | 30 | 24 | 26 | 28 | 31 |
| Izel Kimya | 31 | 34 | 35 | 36 | 38 |
| Ciech Sarzyna | 20 | 20 | 23 | 24 | 26 |
| SIR Industriale SpA | 15 | 14 | 15 | 16 | 18 |
| Meghmani Finechem Limited | 0 | 0 | 0 | 13 | 21 |
| CHANGZHOU HONGCHANG ELECTRONICS CO | 0 | 0 | 0 | 53 | 60 |
| Sinopec Baling Petrochemical Co., Ltd. | 51 | 67 | 69 | 83 | 93 |
| Sika AG | 0 | 0 | 9 | 14 | 14 |
| Hindusthan Speciality Chemicals Limited (HSCL) | 0 | 16 | 21 | 25 | 25 |
| Others | 294 | 357 | 423 | 434 | 461 |
| Total | 2866 | 3246 | 3485 | 3724 | 4119 |

**3.1.3. Operating Efficiency by Company**

**Global Epoxy Resin Capacity, Operating Efficiency, By Company (Percentage), 2015-2030F**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Company | 2015 | 2020 | 2021E | 2025F | 2030F |
| Olin Corporation | 75 | 66 | 72 | 80 | 87 |
| Kukdo Chemical Co., Ltd. | 78 | 60 | 65 | 66 | 73 |
| Huntsman Corporation | 74 | 67 | 68 | 71 | 80 |
| Nan Ya Plastics Corporation | 88 | 89 | 89 | 88 | 99 |
| Hexion Inc. | 77 | 69 | 76 | 81 | 91 |
| Jiangsu Sanmu Group | 81 | 75 | 80 | 78 | 90 |
| The Dow Chemical Company | 74 | 76 | 78 | 81 | 89 |
| Grasim Industries Limited | 70 | 74 | 79 | 87 | 91 |
| Nantong Xincheng Synthetic Material Co Ltd | 83 | 77 | 82 | 78 | 90 |
| Nippon Steel Chemical & Material Co., Ltd. | 82 | 83 | 81 | 88 | 95 |
| NAMA Chemicals | 76 | 75 | 73 | 78 | 88 |
| Zhuhai Hongchang Electronic Material Co Ltd | 87 | 78 | 84 | 85 | 95 |
| Chang Chung Plastics Co Ltd | 74 | 69 | 77 | 80 | 90 |
| Jiangsu Yangnong Kumho Chemical Co., Ltd. | 81 | 75 | 80 | 78 | 91 |
| Sinopec Baling Petrochemical Co.,Ltd | 85 | 84 | 86 | 85 | 95 |
| Kumho P&B Chemicals | 79 | 71 | 76 | 80 | 88 |
| Changchun Chemical (Jiangsu) Co., Ltd. | 85 | 76 | 80 | 79 | 91 |
| Spolchemie A.S. | 73 | 73 | 75 | 80 | 88 |
| Alchemie Ltd. | 73 | 70 | 78 | 82 | 90 |
| Anhui Shanfu New Material Technology Co., Ltd. | 78 | 83 | 86 | 84 | 95 |
| Dalian Qihua New Material Co. Ltd. | 82 | 82 | 80 | 78 | 90 |
| Atul Limited | 63 | 73 | 80 | 88 | 90 |
| Japan Epoxy Resins | 75 | 70 | 73 | 75 | 85 |
| LEUNA-Harze GmbH | 75 | 60 | 65 | 70 | 78 |
| Izel Kimya | 78 | 85 | 88 | 90 | 95 |
| Ciech Sarzyna | 67 | 67 | 77 | 80 | 87 |
| SIR Industriale SpA | 75 | 70 | 75 | 80 | 90 |
| Meghmani Finechem Limited | 0 | 0 | 0 | 52 | 84 |
| Changzhou Hongchang Electronics Co | 0 | 0 | 0 | 75 | 85 |
| Sinopec Baling Petrochemical Co., Ltd. | 0 | 0 | 0 | 83 | 93 |
| Sika AG | 0 | 0 | 60 | 90 | 90 |
| Hindusthan Speciality Chemicals Limited (HSCL) | 0 | 53 | 70 | 83 | 83 |
| Others | 58 | 66 | 76 | 67 | 71 |

*Source: TechSci Research*

**3.1.4. Demand By Type**

**Global Epoxy Resin Demand, By Type (Thousand Tonnes) (%), 2015–2030F**

*.*

*Source: TechSci Research*

*Source: TechSci Research*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Demand by Type** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021E** | **2025F** | **2030F** |
| Bisphenol A Based Resin | 2291 | 2401 | 2579 | 2636 | 2780 | 2689 | 2872 | 3585 | 4415 |
| Bisphenol F Based Resin | 95 | 103 | 115 | 118 | 134 | 137 | 150 | 217 | 315 |
| Epoxy Phenol Novolac Based Resin | 64 | 69 | 72 | 78 | 82 | 81 | 89 | 118 | 160 |
| Cycloaliphatic Epoxy Based Resin | 56 | 57 | 61 | 61 | 64 | 59 | 65 | 82 | 116 |
| Others | 248 | 261 | 284 | 294 | 305 | 295 | 319 | 398 | 505 |
| **Total** | **2754** | **2891** | **3110** | **3187** | **3365** | **3261** | **3494** | **4400** | **5511** |

* Bisphenol A (BPA) based Epoxy resins continues to pull strong number in terms of demand by type due to its cost benefit and process availability. However, increasing awareness towards harmful impacts of BPA and advent of several alternatives for production of Epoxy resins have resulted in consumers opting for comparatively safer alternatives.
* Recently, Bisphenol F based Epoxy resins have gained traction in the market and is likely to consolidate on the demand numbers in the coming years.
* Despite a dip in demand for BPA based Epoxy resins in last few years due to its handling and carcinogenicity, they continue to dominate the market and are likely to maintain a large segment of demand in the coming decade.

**3.1.5. Demand By Grade**

**Global Epoxy Resin Demand, By Grade (Thousand Tonnes) (%), By Volume, 2015–2030F**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Demand by Grade** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021E** | **2025F** | **2030F** |
| Liquid | 1414 | 1493 | 1602 | 1655 | 1748 | 1695 | 1833 | 2315 | 2911 |
| Semi-Solid | 250 | 261 | 275 | 277 | 288 | 284 | 289 | 357 | 430 |
| Solid | 1090 | 1138 | 1234 | 1255 | 1328 | 1283 | 1371 | 1727 | 2170 |
| **Total** | **2754** | **2891** | **3110** | **3187** | **3365** | **3261** | **3494** | **4400** | **5511** |

*Source: TechSci Research*

* Liquid epoxy resin remained the most widely used grade of epoxy which is heavily used across various sectors of applications like housing and infrastructure(new and repair) and likely to grow further in coming years.
* Solid epoxy resin was also not far behind from liquid epoxy in absolute terms whose demand is likely to remain stable.
* The demand of semi solid is anticipated to grow at slower rate than liquid and solid grade due to its diminishing use in various end user industry.

**3.1.6. Global Demand-Supply Gap**

**Global Epoxy Resin Market Demand-Supply Analysis, By Volume (Thousand Tonnes), 2015-2030F**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **2015** | **2016** | **2018** | **2019** | **2020** | **2021E** | **2025F** | **2030F** |
| **Capacity** | 3766 | 3796 | 4284 | 4419 | 4484 | 4519 | 4648 | 4648 |
| **Production** | 2866 | 2986 | 3328 | 3470 | 3246 | 3485 | 3724 | 4119 |
| **Total Demand** | 2754 | 2891 | 3187 | 3365 | 3261 | 3494 | 4400 | 5511 |
| **Demand Supply Gap** |  | | | | | -9 | -676 | -1392 |

*Source: TechSci Research*

**3.1.7. Demand By Sales Channel**

**Global Epoxy Resin Demand, By Sales Channel (Thousand Tonnes) (%), By Volume, 2015–2030F**

*Source: TechSci Research*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Demand by Sales Channel** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** |
| Direct Company Sale | 1535 | 1615 | 1767 | 1818 | 1931 | 1899 |
| Indirect | 1219 | 1276 | 1343 | 1369 | 1433 | 1362 |
| **Total** | **2754** | **2891** | **3110** | **3187** | **3365** | **3261** |

*Source: TechSci Research*

**3.1.8. Demand By Application**

**Global Epoxy Resin Demand, By Application (Thousand Tonnes) (%), By Volume, 2015–2030F**

*.*

*Source: TechSci Research*

*Source: TechSci Research*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Demand by Application** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021E** | **2025F** | **2030F** |
| Paints & Coatings | 1170 | 1238 | 1332 | 1362 | 1440 | 1386 | 1493 | 1902 | 2400 |
| Electrical & Electronics | 699 | 737 | 800 | 821 | 871 | 843 | 911 | 1159 | 1460 |
| Construction | 251 | 262 | 282 | 289 | 307 | 291 | 311 | 394 | 497 |
| Composite Materials | 328 | 347 | 370 | 380 | 400 | 381 | 407 | 506 | 630 |
| Adhesives | 172 | 185 | 198 | 204 | 214 | 208 | 223 | 283 | 356 |
| Others | 134 | 122 | 128 | 131 | 133 | 153 | 148 | 156 | 169 |
| **Total** | **2754** | **2891** | **3110** | **3187** | **3365** | **3261** | **3494** | **4400** | **5511** |

**3.1.9. Sales By Company**

**Global Epoxy Resin Sales, By Company, By Volume, 2020**

*Others include Poliya, Hexion Inc., DIC Corporation, Saudi Arabia Industrial Resins Ltd.., Reinhold GmbH, Interplastic Corporation, Allnex Group, Sewon Chemical, Innovative Resins Pvt. Ltd., Orson Chemicals etc.*

*Source: TechSci Research*

**3.1.10. Demand By Region**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Region/Country** | **2015** | **2020** | **2021E** | **2025F** | **2030F** | **CAGR (2015-2020)** | **CAGR (2021E-2030F)** |
| Asia Pacific | 1594 | 2040 | 2200 | 2870 | 3675 | 5.06% | 5.87% |
| China | 1205 | 1559 | 1714 | 2280 | 2924 | 5.30% | 6.10% |
| South Korea | 77 | 91 | 97 | 121 | 156 | 3.30% | 5.40% |
| India | 65 | 89 | 98 | 140 | 208 | 6.30% | 8.70% |
| Others | 247 | 302 | 292 | 330 | 386 | 4.10% | 3.20% |
| Global APAC (Percentage Share) | 57.90% | 62.60% | 63.00% | 65.20% | 66.70% |  |  |
| Europe | 507 | 551 | 582 | 675 | 822 | 1.67% | 3.91% |
| Germany | 131 | 153 | 161.4 | 191.6 | 226.2 | 3.20% | 3.80% |
| Spain | 29.2 | 31.4 | 33 | 38.2 | 44.4 | 1.50% | 3.40% |
| Italy | 68.5 | 65.1 | 68.8 | 80.7 | 94 | -1.00% | 3.50% |
| Others | 278.2 | 301 | 318.9 | 364.6 | 457.2 | 1.60% | 4.10% |
| Global Europe (Percentage Share) | 18.40% | 16.90% | 16.70% | 15.30% | 14.90% |  |  |
| North America | 299 | 317 | 335 | 397 | 465 | 1.16% | 3.73% |
| USA | 240.5 | 253 | 260.3 | 291.4 | 326.6 | 1.00% | 2.60% |
| Canada | 36.8 | 47.2 | 56.8 | 84.1 | 112 | 5.10% | 7.80% |
| Others | 21.5 | 16.4 | 17.6 | 21.6 | 26.7 | -5.20% | 4.70% |
| Global North America (Percentage Share) | 10.90% | 9.70% | 9.60% | 9.00% | 8.40% |  |  |
| South America | 80 | 83 | 88 | 105 | 124 | 0.81% | 3.94% |
| Brazil | 58.7 | 62.6 | 65.8 | 78.5 | 93.1 | 1.30% | 3.90% |
| Others | 20.9 | 20.3 | 21.8 | 26.2 | 30.9 | -0.60% | 4.00% |
| Global South America (Percentage Share) | 2.90% | 2.50% | 2.50% | 2.40% | 2.20% |  |  |
| Middle East and Africa | 274 | 271 | 289 | 352 | 425 | -0.21% | 4.38% |
| Saudi Arabia | 54.6 | 60.1 | 63.5 | 80.5 | 107.7 | 1.90% | 6.10% |
| Turkey | 21.2 | 20.5 | 21.3 | 26 | 35.3 | -0.70% | 5.80% |
| Others | 198 | 190.4 | 204.4 | 246 | 282.3 | -0.80% | 3.70% |
| Global MEA (Percentage Share) | 9.90% | 8.30% | 8.30% | 8.00% | 7.70% |  |  |
|  |  |  |  |  |  |  |  |
| Asia Pacific | 1594 | 2040 | 2200 | 2870 | 3675 | 5.05% | 5.86% |
| Europe | 507 | 551 | 582 | 675 | 822 | 1.67% | 3.91% |
| North America | 299 | 317 | 335 | 397 | 465 | 1.16% | 3.73% |
| South America | 80 | 83 | 88 | 105 | 124 | 0.81% | 3.94% |
| Middle East and Africa | 274 | 271 | 289 | 352 | 425 | -0.21% | 4.38% |
| Global | 2754 | 3261 | 3494 | 4400 | 5511 | 3.44% | 5.19% |

*Source: TechSci Research*

Region wise, Asia Pacific holds the major share of the global demand for Epoxy Resin with a market share of 62.6% in 2020, which is expected to rise gradually during the forecast period to around 66.68% in 2030. Epoxy Resin has major applications in areas like wind energy, automotive, electrical & electronics and other areas having a demand for high-performance materials with chemical resistance properties. Asia pacific, being home to the China & India are the developing & world’s most populated country, so demand can directly link to this & simultaneously expected to have high demand in the forecast period. With the countries moving towards more and more sustainable energy solutions, the demand for wind energy is expected to grow exponentially in Asia Pacific during the forecast period; hence the region will keep the lion’s share of global demand for Epoxy Resin.

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**ASIA PACIFIC EPOXY RESIN MARKET OUTLOOK**

A picture containing brass, music, indoor

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**3.2.1. APAC Epoxy Resin Capacity & Production, By Volume, 2015 - 2030F (Thousand Tonnes)**

**3.2.2. Capacity By Location**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Company** | **Location** | **2015** | **2020** | **2030F** |
| Nan Ya Plastics Corporation | China | 247 | 247 | 247 |
| Taiwan | 210 | 210 | 230 |
| Kukdo Chemical Co., Ltd. | India | 0 | 40 | 40 |
| China | 80 | 200 | 200 |
| Taiwan | 160 | 160 | 160 |
| Jiangsu Sanmu Group | China | 170 | 220 | 220 |
| Nantong Xincheng Synthetic Material Co Ltd | China | 120 | 130 | 130 |
| Others | Rest of APAC | 1348 | 1649 | 1930 |
| **Total** |  | **2335** | **2856** | **3157** |

**3.2.3. Asia Pacific Demand**

**Asia Pacific Epoxy Resin Demand, By Volume (Thousand Tonnes), 2015–2030F**

**2021E-2030F**

**CAGR**

**5.86% By Volume**

**2015-2020**

**CAGR**

**5.05%% By Volume**

*Source: TechSci Research*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Approach: Growth Forecast Via Factors (Impact Analysis)** | | | | |
| **Factors** | **Sources** | **Value** | **CAGR** | **Weightage** |
| **GDP Growth Rate (2021-2030 Period)** | ***World Bank, IMF, TechSci Estimates*** | ***Forecast*** | 6.12% | 14.00% |
| **GDP Per Capita (%)** | ***World Bank, IMF, TechSci Estimates*** | ***Forecast*** | 4.12% | 5.00% |
| **Average Selling Growth (%)** | ***TechSci Research Estimates*** | ***Forecast*** | 2.73% | 3.00% |
| **Growth in Construction Sector** | ***TechSci Research Estimates*** | ***Forecast*** | 6.12% | 20.00% |
| **Growth in Renewable Sector** | ***TechSci Research Estimates*** | ***Forecast*** | 7.00% | 20.00% |
| **Growth in Automotive Sector** | ***OICA*** | ***Forecast*** | 5.10% | 12.00% |
| **Paint & Coating Industry Growth** | ***Industry Sources & TechSci Research Estimates*** | ***Forecast*** | 6.00% | 18.00% |
| **Market Growth in Historical Period (2015-2020)** | ***Industry Sources & TechSci Research Estimates*** | ***Historical*** | 5.05% | 8.00% |
| **CAGR (2021-2030)** | **5.86%** | | | |

TechSci Research has followed this approach to calculate the growth rates by understanding the impact of various factors of the industry. These factors were given weightage according to the relative importance of each factor. Finally, each factor was multiplied with its weightage and their sum was used to calculate market growth.

**3.2.4. Operating Efficiency**

**Asia Pacific Epoxy Resin Operating Efficiency (Percentage), 2015-2030F**

**Asia Pacific Growth Trend in Foreign Direct Investment, (USD Billion), 2010, 2019 & 2025F**

**3.2.5. Demand By Application**

**Asia Pacific Epoxy Resin Demand, By Application (Thousand Tonnes) (%), By Volume, 2015–2030F**

*Others Marine, Defence, Encapsulation etc.*

*Source: TechSci Research*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Demand by Application** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021E** | **2025F** | **2030F** |
| Paints & Coatings | 702 | 747 | 825 | 850 | 907 | 897 | 971 | 1278 | 1646 |
| Electrical & Electronics | 450 | 476 | 529 | 546 | 583 | 578 | 625 | 818 | 1050 |
| Construction | 144 | 153 | 170 | 176 | 190 | 184 | 199 | 260 | 334 |
| Composite Materials | 140 | 147 | 164 | 169 | 181 | 178 | 192 | 252 | 324 |
| Adhesives | 100 | 105 | 116 | 121 | 128 | 128 | 138 | 181 | 233 |
| Others | 58 | 55 | 60 | 62 | 64 | 75 | 75 | 81 | 88 |
| **Total** | **1594** | **1683** | **1864** | **1924** | **2053** | **2040** | **2200** | **2870** | **3675** |

*Source: TechSci Research*

Demand of Liquid and Solid Epoxy Resin witnessed a strong demand from Auto and Consumer durable leading to uptick in realization and sales volume in China, India, South Korea and Thailand.

Construction industry will be focusing on major investments in the housing, energy, and utility infrastructure.

According to estimates, the construction industry in APAC region is likely to grow by 7.8% in 2021 after a slowdown in the past year due to COVID-19.

Growing IoT ecosystem is expected to uplift demand for electronics products in coming years. Northeast Asia, with the highest concentration of electronic component manufacturing, seems to be making aggressive moves towards expanding their facilities to match global demand. The region holds the largest share in the market.

Demand for composites from renewables, marine and aerospace are rising due to rapid urbanization and industrial and aviation sector growth and considerable opportunities exist for specialized epoxy resin manufacturers to tap the growing market in Asia Pacific region.

Coating

Construction

Electronics

Composites

**3.2.6. Demand By Type**

**Asia Pacific Epoxy Resin Demand, By Type (Thousand Tonnes) (%), By Volume, 2015–2030F**

*Source: TechSci Research*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Demand by Type** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021F** | **2025F** | **2030F** |
| Bisphenol A Based Resin | 1348 | 1421 | 1573 | 1622 | 1732 | 1718 | 1846 | 2378 | 2979 |
| Bisphenol F Based Resin | 55 | 61 | 71 | 73 | 87 | 93 | 102 | 158 | 237 |
| Epoxy Phenol Novolac Based Resin | 24 | 26 | 28 | 34 | 35 | 37 | 41 | 58 | 79 |
| Cycloaliphatic Epoxy Based Resin | 19 | 20 | 22 | 22 | 24 | 22 | 25 | 34 | 56 |
| Others | 148 | 155 | 170 | 173 | 175 | 170 | 186 | 242 | 324 |
| **Total** | **1594** | **1683** | **1864** | **1924** | **2053** | **2040** | **2200** | **2870** | **3675** |

*Source: TechSci Research*

**3.2.7. Demand By Grade**

**Asia Pacific Epoxy Resin Demand, By Grade (Thousand Tonnes) (%), By Volume, 2015–2030F**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Demand by Grade** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021E** | **2025F** | **2030F** |
| Liquid | 799 | 849 | 935 | 970 | 1034 | 1032 | 1115 | 1458 | 1872 |
| Semi-Solid | 135 | 142 | 155 | 159 | 168 | 168 | 179 | 229 | 285 |
| Solid | 660 | 692 | 774 | 794 | 851 | 840 | 907 | 1183 | 1519 |
| **Total** | **1594** | **1683** | **1864** | **1924** | **2053** | **2040** | **2200** | **2870** | **3675** |

*Source: TechSci Research*

**3.2.8. Asia-Pacific Epoxy Resin Market Demand-Supply Analysis, By Volume, 2015-2030F (Thousand Tonnes)**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021E** | **2025F** | **2030F** |
| **Capacity** | 2335 | 2365 | 2607 | 2701 | 2816 | 2856 | 2891 | 3030 | 3030 |
| **Production** | 1819 | 1908 | 2062 | 2142 | 2262 | 2135 | 2303 | 2435 | 2701 |
| **Import** | 383 | 417 | 464 | 446 | 474 | 556 |  | | |
| **Export** | 607 | 642 | 662 | 665 | 683 | 650 |
| **Total Demand** | 1594 | 1683 | 1864 | 1924 | 2053 | 2040 | 2200 | 2870 | 3675 |
| **Demand Supply Gap** |  | | | | | | 102 | -435 | -974 |

*Source: TechSci Research*

**3.2.9. Demand By Sales Channel**

**Asia Pacific Epoxy Resin Demand, By Sales Channel (Thousand Tonnes) (%), By Volume, 2015–2030F**

*Source: TechSci Research*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Demand by Sales Channel** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** |
| Direct Company Sale | 927 | 984 | 1113 | 1165 | 1255 | 1266 |
| Indirect | 667 | 699 | 751 | 758 | 798 | 774 |
| **Total** | **1594** | **1683** | **1864** | **1924** | **2053** | **2040** |

**3.2.10. Sales By Company**

**Asia Pacific Epoxy Resin Sales, By Company, By Volume, 2020**

*Source: TechSci Research*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Region** | **Demand Volume Share (%)** | **2020** | **2021E** |  | **2020** | **2021E** |
| Asia Pacific | Kukdo Chemical | 238 | 221 |  | 11.61% | 10.87% |
| Asia Pacific | Nan Ya Electronic Material (Kunshan) Co. Ltd. | 179 | 189 |  | 8.74% | 9.28% |
| Asia Pacific | Jiangsu Sanmu Group | 148 | 151 |  | 7.22% | 7.44% |
| Asia Pacific | Nan Ya Plastics Co Ltd | 144 | 147 |  | 7.06% | 7.21% |
| Asia Pacific | Nantong Xincheng Synthetic Material Co Ltd | 90 | 87 |  | 4.42% | 4.29% |
| Asia Pacific | Nippon Steel Chemical & Material Co., Ltd. | 82 | 88 |  | 4.04% | 4.32% |
| Asia Pacific | The Dow Chemical Company | 73 | 80 |  | 3.59% | 3.95% |
| Asia Pacific | Others | 1094 | 1073 |  | 53.32% | 52.64% |

*Source: TechSci Research*

**APAC Epoxy Resin Sales, By Company, By Volume, 2020**

Driven by the outstanding performance in the electronics sector in the APAC region, particularly in China and Japan where a trend has been observed which shows increase in the disposable incomes of the middle class. Consequently, sharp rise in demand has also been witnessed consolidating on the substantial growth in electronics and gadgets. Kukdo Chemical a highly specialized company which manufactures highest quality of epoxy resin in the market hold around 11 percent share in Asia Pacific region in 2020. Building on the growth in consumer electronics industry in Asia Pacific region, Nan Ya Electronic Material another key player in the APAC has observed significant growth in its epoxy numbers. The company hold 8.74 percent share in 2020 and is anticipated to increase its market hold in APAC region. Moreover, Market participants will further look to gain from the strengthening construction sector which has been led by infrastructure development and residential buildings.

**APAC Market Insights**

The Asia Pacific Epoxy Resin market has registered a CAGR of 5.05% between 2015-2020 and is anticipated to grow at a CAGR of 5.86% in the period of forecast. The regional Epoxy Resin demand currently stands at 2200 thousand tonnes and is anticipated to reach 3675 thousand tonnes by 2030. The region’s total Epoxy Resin capacity is 2891 KTPA and the region’s cumulative operating efficiency stands around 77.51% in the estimated year (2021).

While China leads the ranks of countries having strong FDIs, a gradual shift in the interest of global players since the pandemic, poses a risk to the country’s industrial progress. Strong FDIs in India due to favourable government policies like PLI scheme, Atmanirbhar Bharat Mission and incentivisation of MSMEs are likely to support FDIs in the Indian Epoxy Resin industry and propel the market growth in the period of forecast. As per our market projections, due to favourable conditions, India is likely attract FDIs worth USD 65 Billion by 2025.

Based on application, the Asian Epoxy Resin market has been segmented into Paints and Coatings, Electrical and Electronics, Construction, Composite Materials, Adhesives and Others. Paints and Coatings region’s total demand. Paints and Coatings sector reported strong growth since 2016 on account of strong performances from construction and automotive sectors. However, since then stabilization has been observed in sector epitomizing the slowdown in economies in APAC region. Furthermore, demand measured a sharp decline in 2020 due to consumption weakening from the key application sectors. Strong signs of improvement have been evident in 2021 for paints and coatings industry as construction sector accelerated consumption after the slump of 2020. On the back of demand strengthening from downstream sectors, it has been estimated that Paints and Coatings industry will be revived in terms of demand by application and is projected to consolidate on 2021 impetus. Technological advancements in the material sciences are likely to affirmatively impact the demand growth trajectory for composite materials after the decline in demand in 2020 due to halt in manufacturing activities around the globe. Aerospace and defence industries are paving for improved consumption and spearheading demand for composite materials.

Based on type, Bisphenol A (BPA)-based Epoxy Resins continue to pull strong number from the total market. However, increasing awareness towards harmful impacts of BPA and advent of several alternatives for production of Epoxy Resins have resulted in consumers opting for comparatively safer alternatives. Recently, Bisphenol F based Epoxy Resins have gained traction in the market and is likely to consolidate on the demand numbers in the coming years. Despite a dip in demand for BPA based Epoxy Resins in last few years, they continue to dominate the APAC Epoxy Resin market and are likely to maintain a large segment of the demand in the coming decade.

By Grade, Liquid Epoxy Resin (LER) remained the most widely used grade of Epoxy, holding demand share of around 50% in 2021. LERs are heavily used as construction chemicals and likely to grow further in coming years. Solid Epoxy Resins are not far behind from liquid Epoxy and its demand is likely to remain stable in the period of forecast. Epoxy Resins are mostly available to the buyers via Direct Company sales.

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**EUROPE**

**EPOXY RESIN MARKET OUTLOOK**

A picture containing food, rice, plate, white

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**3.3.1 Europe Epoxy Resin Capacity & Production, By Volume (Thousand Tonnes), 2015 - 2030F**

*Source: TechSci Research*

**3.3.2. Capacity By Location, By Volume (Thousand Tonnes)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Company | Location | 2015 | 2020 | 2030F |
| Olin Corporation | Germany | 170 | 245 | 245 |
| Italy | 20 | 20 | 20 |
| Hexion Inc. | Spain | 10 | 32 | 32 |
| Netherlands | 70 | 100 | 100 |
| Huntsman Corporation | Switzerland | 50 | 120 | 120 |
| Alchemie Ltd. | United Kingdom | 60 | 60 | 60 |
| Spolchemie A.S. | Czech Republic | 60 | 60 | 60 |
| Others | Rest of Europe | 301 | 301 | 301 |
| Total |  | 741 | 938 | 938 |

*Source: TechSci Research*

**3.3.3. Europe Epoxy Resin Demand**

**Europe Epoxy Resin Demand, By Volume (Thousand Tonnes), 2015–2030F**

**2021E-2030F**

**CAGR**

**3.91% By Volume**

**2015-2020**

**CAGR**

**1.67% By Volume**

*Source: TechSci Research*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Approach: Growth Forecast Via Factors (Impact Analysis)** | | | | |
| **Factors** | **Sources** | **Value** | **CAGR** | **Weightage** |
| **GDP Growth Rate (2021-2030 Period\_** | ***OECD, IMF, TechSci Estimates*** | ***Forecast*** | 3.92% | 20.00% |
| **GDP Per Capita (%)** | ***OECD, IMF, TechSci Estimates*** | ***Forecast*** | 3.22% | 10.00% |
| **Average Selling Growth (%)** | ***TechSci Research Estimates*** | ***Forecast*** | 2.38% | 8.00% |
| **Growth in Construction Sector** | ***TechSci Research Estimates*** | ***Forecast*** | 4.16% | 10.00% |
| **Growth in Renewable Sector** | ***TechSci Research Estimates*** | ***Forecast*** | 4.55% | 20.00% |
| **Growth in Automotive Sector** | ***OICA, ACEA*** | ***Forecast*** | 5.00% | 14.00% |
| **Paint & Coating Industry Growth** | ***Industry Sources & TechSci Research Estimates*** | ***Forecast*** | 4.50% | 10.00% |
| **Market Growth in Historical Period (2015-2020)** | ***Industry Sources & TechSci Research Estimates*** | ***Historical*** | 1.67% | 8.00% |
| **CAGR (2021-2030)** | **3.91%** | | | |

TechSci Research has followed this approach to calculate the growth rates by understanding the impact of various factors of the industry. These factors were given weightage according to the relative importance of each factor. Finally, each factor was multiplied with its weightage and their sum was used to calculate market growth.

**Europe Construction Market Size, By Value (USD Billion), 2016-2020**

*Source: Eurostat*

**3.3.4. Operating Efficiency**

**Europe Epoxy Resin Operating Efficiency (Percentage), 2015-2030F**

*Source: TechSci Research*

**European Countries Real Estate Investment, 2020 (USD Billion)**

|  |  |
| --- | --- |
| **Countries** | **Investment (USD Billion)** |
| Germany | 57 |
| France | 28 |
| Netherland | 14 |
| Spain | 12 |

*Source: TechSci Research*

**3.3.5. Demand By Application**

**Europe Epoxy Resin Demand, By Application (Thousand Tonnes) (%), By Volume, 2015–2030F**

*Others Marine, Defence, Encapsulation etc.*

*Source: TechSci Research*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Demand by Application** | **2015** | **2020** | **2021E** | **2025F** | **2026F** | **2030F** |
| Paints & Coatings | 200 | 216 | 232 | 272 | 283 | 334 |
| Electrical & Electronics | 101 | 113 | 124 | 145 | 151 | 177 |
| Construction | 38 | 38 | 40 | 46 | 48 | 57 |
| Composite Materials | 96 | 106 | 112 | 130 | 135 | 158 |
| Adhesives | 30 | 35 | 37 | 44 | 45 | 54 |
| Others | 42 | 42 | 37 | 38 | 39 | 42 |
| **Total** | **507** | **551** | **582** | **675** | **701** | **822** |

*Source: TechSci Research*

**3.3.6. Demand By Type**

**Europe Epoxy Resin Demand, By Type (Thousand Tonnes) (%), By Volume, 2015–2030F**

*Source: TechSci Research*

**3.3.7. Europe Epoxy Resin Market Demand-Supply Analysis, By Volume, 2015-2030F (Thousand Tonnes)**

*Source: TechSci Research*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021E** | **2025F** | **2030F** |
| **Capacity** | 741 | 741 | 751 | 893 | 913 | 938 | 938 | 938 | 938 |
| **Production** | 526 | 542 | 563 | 670 | 696 | 621 | 677 | 741 | 812 |
| **Import** | 250 | 270 | 283 | 211 | 225 | 210 |  | | |
| **Export** | 260 | 273 | 282 | 296 | 310 | 270 |
| **Total Demand** | 507 | 530 | 555 | 574 | 599 | 551 | 582 | 675 | 822 |
| **Demand Supply Gap** |  | | | | | | 95 | 66 | -10 |

**3.3.8. Demand By Sales Channel**

**Europe Epoxy Resin Demand, By Sales Channel (Thousand Tonnes) (%), By Volume, 2015–2020**

*Source: TechSci Research*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Demand by Sales Channel** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** |
| Direct Company Sale | 284 | 295 | 309 | 310 | 322 | 300 |
| Indirect | 222 | 236 | 246 | 264 | 277 | 250 |
| **Total** | **507** | **530** | **555** | **574** | **599** | **551**  *Source: TechSci Research* |

**3.3.9. Demand By Grade**

**Europe Epoxy Resin Demand, By Grade (Thousand Tonnes) (%), By Volume, 2015–2030F**

*Source: TechSci Research*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Demand by Grade** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021E** | **2025F** | **2030F** |
| Liquid | 251 | 265 | 279 | 297 | 314 | 284 | 317 | 371 | 457 |
| Semi-Solid | 63 | 66 | 67 | 64 | 65 | 63 | 56 | 63 | 73 |
| Solid | 193 | 199 | 209 | 212 | 221 | 203 | 209 | 241 | 292 |
| **Total** | **507** | **530** | **555** | **574** | **599** | **551** | **582** | **675** | **822** |

*Source: TechSci Research*

**3.3.10. Sales By Company**

**Figure 38: Europe Epoxy Resin Sales, By Company, By Volume, 2020**

*Source: TechSci Research*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Region** | **Demand Volume Share (%)** | **2020** | **2021E** |  | **2020** | **2021E** |
| Europe | Olin Corporation | 132 | 145 |  | 24.02% | 24.93% |
| Europe | Huntsman Corporation | 70 | 67 |  | 12.73% | 11.47% |
| Europe | Hexion Inc. | 58 | 66 |  | 10.46% | 11.27% |
| Europe | Spolchemie A.S. | 37 | 40 |  | 6.68% | 6.83% |
| Europe | Alchemie Ltd. | 33 | 37 |  | 6.06% | 6.44% |
| Europe | Others | 221 | 227 |  | 40.05% | 39.06% |

*Source: TechSci Research*

Olin Corporation, Huntsman Corporation and Hexion Inc are the major producers of epoxy resins in the European region, mirroring the trend of North American region. All three are global players catering to the epoxy demand worldwide. Paints and coatings industry has been the key driver of epoxy growth in the region with automotive sector following closely. However, the growth in automotive sector has been underwhelming owing to global shortage of semiconductor chips. All key manufacturers have outstanding previous quarters gaining from the economic recovery in the region. Recent energy crises across Europe have resulted in some unprecedented challenges in the last few years adversely impacting petrochemical industry. This might have a bearing over the producers’ approach in the long term while assessing the market dynamics.

**Europe Market Insights**

Demand for Epoxy Resins has projected a CAGR of around 1.67% from 2015-2020. Between 2021-2030, the demand for Epoxy Resin is expected to witness a CAGR of 3.91%, supported by the increasing consumption of Epoxy resins from downstream automotive and construction sectors

Although, 2020 slowed the demand growth as automotive sector suffered in the wake of covid-pandemic. Demand accelerated as construction sector in Europe has been flourishing in 2021 and pulling some outstanding demand numbers for Epoxy Resins.

Olin Corporation and Hexion Inc. are the two leading producers of Epoxy Resin in Europe, having capacities of 265 and 132 KT, respectively. No expansions are scheduled in the next 10 years as the European market is deemed exhaustive for any capacity additions in the near term.

Paint & Coating along with construction sector garners majority of Epoxy Resin demand in the region. Use of advanced technologies like nanotechnology along with inclination towards eco-friendly paints provide ample opportunities for paints and coatings sector to grow in coming years.

Composite Materials is a potential segment where the demand for Epoxy Resin is expected to grow substantially due to a line of advancements expected in the material science sector.

Bisphenol A Based Resin type drives more than 80% of the overall demand in the European Region.

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**NORTH AMERICA EPOXY RESIN MARKET OUTLOOK**

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**3.4.1. North America Epoxy Resin Capacity & Production, By Volume, 2015 - 2030F (Thousand Tonnes)**

*Source: TechSci Research*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Company | Location | 2015 | 2020 | 2030F |
| Hexion Inc. | USA | 127 | 127 | 127 |
| Olin Corporation | USA | 170 | 170 | 170 |
| Huntsman Corporation | USA | 70 | 70 | 70 |
| Dow Chemical | USA | 60 | 60 | 60 |
| Total |  | 427 | 427 | 427 |

*Source: TechSci Research*

Major Factors Accounting for Growing Demand of Epoxy Resin in North America:

* **Strong Economy (**Low Inflation, Stable Lending Rate, Competitive Tax System, Strong Banking System)
* **Ease of Doing Business**
  + Competitive Business Cost
  + Ease in Establishing and Conducting New Business
* **Better Life Index** (Ranked highest among the G7 countries by OECD based on housing, income, employment, health, safety, etc.)
* Epoxy resin is widely used in green buildings as they significantly reduce the carbon footprint of the building. The demand for sustainable products is increasing owing to the growing trend of ethical consumerism which is boosting the growth of the North America Epoxy Resin Market.
* Renewable energy is the fastest-growing energy source in the US. Renewable energy contributed to more than 17% of the net US electricity generation in 2018, with the bulk coming from hydropower (7.0%) and wind power (6.6%). Currently, 15 US states including California, Hawaii, Maine, Minnesota, Nevada, New Jersey, New Mexico among others have 100% renewable energy/clean energy targets in the next 15-20 years. The increasing use of epoxy-based composites in the manufacturing of rotor blades in wind turbines will boost the North America Epoxy Resin market.

**3.4.2. North America Demand**

**North America Epoxy Resin Demand, By Volume (Thousand Tonnes), 2015–2030F**

*Source: TechSci Research*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Approach: Growth Forecast Via Factors (Impact Analysis)** | | | | |
| **Factors** | **Sources** | **Value** | **CAGR** | **Weightage** |
| **GDP Growth Rate (2021-2030 Period)** | ***World Bank, IMF, TechSci Estimates*** | ***Forecast*** | 4.70% | 18.00% |
| **GDP Per Capita (%)** | ***World Bank, IMF, TechSci Estimates*** | ***Forecast*** | 3.26% | 10.00% |
| **Average Selling Growth (%)** | ***TechSci Research Estimates*** | ***Forecast*** | 3.10% | 15.00% |
| **Growth in Construction Sector** | ***TechSci Research Estimates*** | ***Forecast*** | 4.40% | 8.00% |
| **Growth in Renewable Sector** | ***TechSci Research Estimates*** | ***Forecast*** | 4.00% | 15.00% |
| **Growth in Automotive Sector** | ***OICA, EMA*** | ***Forecast*** | 3.45% | 8.00% |
| **Paint & Coating Industry Growth** | ***Industry Sources & TechSci Research Estimates*** | ***Forecast*** | 4.15% | 19.00% |
| **Market Growth in Historical Period (2015-2020)** | ***Industry Sources & TechSci Research Estimates*** | ***Historical*** | 1.16% | 7.00% |
| **CAGR (2021-2030)** | **3.73%** | | | |

TechSci Research has followed this approach to calculate the growth rates by understanding the impact of various factors of the industry. These factors were given weightage according to the relative importance of each factor. Finally, each factor was multiplied with its weightage and their sum was used to calculate market growth.

**3.4.3. Operating Efficiency**

**North America Epoxy Resin Operating Efficiency (Percentage), 2015-2030F**

*Source: TechSci Research*

**3.4.4 Demand By Application**

**North America Epoxy Resin Demand, By Application (Thousand Tonnes) (%), By Volume, 2015–2030F**

*Others Marine, Defence, Encapsulation etc.*

*Source: TechSci Research*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Demand by Application** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021E** | **2025F** | **2030F** |
| Paints & Coatings | 127 | 132 | 136 | 139 | 144 | 132 | 141 | 169 | 199 |
| Electrical & Electronics | 58 | 60 | 62 | 64 | 66 | 61 | 66 | 79 | 92 |
| Construction | 25 | 25 | 26 | 27 | 28 | 25 | 27 | 32 | 37 |
| Composite Materials | 57 | 60 | 62 | 63 | 65 | 62 | 65 | 78 | 91 |
| Adhesives | 19 | 21 | 22 | 22 | 23 | 21 | 23 | 27 | 32 |
| Others | 13 | 10 | 10 | 11 | 11 | 16 | 13 | 12 | 14 |
| **Total** | **299** | **309** | **318** | **326** | **337** | **317** | **335** | **397** | **465** |

*Source: TechSci Research*

**3.4.5. Demand By Type**

**North America Epoxy Resin Demand, By Type (Thousand Tonnes) (%), By Volume, 2015–2030F**

*Source: TechSci Research*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Demand by Type** | **2015** | **2020** | **2021F** | **2025F** | **2030F** |
| Bisphenol A Based Resin | 226 | 232 | 244 | 288 | 332 |
| Bisphenol F Based Resin | 17 | 18 | 19 | 23 | 29 |
| Epoxy Phenol Novolac Based Resin | 15 | 13 | 14 | 18 | 24 |
| Cycloaliphatic Epoxy Based Resin | 17 | 18 | 20 | 24 | 28 |
| Others | 24 | 35 | 37 | 45 | 52 |
| **Total** | **299** | **317** | **335** | **397** | **465** |

`

*Source: TechSci Research*

**3.4.6. Demand By Sales Channel**

**North America Epoxy Resin Demand, By Sales Channel (Thousand Tonnes) (%), By Volume, 2015–2020**

*Source: TechSci Research*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Demand by Sales Channel** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** |
| Direct Company Sale | 149 | 153 | 159 | 162 | 169 | 158 |
| Indirect | 150 | 156 | 160 | 165 | 168 | 159 |
| **Total** | 299 | 309 | 318 | 326 | 337 | 317 |

*Source: TechSci Research*

**3.4.7. Demand By Grade**

**North America Epoxy Resin Demand, By Grade (Thousand Tonnes) (%), By Volume, 2015–2030F**

*Source: TechSci Research*

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|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Demand by Grade** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021E** | **2025F** | **2030F** |
| Liquid | 166 | 173 | 178 | 183 | 189 | 178 | 188 | 225 | 266 |
| Semi-Solid | 31 | 32 | 33 | 33 | 34 | 32 | 33 | 39 | 44 |
| Solid | 102 | 104 | 107 | 110 | 114 | 107 | 113 | 133 | 156 |
| **Total** | **299** | **309** | **318** | **326** | **337** | **317** | **335** | **397** | **465** |

*Source: TechSci Research*

**3.4.8. North America Epoxy Resin Market Demand-Supply Analysis, By Volume, 2015-2030F (Thousand Tonnes)**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021E** | **2025F** | **2030F** |
| **Capacity** | 427 | 427 | 427 | 427 | 427 | 427 | 427 | 427 | 427 |
| **Production** | 321 | 325 | 318 | 312 | 320 | 287 | 299 | 320 | 357 |
| **Import** | 86 | 96 | 118 | 126 | 136 | 122 |  | | |
| **Export** | 102 | 106 | 112 | 105 | 113 | 87 |
| **Total Demand** | 299 | 309 | 318 | 326 | 337 | 317 | 335 | 397 | 465 |
| **Demand Supply Gap** |  | | | | | | -36 | -77 | -109 |

*Source: TechSci Research*

**3.4.9. Sales By Company**

**North America Epoxy Resin Sales, By Company, By Volume, 2020**

*Source: TechSci Research*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Region** | **Demand Volume Share (%)** | **2020** | **2021E** |  | **2020** | **2021E** |
| North America | Hexion Inc. | 88 | 92 |  | 27.81% | 27.51% |
| North America | Olin Corporation | 121 | 122 |  | 38.28% | 36.32% |
| North America | Dow Chemical | 42 | 45 |  | 13.26% | 13.42% |
| North America | Huntsman Corporation | 46 | 52 |  | 14.48% | 15.51% |
| North America | Others | 20 | 24 |  | 6.17% | 7.24% |

*Source: TechSci Research*

Olin Corporation and Hexion Inc. are the two most important manufacturers of epoxy resins in the North American region, where both shares between them close to two-third of the market share by sales. After slump of 2020 in terms of demand, 2021 brought economic recovery. Demand has increased significantly in the wake of rising consumption from construction industry, electrical and electronics industry along with other sectors. Olin and Hexion both had outstanding quarters Q1 and Q2 in terms of sales where both companies have shown significantly improved performance from the respective quarters of 2020. In the region, Dow Chemical and Huntsman Corporation also produce substantial amounts of epoxy resins where both companies have 13% and 15% of market share by sales, respectively, in the region. There has been no new announcement of upcoming brown field or green field projects from any of the above manufacturer, however given the increasing demand of epoxy resin globally, new capacity or capacity expansion is likely to be around the corner.

**North America Market Insights**

The total epoxy resin capacity in North America stood at 427 thousand tonnes in 2020 without seeing any expansion or commissioning of new plant facilities in the historical years. The key market players include Olin Corporation, Hexion Inc., Huntsman Corporation and Dow Chemical. The production in 2020, reaching to 287.36 thousand tonnes, registered a decrement of 10% from the volumes produced in 2019 owing to the slow operations and difficulties in feedstock availability during COVID19 pandemic period. With rebounding of plant operations, the production is expected to take an upward trend and rise to 356.56 thousand tonnes by 2030.

The market share for epoxy resin in North America has shown a gradual increase in the historical years reaching 317 thousand tonnes after registering a CAGR of 1.16%. The easy feedstock availability also favoured its continued demand in the past years. The epoxy resin market in the upcoming years demonstrates a positive outlook in terms of demand backed by the flourishing construction sector, which is likely to lead with the raging trend in North America to use sustainable products in green buildings. The demand is, therefore, is expected to rise at a healthy CAGR of 3.73% reaching to a consumption volume of 465 thousand tonnes by 2030.

The market players operated with 73-75% utilization of total installed capacity of epoxy resins in the historical years. However, the impact of supply chain disruptions and lockdown constraints marred the operating rate in the Asia-Pacific region to as low as 67% in 2020. The slow recovering operations got further hit in 2021 after the landfall of hurricane Ida causing volatile feedstock prices which resulted to only slight improvement in the operating rates. After the revival of the supply chains an improvement in the operating efficiency is expected and will reach to around 83.5% by the year 2030.

Epoxy resin, owing to its strong binding ability and long durability, finds its varied applications in paints and coatings sector which owns the highest market share of epoxy resin in North America. Epoxy resin is heavily used in concrete reinforcing due to their flexible applicability while automotive, marine, and aerospace apply epoxy coatings for corrosion protection as primers. Rapid growth in industrial coatings as well as automotive coatings is likely to propel paints and coatings sector growth in coming years.

Bisphenol A based resin, Bisphenol F based resin, Epoxy phenol Novalac based resin and cycloaliphatic epoxy-based resin are the major types of epoxy resins where Bisphenol A based resin has the highest demand due to its wide applications in coatings, adhesives, electrical insulating materials. Their demand is expected to see a steady growth over the forecast years.

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**SOUTH AMERICA EPOXY RESIN MARKET**

**OUTLOOK**

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**3.5.1. South America Epoxy Resin Capacity & Production, By Volume, 2015 - 2030F (Thousand Tonnes)**

*Source: TechSci Research*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Company | Location | 2015 | 2020 | 2030F |
| Olin Corporation | Brazil | 33 | 33 | 33 |
| Huntsman Corporation | Brazil | 10 | 10 | 10 |
| Total |  | 43 | 43 | 43 |

*Source: TechSci Research*

**3.5.2. South America Epoxy Resin Demand**

**South America Epoxy Resin Demand, By Volume (Thousand Tonnes), 2015–2030F**

*Source: TechSci Research*

**2021E-2030F**

**CAGR**

**3.94% By Volume**

**2015-2020**

**CAGR**

**0.81% By Volume**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Approach: Growth Forecast Via Factors (Impact Analysis)** | | | | |
| **Factors** | **Sources** | **Value** | **CAGR** | **Weightage** |
| **GDP Growth Rate (2021-2030 Period)** | ***World Bank, IMF, TechSci Estimates*** | ***Forecast*** | 4.25% | 26.00% |
| **GDP Per Capita (%)** | ***World Bank, IMF, TechSci Estimates*** | ***Forecast*** | 3.55% | 10.00% |
| **Average Selling Growth (%)** | ***TechSci Research Estimates*** | ***Forecast*** | 2.12% | 8.00% |
| **Growth in Construction Sector** | ***TechSci Research Estimates*** | ***Forecast*** | 5.04% | 12.00% |
| **Growth in Renewable Sector** | ***TechSci Research Estimates*** | ***Forecast*** | 5.00% | 16.00% |
| **Growth in Automotive Sector** | ***OICA*** | ***Forecast*** | 4.05% | 4.00% |
| **Paint & Coating Industry Growth** | ***Industry Sources & TechSci Research Estimates*** | ***Forecast*** | 3.88% | 18.00% |
| **Market Growth in Historical Period (2015-2020)** | ***Industry Sources & TechSci Research Estimates*** | ***Historical*** | 0.81% | 6.00% |
| **CAGR (2021-2030)** | **3.94%** | | | |

TechSci Research has followed this approach to calculate the growth rates by understanding the impact of various factors of the industry. These factors were given weightage according to the relative importance of each factor. Finally, each factor was multiplied with its weightage and their sum was used to calculate market growth.

**3.5.3. Operating Efficiency**

**South America Epoxy Resin Operating Efficiency (Percentage), 2015-2030F**

*Source: TechSci Research*

**3.5.4. Demand By Application**

**South America Epoxy Resin Demand, By Application (Thousand Tonnes) (%), By Volume, 2015–2030F**

*Others Marine, Defence, Encapsulation etc.*

*Source: TechSci Research*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Demand by Application** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021E** | **2025F** | **2030F** |
| Paints & Coatings | 31 | 33 | 32 | 34 | 34 | 32 | 34 | 41 | 49 |
| Electrical & Electronics | 17 | 18 | 18 | 19 | 19 | 18 | 19 | 23 | 27 |
| Construction | 9 | 9 | 9 | 10 | 10 | 9 | 10 | 12 | 14 |
| Composite Materials | 9 | 10 | 10 | 10 | 10 | 10 | 11 | 13 | 15 |
| Adhesives | 6 | 6 | 6 | 7 | 6 | 6 | 7 | 8 | 10 |
| Others | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 8 | 9 |
| **Total** | **80** | **85** | **82** | **86** | **85** | **83** | **88** | **105** | **124** |

*Source: TechSci Research*

**3.5.5. Demand By Type**

**South America Epoxy Resin Demand, By Type (Thousand Tonnes) (%), By Volume, 2015–2030F**

*Source: TechSci Research*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Demand by Type** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021F** | **2025F** | **2030F** |
| Bisphenol A Based Resin | 69 | 73 | 71 | 75 | 75 | 73 | 77 | 91 | 106 |
| Bisphenol F Based Resin | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 |
| Epoxy Phenol Novolac Based Resin | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 4 |
| Cycloaliphatic Epoxy Based Resin | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| Others | 7 | 7 | 6 | 6 | 5 | 5 | 5 | 7 | 9 |
| **Total** | **80** | **85** | **82** | **86** | **85** | **83** | **88** | **105** | **124** |

*Source: TechSci Research*

**3.5.6. Demand By Sales Channel**

**South America Epoxy Resin Demand, By Sales Channel (Thousand Tonnes) (%), By Volume, 2015–2030F**

*Source: TechSci Research*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Demand by Sales Channel** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** |
| Direct Company Sale | 45 | 48 | 47 | 49 | 49 | 47 |
| Indirect | 35 | 37 | 35 | 37 | 37 | 36 |
| **Total** | **80** | **85** | **82** | **86** | **85** | **83** |

**3.5.7. Demand By Grade**

*Source: TechSci Research*

**South America Epoxy Resin Demand, By Type (Thousand Tonnes) (%), By Volume, 2015–2030F**

*Source: TechSci Research*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Demand by Grade** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021E** | **2025F** | **2030F** |
| Liquid | 46 | 49 | 48 | 51 | 50 | 48 | 51 | 61 | 73 |
| Semi-Solid | 7 | 7 | 6 | 7 | 7 | 7 | 7 | 8 | 10 |
| Solid | 27 | 29 | 28 | 29 | 29 | 28 | 30 | 35 | 42 |
| **Total** | **80** | **85** | **82** | **86** | **85** | **83** | **88** | **105** | **124** |

*Source: TechSci Research*

**3.5.8. South America Epoxy Resin Market Demand-Supply Analysis, By Volume, 2015-2030F (Thousand Tonnes)**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021E** | **2025F** | **2030F** |
| **Capacity** | 43.0 | 43.0 | 43.0 | 43.0 | 43.0 | 43.0 | 43.0 | 43.0 | 43.0 |
| **Production** | 33.5 | 35.8 | 35.2 | 34.5 | 33.2 | 31.8 | 33.0 | 34.6 | 38.2 |
| **Import** | 52.1 | 55.1 | 52.6 | 57.1 | 56.3 | 54.2 |  | | |
| **Export** | 6.0 | 6.2 | 5.7 | 5.4 | 4.2 | 3.1 |
| **Total Demand** | 79.6 | 84.7 | 82.0 | 86.2 | 85.3 | 82.9 | 87.6 | 104.7 | 124.0 |
| **Demand Supply Gap** |  | | | | | | -54.6 | -70.1 | -85.8 |

*Source: TechSci Research*

**3.5.9. Sales By Company**

**South America Epoxy Resin Sales, By Company, By Volume, 2020**

*Source: TechSci Research*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Region** | **Demand Volume Share (%)** | **2020** | **2021E** |  | **2020** | **2021E** |
| South America | Olin Corporation | 16.68 | 17.18 |  | 14.84% | 14.80% |
| South America | Huntsman Corporation | 2.27 | 2.44 |  | 2.02% | 2.10% |
| South America | Kukdo Chemical | 9.72 | 9.66 |  | 8.65% | 8.32% |
| South America | Nan Ya Plastics Co Ltd | 8.23 | 8.22 |  | 7.32% | 7.08% |
| South America | Others | 75.51 | 78.61 |  | 67.17% | 67.70% |

*Source: TechSci Research*

Various other region leaders across the globe are having a stronghold in the South American epoxy market. Primarily, Olin Corporation, a prominent epoxy resin producer globally has been dominating the market with the market share of 15% in terms of sales by an individual company. Other key manufacturers include Korean headquartered Kukdo Chemical, producing highly varied and specialized epoxy resins. Nan Ya Plastics has been another major player capturing a

significant market share with 7% by sales in the region.

**South America Market Insights**

Total capacity of Epoxy resin in South America stood at about 43 KTPA with Olin Corporation holding largest chunk of market share with annual capacity of 33 KTPA.

The South American epoxy resin market grew at an average CAGR of 0.81% in terms of volume during the period 2015-2020 and is forecasted to grow at an average CAGR of 3.94 %. Thereby increasing the total capacity to about 125 thousand tons in absolute terms by 2030.

As the South American market recovers to its pre pandemic levels of economic activity, the demand for resins in general is going to increase significantly showing operating efficiency of more than 70 %

*Demand by Application*

The future of epoxy resin in the composites industry in South America looks good with opportunities in the transportation, marine, wind energy, aerospace, pipe & tank, construction, electrical and electronics, and consumer goods.

In South America, Epoxy resin has major applications in paints and coatings followed by electronics industry, construction, composites etc.

In the backdrop of an emerging global consensus on a sustainable development agenda, demand for epoxy resin is expected to find greater application in Green Buildings and wind turbine industry.

South America being an emerging market is expected to see robust growth rates across sectors like aviation, construction (incl. green buildings), electronics, automotive, telecommunication, roads and railways, renewable energy etc., which in turn would create demand for the resins market.

Thus, our forecast for the decade (2021 to 2030) predicts a strong growth in demand by volume across various verticals concerning epoxy resin market as shown in the bar graph .

*Demand by Type*

The Bisphenol A Based epoxy resin is the most widely used epoxy type as it finds its application in protective coatings, industrial maintenance paints, underwater coatings, structural adhesives and civil engineering applications. The demand for this type is expected cross the hundred-thousand-ton mark by 2030.

The Bisphenol F based epoxy resin type finds its applications in coatings, civil engineering, adhesives, electrical insulating materials, and reactive intermediates. Its demand by volume in absolute terms is expected to increase by 50% by 2030.

The Epoxy phenol Novolac based Resin type finds its usage in high temperature structural adhesives, electrical laminates, high performance composites, and molded parts. Its demand is expected to double by 2030.

The cycloaliphatic Epoxy Resin type finds its application in exterior coatings and adhesives, potting compounds and encapsulations for electronics and electrical components, gel coats, laminates, fiber composites, and various cationic and UV curable resin products. Demand in absolute terms for this resin type is also expected to double by 2030.

*Demand by Grade*

The demand for liquid grade epoxy resin type is expected to increase by more than twenty thousand tons in absolute terms by 2030.

The demand for semi-solid and solid grade resin types is expected to increase by three thousand tons and twelve thousand tons in absolute terms respectively by 2030.



**MIDDLE EAST & AFRICA EPOXY RESIN MARKET**

**OUTLOOK**



**3.6.1. Middle East & Africa Epoxy Resin Capacity & Production, By Volume, 2015 - 2030F (Thousand Tonnes)**

*Source: TechSci Research*

*Source: TechSci Research*

|  |  |  |  |
| --- | --- | --- | --- |
| Company | 2015 | 2020 | 2030F |
| NAMA Chemicals | 120 | 120 | 120 |
| Izel Kimya | 40 | 40 | 40 |
| Others | 60 | 60 | 60 |
| Total | 220 | 220 | 220 |
|  |  |  |  |

GCC nations are at the forefront in developing smart cities. Countries such as Saudi Arabia, Qatar and UAE plan to develop smart cities. Saudi Arabia government plans to invest USD100 billion for the development of King Abdullah smart city and the country has initiated plans to convert Jeddah into smart city. Similarly, UAE government also announced plans to expand Masdar smart city, for an investment of USD20 billion, due to be completed by 2030. Lusail City in Qatar is another smart city project that would be capable of accommodating about 450,000 people. The project is estimated to cost USD45 billion and is slated for completion by 2020. A major chunk of investment in developing these smart cities would be used in developing power transmission and distribution networks, thereby acting as a driving force in boosting growth in the region’s epoxy resin market.

|  |
| --- |
| **Key Goals and Objectives of Vision Document (Saudi Arabia)** |
| * Boosting the government’s revenue from USD159.99 billion in 2016 to USD1866.52 billion by 2030. * To increase share of non-oil-based exports from around 16% in 2016 to around 50% by 2030. * To increase the share of Foreign Direct Investment (FDI) in GDP from 3.8% in 2020 to 5.7% by 2030. * To boost the share of small and medium scale enterprises from 20% in 2020 to 35% by 2030. * To increase the contribution of private sector to around 65% of GDP by 2030, thereby opening different sectors for private players. * The country aims to set up a sovereign wealth fund amounting to around USD2.00 trillion to support the development projects associated with the Vision. FDI worth USD1.00 trillion during 2021-2032 is anticipated to flow in Saudi Arabia, thereby boosting the growth of private sector. |

**3.6.2. Middle East & Africa Epoxy Resin Demand**

**Middle East & Africa Epoxy Resin Demand, By Volume (Thousand Tonnes), 2015–2030F**

**2021E-2030F**

**CAGR**

**4.38% By Volume**

**2015-2020**

**CAGR**

**-0.21% By Volume**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Approach: Growth Forecast Via Factors (Impact Analysis)** | | | | |
| **Factors** | **Sources** | **Value** | **CAGR** | **Weightage** |
| **GDP Growth Rate (2021-2030 Period)** | ***World Bank, IMF, OECD, TechSci Estimates*** | ***Forecast*** | 4.86% | 29.00% |
| **GDP Per Capita (%)** | ***World Bank, IMF, OECD, TechSci Estimates*** | ***Forecast*** | 4.38% | 10.00% |
| **Average Selling Growth (%)** | ***TechSci Research Estimates*** | ***Forecast*** | 3.18% | 6.00% |
| **Growth in Construction Sector** | ***TechSci Research Estimates*** | ***Forecast*** | 4.00% | 15.00% |
| **Growth in Renewable Sector** | ***TechSci Research Estimates*** | ***Forecast*** | 6.50% | 18.00% |
| **Paint & Coating Industry Growth** | ***Industry Sources & TechSci Research Estimates*** | ***Forecast*** | 3.45% | 17.00% |
| **Market Growth in Historical Period (2015-2020)** | ***Industry Sources & TechSci Research Estimates*** | ***Historical*** | -0.21% | 5.00% |
| **CAGR (2021-2030)** | **4.38%** | | | |

TechSci Research has followed this approach to calculate the growth rates by understanding the impact of various factors of the industry. These factors were given weightage according to the relative importance of each factor. Finally, each factor was multiplied with its weightage and their sum was used to calculate market growth.

**3.6.3. Operating Efficiency**

**Middle East & Africa Epoxy Resin Operating Efficiency (Percentage), 2015-2030F**

*Source: TechSci Research*

**3.6.4. Demand By Application**

**Middle East & Africa Epoxy Resin Demand, By Application (Thousand Tonnes) (%), By Volume, 2015–2030F**

*Others Marine, Defence, Encapsulation etc.*

*Source: TechSci Research*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Demand by Application** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021E** | **2025F** | **2030F** |
| Paints & Coatings | 110 | 115 | 118 | 112 | 117 | 108 | 116 | 142 | 173 |
| Electrical & Electronics | 73 | 76 | 78 | 74 | 78 | 72 | 77 | 94 | 114 |
| Construction | 35 | 37 | 38 | 36 | 38 | 34 | 37 | 45 | 54 |
| Composite Materials | 26 | 27 | 28 | 26 | 28 | 26 | 28 | 34 | 41 |
| Adhesives | 17 | 18 | 18 | 18 | 18 | 17 | 19 | 23 | 28 |
| Others | 13 | 11 | 12 | 11 | 11 | 14 | 12 | 14 | 15 |
| **Total** | **274** | **284** | **292** | **277** | **290** | **271** | **289** | **352** | **425** |

*Source: TechSci Research*

**3.6.5. Demand By Type**

**Middle East & Africa Epoxy Resin Demand, By Type (Thousand Tonnes) (%), By Volume, 2015–2030F**

*Source: TechSci Research*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Demand by Type** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021F** | **2025F** | **2030F** |
| Bisphenol A Based Resin | 228 | 235 | 240 | 227 | 237 | 220 | 234 | 282 | 335 |
| Bisphenol F Based Resin | 8 | 8 | 9 | 8 | 9 | 8 | 9 | 12 | 16 |
| Epoxy Phenol Novolac Based Resin | 10 | 11 | 11 | 11 | 12 | 11 | 12 | 16 | 21 |
| Cycloaliphatic Epoxy Based Resin | 8 | 8 | 8 | 7 | 8 | 7 | 8 | 10 | 13 |
| Others | 20 | 22 | 24 | 23 | 25 | 25 | 26 | 33 | 41 |
| **Total** | **274** | **284** | **292** | **277** | **290** | **271** | **289** | **352** | **425** |

**3.6.6. Demand By Sales Channel**

**Middle East & Africa Epoxy Resin Demand, By Sales Channel (Thousand Tonnes) (%), By Volume, 2015–2030F**

*Source: TechSci Research*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Demand by Sales Channel** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** |
| Direct Company Sale | 130 | 135 | 140 | 132 | 137 | 128 |
| Indirect | 144 | 149 | 152 | 145 | 153 | 143 |
| **Total** | **274** | **284** | **292** | **277** | **290** | **271** |

*Source: TechSci Research*

**3.6.7. Demand By Grade**

**Middle East & Africa Epoxy Resin Demand, By Grade (Thousand Tonnes) (%), By Volume, 2015–2030F**

*Source: TechSci Research*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Demand by Grade** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021E** | **2025F** | **2030F** |
| Liquid | 152 | 157 | 161 | 154 | 162 | 152 | 163 | 200 | 244 |
| Semi-Solid | 14 | 14 | 15 | 14 | 14 | 14 | 14 | 18 | 19 |
| Solid | 108 | 113 | 116 | 110 | 114 | 105 | 113 | 135 | 163 |
| **Total** | **274** | **284** | **292** | **277** | **290** | **271** | **289** | **352** | **425** |

*Source: TechSci Research*

**3.6.8. MEA Epoxy Resin Market Demand-Supply Analysis, By Volume, 2015-2030F (Thousand Tonnes)**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021E** | **2025F** | **2030F** |
| **Capacity** | 220 | 220 | 220 | 220 | 220 | 220 | 220 | 220 | 220 |
| **Production** | 167 | 175 | 172 | 170 | 159 | 171 | 183 | 197 | 214 |
| **Import** | 145 | 161 | 185 | 166 | 180 | 146 |  | | |
| **Export** | 34 | 48 | 62 | 55 | 46 | 44 |
| **Total Demand** | 274 | 284 | 292 | 277 | 290 | 271 | 289 | 352 | 425 |
| **Demand Supply Gap** |  | | | | | | -106 | -155 | -211 |

*Source: TechSci Research*

**3.6.9. Sales By Company**

**Middle East & Africa Epoxy Resin Sales, By Company, By Volume, 2020**

*Source: TechSci Research*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Region** | **Demand Volume Share (%)** | **2020** | **2021E** |  | **2020** | **2021E** |
| MEA | NAMA Chemicals | 81 | 95 |  | 30.04% | 32.82% |
| MEA | Izel Kimya | 26 | 35 |  | 9.51% | 12.08% |
| MEA | Olin Corporation | 25 | 31 |  | 9.15% | 10.64% |
| MEA | Hexion Inc. | 23 | 16 |  | 8.33% | 5.65% |
| MEA | Others | 116 | 112 |  | 42.97% | 38.81% |

*Source: TechSci Research*

NAMA Chemicals in Saudi Arabia is the key player in the Middle East epoxy resin market as it captures close to one-third of the market in terms of sales by an individual company. Demand from paints and coatings along with electrical & electronics industries have been the critical drivers of epoxy resin growth in the region. Izel Kimya and Olin Corporation are other two significant epoxy manufacturers in the Middle East and African region. Economic recovery across the world has resulted in increasing demand for energy feedstocks, market participants will be aware of these developments and will look to consolidate by putting an optimistic approach in the long-term which is likely to reflected in new green field and brown field projects.

**Middle East & Africa Market Insights**

Total capacity of Epoxy resin in Middle East stood at about 220 KTPA with NAMA Chemicals holding largest chunk of market share with annual capacity of 120 KTPA.

The Middle East epoxy resin market grew at a negative CAGR of 0.21% in terms of volume during the period 2015-2020 and is forecasted to grow at an average CAGR of 4.38% by 2030.

**Operating Efficiency**

Operating efficiency of all the key manufactures is observed to be more than 70%. There has been a gradual increase in efficiency till 2020.However in the year 2020, companies faced backlog in production owing to supply-chain disruptions as well as lockdown constraints being imposed due to the pandemic. As the Middle East market recovers to its pre pandemic levels of economic activity, the demand for resins in general is going to increase significantly

**Demand By Application**

Epoxy resin has a wide range of applications including paints and coatings, electronics industry, construction, composites etc.

Demand of epoxy resin in paint & coating industry holds the largest market share at 40% as of 2021 in the MEA region. Other applications of epoxy resin include marine, defense, encapsulation etc. The demand of epoxy resins from the Paints and Coatings sector stood at 108 KT in 2020. The sector is estimated to hold a demand share of more than 40% in the forecast period.

**Demand By Type**

Based on type, BPA-based epoxy resin is holds the largest demand share followed as on 2021. Bisphenol A (BPA) based Epoxy resins continue to dominate the market among other categories. However, growing awareness regarding toxic impacts of BPA and awareness about several alternatives for production of Epoxy resins have resulted in consumers opting for comparatively safer alternatives. Bisphenol F based Epoxy resins seem to attract attention of several player into Epoxy Resin production in the coming years.

**Demand By Grade**

Liquid epoxy resin (LER) remained highest in demand, holding a demand share of 56.2% in the MEA epoxy resin market. Solid epoxy resin seems to be second in the league while Demand in semi-solid epoxy resin has witnessed a negative growth and will further decline in coming years.



**INDIA EPOXY RESIN MARKET**

**OUTLOOK**



**3.7.1. India Epoxy Resin Capacity & Production, By Volume, 2015 - 2030F (Thousand Tonnes)**

*Source: TechSci Research*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Company | Location | 2015 | 2020 | 2030F |
| Kukdo Chemical India Private Limited | Gujarat | 0 | 40 | 40 |
| Grasim Industries Ltd. | Gujarat | 44 | 66 | 90 |
| Atul Limited | Gujarat | 30 | 40 | 50 |
| Meghmani Finechem Limited | Gujarat | 0 | 0 | 25 |
| Hindusthan Specialty Chemicals Ltd | Gujarat | 0 | 30 | 30 |
| Others |  | 0 | 0 | 0 |
| Total |  | 74 | 176 | 235 |

*Source: TechSci Research*

* Apart from Grasim Industries, Atul Ltd., Hindustan Specialty and Kukdo Chemical, who manufacture the Base Epoxy Resin in addition to formulations and downstream products, around 10 to 15 small units are also engaged in making formulations of epoxies and epoxy-based products. Epoxy Resin, though produced indigenously, is also imported in substantial quantity into India. Both the raw materials, Bisphenol-A and Epichlorohydrin are imported. Meghmani Finechem Ltd. will become the first manufacturer of ECH with capacity of 50 KTPA.
* Aditya Birla Epoxy India Ltd, renamed as Grasim Industries India Ltd. (Chemicals Division) is the largest manufacturer of basic Epoxy Resin with installed capacity of 66 KTPA. This project was commissioned during the year 2013.
* Atul Ltd., part of the Lalbhai Group, is the second largest producer of Epoxy Resins located at Valsad, Gujarat. The company has a capacity of 40 KTPA for manufacturing Epoxy Resin.

**3.7.2. India Epoxy Resin Demand, By Volume (Thousand Tonnes), FY2016-FY2031F**

**FY2016-FY2021**

**CAGR**

**6.31% By Volume**

**FY2022E-FY2031F**

**CAGR**

**8.69% By Volume**

*Source: TechSci Research*

**3.6.3. Operating Efficiency**

**India Epoxy Resin Operating Efficiency (Percentage), FY2015-FY2031F**

*Source: TechSci Research*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Approach: Growth Forecast Via Factors (Impact Analysis)** | | | | |  |
| **Factors** | **Sources** | **Value** | **CAGR** | **Weightage** |  |
| **GDP Growth Rate (2021-2030 Period)** | ***World Bank, TechSci Estimates*** | ***Forecast*** | 7.50% | 12% |  |
| **GDP Per Capita (%)** | ***World Bank, TechSci Estimates*** | ***Forecast*** | 5.09% | 3% |  |
| **Average Selling Growth (%)** | ***TechSci Research Estimates*** | ***Forecast*** | 2.50% | 3% |  |
| **Growth in Construction Sector** | ***TechSci Research Estimates*** | ***Forecast*** | 8.85% | 21% |  |
| **Growth in Renewable Sector** | ***TechSci Research Estimates*** | ***Forecast*** | 9.50% | 23% |  |
| **Growth in Automotive Sector** | ***OICA, SIAM*** | ***Forecast*** | 7.80% | 14% |  |
| **Paint & Coating Industry Growth** | ***Industry Sources & TechSci Research Estimates*** | ***Forecast*** | 10.50% | 24% |  |
| **Market Growth in Historical Period (2015-2020)** | ***Industry Sources & TechSci Research Estimates*** | ***Historical*** | 7.11% | 1% |  |
| **CAGR (2021-2030)** | **8.69%** | | | |  |

*Source: TechSci Research*

TechSci Research has followed this approach to calculate the growth rates by understanding the impact of various factors of the industry. These factors were given weightage according to the relative importance of each factor. Finally, each factor was multiplied with its weightage and their sum was used to calculate market growth.

**3.7.3. India Epoxy Resin Capacity, By Technology, By Process, By Volume, 2015 - 2030F (Thousand Tonnes)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Company | Technology | Process | 2015 | 2020 | 2030F | References |
| Kukdo Chemical India Private Limited | In house Technology | Advancement | 0 | 40 | 40 | Primary Research\*, Company Press Releases |
| Grasim Industries Ltd. | Tohto Kesia | BADGE & Advancement | 44 | 66 | 90 | Company Press Releases |
| Atul Limited | Ciba-Geigy | BADGE & Advancement | 30 | 40 | 50 | Primary Research\* |
| Meghmani Finechem Limited | In house Technology | BADGE & Advancement | 0 | 0 | 25 | Company Press Releases |
| Hindusthan Specialty Chemicals Ltd | JEIL Chemical Ltd. & Wuxi Bluestar | BADGE & Advancement | 0 | 30 | 30 | Primary Research\* |
| Total |  |  | 74 | 176 | 235 |  |

*Source: TechSci Research*

**\****We do multiple interviews in one organisation at different levels (Mid-Senior) and departments (Sales, Marketing, Production etc.)*

*JEIL Chemical Ltd.- Korean Based Technology. Open for licensing for small capacity plant.*

**India Trade Dynamics, By Value (USD million), By Volume (Thousand tonnes), FY2018 - FY2020**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Imported Country | FY2019 | | | | FY2020 | | | FY2021 | | |
|  | Value | | Volume | | Value | Volume | | Value | | Volume |
| South Korea | 24.84 | | 9.31 | | 32.21 | 14.41 | | 36.3 | | 14.96 |
| China | 8.98 | | 2.4 | | 8.76 | 2.64 | | 5.92 | | 2.2 |
| Taiwan | 7.89 | | 2.58 | | 7.05 | 2.66 | | 5.82 | | 1.78 |
| Japan | 10.37 | | 1.85 | | 9.73 | 1.55 | | 9.87 | | 1.37 |
| Netherland | 4.93 | | 1.68 | | 5.41 | 1.99 | | 4.02 | | 1.14 |
| Others | 40.15 | | 16.73 | | 42.81 | 12.36 | | 37.92 | | 10.28 |
| Total | 97.16 | | 34.55 | | 105.97 | 35.61 | | 99.85 | | 31.73 |
| Exported Country | FY2019 | | | | FY2020 | | | FY2021 | | |
|  | Value | | Volume | | Value | Volume | | Value | | Volume |
| Germany | 18.92 | | 7.18 | | 12.07 | 5.59 | | 13.1 | | 5.61 |
| Italy | 19.7 | | 7.89 | | 14.51 | 6.96 | | 10.64 | | 4.51 |
| United Arab Emirates | 13.28 | | 5.02 | | 7.88 | 3.54 | | 4.72 | | 1.72 |
| Saudi Arabia | 2.81 | | 1.13 | | 2.11 | 0.95 | | 2.46 | | 0.98 |
| Turkey | 1.57 | | 0.54 | | 2.78 | 0.95 | | 2.88 | | 0.85 |
| Others | 30.34 | | 9.3 | | 29.12 | 10.2 | | 25.63 | | 13.4 |
| Total | 86.62 | | 31.0 | | 68.47 | 28.2 | | 59.43 | | 27.1 |

*Source: DGFT*

**3.6.8. India Epoxy Resin Market Demand-Supply Analysis, By Volume, FY2015-FY2031F (Thousand Tonnes)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **FY2015** | | **FY2016** | | **FY2017** | | **FY2018** | | **FY2019** | | **FY2020** | | **FY2021E** | | **FY2025F** | | | **FY2031F** | | |
| **Capacity** | 74 | | 84 | | 84 | | 106 | | 136 | | 176 | | 176 | | 235 | | | 235 | | |
| **Production** | 47 | | 56 | | 69 | | 89 | | 90 | | 102 | | 94 | | 190 | | | 206 | | |
| **Import** | 29 | | 40 | | 38 | | 31 | | 35 | | 36 | | 32 | |  | | | | | |
| **Export** | 11 | | 22 | | 26 | | 31 | | 31 | | 28 | | 27 | |
| **Inventory** | 5 | | 7 | | 9 | | 10 | | 4 | | 6 | | 10 | |
| **Total Demand** | 59 | | 65 | | 72 | | 80 | | 89 | | 103 | | 89 | | 129 | | | 208 | | |
| **Demand Supply Gap** |  | | | | | | | | | | | | | | | 36 | | | 27 | |

*Source: TechSci Research*

**3.7.4. Demand By Application**

**India Epoxy Resin Demand, By Application (Thousand Tonnes) (%), By Volume, FY2015–FY2031F**

*Others Marine, Defence, Encapsulation etc .*

*Source: TechSci Research*



|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Demand by Application** | **FY2016** | **FY2017** | **FY2018** | **FY2019** | **FY2020** | **FY 2021E** | **FY2025F** | **FY2031F** |
| **Paints & Coatings** | 29 | 32 | 35 | 39 | 46 | 40 | 57 | 91 |
| **Electrical & Electronics** | 17 | 18 | 20 | 23 | 26 | 23 | 33 | 53 |
| **Construction** | 7 | 8 | 9 | 10 | 12 | 10 | 15 | 24 |
| **Composite Materials** | 5 | 6 | 7 | 8 | 9 | 8 | 11 | 18 |
| **Adhesives** | 4 | 4 | 5 | 6 | 6 | 6 | 8 | 14 |
| **Others** | 3 | 3 | 4 | 4 | 4 | 3 | 5 | 7 |
| **Total** | 65 | 72 | 80 | 89 | 103 | 89 | 129 | 208 |

*Source: TechSci Research*

The rapid growth in the Indian paints and coatings industry (mainly automotive, industrial coatings, Medical Sector & wind energy) is expected to propel the growth of the epoxy resins market during the forecast period. Epoxy resin is extensively used in electrical and energy distribution systems as adhesives, coatings, and sealants, also in the manufacturing of transformers, insulators and bushings (these are used as protective coatings in large generators & on printed circuit board). In Commercial construction, it provides particularly strong bonding adhesives, sealants and fillers, epoxy resins are suitable for internal and external use given them strength, durability and chemical resistance of mechanical fixings and to repair bridge & decks.

**3.7.5. Demand By Grade**

**India Epoxy Resin Demand, By Grade (Thousand Tonnes) (%), By Volume, FY2015–FY2031F**

*Source: TechSci Research*

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Demand by Grade** | **FY2016** | **FY2017** | **FY2018** | **FY2019** | **FY2020** | **FY2021E** | **FY2025F** | **FY2030F** |
| Liquid | 30 | 33 | 36 | 41 | 47 | 41 | 59 | 99 |
| Semi-Solid | 4 | 5 | 5 | 6 | 7 | 6 | 8 | 97 |
| Solid | 31 | 34 | 38 | 43 | 49 | 42 | 61 | 12 |
| **Total** | **65** | **72** | **80** | **89** | **103** | **89** | **129** | **208** |

*Source: TechSci Research*

**3.7.6. Demand By Sales Channel**

**India Epoxy Resin Demand, By Sales Channel (Thousand Tonnes) (%), By Volume, FY2015–FY2030F**

*Source: TechSci Research*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Demand by Sales Channel** | **FY2016** | **FY2017** | **FY2018** | **FY2019** | **FY2020** |
| Direct Company Sale | 37 | 40 | 45 | 50 | 58 |
| Indirect | 29 | 32 | 35 | 39 | 45 |
| **Total** | **65** | **72** | **80** | **89** | **103** |

*Source: TechSci Research*

**3.7.7. Demand By Type**

**India Epoxy Resin Demand, By Type (Thousand Tonnes) (%), By Volume, FY2015–FY2031F**

*Source: TechSci Research*

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Demand by Type** | **FY2016** | **FY2017** | **FY2018** | **FY2019** | **FY2020** | **FY2021E** | **FY2025F** | **FY2031F** |
| Bisphenol A Based Resin | 57 | 64 | 69 | 78 | 90 | 77 | 110 | 169 |
| Bisphenol F Based Resin | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 14 |
| Epoxy Phenol Novolac Based Resin | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 4 |
| Cycloaliphatic Epoxy Based Resin | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 3 |
| Others | 5 | 5 | 6 | 7 | 7 | 6 | 10 | 18 |
| **Total** | **65** | **72** | **80** | **89** | **103** | **89** | **129** | **208** |

*Source: TechSci Research*

**3.7.8. India Epoxy Resin Market Demand and Gap Analysis, By Volume, FY2021E, FY2024F, FY2028F and FY2031F – Optimistic, Pessimistic and Realistic**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Demand Scenario** | **FY2020** | **FY2021E** | **FY2024F** | **FY2028F** | **FY2030F** |
| **Pessimistic** | **88.83** | **92.09** | **110.92** | **137.53** | **168.44** |
| **Demand Supply-Gap** |  | **27.71** | **79.08** | **67.47** | **41.56** |
| **Realistic** | **103** | **88.83** | **117.69** | **164.87** | **192.79** |
| **Demand Supply-Gap** |  | **21.69** | **61.47** | **26.59** | **13.01** |
| **Optimistic** | **88.83** | **103.25** | **144.75** | **220.08** | **255.62** |
| **Demand Supply-Gap** |  | **16.55** | **45.25** | **-15.08** | **-45.62** |

**Optimistic CAGR- 10.60% with GDP growth rate of 10.00%.**

**Pessimistic CAGR- 6.94% with GDP growth rate of 6.50%.**

**Realistic**

There are certain challenges which include volatility in the energy market and demand deterioration by pandemic as well as logistics problems in the short term. However, in the long term these factors will have little to no impact on overall growth of epoxy resin market resulting in a balanced performance during the forecasted period. For the major part, market will be driven by the opportunities in the downstream sectors on the back of stable recovery of GDP growth rate levels in India. Demand growth is likely to revert back to pre-pandemic levels gradually prompting producers to look towards expansion in capacities around the country.

**India Projected GDP growth rate FY2023, FY2025F and FY2030F**

|  |  |  |  |
| --- | --- | --- | --- |
| **Country** | **FY2023** | **FY2025** | **FY2030** |
| **India** | **7.95%** | **7.52%** | **7.24%** |

*Source: OECD, World Bank*

**Optimistic**

Driven by V-shaped recovery of the GDP growth rate in the region, consumption levels from key downstream sectors will increase sharply. Government schemes including “Housing for All”, “Smart Cities Mission” to promote the growth of construction sector will push the country’s Epoxy Resin demand growth. Due to its growing inclination towards digitization, demand for Epoxy Resin reinforced PCBs looks to gain traction with Bharat Net and growing push for complete digital literacy. Indian government has envisioned to make the country a manufacturing hub and increasing its GDP share to 25% by 2022. In lieu of that, the Indian government has taken several initiatives and made various policy changes to attract FDIs as well as promote local manufacturing. India is in line with its renewable energy targets and its investments in renewable sources of energy, particularly wind energy is growing tremendously. Advancements in material science present opportunities to explore growth in the renewable energy sector through manufacturing of wind turbines and other equipment manufacturing. Growth prospects in the construction industry, electrical and electronics industry along with automotive industry will led the Epoxy Resin demand growth and will propel capacity expansions in the coming years.

**Pessimistic**

Epoxy Resin market in India is likely to face numerous challenges in the long-term starting from volatility in the energy market. Being a key importer of crude oil and key raw materials, uncertainties in energy feedstock market outlook adversely impact the country’s petrochemicals market. In lieu of that, the India’s Epoxy Resin market is subject to acute volatility. Series of covid waves due to multiple variants of coronavirus will be a key market determinant in the long term which may affect the GDP growth rate. Covid in the past has resulted in demand deterioration and supply chain disruptions which turned global market upside down and sent GDP growth rates worldwide onto a downward spiral. Growth in economy is vital to some key sectors including construction. The Indian construction industry is driven by infrastructure and housing development, any stagnancy or dip in GDP number is likely to be reflect in its consumption pattern and may hamper epoxy demand growth. Continuous increase in the cost of production (due to rising costs of raw materials, logistics problems and other factors) has also resulted in lopsided market dynamics. In the wake of above factors, manufacturers may take a conservative approach which results in stagnant production and constrained supply fundamentals in the long term.

**3.7.9. Sales By Company**

**India Epoxy Resin Sales, By Company, By Volume, FY2020**

*Source: TechSci Research*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sales Volume (Thousand Tonnes)** | **FY2020** | **FY2021E** |  | **FY2020** | **FY2021E** |
| Grasim Industries Ltd. | 36 | 39 |  | 40.27% | 39.34% |
| Atul Ltd. | 20 | 21 |  | 22.45% | 21.62% |
| Hindustan Specialty Chemicals Ltd | 10 | 17 |  | 11.60% | 17.80% |
| Kukdo Chemical India Private Limited | 0 | 2 |  | 0.00% | 1.57% |
| Import - Others (Nan Ya Plastics, Kukdo Japan, Aditya Birla Thailand, Hexion)\* | 23 | 19 |  | 25.68% | 19.67% |

\**TechSci Research has not included the shares of Kukdo Japan and Aditya Birla Thailand in their subsidary and parent companies operating in India.*

*Source: TechSci Research*

Indian Epoxy resin market has three key manufacturers mainly, Grasim Industries, Atul Industries and Hindustan Specialty Chemicals. Among these manufacturers Grasim Industries has the largest market share in terms of sales where company held more than 40% of market share. The company has shown outstanding numbers in previous two quarters i.e., Q4 2021 and Q1 2022 where Grasim Industries observed substantial increase in its net profits consolidating on the economic recovery in the Indian sub-continent region. Huge boost in advanced materials has been at the helm of driving demand in renewable energy which dually benefitted epoxy prospects in the region. Impressive performance in last quarter of 2021 for Atul industries in its epoxy business has been building on the demand growth, however a dip in Q1 2022 numbers has been witnessed epitomizing the effects of second covid wave in the region. Overall, epoxy market sentiments look optimistic and will consolidate on the demand growth in the region.

**India Epoxy Resin Demand**

Epoxy resin demand in stood at 98 KTPA in FY21 and the demand is expected to register a robust CAGR of 8.69% between 2021-2030. Rise in the market growth is largely attributed to growth in the country’s construction sector and increasing industrialisation and incentivisation of domestic producers.

Kukdo Chemical India Private Limited, Grasim Industries, Atul Limited are top three players operating in the India Epoxy Resin market. As per our market study, BADGE and Advancement process is mainly used in Epoxy Resin manufacturing. While Kukdo chemicals and Meghmani use in- house technology for Epoxy Resin manufacturing, other Indian manufacturers have sourced technologies from Japan (Tohto Kesia) and Germany (Ciba-Geigy) for Epoxy Resin manufacturing.

India is the key importer of Epoxy Resin with South Korea, China, Taiwan, Japan, Netherlands as its key trade partners between 2019-2021. India also exported significant volumes of Epoxy Resin to Germany, Italy, UAE, Saudi Arabia, Turkey and other countries between 2019-2020.

Paints and Coatings industry dominates the India Epoxy Resin Demand, holding around 44.2% demand share in 2021. Electrical and electronics and construction sector collectively hold nearly 30% share in the India Epoxy Resin demand. Epoxy Resins are being used as a replacement for mechanical fixings to provide internal and external strength, weather resistance and durability in Construction and Electrical and Electronics Industry specifically. India is witnessing high growth in the demand of epoxy resins due to increased consumption in protective coatings to prevent corrosion in Food and Beverage Sector, Automotive/Transportation etc.

The demand for Solid Epoxy Resin is estimated at around 47.7 KT in 2021 while demand for Liquid Epoxy Resin (LER) stands at 45.8 KT in the same period. It is expected that there would be substantial growth in demand for LER in the coming years while some slowness could be sensed in the demand for Solid Epoxy Resins. In India, majority of Epoxy Resin is sourced directly from producing companies. Bisphenol A (BPA)-based Epoxy Resins hold majority share the country’s Epoxy Resin demand. Due to growing awareness about environmental and toxic impacts of BPA-based Epoxies, it is expected that the demand for Bisphenol-F based will increase tremendously as a substitute of BPA.

**West and South are the dominating region in India Epoxy Resin Market**

**KEY GROWTH FACTORS**

**01**

**02**

**03**

**Rising Disposable**

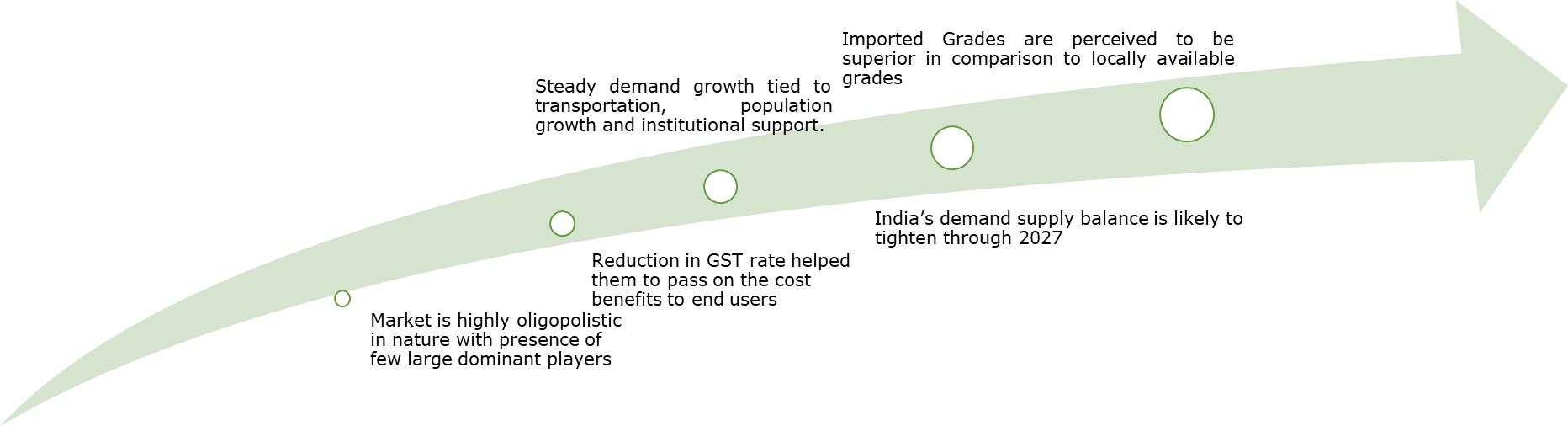
**Income**

**Shorter Repainting Cycle**

**Robust Automotive and Consumable Sector**

**04**

**Increasing Focus on Renewable sector**



**India Industrial Dynamics**

1. ***Market is highly oligopolistic in nature with the presence of few large dominant players***

Currently, there are only four business groups that are indulging in the production of epoxy resin in India. The market players include Kukdo Chemical India Pvt. Ltd., Grasim Industries, Atul Limited, Hindustan Specialty Chemicals Ltd. Grasim Industries is the oldest market player that hold the highest production capacity in India and has plans to further expand its epoxy resin production by 2025. Atul Limited has been an active player in epoxy resin production in the past and is expecting to raise the production capacity by 2024. Due to growing epoxy resin demand in coatings, adhesives, and composites applications and low market competitiveness has attracted a few more players to foray into epoxy resin production. For instance, Hindustan Specialty Chemicals started operating 30 KTPA epoxy resin plant in 2018. Kukdo Chemical India Pvt. Ltd. also ventured in epoxy resin production last year with its 40 KTPA production unit in Dahej, Gujarat. On the other hand, Meghmani Fine Chemicals is in plans to bring on-steam a 25 KTPA epoxy resin plant in Gujarat by 2024. The advent of new players in this field has mostly remained restricted owing to the high investment cost and dependence on imports for feedstocks. However, the fast-growing epoxy resin market in India and limited competition from other players is expected to compensate the investment cost with high output returns, making the India epoxy resin market and an attractive spot for new entrants.

1. ***Reduction in GST rate helped them to pass on the cost benefits to end users***

The Goods and Services Tax (GST) is an indirect tax imposed on goods and services sold domestically. Replacing all other kind of taxes levied by the state or central governments, GST is a single tax charged by the last dealer and is borne by the end-user alone. The imposition of GST has benefitted the chemical industries by ridding them from the burden of added taxations that led to high production costs. Now, with mitigation of VATs, CGST, SGST, IGST etc., that eventually caused the manufactures to pay more under the cascading effect, the gross production costs are significantly reduced giving the manufacturers more room to expand and sell their products anywhere across India. The low production costs are eventually passed on to end users who enjoy procurement of the chemical products at stable and affordable prices.

1. ***Steady demand growth tied to transportation, population growth and institutional support***

Engrossed with properties like high mechanical strength, strong adhesion, electrical insulation, chemical resistance, and low toxicity makes it a vital component in important end-user industries like transportation, buildings and construction, electricals and electronics, aerospace, wind-turbines etc. The growing population in India and their improving standard of living drives the growth in the transport and construction sectors with growing affordability. Hence, the transport sector where epoxy resins are extensively used in paints, engine components, structural inserts, and the construction sector where epoxy resins have multitudinous applications in coatings, paints, primers, sealers, flooring etc., are expected to maintain a firm demand for epoxy resins in the market.

1. ***Imported grades are perceived to be superior in comparison to locally available grades***

The imported epoxy resin grades like DERTM 337-DA97 (liquid phase) and DERTM 660-B80 (solid phase) from Olin Corporation, ARALDITE from Huntsman Corporation, EPONTM Resin 824 from Hexion, have gained huge popularity among the Indian end-user sectors due to their remarkable product quality. The imported epoxy resin grades have captured a significant share in the Indian market due to a general perception of being superior and reliable in comparison to the locally produced grades. Entrance of a player having technological expertise and could produce epoxy resin grades with qualities at par with imported ones, could really prove to be a game changer in the current scenario. The increase in high quality epoxy resin capacities could reduce India’s reliance from overseas imports and strengthen its position in the international exports.

1. ***India’s demand supply balance is likely to tighten through 2027***

The total consumption of epoxy resin is met through domestic production and overseas imports. The projected heavy growth in the transport industry as well as the construction activities in the coming 5 years is expected to raise the demand for epoxy resin by more than 50% of the volume consumed in 2020. The projected surge in epoxy resin demand without any significant additions in the production capacities are expected to bring a discord in the supply-demand balance. This could lead to increased dependence of the end user industries on imports which are bound to escalate under the influence of supply deficit market, a scenario liable to set the inflation rates high. However, the prospects of addition of new capacities could steer the market dynamics in its favor by catering to the rising demand in the end-user industries.

***3.8. MARKET DYNAMICS***

***Shape

Description automatically generated***

**Government Support and Initiatives**

**Rising Disposable Income & High Living Standards**

**Focus on renewables**

Drivers / Headwinds

Challenges / Tailwinds

**Rising investment in building & construction sector**

**Growing usage of specialty resin in automotive and industrial applications aerospace sector**

**Fluctuation In Raw Material Prices**

**Overcapacity in some region**

**Supply Chain Disruption**

***Market Drivers***

***Rising Investments in Building & Construction Sector***

The increasing population and continuously evolving economies have given way to increased expenditure on advanced infrastructure across the globe. Factors such as significant rise in purchasing power parity, especially in developing nations, and growing investments in the real estate sector are boosting the growth of construction sector, globally. Hence, the construction sector remained the major driver of epoxy resin market all throughout the historical years. After witnessing subdued activity during the COVID19 pandemic spread, the construction sector is rebounding in full force as the incomplete projects are being expedited and new projects are under pipeline. Various government sponsored projects across the globe such as smart cities, AMRUT, freight corridor and urban transport, etc., are expected to further accelerate the construction activities in the coming years in Southeast Asia, GCC, Central Europe and North Africa, thereby positively impacting the global epoxy resin market.

**European Countries Real Estate Investment, 2020 (USD Billion)**

|  |  |
| --- | --- |
| **Countries** | **Investment (USD Billion)** |
| Germany | 59 |
| France | 29 |
| Netherland | 16 |
| Spain | 13 |
| Italy | 10 |

*Source: Meed Projects*

***Government Support and Initiatives***

Driven by strong demand from various end-use industries such as wind energy, transportation, electrical and electronics, defense, aerospace, pipes and tanks, construction and marine, the composite industry, also known as fiber-reinforced plastics (FRP) industry, has witnessed a sharp rise in the past decade. The per capita consumption of composites in the United States, China and India were reported to be 11.4 kg, 2.8 kg, and 0.36 kg respectively. Owing to its multitudinous applications in various segments of the construction sector, the composite industry is set to play a pivotal role in supporting government’s initiatives across various developing countries. For instance, the ‘Make in India’ and ‘Housing for All’ initiatives launched by the Indian government warrant a surge in the construction activities that are expected to give a big push to the epoxy resin market. The increasing demand for composites manufacturing across the globe for numerous applications including aerospace structure & other composite parts would spur the demand for Epoxy Resins in the coming years.

***Growing usage of specialty resin in automotive and industrial applications aerospace sector***

Epoxy resin has a history of serving the automobile industry owing to its robustness, adhesive quality, and heat resistance nature. Epoxy resins are predominantly used to add protective coatings on automobile metal parts to increase their shelf life by preventing them from corrosion. The anti-corrosion epoxy coatings are applied as a primer on the metal parts using the ‘waterborne cathodic electrodeposition’ technique. Germany, boasting the largest automobile industry in Europe, owns a huge share in the epoxy resin consumption. China with its huge electronics base and high industrial growth also exhibits high consumption rate of epoxy resin. The flourishing automobile sector backed by the increasing population and growing income slab of the middle-class communities in the developing countries are expected to propel the demand for epoxy resins in the automobile industry in the coming years.

Epoxy resins form an indispensable part of the continuously evolving aerospace technologies, owing to its ability to withstand harsh conditions of space and resist microcracking. High-quality epoxy resins are in great demand in spacecraft for a myriad of applications like coating, bonding, encapsulation, staking, sealing, potting. Epoxy resins based composite fabrics have also gained a huge preference for the designing of durable and lightweight spacesuits with flame retardancy properties. With the growing government thrust towards active research in new space programs and increasing space excursions by the world’s top research organizations, the aerospace sector is expected to pick momentum by 2030 thereby becoming a large hub for the consumption of epoxy resins.

***Rising Disposable Income & High Living Standard***

As the industrialization and economic growth across the world has enhanced dynamically, there has been a significant rise in the earned income and expenditure incurred on lavish lifestyles by the people across the globe, thus giving impetus to the epoxy-based lightweight coatings and adhesives over the years. The high living standards across developed nations and the improving disposable income across developing countries is going to further drive the demand for advanced and premium quality paints & coatings in the housing and construction sector where epoxy resins are extensively applied in the forthcoming years. The demand will get further support from increasing per capita expenses on premium cars across the globe which will be driving the epoxy resin market worldwide.

***Focus on Renewables***

Many countries are targeting to reduce global carbon footprint by increasing investments in renewable energies which has attracted around USD 1.9 trillion capital spending in 2021 and the investment rate is expected to gain 10% year-on-year growth in the upcoming years. India has set a target of having 175 GW of renewables capacity by 2022. This shows that the country is focusing on renewable energy for its energy needs. India is also a party to the United National Convention on Climate Change which requires India to have some commitments till 2030 in order to support the world in the fight against climate change. India’s commitment includes that 40% of the country’s total electricity needs should come from renewable energy. This has caused the demand for wind energy to rise in India and globally. As epoxy resins are a major component of the composite material used to manufacture windmills, the demand for epoxy resins is also set to rise in India with the rise in the demand of wind energy. The energy outlook varies from country-to-country, however the favorable government policies across the world is enough to instigate confidence among the existing and new market players towards renewables business that is eventually going to strengthen the global demand for epoxy resin.

*Source: MNRE*

***Market Challenges***

***Volatility in Raw Material Prices***

An increase in the cost of raw materials, i.e., ECH and BPA, that are being used in the manufacturing of the epoxy resin have driven down the market sales since last year due to several disruptions caused by the COVID-19 outbreak worldwide followed by the energy crunch and crude oil price surge in the current year. The rising crude oil prices directly impact the operating cost and profit margins of the industry, and transportation costs, adding up the price of epoxy resins in the global market. However, the petrochemical sector is walking the path to recovery with loosening of pandemic constraints and return of workforce. Furthermore, the crude oil prices in a few regions, like North America, have begun to fall in the fourth quarter of 2021, which should ripple across the other parts of the world in the following year. These trends advocate the optimism in stabilization in the prices of raw materials in future favoring a positive epoxy resin market outlook.

***Supply Chain Disruptions***

Due to onset of COVID-19, disruptions in business cycles impacted the demand for all core industries, globally. The virus outbreak has affected supply chain, trade and industries worldwide. Severity of pandemic was compounded by the fact that many industries are operating at reduced capacity, consequently lowering the number of employees as well. Pandemic outbreak also led to delays in all commercial decisions in the short term, but the long-term impact remains unknown as the longevity of the crisis is uncertain. Moreover, in second half of 2021, traffic at the Chinese ports coupled with the tightened availability of freight vessels gathered adequate momentum to strengthen the will of manufacturers to raise the offered quotations in the APAC market.

Most of Indian businesses are traditionally run with procurement of raw materials done through a lengthy and complex decision-making process. This necessitated forward contracts and long-term contracts to hedge against uncertainties. Changing geopolitical pattern coupled with onset of the global pandemic COVID-19 has re-routed the procurement process, with procurement professionals targeting more short-term contracts for institutional and bulk purchases. Similarly, changing equations between India and China have curbed Chinese supply and Indian importers are now shifting their focus to other Southeast Asian countries for product sourcing.

**3.9. Market Trends & Developments**

**Liquid Epoxy Resin (LER)-Feedstock Margin Spread**

As of October 2021, FOB Ningbo price of Liquid Epoxy Resin was around $5915-6000/ tonne, while the price at the end of June was less than $4900/tonne. The abrupt surges in LER pricing are largely attributed to high priced feedstock Epichlorohydrin (ECH).

Several Chinese Epoxy producers complained of compressed margins and ChemAnalyst data shows that the spread between ECH and Epoxy Resins narrowed to USD 2710 per tonne levels in October. over USD 3500 level in April. 2021. This is majorly attributed to strong ECH pricing environment and dramatic contraction of Epoxy Resin supplies in East China.

With China’s latest norms on energy consumption and dual control management, companies with captive power plants, boilers, and steam need to meet the compliance with many Epoxy Resin companies in Jiangsu in the ranks. Due to uncertain market outlook, many Epoxy Resin companies have curtailed their operating rates and many have also closed. As per traders, several end-users are obviously resistant to high prices and waiting for the situation to normalise. The demand for coatings, laminates, electrical and electronics continues to improve in October due to peak demand season in Q4 2021.

Moreover, rising crude oil prices, lead to increase in production cost of essential raw materials such as epichlorohydrin and BPA.

**Liquid Epoxy Resin (LER) Price Forecast**

It is estimated that the market price of LER will remain at high levels, with slight fluctuations as the market has already attained consolidation. FOB East China prices in China will likely stay between $5900-6000/mt in October. The relationship between resin supply and demand is tight, and the prices will stay firm in October. In China, raw material epichlorohydrin (ECH) supply may further tighten in China as a major facility in Jiangsu province may remain shut in the wake of the country’s new environmental policies.

***Cost pressure over downstream industries***

Several downstream consumers of Epoxy Resins reported pressured margins due to unexpected surges in Epoxy Resin pricing in Q3. For example, in August 2021, because of the rise in the price of Epoxy Resin in China, the price of copper clad laminates also showed signs of increase. In its interim report Changchun Chemical announced price increase of its copper clad laminates in Q3 due to soaring price of Epoxy Resin in addition to other key raw materials used in the laminate manufacturing. The company also projected in its financials that prices copper clad laminates may increase again in the future due to high raw material cost. Changchun announced that the prices of all copper clad laminate products increased by 10% early in September. In addition, Hong Kong based Kingboard laminates increase HB/VO (all thickness) price w.e.f. August 30. In August itself, Shengyi Technology also announced an increase in the price of copper clad laminates led by strong copper foil and Epoxy Resin pricing.

(The primary raw material for Printed Circuit Boards is the Copper Clad laminates (CCL) which are made up of copper foil, Glass fibre and Resin. The cost breakup for CCL is- 30-50%: copper foil, 24-40%: Glass fibre and 25-30%: Epoxy Resin)

***Expansion of Production Facilities***

With the growing demand for Epoxy Resin in various sectors such as automotive, construction, electrical & electronics etc., companies have started investing in expanding and setting up manufacturing facilities across multiple locations worldwide. Moreover, companies are increasingly focusing on investing largely across developing nations due to the availability of cheap labor such as in India, China and others. For instance, Kukdo Chemical Pvt Ltd, one of the leading Korea-based companies, has recently set up greenfield epoxy resin production unit in India with a capacity of around 40 KTPA in 2020 and is further planning to expand its capacity by 60 KTPA by 2024 to address the growing demand across the country and to capture the maximum share in Asian market.

***Growing Demand for Lightweight Material in Automotive and Auto Ancillaries Sectors***

Rising demand for polypropylene and other petrochemical derivatives in the automotive sector is increasing as companies are focusing more on the development of new products and reducing the carbon footprint. Most of the automotive manufacturers are launching hybrid and electric vehicles across the globe. Furthermore, with rising investments in new product development and adopting new technologies, companies are focusing on using more light and composite materials for automotive manufacturing, which is leading to a surge in the demand for petrochemicals and their derivatives.

***Hazards of Bisphenol A and the related shift from Bisphenol A market***

BPA is used in the manufacturing of epoxy resins and due the high demand and related mass production, the presence of BPA is ubiquitous in the environment, and it can enter the body via the digestive tract, respiration system, and dermal tract. BPA by nature is an endocrine disruptor and affects the hormonal levels in the body. BPA has estrogen and anti-androgen effects which damages tissues and organs including the reproductive system, immune system, and neuroendocrine system. Due to its hazardous properties BPA is being replaced by BPS in thermal paper in Europe. The ECHA restriction for BPA in thermal paper was implemented in 2020. Similar restrictions are expected in the US market in the upcoming years. this has caused the shift from the Bisphenol A market to various substitutes including BPS.

**3.10 Pricing Analysis Epoxy Resin (USD/ ton)**

Epoxy resin market fundamentals differs region by region, and usually prices vary with fluctuations in raw material cost. Steep economic rebound has favoured sharp hike in price of raw material coupled with rising consumptions across global market, that supported the steep rise in Epoxy resin prices. Countries like UK, frequently face scarcity of raw material bisphenol A (BPA), as industries based in UK are highly dependent on imports. There were other factors which also impacted the trade activities, like spiralling freight cost, crippling availability of shipping containers, and rise in countries’ domestic consumption in effect of revival from pandemic repercussion. Moreover, during Q1 2021, USA faced devastating weather that caused disturbance in manufacturing of upstream chemicals, conclusively exacerbated the overall halt in USA-Europe trade activities. Meanwhile, India had to battle with second wave of pandemic during Q2 2021 that overall dented the Epoxy resin market sentiments for a considerable timespan. However, revival of industrial activities has improved the demand fundamentals in Indian market since August 2021. Conclusively Epoxy resin prices witnessed an overseas hike since the month of January 2021.

*Source: TechSci Research*

**South Korea**

**Germany**

**United States of America**

Epoxy Resin pricing varies geographically as quality of the product differs region-wise. In H1 2021, raw material pricing and availability remained a key issue for North America and Europe while the Asian stocks have shown a different picture altogether due to better product availability and lower production cost. As per our study, the same Epoxy Resin grade of the European origin is much costlier over the Asian make. For e.g., Huntsman quotes the same material at a higher price than the Chinese/Indian material. Hence, brand makes a significant difference if we talk of Epoxy Resins (both solid and liquid).

The Asian Epoxy Resin market is more fragmented with greater number of competitors operating locally. Higher competition over other regions weighs over the Asian Epoxy Resin pricing. In addition, better labour availability, particularly in Asia and variation in contract terms country over country make the prices differ with respect to location.

Epoxy resin pricing dynamics have been different by region. In Asia, resin prices escalated dramatically in early 2018 and moderated during the first and second quarters of 2018. In North America and Europe, prices increased late in Q4 2017 and through the beginning of the second quarter of 2018 and then eased slightly. Hence, overall market dynamics and timeframes for price increases vary significantly in different regions.

In addition, some global producers also show greater flexibility for contract buyers observing a structural shift in demand patterns after the pandemic.

Largest crude oil price slump of modern history in 2016, impacted most of the downstream commodities including Epoxy resin across global market. Epoxy resin prices slipped significantly during that period, despite of stable demand fundamentals across the global market. In Asia, Chinese Epoxy market usually influence other neighbouring countries. During 2019, China witnessed a huge fall in prices of Epoxy resin, bolstered by astonishing decline in price of its raw materials including Epichlorohydrin (ECH) and BPA, that also affected the overall Asian market during that timeframe. Meanwhile, Europe and North America market wasn’t affected from this price trend due to a significant demand-supply gap in respective markets. Later, during 2020, COVID-19 pandemic related restrictions further squeezed market dynamics across Asia and marked a significant dent on Europe and North America regional market. Global market has been recovering from the repercussion of pandemic since January, thus witnessing a consistent inclination in prices of Epoxy across global market.

**Basis for Price Forecasting**

The price of epoxy resin has been forecasted by using annual average delta method, wherein:

·                 the price during last ten years is considered.

·                 these prices, if available monthly or quarterly are

          averaged on annual basis.

  ·                 the annual delta for last ten years is worked out.

·                 the average annual delta is computed.

The delta takes into consideration the anomalies of price fluctuation due to many factors such as:

-                  Exchange rate

-                  Conversion rate

-                  Demand / availability scenario

-                  Feedstock price changes

-                  Geo-political scenario

-                  Global economy, etc.

-                  Inflation

-                  Taxation.

The annual average delta is used to forecast the price taking current price as a base. The above factors are in- built in annual average delta.

Presently, crude oil price fluctuations are showing considerable volatility due to several socio-political factors worldwide. Various influencing factors for price forecast include raw-materials / feedstock prices and demand – supply balances in the region which built the relationship of product to substitute products having comparable properties and common end-uses as well as their prices.

Feedstock prices directly affect the price of product. Increased feedstock prices, if passed on to end-users, increase the inflation and if not, they squeeze the margins of producers leading to making the industry unattractive for further investments. This leads to supply crunch and shortage of product in the market. The shortage leads to further increase in prices of product.

The uncertainty over development of economic environment renders the forecasting exercise futile. Therefore, the forecasting exercise is always done with set of assumptions. The assumptions in this exercise are as under:

* The crude oil prices will remain within average limits during the next ten years.
* The technologies in exploration and production activities will continuously evolve leading to lower cost of production, better margins and extra investment in E&P activities.
* No technological innovations of substantial magnitude will take place which may lead to sea-change in technologies / processes used today.
* Current Exchange Rate will change during the forecast period.

**3.12. Value Chain Analysis**

This section shows the variety of activities that are incorporated to bring epoxy resin from conception, throughout the intermediary stages of production and reaching to final consumer. In epoxy resin value chain analysis, the raw material cost contributes the major share in the selling price of epoxy resin. Through direct sales, the company undergoes more profit margin than indirect sales. Captive refers to direct consumption of the product manufactured either as a main product or as a by-product. Non-Captive refers to extraction of the product for usage and trading of the products.

*NOTE- The value chain has been calculated based on prevailing prices during the month of September 2021.*

**Value Chain Flow for Captive Liquid Epoxy Resin Manufacturer (Bisphenol A)**

**BPA:** Phenol & Acetone

(Mole Ratio 2:1)

**Manufacturer**

**Direct Sales**

**ECH**: Propylene, Chlorine Gas & Lime (Mole Ratio 2:2:1)

Raw Material Cost

(USD 1.518/kg)

Overhead\* + Packaging Cost (USD 0.433 /kg)

Caustic Soda Lye (48%)

Catalyst & Chemical

Current Selling Price (USD 3.06/kg) Direct Sales

Total Cost Incurred (USD 1.92/ kg)

Current Selling Price (USD 3.01/kg) In-Direct Sales (Inclusive Freight Charges)

**Percentage Margin 60.9 %**

**In-Direct Sales**

**Percentage Margin 56.25 %**

**Including Transportation charges**

**Epoxy Resin Value Chain**

**Company Website/Direct Export/Direct Sales**

**Distributor/Retailer**

**End User**

**\****Overhead Cost includes Rent, Insurance and Utilities expenses*

**Value Chain Flow for Captive Liquid Epoxy Resin Manufacturer (Bisphenol F)**

**BPF:** Phenol & Formaldehyde

**Manufacturer**

**Percentage Margin 29 %**

**Including Transportation charges**

**Direct Sales**

**Company Website/Direct Export/Direct Sales**

Raw Material Cost

(USD 3.2/kg)

Overhead\* + Packaging Cost (USD 0.72 /kg)

**ECH**: Propylene, Chlorine Gas & Lime

Caustic Soda Lye

Current Selling Price (USD 5.22/kg) Direct Sales

Total Cost Incurred (USD 3.92/ kg)

Current Selling Price (USD 5.16/kg) In-Direct Sales (Inclusive Freight Charges)

**Percentage Margin 32 %**

**In-Direct Sales**

**Epoxy Resin Value Chain**

**Distributor/Retailer**

**End User**

**\****Overhead Cost includes Rent, Insurance and Utilities expenses*

**Value Chain Flow for Captive Solid Epoxy Resin Manufacturer**

Liquid Epoxy Resin 1.92

**Epoxy Resin Value Chain**

**Manufacturer**

Current Selling Price (USD 2.60/kg) In-Direct Sales

Raw Material Cost (USD 1.38/kg)

**In-Direct Sales**

**Direct Sales**

**Percentage Margin 50%**

**Company Website/Direct Export/Direct Sales**

Bisphenol-A 1.35

Overhead + Packaging Cost (**USD** 0.4 /kg)

Xylene 1.47

Catalyst (Recoverable)

Current Selling Price (USD 2.67/kg) Direct Sales

Total Cost Incurred (USD 1.78/Kg)

**Percentage Margin 46%**

**Including Transportation charges**

**Distributor/Retailer**

**End User**

**Value Chain Flow for Non-Captive Liquid Epoxy Resin Manufacturer**

BPA: USD 1.35/kg

**Manufacturer**

**Percentage Margin 30.1%**

**Including Transportation charges**

**Percentage Margin 32.7 %**

ECH: USD 1.47/kg

Overhead + Packaging Cost

(USD 0.433/Kg)

Raw Material Cost (USD 1.872/kg)

Caustic Soda Lye(48%): USD 0.15/kg

Current Selling Price (USD 3.06/kg) Direct Sales

Total Cost Incurred (USD 2.305/kg)

Current Selling Price

(USD 3.0/kgIn-Direct Sales (Inclusive Freight Charges)

**Direct Sales**

**In-Direct Sales**

**Epoxy Resin Value Chain**

**Company Website/Direct Export/Direct Sales**

**Distributor/Retailer**

**End User**

**Value Chain Flow for Non-Captive Solid Epoxy Resin Manufacturer**

Liquid Epoxy Resin: USD 2.305/kg

**Epoxy Resin Value Chain**

**Manufacturer**

**Percentage Margin 32 %**

**Including Transportation charges**

Current Selling Price (USD 2.60/kg) In-Direct Sales

Current Selling Price (USD 2.67/kg) Direct Sales

Raw Material Cost (USD 1.5/kg)

**In-Direct Sales**

**Direct Sales**

**Percentage Margin 35%**

**Company Website/Direct Export/Direct Sales**

Bisphenol-A: USD 1.35/kg

Overhead + Packaging Cost (USD 0.40 /kg)

Xylene: USD 0.55/kg

Catalyst (Recoverable)

Total Cost Incurred (USD 1.97/kg)

**Distributor/Retailer**

**End User**

**3.13. Customer Analysis**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Country** | **Product Description** | **Customer / Distributor Name** | **End Use Application** | **Plant Location** | **Supplier Name** | **Annual Off-take Quantity (Tonnes)** | **Price Ranges (USD/kg)** |
| India | Bisphenol A based liquid epoxy resin | Ppg Asian Paints Private Limited | Paints & Coatings | Mumbai, Bangalore, New Delhi, Chennai | Ppg Industries Korea Ltd, South Korea & Kumho P & G Chemicals Ltd., South Korea | 6250 | 1.46-1.81 |
| India | Bisphenol A based liquid epoxy resin | Kansai Nerolac Paints Limited | Paints & Coatings | Mumbai, Bangalore, New Delhi | Kukdo Chemical Co Ltd, South Korea & Aditya Birla Chemicals Thailand Ltd., Thailand | 5100 | 2.9-3.61 |
| India | Bisphenol A based liquid epoxy resin | Kansai Nerolac Paints Limited | Paints & Coatings | Mumbai, Bangalore, New Delhi | Kukdo Chemical Co Ltd, South Korea & Aditya Birla Chemicals Thailand Ltd., Thailand | 5000 | 2.25-2.8 |
| Indonesia | Bisphenol A based liquid epoxy resin | Pt. Nipsea Paint And Chemicals | Paints & Coatings | Jakarta | Aditya Birla ChemicalsLtd., Thailand & Nan Ya Plastics Corporation, Taiwan | 2150 | 2.44-3.04 |
| Indonesia | Bisphenol F based liquid epoxy resin | Pt. Sika Indonesia | Adhesives and Chemicals | Bekasi, West Java | Aditya Birla ChemicalsLtd., Thailand & Nan Ya Plastics Corporation, Taiwan | 1360 | 4.49-5.59 |
| India | Bisphenol A based liquid epoxy resin | Jotun India Private Limited | Paints & Coatings | Mumbai | Kukdo Chemical Co.Ltd., South Korea | 1250 | 2.03-2.52 |
| India | Bisphenol A based liquid epoxy resin | Siegwerk India Private Limited | Adhesives | Mumbai, Bangalore, New Delhi | Qualipoly Chemical Corporation, Taiwan & Eternal Materials Co., Ltd. Taiwan | 1180 | 2.84-3.53 |
| Indonesia | Bisphenol F based liquid epoxy resin | Pt. Hempel Indonesia | Paints & Coatings | Jawa Barat | Chang Chun Plastics Co.,Ltd, Taiwan | 1050 | 3.92-4.87 |
| Indonesia | Bisphenol F based liquid epoxy resin | Pt. Panasonic Industrial Devices Batam | Electronics | Jakarta | Panasonic Industrial Devices Singapore, Singapore | 990 | 11.13-13.85 |
| India | Bisphenol A based liquid epoxy resin | Jotun India Private Limited | Paints & Coatings | Mumbai, Kanchipuram | Kukdo Chemical Co.Ltd., South Korea | 950 | 2.92-3.63 |
| India | Bisphenol F based liquid epoxy resin | Napino Auto Electronics Ltd | Electronics | Mumbai, New Delhi | Shindengen Electric Manufacturing, Japan | 850 | 4.33-5.39 |
| Indonesia | Bisphenol F based liquid epoxy resin | Pt. Propan Raya Industrial Coating Chemicals | Paints & Coatings | Tangerang, Banten | Aditya Birla Chemicals (Thailand) Ltd., Thailand | 800 | 3.67-4.57 |
| India | Bisphenol F based liquid epoxy resin | Huntsman International India Pvt Ltd | Adhesives | Mumbai, Bangalore, New Delhi | Huntsman Advanced Materials Europe Bvba, United Kingdom & Germany | 750 | 5.36-6.66 |
| India | Bisphenol F based liquid epoxy resin | Stonera Systems Pvt Ltd | Electronics | Mumbai, Bangalore, New Delhi | Isep Srl, Italy | 600 | 3.65-4.54 |
| India | Bisphenol F based liquid epoxy resin | Vimal Intertrade Pvt Ltd | Composites | Mumbai | Evonik Ressource Efficiency Gm, Germany | 600 | 7.42-9.23 |
| India | Bisphenol A based liquid epoxy resin | Champion Advanced Materials Pvt Ltd | Composites | Bangalore | Kukdo Chemical Co.Ltd., South Korea | 240 | 2.03-2.52 |
| India | Bisphenol F based liquid epoxy resin | Yamaha Motor Electronics India Private Limited | Automotive | Mumbai, Bangalore | Yamaha Motor Electronics Taiwan Co., Taiwan & Towa Denki Trading (S) Pte Ltd, Singapore | 230 | 21.72-27.03 |
| Pakistan | Bisphenol A based liquid epoxy resin | Berger Paints Pakistan Limited. | Paints & Coatings | Karachi | Hls Technology Development, China | 200 | 2.83-3.52 |
| Pakistan | Bisphenol F based liquid epoxy resin | Awan Sports Industries (Pvt) Ltd | Consumer Durables | Sialkot | Kukdo Chemical Co.Ltd., South Korea | 190 | 3.78-4.7 |
| Pakistan | Bisphenol A based liquid epoxy resin | Famsa Polymers Industry Private Limited | Paints & Coatings | Karachi | Jubail Chemical Industries Co. (Jana)., Saudi Arabia | 90 | 1.91-2.37 |
| India | Bisphenol F based liquid epoxy resin | Precision Electronic Component Mfg Co | Electronics | Mumbai | Synresalmoco Bv, Netherlands | 25 | 8.55-10.64 |
| India | Bisphenol F based liquid epoxy resin | Fasto Advance Adhesive Technologies | Adhesives | Bangalore | Fastfix-It Enterprise Co Ltd, Taiwan | 25 | 5.24-6.52 |

**\****Estimated Consumption is of 2021 on the basis of 8 months actual data*

*Source: TechSci Research*

**Global Epoxy Resin Trade Dynamics – Import (USD Million and Thousand Tonnes), 2018-2020**

**3.14. Global Epoxy Resin Foreign Trade Analysis, 2018-2020**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Country** | **2018** | | **2019** | | **2020** | |
| **Import** | **Value** | **Volume** | **Value** | **Volume** | **Value** | **Volume** |
| China | 776.66 | 235.42 | 995.15 | 288.77 | 1255.09 | 404.81 |
| Germany | 550.57 | 169.86 | 570.11 | 155.49 | 491.00 | 142.12 |
| United States | 318.08 | 94.97 | 451.16 | 108.62 | 351.99 | 88.55 |
| Italy | 166.56 | 70.50 | 190.60 | 64.02 | 164.31 | 58.16 |
| Turkey | 107.77 | 44.33 | 168.58 | 56.39 | 154.10 | 52.96 |
| Netherlands | 100.26 | 41.98 | 134.65 | 42.40 | 157.70 | 45.77 |
| Russia | 109.71 | 38.84 | 151.31 | 47.90 | 145.13 | 45.74 |
| United Kingdom | 201.33 | 55.63 | 214.34 | 55.56 | 155.62 | 45.43 |
| Japan | 137.89 | 48.41 | 169.31 | 50.05 | 149.23 | 44.35 |
| India | 89.36 | 26.37 | 93.18 | 32.05 | 90.14 | 29.81 |
| Others | 397.79 | 156.73 | 588.1 | 242.73 | 433.1 | 151.07 |
| **Total** | **2955.98** | **983.04** | **3726.49** | **1143.98** | **3547.41** | **1108.77** |

*Source: TechSci Research*

**Global Epoxy Resin Trade Dynamics – Export (USD Million and Thousand Tonnes), 2018-2020**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Country** | **2018** | | **2019** | | **2020** | |
| **Export** | **Value** | **Volume** | **Value** | **Volume** | **Value** | **Volume** |
| **South Korea** | 531.18 | 174.35 | 515.11 | 192.77 | 508.36 | 206.53 |
| **Germany** | 709.79 | 170.67 | 646.04 | 161.96 | 599.19 | 161.67 |
| **Taiwan** | 406.23 | 131.75 | 395.48 | 145.36 | 408.98 | 153.53 |
| **USA** | 414.40 | 95.21 | 445.60 | 123.36 | 413.17 | 105.89 |
| **Netherlands** | 225.08 | 79.40 | 210.66 | 79.99 | 210.31 | 74.36 |
| **Thailand** | 110.80 | 34.13 | 105.40 | 35.19 | 104.84 | 38.01 |
| **Czech Republic** | 96.63 | 32.77 | 86.29 | 33.90 | 79.73 | 34.00 |
| **China** | 108.68 | 34.66 | 83.56 | 28.88 | 78.38 | 28.31 |
| **Switzerland** | 207.28 | 37.91 | 178.97 | 33.56 | 133.35 | 26.45 |
| **Japan** | 300.07 | 29.64 | 288.44 | 26.68 | 298.14 | 24.84 |
| **Others** | 667.44 | 263.15 | 612.34 | 282.33 | 640.37 | 255.17 |
| **Total** | **3777.59** | **1083.63** | **3567.88** | **1143.98** | **3474.82** | **1108.77** |

*Source: TechSci Research*

**3.15. Suggested Capacities (Ideal Product Mix and Capacity recommendation)**

Suggested capacity is 84 KTPA, which is to be implemented in two phases: 1st Phase - 2024 and 2nd Phase -2028.

Regarding Market distribution, in 1st phase of operation, 20-35% of the total base and novolac epoxy resin manufactured can be used as raw material for the Vinyl ester resin. Superior grades of formulated epoxy resins can be exported to Europe, Northeast Asia and North America.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Suggested Capacity** | | | | **2024** | | **2028 (Additional Capacity)** | | |
| **Value in Tonnes** | | | | | | | | | |
|  | | | | | | | | | |
| **1. Liquid Epoxy Resin** | | **Product Specifications** | |  | | |  | |
| *Bisphenol A (80%)* | | *Unmodified with EEW range 172-204* | | 22,000 | | | 22,000 | |
| *Bisphenol F and S (20%)* | |
| **2. Semi-Solid BP-A based Resins** | | *EEW range 240-720* | | 3,000 | | | 3,000 | |
| **3. Solid Epoxy Resin** | | 10,000 | | | 10,000 | |
| **4. Specialized Epoxy Resin** | | *Multifunctional (Novolac Epoxy Resin, Phenol / Cresol), Cycloaliphatic)* | | 6,500 | | | 6,500 | |
| **5. Others** | | *Dimer Acid Modified Epoxy Resins, Brominated Epoxy Resins, Glycidyl amine Epoxy Resins others)* | | 500 | | | 500 | |
| **Total (1+2+3+4+5)** | | | | **42,000** | | | **42,000** | |
| **Epoxy System Plant Capacity\*** | |  | |  | | |  | |
| **Formulated Epoxy Resin** | |  | | 10,000 | | | 10,000 | |
| **Hardeners** | | 5,000 | | | 5000 | |
| **Reactive diluents** | | 3,000 | | | 3000 | |
| **Total Epoxy Resin and System** | | | | **60,000** | | | **60,000** | |

1. *LER capacity is meant for both captive and merchant sales.*
2. *Epoxy resin systems comprise of epoxy resin, reactive diluents and curing agents. Reactive diluents and Curing agents are other two components of epoxy system. Reactive diluents are used to reduce the viscosity of the base resin based on Bisphenol-A and F. and in epoxy phenol novolac resins. Besides, they are also used to optimise performance properties such as impact strength, adhesion, flexibility, filler-loading and solvent resistance of the epoxy system. They are used in formulating solvent-free paint and coating compounds as well as additives in combination.*

**Basis for Suggested Capacity**

* **Likely demand, supply, and gap to be emerged during forecast period.**
* **Suggested capacities are based on the optimistic scenario and anticipated higher growth in various end use industry.**
* **RIL needs to export up to 20% of the production during initial year of operation.**
* **In India, all the existing players have expanded their capacity in phases.**
* **In Initial years,**

***Global Scenario:*** The current global capacity of Epoxy Resin is approximately 4.5 million tonnes. Top ten producers account for 55 percent of the total capacity in 2021. In 2021, global consumption of Epoxy Resin was approximately 3.5 million tonnes. Regional analysis indicates surplus in Western Europe & APAC and deficit in North America, South America, Oceania, and Africa, resulting in heavy trade within the region as well as international trade. Within Asia, India (In optimistic case), Pakistan, Indonesia, Malaysia, and Vietnam are expected to remain deficit areas while South Korea and Taiwan are expected to be surplus.

***Indian Scenario:*** Present capacity in the country is 0.18 million tonnes per annum. Entire capacity is shared by four manufacturers – Grasim Industries Ltd, Atul Ltd, Hindusthan Specialty and Kukdo Chemicals. The annual average consumption growth over the last five years period has remained 6.31 percent per annum and over the last 10 years, 8.4 percent per annum, indicating a healthy trend in consumption. It is expected that, based on individual end-use sector growth, consumption of Epoxy Resin will register an overall growth of about 8.8 percent per annum average growth over the next ten years’ period.

India is expected to remain a deficit area despite capacity additions by existing suppliers in optimistic scenario.

Considering demand – supply situation and export market, enough scope exists in the country for a 84 thousand tonnes per annum epoxy resin unit by 2028 in two phases. Setting up a dedicated unit is advisable so that niche grades can be produced. Adequate export market potential also exists. However, exports from India are not advisable as manufacturers tend to get better realization in terms of pricing within India over competing for exports. Moreover, due to high competition over quality, local selling of Epoxy Resins offers more lucrative opportunity for the domestic players.

**Recommendations**

* Reliance Industries Ltd may consider setting-up a 84 thousand tonnes Epoxy Resin (base resin, formulated resin, hardener and diluent) unit by the year 2028 as enough scope exists from demand – supply point of view. However, before taking up this decision, Reliance Industries Ltd should also consider the project from economic viability point of view.
* The company can use one third of epoxy resin (liquid and solid) to produce vinyl ester resin.
* Reliance Industries Ltd needs to explore export market for both standard and specialized epoxy resin.
* The capacity we have considered is in the ratio of 53:47 for Liquid vs Solid / Semi-Solid Epoxy resin. The capacity ratio may change, and it is a discretionary power of the management to change the product-mix depending on prevailing demand-supply situation in the domestic and international market.
* Reliance Industries Ltd may consider of backward integration by setting up project of Epichlorohydrin, key raw material for Epoxy Resin (Liquid / Standard) which will be based on glycerine as feed stock which is obtained from 100% renewable resources. This is not a part of pre-feasibility study, however it is of great interest to downstream users who are concerned about a cost-effective production route whilst taking advantage of an abundant renewable feedstock to reduce their carbon footprint.

**4. Project Description**

**4.1 Type of Project –** This project will be categorized as greenfield project. Reliance Industries Ltd need to acquire fresh land for the project as entire project will require civil work including land acquisition. Reliance Industries Ltd is currently not producing any raw material hence unit will not be backward integrated.

**4.2 Magnitude of the Operation-**

It is an integrated petrochemical complex comprising of,

* Epoxy Resin plant 84 KTPA.
* Captive power plant focusing on renewable energy.
* Water Desalination Plant (RO process).
* All other associated utilities such as DM Plants, Effluent treatment plants, Sewage treatment plant, Compressed air & Nitrogen generation plant and infrastructure facility.

**Plot Plan Area:**

* The proposed project considered as greenfield and will be set up to manufacture various grades epoxy plant to produce starting from base resins to specialties to cover wide range of application
* The proposed land use at project site will be around **15 Acre**. This includes raw material storage, product storage, waste storage area, water treatment facility, main plan 1 (for liquid Epoxy Resin), air conditioning storage, main plant 2 (for solid epoxy resin), ETP plant, administration building, space for future expansion, green area etc.
* Adequate land need be available for open spaces and other non-building purposes. ~10-13 % area (i.e., as per the government norms) of total plot area need be reserved for green cover / lawn development in the proposed facility. Suitable plant species of local varieties must be planted with adequate spacing and density for their fast growth and survival shall be ensured by taking due care.

**4.3 Setup Related Details**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **4.1.1. Target End-Use Applications (Grade wise application details of Epoxy Resin)**  There are many customised Epoxy Resin types commercially available from global manufacturers, compatible with a wide range of modifying resins, reactive and nonreactive diluents, curing agents, additives, rheology modifiers, and fillers.   |  |  |  | | --- | --- | --- | | **BISPHENOL-A BASED LIQUID EPOXY RESINS** | | | | **Application** | **EEW** | **Viscosity @ 25°C** | | **g/eq** | **mPa∙s** | | Multiple application including Adhesive, Coating, Construction, Electrical and Composites | 184 - 191 | 11,000 - 15,000 | | Coatings and Adhesive formulations | 213 - 233 | 20,000 - 26,000 | | Adhesives and Prepregs | 225 - 280 | 450 - 800 (70% solution in butyl corbitol) | | Multiple application including Adhesive, Coating, Construction, Electrical and Composites | 180 - 187 | 8,000 - 11,000 | | Coatings and Adhesives | 280 - 300 | 500 - 1,500 (70% solution in butyl corbitol) | | |
| |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | **BISPHENOL-A BASED SOLID RESINS** | | | | | | | | **Application** | **EEW (g/eg)** | | **Viscosity 25°C (mPa∙s)** | | **Softening point (°C)** | | | Powder Coating formulation | 653 - 704 | | 375 - 475 | | 80 - 90 | | | Powder Coating formulation with high glass transition temperature | 769 - 847 | | 6,000 - 8,000 @ 150°C | | Tg = Min 55 | | | Hybrid powder coatings | 714 - 752 | | 500 - 600 | | 95 - 101 | | | Powder Coating formulation | 781 - 855 | | 480 - 580 | | 85 - 90 | | | Protective Coating | 450 - 465 | | 160 - 190 | | 65 - 75 | | | Enamels and exterior coating of cans and tubes | 833 - 893 | | 550 - 700 | | 90 - 102 | | | Internal coating of cans and tubes | 1,695 - 1,887 | | 1,800 - 2,600 | | 110 - 120 | | | **BISPHENOL-F BASED LIQUID EPOXY RESINS** | | | | | | | **Application** | | **EEW (g/eg)** | | **Viscosity 25°C (mPa∙s)** | | | Coating applications, Composites, Construction and Electrical casting | | 159 - 175 | | 2,000 - 5,000 | | | 164 - 172 | | 2,000 - 3,300 | | | 164 - 172 | | 3,300 - 4,100 | | | 159 - 172 | | 5,000 - 7,000 | | | Coatings, Composites, Construction applications and Floor coatings. | | 172 - 180 | | 6,500 - 8,500 | | | 174 - 182 | | 4,500 - 6,500 | | | High Solids coatings, Construction and Floor coatings. | | 185 - 196 | | 6 860 - 960 | |  |  |  |  | | --- | --- | --- | | **CYCLOALIPHATIC RESINS** | | | | **Application** | **EEW (g/eg)** | **Viscosity 25°C (mPa∙s)** | | Electrical component castings, Potting and Outdoor coatings. | 159 - 182 | 500 - 1,100 | | Electrical cast components | 180 - 200 | 350 - 750 | | Outdoor coatings, Flooring, Electrical castings and composite parts | 220 - 240 | 2,000 - 4,000 | | Outdoor coatings, Flooring, Electrical castings and Composite | 210 - 230 | 1,300 - 2,500 | | Electrical component castings, Potting and Outdoor coatings | 130 - 143 | 250 - 450 |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | **EPOXY PHENOL NOVOLAC RESINS** | | | | | | | | **Application** | | **EEW (g/eg)** | | **Viscosity 25°C (mPa∙s)** | | | | Composites, Electrical and Coating applications. | | 172 - 179 | | 1,100 - 1,700 @ 52°C | | | | Composites, Electrical, Chemical resistant coatings and Flooring | | 175 - 182 | | 20,000 - 50,000 @ 52°C | | | | Chemical resistant coatings, Electrical and Composite applications. | | 215 - 231 | | 150 - 350 | | | | Chemical resistant coatings, Electrical and Composite applications. | | 215 - 231 | | 800 - 1,500 | | | | **GLYCIDYL AMINE BASED MULTIFUNCTIONAL RESINS** | | | | | | | **Application** | **EEW (g/eg)** | | **Viscosity 25°C (mPa∙s)** | | **HyCl %** | | High Performance Composites (aviation and marine) | 117 - 134 | | 7,000 - 11,000 @ 50°C | | Max 0.10 | | 118 - 134 | | 7,000 - 19,000 @ 50°C | | Max 0.10 | | 111 - 117 | | 3,000 - 6,000 @ 50°C | | Max 0.10 | | 118 - 133 | | 7,000 - 12,000 | | Max 0.10 | | 105 - 115 | | 2,000 - 5,000 | | Max 0.30 |  |  |  |  |  | | --- | --- | --- | --- | | **5. BROMINATED RESINS** | | | | | **Application** | **EEW (g/eg)** | **Viscosity25°C (mPa∙s)** | **Bromine content %** | | Prepregs and Laminates | 450 - 500^2 | 2,200 – 3,000 | 19 - 23 | | Electrical | 250 - 280 | 700 – 1,100 @ 70°C | 21 - 26 | | Vinyl Ester and Electronic components. | 319 - 410 | – | 44 - 48 |  |  |  |  |  | | --- | --- | --- | --- | | **SOLVENT CUT RESINS** | | | | | **Applications** | **EEW (g/eg)** | **Viscosity 25°C (mPa∙s)** | **Non-volatile content %** | | Films Coatings | – | 50 - 350 | 50 - 55 | | Films Coatings | – | 50 - 350 | 50 - 55 | | Coatings | 294 - 323 | 600 - 850 | 79 - 81 (150°C/1h) | | Paints and Coatings (Xylene is used as a solvent) | 606 - 702 | 9,000 - 13,000 | 74 - 76 (105°C/2h) | | 606 - 741 | 14,000 - 20,000 | 74 - 76 (105°C/2h) | | Primers and Enamels | 12500 | 2,000 - 5,000 | 49 - 51 (160°C/2h) | | Paints and Coatings (Xylene is used as a solvent) | 300 - 336 | 3,500 - 7,000 | 79 - 81 |   *\* Epoxide Equivalent Weight (EEW)*  *EEW is the weight of the resin in grams that contains one gram equivalent of epoxy. An interchangeable term, Epoxy Value (EV) may also be used. EV represents the fractional number of epoxy groups contained by 1,000 grams of resin. EEW can be obtained if 1,000 is divided by EV.*  *\*Softening point*  *The softening point is the temperature at which a material softens beyond some arbitrary softness.*  *\*Viscosity (Brookfield)*  *Brookfield viscosity usually refers to a viscosity measurement performed with a Brookfield Viscometer, sometimes referred to as a Brookfield viscosimeter. There are several models of viscometer available from Brookfield, but the majority operate in the same manner: the viscometer motor rotates the spindle at a defined speed (measured in rpm) or shear rate and the viscometer measure the resistance to rotation and reports a viscosity value.*  *\** *HyCl*  *The hydrolyzable chloride content of epoxy resins is a vital characteristic in deciding their reactivity and the expected properties of coatings made using such resins. HyCl is hydrolyze chloride content*  **EEW Epoxy Equivalent Weight:** The epoxy content of liquid resins is frequently expressed as *epoxide equivalent weight (EEW)* or *weight per epoxide (WPE)*, which is defined as the weight in grams that contains 1 g equivalent of epoxide. A common chemical method of analysis for epoxy content of liquid resins and solid resins is titration of the epoxide ring by hydrogen bromide in acetic acid   |  |  |  |  |  | | --- | --- | --- | --- | --- | | Resin Type | n Value | EEW | Molecular weight | Viscosity at 25°C Mpa.s (= cP ) | | Low viscosity LER | <0.1 | 172–176 | ∼350 | 4,000–6,000 | | Medium viscosity LER | ∼0.1 | 176–185 | ∼370 | 7,000–10,000 | | Standard grade LER | ∼0.2 | 185-195 | ∼380 | 11,000–16,000 | | Type 1 SER | ∼2 | 450–560 | ∼1,500 | 160 – 250c | | Type 4 SER | ∼5 | 800–950 | ∼3,000 | 450 – 600c | | Type 7 SER | ∼15 | 1,600–2,500 | ∼10,000 | 1,500–3,000c | | Type 9 SER | ∼25 | 2,500–4,000 | ∼15,000 | 3,500–10,000c | | Type 10 SER | ∼35 | 4,000–6,000 | ∼20,000 | 10,000–40,000c | | Phenoxy resin | ∼100 | >20,000 | ∼40,000 |  |   *an value is the number-average degree of polymerization which approximates the repeating units and the hydroxyl functionality of the resin.*  *bMolecular weight is weight average (Mw) measured by gel-permeation chromatography (GPC) using*  *polystyrene standard.*  *cViscosity of SERs is determined by kinematic method using 40% solids in diethylene glycol monobutyl ether solution.*  **Hydrolyzable chloride** (HyCl) content of liquid and solid epoxy resins is determined by dehydrochlorination with potassium hydroxide solution under reflux conditions and potentiometric titration of the chloride liberated by silver nitrate. Hydrolyzable HyCl content, which reflects the degree of completion of the dehydrochlorination step in the epoxy resin manufacturing process, is routinely determined by a method using methanol and toluene as solvents. This is the method most commonly used to characterize LER and SER.  **Softening Point**  Since epoxies are thermosetting resins, they have a softening point called the glass transition temperature (Tg). Heating above the Tg will soften the material slightly and allow the epoxy to be pried away more easily.  Traditionally, measure the softening point of SERs, which is important in applications such as powder coatings. The Durran’s method involves heating a resin sample topped with a certain weight of mercury in a test tube until the resin reaches its softening point and flows, allowing the mercury to drop to the bottom of the test tube. The method is accurate but involves handling of highly hazardous mercury at elevated temperatures.  **4.1.2 Plant Process-description (Evaluation of major process commercially available for licensing):**  **Production process of Liquid Bisphenol-A Epoxy Resin**: The one-step process proceeds via polycondensation of reacting [epichlorohydrin](https://en.wikipedia.org/wiki/Epichlorohydrin) (ECH) with [bisphenol A](https://en.wikipedia.org/wiki/Bisphenol_A) (BPA),  resulted with different chemical liquid substance known as [bisphenol A diglycidyle ether](https://en.wikipedia.org/wiki/Bisphenol_A_diglycidyl_ether) (commonly known as BADGE or DGEBA). Bisphenol A-based resins are most widely commercialised resins (75-80%).  **Badge Process:**  Bisphenol A or 2,2'bis(p-hydroxyphenyl) propane is produced from acetone and phenol with an acid catalyst such as 75% sulphuric acid or dry hydrogen chloride. The reaction conditions will depend on the design of the production unit. The purity of the product is high, >95% p,p'-isomer (para-para); the other isomers formed are o,p'(ortho-para) and o,o (ortho- ortho)'. For resin manufacture the p,p' isomer (para-para) content should be at least 98%. The light-yellow colour of some Epoxy Resins may be due to trace impurities in the bisphenol A, such as iron, arsenic and highly coloured organic compounds. When a large excess of epichlorohydrin is reacted with bisphenol A with a stoichiometric amount of sodium hydroxide at about 65-70°C the resin produced contains about 50% diglycidyl ether of bisphenol A, DGEBA(BADGE) and the reaction may be represented formally as below:  Diagram  Description automatically generated  **Two-step process** The two-step process is the reaction of bisphenol A and epichlorohydrin under the action of a catalyst (such as a quaternary ammonium salt), the first step by an addition reaction to form a diphenol-propane chlorohydrin ether intermediate, and the second step is carried out in the presence of NaOH. A closed loop reaction produces an epoxy resin.  The advantages of the two-step method are: short reaction time; stable operation, small temperature fluctuation, easy to control; short alkali addition time, can avoid large-scale hydrolysis of epichlorohydrin; product quality is good and stable, and the yield is high. The domestic E-51 and E-54 epoxy resins are synthesized by a two-step process.  One key disadvantage of catalysts based on inorganic bases and salts is the increased ionic impurities added to the resin, which is not desirable in certain applications.  Diagram  Description automatically generated  **Solid Epoxy Resin**  **Production process of solid bisphenol A Epoxy Resin**  **One Step Process:**  **Higher molecular weight bisphenol A resins:** Bisphenol A/epichlorohydrin ratio is important for control of the average molecular weight of the resins produced. Larger the value of n the smaller the epichlorohydrin / bisphenol A ratio required. The purity of the reactants is important and monofunctional reactants are chain terminators and hence their concentration has to be controlled. However, it is also necessary to optimize the reaction conditions to achieve the degree of polymerization required. For the production of oligomers with 1 ≤n ≤ 4, the so-called 'Taffy' process could be used but for much higher molecular weight polymers 3 ≤ n ≤ 20 the fusion or chain extension process (also called advancement process) is used.  **Taffy Process**:  In taffy process,1-3 bisphenol A is reacted at 85–95°C in a controlled excess of epichlorohydrin (ECH) (to give polymer molecules along with glycidyl ether groups, at both ends) in the presence of Caustic and an inert solvent. This reaction is used to produce lower molecular weight (MW) epoxides. The low molecular weight epoxides are polydisperse mix of epoxides with “n” values lies between 0 and 1 and have an average molecular weight of 340-600.  **Detail Description of Taffy Process:** A mixture of bisphenol A and 10% aqueous sodium hydroxide solution is introduced in a reactor equipped with high-speed powerful agitator. The mixture is heated up to 450 C and Epichlorohydrin is added rapidly with agitation, giving off heat. The temperature is allowed to rise to 950 C, where it is maintained for approx. 80-85 min for the completion of reaction. Agitation is stopped, and mixture gets separate in two layers. The heavier aqueous layer is drawn off from bottom and the molten, taffy-like product is washed with hot water until the wash water gets neutral PH. The taffy-like product is dried at 1350 C, gives solid resin with softening point of 70-750 C and an EEW value of 500. Alternatively, epichlorohydrin are removed by vacuum distillation at temperatures up to 1800 C approx. The crude resin is then dissolved in a secondary solvent (Toluene) to facilitate water washing and salt removal. This secondary solvent is then recovered via vacuum distillation in order to obtain the resin product.  The charge is such that the epichlorohydrinl bisphenol A ratio along with stoichiometric amount of caustic soda inaqueous solution is added with stirring and the reaction temperature will yield a resin with the required value of the degree of polymerization 1≤ n ≤ 4.  **Reaction Taffy Process** Diagram  Description automatically generated:  Graphical user interface, text, application  Description automatically generated  One of the major drawbacks of this process is that insoluble polymers are formed, which create handling and disposal problem.  **Two Step Process:**  **Advancement Process**: For manufacturing of higher molecular weight Epoxy Resins, liquid Epoxy Resin (LER) is reacted with calculated amount of bisphenol A, further catalyst\* solution is added to boost the reaction and the temperature is maintained at approx. 160 °C. This process is known as "Advancement process". The high molecular weight epoxides are manufactured by “Advancement” process using Benzyl trimethyl ammonium hydroxide as a catalyst.  **Detail Description of Advancement Process:** Advancement process is widely practiced by coating producers to facilitate the handling of the high molecular weight, highly viscous Epoxy Resins used in many paint & coating formulations. The degree of polymerization is calculated by ratio of LER (formed from BADGE Process) to bisphenol A; an excess of the former provides epoxy terminal groups. The actual molecular weight obtained depends on purity of the starting materials, solvents & catalyst used. Reactive mono-functional groups are used as chain terminators to control MW and viscosity build. The below formula is used to calculate the amount of bisphenol A that is to be reacted with Epoxy Resin (LER) to obtain an advanced Epoxy Resin of predetermined EEW value. (EEW is Epoxy Equivalent Weight) is a measure of compounds which epoxy containing groups. The epoxy equivalent weight describes the mass in grams which one mole of epoxy groups contains.). The following formula can be used to calculate the relative amount of bisphenolA that must be reacted with epoxy resin to give an advanced epoxy resin of  predetermined EEW  BisA = (EEWi-1 – EEWf-1)/ (EEWi-1 + PEW-1)  Source - <https://pdfhall.com/epoxy-resins-in-encyclopedia-of-polymer-science-and-fr_5b1c54ae7f8b9a68778b4570.html>  where Bis A is the mass fraction of bisphenol A in the mixture prior to advancement. EEWi is the EEW of the Epoxy Resin that is to be advanced (i stands for initial), EEWf is the EEW (f stand for Final) of the advanced Epoxy Resin, and PEW is the phenol equivalent weight of the bisphenol, its value is 115.1 g per equivalent for bisphenol A. In an advancement process, bisphenol A and a liquid BADGE resin (170–180 EEW) are heated to 155–199 0C in the presence of a catalyst and reacted (i.e., advanced) to form a high MW resin. This oligomerisation process is exothermic and proceeds rapidly to completion. The exotherm temperatures depends on the reaction mass and targeted EEW. In the cases of higher MW resins, exotherm temperature can reach >190-205 0C. Reaction catalysts facilitate the rapid preparation of medium to high MW linear resins, also control side reactions inherent with Epoxy Resin preparations, e g, chain branching, by addition of the alcohol group generated in the chain-lengthening process to the epoxy group. Nuclear Magnetic Resonance (NMR) spectroscopy Methodcan be used to determine the extent of branching.  **Reaction (Advancement Process):** here n varies between 2 and 35.  Diagram  Description automatically generated  **Bisphenol F based Epoxy Resin**: Any multifunctional, f ≥ 2, phenolic compound is a potential starting material for the manufacture of Epoxy Resins, these are 'formulated' to meet specific requirements. Also, some monofunctional phenols have been reacted with epichlorohydrin to produce monofunctional reactants for use as modifying diluent agents. The dihydric phenol which is produced by reaction of phenol with formaldehyde is called bisphenol F.  Graphical user interface, diagram, text  Description automatically generated  Resins can be manufactured from bisphenol F by similar methods to those used for bisphenol A and epichlorohydrin with a catalyst such as NaOH. These resins have lower viscosities than the equivalent DGEBA.  **Bisphenol-F and Bisphenol-A/F Blends:** One can go with pure Bisphenol -F, Bisphenol A or Bisphenol A/F based Epoxy Resin. Bisphenol-F based resins are best known for low viscosity, chemical resistance and low crystallisation tendency in cold conditions. Bisphenol-F based pure and Bisphenol-A/F blend resins are recommended in varying viscosities for several applications like coatings, composites, floor coatings and construction applications.  **Epoxy Phenol Novolac (EPN) resins:** Graphical user interface, text, application, Word  Description automatically generated  These are generally referred to as multifunctional epoxy resins as they consist of more than two epoxy groups per molecule. EPN resins are produced by reaction of phenolic novolac with epichlorohydrin. After curing they result in a mesh like structure possessing high cross-linking density.  The mechanism of formation involves reaction of phenolic novolac with epichlorohydrin in alkaline medium (sodium hydroxide). Initially phenol hydroxyl group is deprotonated by hydroxide ions  (OH-) of NAOH, thereby producing nucleophilic phenyl hydroxide (R-O-).  Further, the chloride of epichlorohydrin is substituted with the hydroxide of phenol hydroxyl group resulting in linking of phenolic unit with the epoxide.  Text  Description automatically generated  **Cresol Novolac Resin:**  Epoxy novolac are multifunctional epoxies based on phenolic formaldehyde novolac. Epoxy Cresol Novolac Resin is formed by reacting Cresol with Formaldehyde to make Cresol Novolac, which is further reacted with Epichlorohydrin to make ECN (Epoxy Cresol Novolac Resin), here R is H in case of EPN (Epoxy Phenol Novolac Resin) & R is CH3 in case of ECN (Epoxy Cresol Novolac Resin)  An increase in the molecular weight of the Novolac increases the functionality of the resin. This is accomplished by changing the cresol to formaldehyde ratio.  Text  Description automatically generated + HCl  **Phenol Formaldehyde Epoxy Resin (Basic Chemistry)**   1. **Methylol monomer formation:**   Diagram  Description automatically generated   1. **Linear Polymer**   Text  Description automatically generated with low confidence   1. **Cross-linked tridimensional polymer**   Diagram  Description automatically generated  Phenolics are low-cost polymers with excellent physical & electrical properties and fast curing characteristics. Their poor colour characteristic can be partially overcome by adding pigment, dyes & fillers.  **Cycloaliphatic Epoxy Resin:**  Cycloaliphatic epoxy resins have been found to be useful in a variety of industrial applications, such as coatings, reactive diluents, vacuum pressure impregnation of coils, molded compounds, encapsulation of electronic circuit elements, and printed circuit board because of their low viscosity prior to curing, and good heat and chemical resistance, superior mechanical and electrical properties after curing as well as excellent processability. They are highly resistant to ultraviolet light and more durable for outdoor applications such as electrical insulators.  Cycloaliphatic epoxy resin containing hydroxyl group (DMTMP) is prepared by the transesterification between methyl-3, 4-epoxycyclohexane carboxylate (MEC) and trimethylolpropane (TMP) using anhydrous sodium acetate as catalyst as per the below given Reaction.  Diagram, engineering drawing  Description automatically generated  Properties of Cycloaliphatic epoxy resin:   * Higher resistance to UV and moisture * Excellent electrical properties * Superior deflection temperature * Low viscosity   **Glycidyl Amine Based Multifunctional Resins:** These are high-performance multifunctional epoxy resins that are produced by the reaction of aromatic amines with epichlorohydrin.  Diagram, schematic  Description automatically generated  They are commonly of two types:   * triglycidyl para-aminophenol (TGPAP) * triglycidyl of 4-(4-aminophenoxy) phenol (TGAPP)   They are increasingly used in the manufacturing of high-performance composites, adhesives and coatings in aircraft and aerospace industry.  **Brominated Epoxy Resin**  **Brominated Epoxy Resin:**  Brominated epoxy resin was first developed by Tokyo shipo company in 1982.Because it has many excellent properties: excellent thermal stability and photostability, excellent melt flow speed, high flame retardant efficiency. In the electronics industry, brominated epoxy resin is the most used filling material. Especially, the high molecular weight brominated epoxy resin can be used as flame retardant and has very good effect. For the flame retardant material, it has good physical and mechanical properties  A common method of imparting this ignition resistance is the incorporation of tetrabromobisphenol A (TBBA), 2,2-bis(3,5-dibromophenyl) propane, or the diglycidyl ether of TBBA, 2,2-bis[3,5-dibromo-4-(2,3-epoxypropoxy) phenyl]propane, into the resin formulation.  The diglycidyl ether of TBBA is produced via conventional liquid epoxy resin processes. Higher MW resins can be produced by advancing LERs or diglycidyl ether of TBBA with TBBA  Graphical user interface, text  Description automatically generated  **4.1.3. Process Flow Diagram & Technology Licensor**  **Technology licensor**  The most accepted technology is currently Ciba-Geigy AG in India. Grasim licensed the technology from Tohto Kasei Co. Ltd. in 2014-2015 but Hindustan Speciality employed the technology of JEIL Chemical Ltd. (Korean Technology) & Wuxi Bluestar Epoxy Co., Ltd... The manufacturing companies based in APAC region are based on Tohto Kasei Co. Ltd. whereas Ciba-Geigy AG’s technology for epoxy resin production is globally proclaimed.  According to the key opinion leaders, the technology employed by Ciba-Geigy AG has low solvent requirement than the Tohto Kasei Co. Ltd. technology. Other than this, few variations in process parameters are the only observable differences.  **Ciba Geigy (Huntsman Corporation)**, now open for licensing.  **Tohto Kasei (Japan) (Now known as Nippon Steel & Simikin Chemical Co Ltd.),** leader in resin producer, have its own epoxy licensing technology arrangements with numerous resin manufacturers in Asia. In India Grasim, Vilayat use this technology.  **Olin Systems:** Olin Corporation is the leading manufacturer & distributor of Epoxy Resin, which offers highly advanced Epoxy & leading customer support worldwide. The company doesn’t share their inhouse technology.  **Kukdo’s System** (Korean Technology)**:** Kukdo’s system is leading the global market through customized products and R&D. This companies all branches use their own technology.   * The major licensors and manufacturers of Epoxy Resins. Only two of the following licensors i.e., Ciba-Geigy AG and Tohto Kasei Co., Ltd are open to share the technologies with new entrants. * Both the technologies give favorable outcomes qualitatively & quantitatively. Also, both technologies are being used in India by leading epoxy resin manufacturers like Grasim Industries and Atul Ltd. * Kukdo Chemical Co., Ltd and Olin Corporation do not share the technological process and process parameters and employ the manufacturing process in its own specific plants. * The quality of product provided by Kukdo Chemical Co., Ltd is very superior in comparison to other technology licensors and it provides crystal clear liquid epoxy resin to the clients. * Ciba- Geigy AG has low solvent requirements than the Tohto Kasai Co., Ltd.  |  |  | | --- | --- | | **Technology** | **Open for Third Party Licensing** | | **Ciba-Geigy AG** | Badge Tick1 with solid fill | | **Tohto Kasei Co. Ltd.** | Badge Tick1 with solid fill | | **Kukdo Chemical Co., Ltd** | Badge Cross with solid fill | | **Olin Corporation** | Badge Cross with solid fill | | **Dow Chemicals** | Badge Cross with solid fill | | **JEIL** | Badge Tick1 with solid fill | | **Wuxi Bluestar** | Badge Tick1 with solid fill |   **Wu Xi Blue Star Co. Ltd.’s Method of catalytic refining process:**  A process for the production of liquid epoxy resins, the process consisting essentially of: contacting a polyhydric phenol (Bisphenol A) and an epihalohydrin (Epichlorohydrin) in the presence of an ionic catalyst comprising of a quaternary ammonium halide (Benzene triethyl Ammonium Chloride) and a basic ionic exchange resin to form a halohydrin intermediate reaction product; concurrently: reacting a portion of the halohydrin intermediate reaction product with an alkali hydroxide (Sodium Hydroxide) to form a solid salt suspended in a liquid mixture comprising a dehydrohalogenated product and unreacted halohydrin intermediate, wherein the alkali hydroxide is used at less than a stoichiometric amount; and removing water and epihalohydrin as a vapor from the reacting mixture; separating the solid salt from the liquid mixture; reacting at least a portion of the unreacted halohydrin intermediate with an alkali hydroxide in the presence of water to form an organic mixture comprising an epoxy resin and unreacted epihalohydrin and an aqueous solution comprising a salt; separating the aqueous mixture from the organic mixture using an organic solvent (toluene); and separating the unreacted epichlorohydrin from the liquid epoxy resin.  The method involves:   * Feeding Bisphenol-A and Epichlorohydrin in the mass ratio of 1:2.5. * Adjusting the temperature to 55°C to 65°C and pressure to 14 kPa to 19 KPa and adding resin (anionic resin, usually one involving quaternary ammonium ion) of 150 kg to 200kg per ton theoretical yield of epoxy resin as catalyst for coupling process or etherification process. * Benzene Triethyl Ammonium Chloride in stoichiometric amounts about 4.5% of the weight of final resin to be produced is added to the reactor. * The intermediate is formed during the coupling process after 3 to 5 hours of reaction. The reactor contents are then treated with an aqueous solution of 12% to 15% NaOH in less than stoichiometric proportion (75%-90%) to partially dehydrohalogenate the intermediate. Lesser amounts of alkali prevent unwanted polymerization. * Water may be removed along with excess epichlorohydrin by maintaining the agitated reactor at low pressures like those maintained in the etherification process as presence of water may cause unnecessary by product formation. * The reactor contents are then transferred into the next reactor where they are treated again with aqueous sodium hydroxide to complete the dehydrogenation process. The salts formed during the reaction are suspended over the aqueous layer. * Toluene is then added to remove traces of intermediate as well as epichlorohydrin from the organic layer. The excess solvent can be removed by sloughing the solvent off of the resin.   **4.1.5. Technology Licensor**  **Technology 1: Ciba Geigy (Huntsman Corporation)**  **Process Flow Diagram: CIBA**  The commercial interest in the epoxy resin was first made apparent by the publication of German patent by I.G. Farben in 1939. In 1943 P. This important process was subsequently explored by the **CIBA Company**.  **Reactor,**  **Temp: 65o C**  **Press:0.22kg/cm2**  **Evaporator (110-150oC)**  **Gravity Separation (with Stirring & settling) stirrer at 60 RPM**  **Evaporator**  **Salt Disposal**  **Solid Disposal**  **Filter (Sparkler/ Cartridge Filter**  **BPA, ECH, NaOH 48%**  **Dehydrated H2O**  **DM Water**  *Source: PFD has been validated by Indian manufacturer and only major processes have been considered.*  *2015 –FY2030*  **Condensor**  **Wastewater Treatment**  **BPA Hopper**  **ECh Storage**  **NaOH Storage**  **Toluene**  PE 25  PE 25  PE 25  **Recovered ECH**  **Recovered Toluene**  **Liquid Epoxy Resin**  **Liquid Epoxy Resin + Salt**  PE 50  PE 50  PE 50  Exothermic Reaction (Esection  Dehydration section  Refining Section  Dissolvent section  Filtration section  ECH recovery Section  Resin & salt          Filter cake            **CIBA Process Flow Diagram Description**   1. **Reaction Section**   **Pre-Reactor:** Reaction starts with adding Excessive quantity of Epichlorohydrin (Fresh & recovered) with prescribed quantity of Bisphenol-A by using NaOH (48%) as Catalyst to yield chlorohydrin. As result of this reaction, Bisphenol-A chlorohydrin intermediate is formed. Temperature to be maintained between 65 – 70 0C and at atmospheric pressure.  NaCL  **Reactor**  In the same Reactor, Bisphenol-A chlorohydrin intermediate formed from the pre-reaction section is further charged with stoichiometric amount of NaOH (48%) to form liquid epoxy resin (i.e., by dehydrohalogenation of the chlorohydrin intermediate). Here also temperature to be maintained between 65 – 70 0C  Text  Description automatically generated   1. **Dehydration:**   **Condenser:** Water Evaporated during reaction contains ECH and water. Same is passed through condenser, it forms two layers of ECH & water, ECH is separated out & reused.   1. **ECH Recovery**   **Evaporator:** Here ECH is separated from Resin & Salt solution, temperature is increased further to 110-150oC under vacuum, so that whole of the ECH is removed via Condenser. In order to protect the epoxy resin from thermal effect, vaporization of ECH is done under vacuum conditions, at the lowest possible temperature and in the shortest possible time. Approximately 95% ECH can be recovered which will further reduce the cost of production under the standard/developed procedure.  During this process, solid salt is produced as a by-product which may get disposed off via landfilling process.   1. **Refining Section**   **Gravity Separator:** In this section, washing & separation takes place at atmospheric pressure  and at temperature 65-70oC Toluene is added to dissolve resin and the salt solution is separated from the resin manually by adding demineralised water. Three layers are formed; the resin and toluene stay in the upper layer (called organic layer) & NaCl-water in the lower layer & centre one is the unreacted BPA, it is called emulsion layer. Again, Demineralised (DM) water is added to wash the resin and remove the traces of salt from it.  The recovered unreacted BPA with impurities can be further purified and reused in the next batch once production process gets developed.   1. **Dissolvent:**   **Evaporator:** In this section, dissolvent is done to remove the solvent, toluene from the resin by passing through evaporator (falling film thin evaporator & Rotary film thin Evaporator can be used for better efficient solvent recovery) under vacuum and at around 1100 C. Around 95% toluene can be recovered which will further be used in the next batch once production process gets developed.   1. **Product Finishing Section**   **Filtration:** Epoxy resin is finally filtered to remove the traces of salt / impurities via sparkler filter or cartridge filter. Final product Liquid Epoxy Resin is produced and send to the packer section for drum packaging.  **Solid Epoxy Resin:**  **Process Flow Diagram:**  Reaction Section  **Jacketed Reactor**  **180°C -190°C**  **Reactor2**  **Reaction Section 70°C-80°C, 4 hrs**  **Flaker, 15°C chilled water**  **Crusher**  **Packer**  **Dust Collector**  **Xylene**  **Hot Oil, 220°C**  **Oil, 50°C**  **5-7 Bar**  **BPA Storage**  Solidification Section  **Solid Handling Section**  **Methanol Storage**  **Solid Epoxy Resin**  **Catalyst Storage**  **NaOH (48%) Storage**  **Liquid Epoxy Resin Storage**  **Refined**       1. **Reaction Section**   **Reactor 1:** In this section, Liquid Epoxy Resin, Bisphenol A & Catalyst is added into the jacketed reactor (BPA & Catalyst is added in 2 Stages i.e. With progress of the reaction, 2nd lot of BPA & catalyst is added to avoid side reactions and unwanted products, also reactants are added in lots to improve yield.) Temperature to be maintained around 180-1900 C.  For the suppression of catalytic reaction, a small quantity of Methanol is also added in reactor  **Reactor 2:** Here reaction mixture from the pre reaction section is added with a solvent in control range of pressure (5-7 Bar) & temp (70-750 C) approximately with continuous stirring.  Note: The reaction can be carried out with or without solvents  Diagram  Description automatically generated  Graphical user interface, text, application  Description automatically generated  **2. Solidification Section**  **Flaker:** Here Epoxy Resin (i.e., formed in reaction section) is passed through the flaker (with required utilities (chilled water & steam)) at temperature around 150 C.  **3. Solid Handling Section**  **Crusher:** After flaker, product is further passed through the crusher to collect the final mesh size solid product.  **Dust collector:** It is installed with crusher & packer to collect the product dust. Which is refined and send to the for packer  **Packer:** Product is finally sent to the packer for the packaging in respective size Bag (20 Kg, 25 Kg, 50 Kg, 100 Kg etc.) i.e., as per the requirement.      **Formulated Resins:**  **Mixing:** Different grade Liquid Epoxy Resin is mixed with various types of additives or Reactive Diluents to meet customer specific applications or other special Resin.    Mixing  Reactive Diluents / Additives: Solid Waste  LER:  Formulated Product  **Example**: Amine cured epoxy coating is an epoxy coating where an anime-based hardener was used in the curation process.   |  | | --- | | **Hardeners:** Hardeners are required to make an epoxy resin useful for its intended purpose. The correct type of hardener must be selected to ensure the epoxy mixture will meet the requirements of the application. Mixing epoxy resin and hardener begins a chemical reaction that transforms the combined liquid ingredients to a solid. The time it takes for this chemical transformation from liquid to solid is called cure time. As it cures, the epoxy passes from the liquid state, through a gel state, before it reaches a solid state. Common examples of epoxy hardeners are anhydride-based, amine-based, polyamide, aliphatic and cycloaliphatic. |  Diluents or Diluting Agent: Diluents are low-molecular-weight, low-viscosity compounds that are used to reduce the viscosity or enhance the solubility of a resin and/or hardener, Diluents may be either reactive or non-reactive. However, the reactive types are more desirable since they combine chemically with the main resin during cure and are not free to outgas or leach. Examples of diluents for epoxy resins include: phenylglycidyl ether, butylglycidyl ether, allylglycidyl ether, [butanediol](https://www.sciencedirect.com/topics/engineering/butanediol) diglycidyl ether and glycerol-based epoxy resin.Additives: Epoxy resin additives are often used for multiple purposes. They can enhance the appearance of given resin and can even strengthen the resin. resin additives include metallic powders, liquid epoxy dye, spray paints, and glitter adhesives.Fillers: Major fillers include Graphene, Poly(2-butylaniline) functionalized Graphene & Waste Tire Rubber Particles. Fillers are used to affect the tensile strength, compressive strength impact resistance, viscosity, and shrinkage.  |  |  | | --- | --- | | **Fillers** | **Dispersion technique** | | Graphene | Epoxy Resin + graphene is dispersed by mechanical blending for 10 min + ultrasonic dispersion for 30 min. | | Poly(2-butylaniline) functionalized Graphene | Poly(2-butylaniline) + Tetrahydrofuran (THF) sonicated for 30 min. Addition of epoxy with 10 min stirring. Removal of THF by rotary evaporation; addition of curing agent followed by blending at 4000 rpm for 5 min; room temperature degassing in vacuum oven. | | Waste Tire Rubber Particles | Epoxy Resin + (1–20 wt%) Micronized Tire Rubber Manual Stirring for 10 min; Addition of curing agent followed by manual stirring for 5 min. |   **Technology- 2: Tohto Kesai**  **Process Flow Diagram: Tohto Kesai**  **Tohto Kasei (Japan) (Now known as Nippon Steel & Simikin Chemical Co Ltd.),** leader in resin producer, have its own epoxy licensing technology arrangements with numerous resin manufacturers in Asia.  Evaporator (Temp.: 110-120o C)  Liquid Epoxy Resin  Refining Section  Pre-Reactor  Reactor  Evaporator (Under Vacuum). Temp. 110-150oC  Fa  Gravity Separator (Refining) at 65-70o C and Atm. pressure  Waste Polymer  Wastewater Treatment  Hopper For BPA Addition  NaOH Storage tank  ECH Tank  Toluene  PE 50  PE 50  PE 50  PE 25  Condensor  **DM Water**  Catalyst  Recovered ECH  Dehydrated Water  Recovered ECH  Dehydration section  Reaction Section  ECH recovery Section  Filter 65-70o C  Solid Waste  PE 25  PE 25  Resin & Salt  Filter Cake          Steam      Toluene(S1)    Filtration section  Recovered S1  Dissolvent Section    **Tohto Kesai Process Details:**   1. **Reaction Section:**   **Pre-reactor**  Reaction starts with adding excessive quantity of Epichlorohydrin (fresh & recovered) with prescribed quantity of Bisphenol-A by using NaOH as catalyst at 65o C. In this section one more catalyst\* is also added along with NaOH. As result of this reaction, Bisphenol-A chlorohydrin intermediate is formed.  \*Catalyst can be lithium salts, quaternary ammonium salts or any other catalyst.  Diagram  Description automatically generated  **Reactor**  Bisphenol-A chlorohydrin intermediate formed from the pre-reaction section is further changed to liquid epoxy resin by reaction with NaOH. Optimum process conditions are maintained in the reactor which minimize hydrolysis of ECH and formation of by-product waste polymer and enables the production of high-quality epoxy resin of the required viscosity at high yields.  Note\*: it is advisable to add optimum ratio of BPA to ECH, which will form less side product / oligomers / Impurities etc. In India, Grasim Industries Ltd having Tohto Kesai Process, uses 1:6 BPA to ECH ratio (2 moles of fresh ECH & 4 Mole of recovered ECH).   1. **Dehydration Section**   **Condenser:** Water evaporated during reaction contains ECH and water. Same is passed through condenser, it forms two layers of ECH & water. ECH is separated out & reused and water sent to the ETP section.   1. **ECH Detachment Section**   **Evaporator:** After the reaction process is done, excessive quantities of unreacted ECH are separated from the product by increasing the temperature to 110-1500 C through a vaporizer (Evaporator), same is returned via condenser for reuse. The crude epoxy is then sent to the next refining section. In order to protect the epoxy resin from thermal effect, vaporization of ECH is done under vacuum conditions, at the lowest possible temperature and in the shortest possible time. Around 95% toluene can be recovered which will further be used in the next batch once production process gets developed.   1. **Refining**   **Gravity Separator:** In this section washing & separation takes place at atmospheric pressure. Toluene and water are added to dissolve resin in it and the salt solution is separated from the resin manually by adding demineralised water. Three layers are formed; the resin and toluene stay in the upper layer (called organic layer) & NaCl-water in the lower layer & centre one is the unreacted BPA, it is called emulsion layer. Again, Demineralised (DM) water is added to wash the resin and remove the traces of salt from it.  The recovered unreacted BPA with impurities can be further purified and reused in the next batch once production process gets developed.   1. **Product Finishing Section**   **Filtration:** Finally, Epoxy resin is filtered to remove suspended particle via filter and is sent to the next section for solvent recovery. Filter Cake removed from the filter is sent to the waste management section.  Filter used can be sparkler filter or cartridge filter. Final product Liquid Epoxy Resin is produced and send to the packer section for drum packaging.   1. **Dissolvent**   **Solvent Recovery:** In this section solvent is removed from the resin by passing through evaporator (falling film thin evaporator & rotary film thin evaporator) under vacuum and product then packed through packer).  **Solid Epoxy Resin:**  **Process Flow Diagram:**  **Jacketed Reactor.**  **180°C -190°C**  **Reactor2**  **Reaction Section 70°C-80°C, 4 hrs**  **Flaker, 15°C chilled water**  **Crusher**  **Packer**  **Dust Collector**  **Xylene**  **Hot Oil, 220°C**  **Oil, 50°C**  **5-7 Bar**  **Solid Epoxy Resin**  **Catalyst Storage**  **NaOH (48%) Storage**  **Liquid Epoxy Resin Storage**  **BPA Storage**  **Methanol Storage**  Reaction Section  Solidification Section  **Solid handling section**  **Refined**   1. **Reaction Section**   **Reactor 1:** In this section, Liquid Epoxy Resin, Bisphenol A & Catalyst is added in to the jacketed reactor (BPA & Catalyst is added in 2 Stages i.e. With progress of the reaction, 2nd lot of BPA & catalyst is added to avoid side reactions and unwanted products, also reactants are added in lots to improve yield.)  \*For the suppression of catalytic reaction, small quantity of Methanol is also added in reactor.  **Reactor 2:** Here reaction mixture from the pre reaction section is added with a solvent in control range of pressure (5-7 Bar) & temp (70-750 C) approximately with continuous stirring.  Note\*: The reaction can be carried out with or without solvents   1. **Solidification Section:**   **Flaker:** Here Epoxy Resin (i.e., formed in reaction section) is passed through the flaker (with required utilities (chilled water & steam)).   1. **Solid Handling Section**   **Crusher:** After flaker, product is further pass through the crusher to collect the final mesh size solid product.  **Dust collector:** It is installed with crusher & packer to collect the product dust, which is refined and send to the packer.  **Packer:** Product is finally sent to the packer for the packaging in respective size Bag (20 Kg, 25 Kg, 50 Kg, 100 Kg etc.) i.e., as per the requirement.  **Observations:**   1. In Ciba Technology, only one reactor is used for the catalytic reaction as well as dehydrohalogenation of the chlorohydrin intermediate using NaOH as Catalytic and dehydrohalogenation agent. While in Tohto Kesai Technology, reaction take place in two reactors (Pre-Reactor & Reactor), using NaOH and ammonium salt as catalyst & NaOH as Dechlorinating agent. 2. Major difference between two technology is process parameter (Pressure, Temperature, Retention time etc.), Solvent, Catalyst, Additives, Hardeners, fillers used etc. 3. In Tohto Kesai, filtration is done first, then after distillation is done to recover solvent used. While in Technology 2 (CIBA), First Distillation (under Vacuum) is done to recover solvent and then filtration is done. 4. Catalyst used in Tohto Kesai technology contributes to impurities in the product that need to be removed.   According to the key opinion leaders, the technology employed by Ciba-Geigy AG process is less complex than the Tohto Kasei Co. Ltd. technology. Other than this, few variations in process parameters (like Reaction time, flow rate of Solvent, Catalyst used, BPA to ECH ratio) are the only observable differences.  **CIBA Geigy (Huntsman Corporation) is also characterized by the following strengths:**   * Well established and mature Technology. * High-quality and low-cost production facilities * Well-invested plants across the Globe (e.g. Nanya Plastic (China), Huntsman, Atul ltd (India), etc.) * Economies of scale * Leading market positions for licensing * Operating diversity – Plant process route, Grades Availability | | | |
|  | | | |
| * + 1. **Utilities Overview (Cooling Water System, DM Water Plant, Compressed Air System, power, steam & effluent processing details): For 84 KTPA capacity in two phases)**  |  |  |  |  | | --- | --- | --- | --- | | Companies | Freshwater Requirement (KL/Day) | Recycled Water (KL/Day) |  | | Kukdo Chemical India Pvt. Ltd. (For 115 KTPA) | 923 | 710 | 923 KLD Fresh water from GIDC and 710 KLD recycled water after UF/RO System | | Hindusthan Specialty Chemicals Ltd. (For 100 KTPA) | 988 | 188 |  |  * Freshwater requirement will be around 830 KLD for 84 KTPA. The water reusable from RO plant will be around 610 KLD. The fresh water will be sourced from GIDC water supply. * Installation of water meter can be done which will be recording daily and monthly water consumption. No ground water will be used inn any case. * RO permeate of RO-1 plant shall be used for process and Boiler & Reject streams shall be sent for RO-2. * Reject stream from RO-1 plant, Boiler blow down and cooling tower bleed off will be sent to RO-2. Permeate from RO-2 will be reused for cooling tower. * Total 270 KLD of the wastewater conforming to the GPCB norms will be discharged into the GIDC drain for final disposal by the NCTL into the deep sea. * The unit will provide adequate effluent treatment plant (ETP), RO plants, MEE plant for evaporation of industrial effluent and it will be operated regularly and efficiently so as to achieve the GPCB norms at the final output. * The domestic wastewater generation will be around 7 KLD and it will be treated in ETP with industrial wastewater. * The unit will provide metering facility at the inlet and outlet of the ETPs and maintain the records for the same. The unit should also provide on line pH meter and TOC meter for online monitoring of the treated effluent. * The unit should provide metering facility at the inlet/outlet of the ETP, RO system, Reuse system and MES system and maintain records the same. * A separate electric meter should be placed for the ETP, RO and MEE system.   **Water Conservation Measures**  Adequate measures are taken to reduce freshwater demand by following measures:   * Use of treated water by installing recycling RO which will reduce the freshwater demand. * Explore the possibility condensate recovery from the boiler. * Use of equipment washing water for further cleaning. * Use of high-pressure wash systems, reducing wash waters. * Use of drip irrigation system for gardening to conserve water   **Nitrogen:** The reaction is carried out in reactor under ‘nitrogen blanket'.  **Power Requirement**  Nearest State Electricity Board will supply power through grid in that area. The peak demand of power would be approx. 5500 kVA. DG sets will be installed as a backup arrangement. | | | |
| **4.1.7. Waste generation, Management, and disposal:**  The effluent treatment unit is basically a bio-treatment system which consists of aeration basins, equalization tank and clarifiers for the reduction of the BOD and COD to the acceptable levels before discharging it to common GIDC facility. A recycle system post ETP is considered for meeting the discharge limits and to optimize the freshwater intake.  The process effluents possess high COD/ BOD ratio which is treated by diluting it with cooling tower blow down or DM/CPU regeneration waste for meeting the requirements of bio-treatability.  The Organic stream possess high COD which consist of process wastewater from Epichlorohydrin and Epoxy resin plant. The generated waste will be treated in separate ETP-2 and treated water will be discharged into GIDC drain for sea disposal.   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | **Characteristics of Organic Streams** | | | | | | | Product Name | Flow (m3/day) | pH | COD (mg/l) | BOD (mg/l) | TDS (mg/l) | | Epichlorohydrin | 390 | 4.0-5.0 | 2000 | 600 | 4000 | | Epoxy Resin | 160 | 4.0-5.0 | 8000 | 1500 | 5000 | | Total | 550 | - | - | - | - |   **Design Inlet & Outlet Characteristics of ETP**  The design base inlet and outlet characteristics of the wastewater are presented in below table:   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **S.No.** | **Parameters** | **Unit** | **ETP Inlet** | **ETP Outlet** | | 1 | pH | pH | 5.5 | 6.5-8.0 | | 2 | BOD | mg/l | 1421 | 100 | | 3 | COD | mg/l | 3929 | 250 | | 4 | TSS | mg/l | 101 | 100 | | 5 | TDS | mg/l | 11709 | - |   **Process Description of ETP:**  **Primary Treatment**  Lime dosing of process effluent is done in the reaction tank to increase the pH from 5.5 to 7.8 resulting in the formation of sludge which is removed in the primary clarifier. The sludge formed due to lime is settled at the bottom of the primary clarifier which will be separated and pumped to the sludge pump. The clarified effluent flows to the equalization tank.  The oil-bearing streams from the plant will be pumped to the Oil Trap Tank to separate the free oil following which it is mixed with other streams in the equalization tank.  **Secondary Treatment**  The extended aeration tanks system is used for biological treatment where equalized effluent is transferred in which organic matter is degraded aerobically by the microbes. Extended aeration process is a two-stage process in series. The equalized effluent is introduced into the extended aeration tank-1 where aerobic bacterial culture is maintained in suspension in the form of bio-sludge.  Diffused aeration system is used for providing the desired oxygen to microbes which also serves to maintain the reactor contents in a completely mixed regime & Dissolve Oxygen (DO) level of 2 ppm. At the end of the aeration period the wastewater biological mass mixture (mixed liquor) reaches the effluent end of the chamber and flows in a trough to the Secondary Clarifier-1 for the separation of sludge and liquid. In order to ensure required population of bacteria in extended aeration System, i.e., Mixed Liquor Suspended Solids (MLSS) and also Food to Microorganisms ratio (F/M), part of the settled sludge from the Secondary Clarifier-1 is re-circulated back to Extended Aeration tank-1 while the liquid effluent overflows over weir into Extended Aeration System II. Here, further reduction in BOD takes place as per the mechanism described above.  A part of the separated solids is returned to the Extended Aeration tank-II as return sludge while the liquid overflows over weir into Collection Tank-II where other streams like cooling tower blow-down and DM-CPU regeneration wastes are mixed with it  **Tertiary Treatment**  The Mixed Liquor from Collection Tank II enters the Lamella Clarifier for separation of sludge and liquid via SMFT (Static Mixer and Flocculation Tank). Flocculant and Coagulant is added in SMFT. The main purpose of this tank is to mix the FeCl3 and Polymer with the effluent so that flocs will be formed in Lamella Clarifier which will help in settling suspended solids. The clarified water from the lamella clarifier is taken to the clarified water tank which also acts as a chlorine contact tank. Here hypochlorite dosing is done to further reduce the BOD for preventing biofouling in downstream filters.  The effluent from clarified water tank is pumped into Multi Grade filter (MGF) for the reduction of suspended solids & turbidity before taking the effluent to downstream membrane systems. This unit works on the phenomenon of surface filtration. At a pre-determined pressure drop the backwash of filter is initiated to clean the filter bed.  The effluent from Multi Grade filter is the fed to Activated Carbon filter (ACF) to ensure reduction in excess chlorine, colour, residual recalcitrant & organics. Activated carbon is a porous material, mainly consisting of elementary carbon in a graphite-like structure.  Treated water from ACF will be collected in filtered water tank which will act as collection tank, from where one stream will go to Guard Pond + RO Reject Tank and the other stream will go to for processing in the UF-RO system.  **Ultra-Filtration system:**  Ultra-filtration is a low-pressure membrane process for the removal of colloidal silica and colloidal particles (measured in terms of Silt Density Index). The feed water flows from the inside of the fibres, permeates through the membrane and is removed as the product from the shell side.  In Ultra-filtration, small molecules such as water, monosaccharide, simple alcohol and all ionic species pass through the membrane while larger molecules, colloidal particulate matter and bacteria are retained.  Ultra-filtration is the best pre-treatment technique for cost effective performance of the Reverse Osmosis System as it leads to increased RO membranes life and reduced cleaning frequency. This ultimately reduces the operating expenditure incurred on the RO system. The treated water from Ultra-filtration system will be collected in the RO feed tank for temporary storage & the treated water will be transferred to Reverse Osmosis System through pump for further treatment as well as will be used during cleaning of Ultra-filtration system.  **Reverse Osmosis System**  The treated water from the RO feed tank is subjected to sodium Bisulphite (SBS) and Antiscalant dosing prior to feeding in the cartridge filter. The Antiscalant Dosing System is provided to prevent precipitation of sparingly soluble salts and hence to inhibit scale formation on RO membranes.  The SBS (sodium bisulphite) Dosing System is provided to remove traces of chlorine present in raw water to protect the membranes. Also, provision of shock dosing of SBS is made in case of any excess free chlorine coming into safeguard RO membranes. The RO unit comprises of cartridge filters & high-pressure pump. Cartridge Filters are used to further reduce suspended solids to a level acceptable to the downstream.  Effluent stream from UF system will be stored temporarily in RO feed tank from where it will be pumped to RO system for further reduction of dissolved solids. The RO system comprises of cartridge filters and high-pressure pumps. Prior to cartridge filters Sodium- metabisulfite (SMBS) and antiscalant will be dosed for efficient operation of the RO unit. SMBS dosing removes traces of chlorine in the feed water to protect the membranes while antiscalant serves to inhibit the scale formation on the membranes. The cartridge filters will reduce the suspended solids further to a level acceptable to the downstream RO membranes. From the cartridge filters effluent will be fed to the RO skid comprising of 2 trains. Permeate from the RO unit will be stored in the RO permeate tank while the reject will be stored in the RO reject tank. Cartridge Filters are used to further reduce suspended solids to a level acceptable to the downstream.  **Sludge Treatment**  Sludge from Lamella Clarifier, primary clarifier, Secondary Clarifier I and II shall be collected in sludge sump and pumped to Filter Press for further treatment. The filtrate from the Filter Press is sent back the Equalization Tank while the sludge cake formed will be disposed of as landfill. Additionally, sludge drying beds are provided for drying the sludge cake formed from the Filter Press  Hazardous wastes like resin sludge with polymers, resin-soaked cotton waste / gloves & chemical contaminated saw dust, office garbage, filter material, waste glycerine, spent solvent, spent oil, activated carbon, ETP (Effluent Treatment Plant) sludge, and waste barrel will be generated during the production. MEE/MVR salts (i.e., NaCl Salt) need to be send to authorized vendors & to managed as per the Hazardous Wastes (Management, Transport and Transboundary) Rules 2016 as amended till date.  **Block Diagram for Effluent Treatment Plant**  Effluent form plant  Reaction Tank  Primary clarifier  Equalization tank  Aeration Tank  Secondary clarifier 2  MGF  Overflow Water Tank  Clarified Water Tank  Secondary clarifier 3  Aeration tank 3  Secondary clarifier 2  Aeration tank 2  ACF  UF  RO  Guard Pond  Sludge Pump  Filter Press  Sludge Drying Bed  Sewage + Floor washing + CTBD  DMW Effluent + CTBD  To cooling tower, make up   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | **S.No** | **Type of Waste** | **Source** | **Quantity per Year (MT)** | **Method of collection** | **Treatment/Disposal** | | 1 | ETP Sludge + Evaporation residue | Process | 2.1 | Bag | Collection, storage and Disposal at Approved TSDF Site | | 2 | Resin-Soaked Cotton Waste/ Gloves, Chemical, Contaminated Saw dust, Office Garbage | Process | 0 | Bag | Incineration | | 3 | Filter Material | Process | 1.46 | Bag | Incineration | | 4 | Waste Glycerine | Maintenance | 10.95 | Drum | Incineration | | 5 | Spent Solvent | Process | 87.6 | Drum | Collection, storage and Disposal at Approved TSDF Site | | 6 | Spent Oil | Maintenance | 0 | Drum | Via Register Recycler | | 7 | Activated Carbon | Process | 0.43 | Bag | Via Register Recycler | | 8 | ETP Sludge | ETP | 0 | Bag | Via TSDF | | 9 | Discarded Container | Process | 534.6 | Drum | Via Authorised Vendor | | 10 | Process Residue | Process | 0 | Drum | Via CHWIF | | 11 | Salt (NaCl) | Process | 15149.2 | Bag | Sell to Authorised Vendor | |
| **TSDF:** Treatment, Storage, & Disposal Facility.  **CHWIF:** Common Hazardous waste Incineration facility.  **CETP:** Common Effluent Treatment Plant | | | |

**4.1.8. Raw Material Required (Detail list of all raw major raw material used for the manufacturing of Epoxy Resin):**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Chemical Name | Molecular Weight | Flash Pt.(°C) | Boiling Pt (°C) | Melting pt. (°C) | Density (g/cm³) | Autoignition temp. (°C) | Solubility in water |
| Epichlorohydrin | 92.5 | 31 | 117.9 | -25.6 | 1.1812 | 385 | Insoluble |
| Isopropyl alcohol | 60.1 | 11.7/13 | 82.5 | -89 | 0.786 |  | Soluble |
| Bisphenol-F | 200.24 | 177.1 | 362.5 °C at 1 atm |  | 1.208g/cm³ |  | Low |
| Bisphenol-A | 228.9 | 227 | 360 | 158 | 1.2 | 600 | Insoluble |
| Caustic soda lye | 40 |  | 1390 | 318 | 2.1 (Solid) |  | Soluble |
| Toluene | 92.14 | 4.4/16 | 110.6 | -95 | 0.8636 | 1.53 | Insoluble |
| Phenol | 94.11 | 79 |  | 40.5 | 1.07 |  | 8.3g/100ml |
| o-cresol | 108.14 | 81 | 191 | 29.8 | 1.05(solid) 1.03(liq.) |  | 2.5g/100ml |
| 1,4-Butanediol | 90.12 | 121 | 235 | 20.1 | 1.0171 at | 350 | Soluble |
|  |  |  |  |  | 20° C |  |  |
| Cardanol | 300 |  |  | 57-65 | 1 at 25° C |  | Less than 1g/L at 25° C |
| Polypropylene glycol | 76.09 | 99 | 188.2 | -59 | 1.036 at 20° C | 371 |  |
| Hexahydropthalic anhydride | 154.2 | 152 | 296 | 37.5 | 1.18 | 395 | 7g/L at 20° C |

**Major Raw Material Vendors**

|  |  |
| --- | --- |
| **Bisphenol A** | **Epichlorohydrin** |
| Mitsui Phenols Singapore Pte Ltd | Advanced Biochemical Thailand Co |
| Hexion B V | The Kouyou Trading Co Ltd |
| Kumho P And B Chemicals Inc | Inovyn Europe Ltd |
| Chang Chun Plastics Co Ltd | Mitsui Co Ltd |
| Samsung C And T Corporation | Sumitomo Corporation |
| PTT Phenol Company Limited | Samsung C And T Corporation |
| Nan Ya Plastics Ltd | Jubail Chemical Industries Co |
| LG Chem Ltd | Jiangshu Ruixiang Chemical Co Ltd |
| **Caustic Soda** | Formosa Plastics Corporation |
| Grasim Industries Ltd | Hanwha Corporation |
| Meghmani Finechem Ltd | Tokyo Chemical Industry Private Limited |
| DCM Shriram Ltd. | **Norbornene** |
| GACL | Puyang Huicheng Electronic Material |
| Kutch Chemicals | **Lauryl Myristyl Alcohol** |
| The Andhra Sugars Limited | Ecogreen Oleochemicals Singapore |
| Nirma Ltd | **Hexahydrophthalic Anhydride** |
| **Methyltetrahydrophthalic Anhydride** | Puyang Huicheng Electronic Material |
| Shanghai Howell Petroleum Additives | Kenko Corporation |
| Puyang Huicheng Electronic Material Co Ltd |  |

*Orange colour denotes major raw materials Blue colour denotes Catalyst and chemicals*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Raw Material | Supplier 1 | Supplier 2 | Supplier 3 | Supplier 4 | Supplier 5 |
| Phenol | Deepak Phenolics | HOCL | INEOS | Sasol |  |
| Acetone | Hindustan Organic Chemicals Ltd. | Deepak Phenolics Ltd | Kumho P & B Chemicals | Solvay | SABIC |
| Propylene | Manali Petrochemical | Dow | BASF SE | INEOS | Sumitomo Chemical Co. Ltd. |
| NAOH | Tata Chemicals Ltd. | Gujarat Alkalies and Chemicals Limited | Solvay Chemicals | Aditya Birla Chemicals (India) Limited | Dow |
| Cl2 Gas | Tata Chemicals Ltd. | Gujarat Alkali and Chemicals Limited | Hanwha Chemical Corporation | Occidental Petroleum Corporation | PPG Industries |
| BPA | Atul Ltd. | Dow Chemical | LG Chem | Mitsubishi Chemical | Mitsui Chemicals |
| ECH | Dow Chemical | Solvay SA | Momentive Performance Materials Inc. | Solvay Chemicals | NAMA Chemicals |
| Toluene | Reliance Industries | Indian Oil Corporation Limited | Exxon Mobil Corporation | Covestro AG | BASF |
|  |
| Lime | Innova Corporate | United States Lime & Minerals, Inc | Graymont Limited | Hydrite Chemical Co. |  |  |

**Different Raw Materials used in the Production of Epoxy Resin Process**

Reactor - 1

Reactor - 2

Resin – Toluene solution

Falling Film Evaporator

Liquid Epoxy Resin

Liquid Epoxy Resin

Liquid Epoxy Resin

Solid Epoxy Resin

Solvent Solution Epoxy Resin

Epichlorohydrin (ECH)

Bisphenol (BPA)

Liquid Soda (50%)

H₂O

Toluene

Liquid Soda (50%)

H₂O

Aging Resin

Toluene

Flow to a toluene storage tank

Heating

BPA

Tert-Butyl Phenol

Methyl-isobutyl Ketone

BPA

Tert-Butyl Phenol

Methyl-isobutyl Ketone

Dimethylbenzene

to flaker

**5. Economic Evaluation**

Estimated cost analysis for the suggested capacity of 84 KTPA.

**5.1 Fixed Cost & Variable Cost Analysis (CAPEX):**

In particular, the total capital investment was based on the percentage of the delivered equipment cost method for a solids and liquids processing plant.

The total cost of the process equipment (including auxiliary equipment) as the 100% value, the total capital investment for the base case is estimated at USD 34.14 million.

below tabular data breakdown is based as per proposed weightage of planned production as per analyst inferences:

* Phase-1 i.e. in 2024 will incur approximately 65% of the total CAPEX which includes Electrical Supply Installation & Commissioning, Instrumentation and Process Equipment, Mechanical Structure & Piping
* Phase-2 i.e. 2028 will incur remaining share of CAPEX based on repeat scope of Phase-1 components.
* Civil work costs will be undertaken during Phase-1 initiation (95% of overall cost) and Phase-2 initiation (5% remaining share of overall cost)

|  |  |  |  |
| --- | --- | --- | --- |
|  | **ITEM** | **Percentage (%)** | **USD Million** |
| **A** | **TOTAL FIXED-CAPITAL INVESTMENT** |  | **33.4** |
| A1 | TOTAL DIRECT PLANT COST |  | 23.7 |
| 1 | Delivered main equipment (includes auxiliary equipment) | 100% | 7.7 |
| 2 | Purchased-equipment installation | 39% | 3.0 |
| 3 | Instrumentation and controls (installed) | 26% | 2.0 |
| 4 | Piping (installed) | 31% | 2.4 |
| 5 | Electrical (installed) | 10% | 0.7 |
| 6 | Buildings (including services) | 29% | 2.2 |
| 7 | Service facilities (installed) | 55% | 4.2 |
| 8 | Others | 18% | 1.4 |
| **A2** | **TOTAL INDIRECT PLANT COST** |  | **9.7** |
| 9 | Engineering and supervision | 32% | 2.5 |
| 10 | Construction expenses | 34% | 2.6 |
| 11 | Legal expenses | 4% | 0.3 |
| 12 | Contractor’s fee | 19% | 1.5 |
| 13 | Contingency | 37% | 2.8 |
| **B** | **WORKING CAPITAL** |  | **0.8** |
| 14 | Safety and hazard analyses | 10% | 0.8 |
|  | **TOTAL CAPITAL INVESTMENT (A+B)** |  | **34.14** |

*Note: All calculation is based on the prevailing prices of equipment during Q2 and Q3 of 2021. As per the market participants, the prices may get revised upwards in next 2-3 years due rising commodity prices.*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **PARAMETERS** | | **COST OF PRODUCTION: Technology 1 CIBA)** | | | **COST OF PRODUCTION: Technology 2 (Tohto Kesai)** | | |
|  |
|  | | **Quantity** | **Unit Rate** | **Amount** | **Quantity** | **Unit Rate** | **Amount** |  |
| **Tonne** | **USD/Tonne** | **USD** | **Tonne** | **USD/Tonne** | **USD** |  |
| **A** | **VARIABLE COST** |  | | | | | |  |
| 1 | Raw Materials |  |
| Bisphenol A | 0.7 | 1350.0 | 945.0 | 0.7 | 1350.0 | 945.0 |  |
| Epichlorohydrin | 0.6 | 1470.0 | 823.2 | 0.6 | 1470.0 | 837.9 |  |
| Caustic Soda | 0.5 | 150.0 | 75.0 | 0.5 | 150.0 | 75.0 |  |
| Sub-Total (1) |  |  | 1843.2 |  |  | 1857.9 |  |
| 2 | Utility, Catalyst, Solvent, Labour, Packaging, R & D and Selling & Transportation |  | | 403.4 |  | | 436.2 |  |
|  | Utility | 77.4 | 98.0 |  |
|  | Catalyst & Solvent | 29.3 | 32.0 |  |
|  | Labor | 23.4 | 33.0 |  |
|  | Miscellaneous (R & D and Selling & Transportation) | 273.4 | 273.4 |  |
|  |  |  |  |  |
|  | **TOTAL VARIABLE COST** | **2246.6** | **2248.1** |  |
|  | |  |  |  |
| **B** | **FIXED COST** |  |
| 1 | Maintenance and repairs | 10.2 | 10.8 |  |
| 2 | Plant-Overhead Costs | 45.4 | 47.8 |  |
| 3 | Administrative costs | 3.7 | 4.2 |  |
|  | **Total Fixed Cost** | 69.5 | 74.7 |  |
| **C** | **Total Production Cost** | **2305.9** | **2368.1** |  |

***Assumptions and Findings***

1. Solvent recovery in CIBA Technology is quite better than that of Tohto Kesai
2. Catalyst & Chemical cost is higher in Tohto Kesai.
3. Prices of raw material and catalyst for both licensors are computed on the basis of moving monthly average of Reliance Industries Ltd 2019-March 2021 and for liquid epoxy resin.
4. The cost of power used by the plant considered as INR5.50 per kWh. Further, the companies interviewed were grid connected for their power requirements. Tariff of electricity was derived from public documents of manufacturers and power distribution companies.
5. The other utilities mainly include raw water, and its cost has been taken as INR1.25 per m3
6. Per kg costs for the fixed items are calculated based on primary research. Further, Repair and maintenance cost is 2.5% of plant & machinery cost. Interest on working capital is around 10% and depreciation has been calculated based on 10 years.

**5.2. Machinery & Equipment Cost Analysis:**

The total cost of the equipment is approximately USD 7.7 million (Ciba Process) including the auxiliary equipment. Considering the reactor and flaker as a complex part of the epoxy resin manufacturing, hence are considered as auxiliary equipment and the construction material is SS 304. The client is preferred to outsource the complex equipment (reactor and flaker) from the technology provider itself or under their recommendation. The equipment cost might vary for different manufacturers depending on the complexity and the material of construction. Construction and Installation of large size equipment (volume more than 100m3) like LER Storage Tanks is done on-site as the transportation of such equipment is not feasible.

**Equipment Cost**

**Assumptions:**

1. Each tank will have pump in its downstream section.
2. Continuous Process.
3. In one Reactor more than one number of grades can be formed. (For Information only: M/s Atul ltd. uses 20 No's Reactor for producing)
4. Storage Tank for the Liquid Epoxy Resin is Considered (In Case if M/s Reliance goes for buying liquid Epoxy Resin from Outside Market).
5. Considered Equipment Cost will be ±20 -25 % accurate.

This analysis is provided for uninterrupted production process:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| CIBA | | | | | | |
|  | **MAIN PROCESS EQUIPMENTS** | **CAPACITY & MOC** | **Qty** | **Unit Rate** | **Category** | Remarks |
| **[USD Million]** |
| 1 | Caustic Preparation Solution Tank (48% Caustic) | m3,PP | 1 | 0.098 | Indigenous |  |
| 2 | Caustic transfer pump | m3/hr,PP | 2 | 0.033 | Indigenous | 1 Standby & 1 working |
| 3 | BPA Hopper (if Solid) | m3, SS304 | 1 | 0.033 | Indigenous |  |
| 5 | ECH Storage Tank | m3, SS304 | 1 | 0.164 | Indigenous |  |
| 6 | ECH Transfer Pump | m3/hr, SS304 | 2 | 0.033 | Indigenous | 1 Standby & 1 working |
| 7 | Pre-Reactor | Not Required | | | | |
| 8 | Reaction solution Transfer pump |
| 9 | Reactor | m3, SS304 | 1 | 0.491 | Auxiliary | For more no of grade, Reactor will be increased accordingly |
| 10 | Reaction solution Transfer pump 2 | m3/hr, SS304 | 2 | 0.033 | Indigenous | 1 Standby & 1 working |
| 12 | Evaporator | m3, SS304 | 3 | 0.131 | Indigenous |  |
| 13 | Solvent Storage Tank (Toluene) | m3, SS304 | 1 | 0.164 | Indigenous |  |
| 14 | Solvent transfer pump | m3/hr, SS304 | 2 | 0.016 | Indigenous | 1 Standby & 1 working |
| 15 | Washing Tower | m3, SS304 | 1 | 0.098 | Indigenous |  |
| 16 | Gravity Separator | m3, SS304 | 1 | 0.164 | Indigenous |  |
| 17 | Soln Transfer pump | m3/hr, SS304 | 2 | 0.016 | Indigenous | 1 Standby & 1 working |
| 18 | Condensor | m3, SS304 | 3 | 0.131 | Indigenous |  |
| 19 | Soln Transfer pump 2 | m3/hr, SS304 | 2 | 0.033 | Indigenous | 1 Standby & 1 working |
| 20 | Filter | m3, SS304 | 2 | 0.164 | Indigenous |  |
| 21 | Mixing Tank | m3, SS304 | 1 | 0.196 | Indigenous |  |
| 22 | Feed Pump | m3/hr, SS304 | 2 | 0.033 | Indigenous | 1 Standby & 1 working |
| 23 | Product Tank | m3, SS304 | 1 | 0.246 | Indigenous |  |
| 24 | UF/RO System | m3/hr, SS304 | 1 | 0.164 | Indigenous |  |
| 25 | Evaporator (Thin Evaporator & Rotary film thin evaporator) | m3, SS304 | 1 | 0.049 | Indigenous |  |
| 26 | Cooling Tower | m2, SS304 | 1 | 0.098 | Indigenous |  |
| 27 | DG’s, Generator’s | 400 KV | 2 | 0.131 | Indigenous |  |
| 28 | DCS System (Instrumentation Item) |  | 1 | 0.491 | Indigenous |  |
|  | **Total** |  |  | 3.21 |  |  |
| 1.2 | Equipment list for SER |  |  |  |  |  |
| 1 | LER Storage tank | 375m3, SS304 | 2 | 0.327 | Indigenous |  |
| 2 | Xylene Storage Tank | 110m3, SS304 | 1 | 0.147 | Indigenous |  |
| 3 | Condenser | 7m2, SS304 | 1 | 0.041 | Indigenous |  |
| 4 | Feed Pump | 18m3/hr, SS304 | 4 | 0.02 | Indigenous | 2 Process pump & 2 Standby |
| 5 | Weighing Tank | 14m3, SS304 | 1 | 0.041 | Indigenous |  |
| 6 | Hoist | 3-4 Ton/hr, SS304 | 1 | 0.025 | Indigenous |  |
| 7 | BPA Hopper | 08-12m3, SS304 | 1 | 0.02 | Indigenous |  |
| 8 | Reactor | 15 m3, SS304/CS | 1 | 0.491 | Indigenous |  |
| 9 | Resin Hopper | 1.2m3, SS304 | 1 | 0.02 | Indigenous |  |
| 10 | Condenser | 7.5m2, SS304 | 1 | 0.033 | Indigenous |  |
| 11 | Reactor | 15m3, SS304 | 1 | 0.491 | Auxiliary |  |
| 12 | Condenser | 7.5m2, SS304 | 1 | 0.049 | Indigenous |  |
| 13 | Raw material Hopper | 0.2m3, SS304 | 1 | 0.003 | Indigenous |  |
| 14 | BPA Dust Collector | 25m3, CS | 1 | 0.016 | Indigenous |  |
| 15 | Reactor | 16m3, SS304 | 1 | 0.491 | Auxiliary |  |
| 16 | Resin hopper | 1.2m3, SS304 | 1 | 0.005 | Indigenous |  |
| 17 | Condenser | 7.5m2, SS304 | 1 | 0.049 | Indigenous |  |
| 18 | Dust Collector | 25m3, CS | 1 | 0.016 | Indigenous |  |
| 19 | Cut Tank | 17m3, SS304 | 1 | 0.327 | Auxiliary |  |
| 20 | Condenser | 25m2, SS304 | 1 | 0.065 | Indigenous |  |
| 21 | Product filter | 15m3/hr, SS304 | 1 | 0.016 | Indigenous |  |
| 23 | Flaker hopper | 4,000kg/hr, SS 304 | 1 | 0.033 | Indigenous |  |
| 24 | Circle Feeder | 7.5 ton/hr, SS 304 | 1 | 0.065 | Indigenous |  |
| 25 | Crusher | 4500kg/hr, SS304 | 1 | 0.131 | Indigenous |  |
| 26 | Packer | **(25 Kg, 100 Kg, 200Kg, 500 Kg /bag,)** SS 304 | 4 | 0.098 | Indigenous |  |
| 27 | Product Dust Collector | 40m3/hr, SS314 | 1 | 0.025 | Indigenous |  |
| 28 | Product Tank | 150m3, SS304 | 4 | 0.698 | Indigenous |  |
| 29 | Vent Condenser | 6m2, SS304 | 4 | 0.098 | Indigenous |  |
| 30 | Product Filter | 15m3/hr, SS304 | 4 | 0.079 | Indigenous |  |
|  | Feed Pump | 18m3/hr, SS304 | 5 | 0.082 | Indigenous |  |
|  | Total |  |  | 4.002 |  |  |
| 1.3 | ETP Plant | 800 KD |  | 0.477 |  |  |
| 1.4 | Warehouse | 1.8 Acre |  | 0.27 |  |  |
|  | Final Total (1.1 + 1.2 + 1.3+1.4) |  |  | **8.49** |  |  |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Tohto Kesai | | | | | | |
|  | **MAIN PROCESS EQUIPMENTS** | **CAPACITY & MOC** | **Qty** | **Unit Rate** | **Category** | Remarks |
| **[USD Million]** |
| 1 | Caustic Preparation Solution Tank (48% Caustic) | m3,PP | 1 | 0.098 | Indigenous |  |
| 2 | Caustic transfer pump | m3/hr,PP | 2 | 0.033 | Indigenous | 1 Standby & 1 working |
| 3 | BPA Hopper (if Solid) | m3, SS304 | 1 | 0.033 | Indigenous |  |
| 5 | ECH Storage Tank | m3, SS304 | 1 | 0.164 | Indigenous |  |
| 6 | ECH Transfer Pump | m3/hr, SS304 | 2 | 0.033 | Indigenous | 1 Standby & 1 working |
| 7 | Pre-Reactor | m3, SS304 | 1 | 0.491 | Auxiliary |  |
| 8 | Reaction solution Transfer pump | m3/hr, SS304 | 2 | 0.033 | Indigenous | 1 Standby & 1 working |
| 9 | Reactor | m3, SS304 | 3 | 0.491 | Auxiliary | For more no of grade, Reactor will be increased accordingly |
| 10 | Reaction solution Transfer pump 2 | m3/hr, SS304 | 2 | 0.033 | Indigenous | 1 Standby & 1 working |
| 12 | Evaporator | m3, SS304 | 1 | 0.131 | Indigenous |  |
| 13 | Solvent Storage Tank (Toluene) | m3, SS304 | 1 | 0.164 | Indigenous |  |
| 14 | Solvent transfer pump | m3/hr, SS304 | 2 | 0.016 | Indigenous | 1 Standby & 1 working |
| 15 | Washing Tower | m3, SS304 | 1 | 0.098 | Indigenous |  |
| 16 | Gravity Separator | m3, SS304 | 1 | 0.164 | Indigenous |  |
| 17 | Soln Transfer pump | m3/hr, SS304 | 2 | 0.016 | Indigenous | 1 Standby & 1 working |
| 18 | Condenser | m3, SS304 | 1 | 0.131 | Indigenous |  |
| 19 | Soln Transfer pump 2 | m3/hr, SS304 | 2 | 0.033 | Indigenous | 1 Standby & 1 working |
| 20 | Filter | m3, SS304 | 2 | 0.164 | Indigenous |  |
| 21 | Mixing Tank | m3, SS304 | 1 | 0.196 | Indigenous |  |
| 22 | Feed Pump | m3/hr, SS304 | 2 | 0.033 |  | 1 Standby & 1 working |
| 23 | Product Tank | m3, SS304 | 1 | 0.246 | Indigenous |  |
| 24 | UF/RO System | m3/hr, SS304 | 1 | 0.164 | Indigenous |  |
| 25 | Evaporator (Thin Evaporator & Rotary film thin evaporator) | m3, SS304 | 1 | 0.049 | Indigenous |  |
| 26 | Cooling Tower | m2, SS304 | 1 | 0.098 | Indigenous |  |
| 27 | DG’s, Generator’s | 400 KV | 2 | 0.131 | Indigenous |  |
| 28 | DCS System (Instrumentation Item) |  | 1 | 0.491 | Indigenous |  |
|  | **Total** |  |  | 3.733 |  |  |
| 1.2 | Equipment list for SER |  |  |  |  |  |
| 1 | LER Storage tank | 375m3, SS304 | 2 | 0.327 | Indigenous |  |
| 2 | Xylene Storage Tank | 110m3, SS304 | 1 | 0.147 | Indigenous |  |
| 3 | Condenser | 7m2, SS304 | 1 | 0.041 | Indigenous |  |
| 4 | Feed Pump | 18m3/hr, SS304 | 4 | 0.02 | Indigenous | 2 Process pump & 2 Standby |
| 5 | Weighing Tank | 14m3, SS304 | 1 | 0.041 | Indigenous |  |
| 6 | Hoist | 3-4 Ton/hr, SS304 | 1 | 0.025 | Indigenous |  |
| 7 | BPA Hopper | 08-12m3, SS304 | 1 | 0.02 | Indigenous |  |
| 8 | Reactor | 15 m3, SS304/CS | 1 | 0.491 | Indigenous |  |
| 9 | Resin Hopper | 1.2m3, SS304 | 1 | 0.02 | Indigenous |  |
| 10 | Condenser | 7.5m2, SS304 | 1 | 0.033 | Indigenous |  |
| 11 | Reactor | 15m3, SS304 | 1 | 0.491 | Auxiliary |  |
| 12 | Condenser | 7.5m2, SS304 | 1 | 0.049 | Indigenous |  |
| 13 | Raw material Hopper | 0.2m3, SS304 | 1 | 0.003 | Indigenous |  |
| 14 | BPA Dust Collector | 25m3, CS | 1 | 0.016 | Indigenous |  |
| 15 | Reactor | 16m3, SS304 | 1 | 0.491 | Auxiliary |  |
| 16 | Resin hopper | 1.2m3, SS304 | 1 | 0.005 | Indigenous |  |
| 17 | Condenser | 7.5m2, SS304 | 1 | 0.049 | Indigenous |  |
| 18 | Dust Collector | 25m3, CS | 1 | 0.016 | Indigenous |  |
| 19 | Cut Tank | 17m3, SS304 | 1 | 0.327 | Auxiliary |  |
| 20 | Condenser | 25m2, SS304 | 1 | 0.065 | Indigenous |  |
| 21 | Product filter | 15m3/hr, SS304 | 1 | 0.016 | Indigenous |  |
| 23 | Flaker hopper | 4,000kg/hr, SS 304 | 1 | 0.033 | Indigenous |  |
| 24 | Circle Feeder | 7.5 ton/hr, SS 304 | 1 | 0.065 | Indigenous |  |
| 25 | Crusher | 4500kg/hr, SS304 | 1 | 0.131 | Indigenous |  |
| 26 | Packer | (25 Kg, 100 Kg, 200Kg, 500 Kg /bag,), SS 304 | 4 | 0.098 | Indigenous |  |
| 27 | Product Dust Collector | 40m3/hr, SS314 | 1 | 0.025 | Indigenous |  |
| 28 | Product Tank | 150m3, SS304 | 4 | 0.698 | Indigenous |  |
| 29 | Vent Condenser | 6m2, SS304 | 4 | 0.098 | Indigenous |  |
| 30 | Product Filter | 15m3/hr, SS304 | 4 | 0.079 | Indigenous |  |
|  | Feed Pump | 18m3/hr, SS304 | 5 | 0.082 | Indigenous |  |
|  | Total |  |  | 4.002 |  |  |
| 1.3 | ETP Plant | 800 KD |  | 0.477 |  |  |
| 1.4 | Ware House | 1.8 Acre |  | 0.27 |  |  |
|  | Final Total (1.1+1.2+1.3+1.4) |  |  | **7.96** |  |  |

**5.3. Operating Cost of Production**

Operating cost of production are the expenses, or the cost incurred by a business for its operational activities. In simple words, the operating expenses are the cost that a company must make to perform itsd operational activities which the includes the commercial activities. As per the market scenario, the cost of raw materials is the major contributor to total production cost which is approximately 82%. The rest 18% of the cost is contributed by variable overheads, fixed overheads, and selling overheads.

The data has been sourced from extensive primary and secondary research which includes published documents, annual reports, journals etc.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **ITEM** |  | **[USD]** |
| C | **MANUFACTURING COST** | C1 + C2 + C3+ C4 | **17,06,18,794** |
| C1 | **Raw materials** |  | **15,54,71,000** |
| 1 | **Raw materials** | - | **15,25,32,000** |
| 2 | **Catalyst & Chemicals** |  | **29,39,000** |
| C2 | **Labour** |  | **18,30,384** |
| 3 | **Salaries & Wages (calculated)** | - | **18,30,384** |
| C3 | **Variable Overheads** |  | **1,09,87,692** |
| 4 | **Packaging Cost (calculated)** |  | **2275000** |
| 5 | **Utilities (calculated)** |  | **87,12,692** |
| C4 | **Fixed Overheads** |  | **23,29,718** |
| 6 | **Maintenance and repairs (2.5% of fixed-capital investment)** | 2.50% | **8,53,553** |
| 7 | **Plant Overhead Costs (45% of 3 + 6)** | 45.00% | **12,07,772** |
| 8 | **Administrative costs (10% of 3 + 6)** | 10.00% | **2,68,394** |
| D | **Selling Overheads** |  | **2,04,74,255** |
| 9 | **Distribution and selling costs (10% of manufacturing cost)** | 10.00% | **1,70,61,879** |
| 10 | **Research and development costs (2% of manufacturing cost)** | 2.00% | **34,12,376** |
|  | **Total Production Cost** | C + D | **19,10,93,050** |

* 1. **Payback Period:**

The payback period is an effective measure of investment risk. It is the number of years it would take to get back the initial investment made for a project. Therefore, as a technique of capital budgeting, the payback period will be used to compare projects and derive the number of years it takes to get back the initial investment. The project with the least number of years usually is selected.

The data has been sourced from extensive primary and secondary research which includes published documents, annual reports, journals etc.

|  |  |
| --- | --- |
| **PROFITABILITY PARAMETER** | |
|  | **Value (USD Million)** |
| **NPV @ 10%** | 219.36 |
| **Internal Rate Of Return (%)**  ***On Total Capital -*** ***Before Taxes*** | 73 % |
| **Payback Period, Years** |  |
| Simple | 1.77 |
| Discounted @ 12% | 2.38 |

**Assumptions-**

1. Cost of Capital will be assumed as 10%
2. Tax rate will be assumed as 30%
3. Amortization will be presumed to be in next 10 years on equal basis.
4. Capacity will be installed in two phases: -
5. 50 % will be installed initially in first year, later 50 % will be installed in fifth year.
6. Operating Revenue will be bifurcated between: -

|  |  |
| --- | --- |
| LER | 53% |
| Solid Epoxy Resin | 24% |
| Semi Solid and Specialized Epoxy Resin | 23% |

1. Accounts Receivables will be taken as of 60 Days.
2. Accounts Payables will be taken as of 60 Days.
3. Inventory will be taken as of 30 Days.
   1. **Project Sensitivity Analysis:**

Project sensitivity is a holistic evaluation of how likely it is that a project will succeed through data-driven forecasting. It also identifies risks, quantifies their impact, and separates high-risk tasks from low ones. Project sensitivity is defined by both a written analysis and a mathematical formula that includes average task durations based on past data, simulated durations based on hypothetical models, and an average task duration for both of those projections.

Observations:

1. IRR is highly attractive
2. Project is moderately sensitive to variations in Investment and highly sensitive to Selling Price as also the Feedstock prices. Relative sensitivity, in decreasing order is:
3. Selling Price (i.e., Revenue)
4. Feedstock Prices (i.e., Raw Material Costs)
5. Investment (i.e., Capital Cost)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ***NPV in USD Million*** | | | | | |
|  | BASE CASE | 90.00% | 95.00% | 105.00% | 110.00% |
|  | **CAPITAL COST** | | | | |
| IRR% | 73.00% | 72.48% | 72.74% | 73.26% | 73.53% |
| NPV | 219.36 | 217.89 | 218.63 | 220.1 | 220.83 |
| Payback Period | 1.77 | 1.78 | 1.78 | 1.76 | 1.75 |
|  | **REVENUE** | | | | |
| IRR% | 73.00% | 54.54% | 63.99% | 81.71% | 90.22% |
| NPV | 219.36 | 139.04 | 179.2 | 259.52 | 299.68 |
| Payback Period | 1.77 | 2.35 | 2.02 | 1.58 | 1.43 |
|  | **RAW MATERIALS COST** | | | | |
| IRR% | 73.00% | 83.21% | 78.14% | 67.78% | 62.45% |
| NPV | 219.36 | 265.46 | 242.41 | 196.31 | 173.26 |
| Payback Period | 1.77 | 1.55 | 1.65 | 1.91 | 2.07 |



**6. Project Schedule:**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **PROJECT IMPLEMENTATION SCHEDULE FOR EPOXY RESIN PLANT** | | | | | | | | | | | | | | | | | | | | | | | | |
| **Activity** |  | **Month** | | | | | | | | | | | | | | | | | | | | | | |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 18 | 16 | 18 | 22 | 24 | 26 | 28 | 29 | 30 |
| 1. Kick Off Meeting, Detailed Engineering and Licensing |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **1. Civil Work** | | | | | | | | | | | | | | | | | | | | | | | | |
| Company Registration |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Land Acquisition |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Finalisation of Building Design |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Invitation of Tenders and Award |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Factory Shed |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Auxiliary Building |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Administrative Block |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Other Construction |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Disbursal of Finances |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **3. Plant and Machinery** | | | | | | | | | | | | | | | | | | | | | | | | |
| Specification Detailing |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Invitation of Quotations |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Placing Orders |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Delivery at Plant Site & Inspection |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Installation and Commissioning |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Check-up of the Plant & Machinery |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **4. Arrangement of Power/Water** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **5. Other Items** | | | | | | | | | | | | | | | | | | | | | | | | |
| Finalize Management Reporting |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Finalize Official Practices |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Executive Systems |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **6. Training and Personnel** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **7. Start -up/ Commercial Production** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

**7. Project and Business Risk on setting up Epoxy Resin plant in West Region of India**

* **Cost Escalation-** There may be cost escalation and time overrun due to Covid-19 pandemic-related challenges, unusual rise in commodity prices and land conversion issues. It may also face cost overrun due to increase in foreign exchange component, increase in cost towards storage and preservation of equipment and interest during construction (IDC). As commodity prices like crude oil, steel, natural gas, coal & electricity are increasing which will be impacting the overall cost of the project. As per industry experts, the bullish market for the next few months will be noticing the upward trend in the commodity prices.
* **Domestic/ Geo-Political scenario-** In western India, Gujarat, Maharashtra, and Madhya Pradesh are three major states, where setting up of plant can be considered. The political scenario will not be much impact on the project and businesses as any incumbent government majorly focuses on industrial development. Moreover, Reliance as a brand is considered as the major contributor for the socio-economic growth in Western region.
* **International/ Geo-Political Scenario-** India is not immune to geo-political scenario prevailing all over the global. In recent years, the following points have impacted the geopolitical scenario of India-
* The conflict among GCC (Gulf Cooperation Council) nations have impacted the prices of commodities (crude oil, natural gas).
* In past, the trade war between US – China, have impacted the global foreign trade from and to India.
* The natural calamities like hurricanes, floods etc. are prevalent in the North America and Europe which hampers the export market.
* **Trade Barriers and Free Trade Agreement -** Many countries impose trade barriers / anti-dumping duties to protect their domestic industry. For initial period of operation, Reliance needs to explore export market. If any country imposes any safeguard duty from India’s import, then it may impact realization/revenue.

India has agreement with ASEAN nations for trade which attracts zero or lesser custom duties which has resulted in increased import from South Korea and Thailand in recent years.

* **Social Economic Factor:** All major social economic factor is favorable for the project in western region. Social economic factor includes infrastructural facilities, provisions for public health, education, communication, and banking facilities etc. Development of social sector along with technology absorption could be considered as the primary objective of any economic developmental effort. Many developmental programs have been taken up in western region in a planned way with the main objective of enhancing the quality of life of people by providing the necessities as well as effecting improvement of economic wellbeing. When it comes to social indicators (like Female literacy rate & Empowerment, Education quality, Low conviction rates for crimes against scheduled castes, tribes), there has been seen lot of development in past few years & same is continuously developing under current government new policies & regulations.

Gujarat and Maharashtra economy are largely supported by industries located in districts near the coastline. The districts away from the coast are agrarian eco

**8. Abbreviations**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  | | --- | --- | | **FY**  **EEW**  **SEAC**  **FDI**  **GDP**  **BPA**  **ECH**  **BADGE**  **TGPAP**  **TGAPP)**  **MW**  **CPA**  **EPN**  **LMW**  **NMR**  **FRP**  **mPa.s**  **OSHA**  **THF**  **UF/RO**  **MEE/MVR**  **TSDF**  **CHWIF**  **CETP**  **NPV**  **FOB**  **SPSS**  **SIR**  **SEZ**  **PCPIRs**  **INS** | **Financial Year**  **Epoxy Equivalent weight**  **State Expert Appraisal Committee**  **Foreign Direct Investment**  **Growth Domestic Product**  **Bisphenol A**  **Epichlorohydrin**  **Bisphenol A DiGlycidyl Ether**  **Triglycidyl para-aminophenol**  **triglycidyl of 4-(4-aminophenoxy) phenol**  **Molecular Weight**  **Centi Pascal**  **Epoxy phenol/cresol Novolac**  **Lower Molecular Weight**  **Nuclear Magnetic Resonance**  **Fibre-Reinforced Plastic**  **millipascal second**  **Occupational Safety and Health Administration**  **Tetrahydrofuran**  **Ultra-Filtration/Reverse Osmosis**  **Multi Effect Evaporator/ Mechanical Vapor Re-compressor**  **Treatment, Storage, & Disposal Facility**  **Common Hazardous waste Incineration facility.**  **Common Effluent Treatment Plant**  **Net Present Value**  **Free on board**  **Statistical Package for the Social Sciences,**  **Special Investigation Region**  **Special Economic Zone**  **Petrochemical Investment Region and manufacturing as well as logistic park**  **Indian Nava; Ship**  **`** | | **VER**  **NZE**  **GW**  **DG**  **GW** | **Vinyl Ester Resin**  **Net Zero Emissions**  **Diesel Generator**  **Giga Watt** | | **PE**  **SDS** | **Polyethylene**  **Sustainable Development Scenario** | | **PP** | **Polypropylene** | | **PVC** | **Polyvinyl Chloride** | | **MT** | **Metric Tonne** | | **FDI** | **Foreign Direct Investment** | | **FRP** | **Fiberglass Reinforced Plastics** | | **CAGR** | **Compound Annual Growth Rate** | | **BPA** | **Bisphenol A** | | **KTPA**  **MTPA** | **Kilotonne per annum**  **Metrictonne per annum** | | **GCC**  **AMRUT**  **CCL** | **Gulf Cooperation Council**  **Atal Mission for Rejuvenation and Urban Transformation**  **Copper Clad laminates** | | **IoT** | **Internet of Things** | | **KT** | **Kilotonne** | | **Kg** | **Kilograms** | | **LCD** | **Liquid Crystal Displays** | | **2025 F**  **NAOH**  **APAC** | **2025 Forecast**  **Sodium Hydroxide**  **Asia Pacific** | | **TRAI** | **Telecom Regulatory Authority of India** | | **Inc.** | **Incorporated** | | **EPA** | **Environmental protection Agency** | | **EW** | **Equivalent Weight** | | **KW** | **Kilo watt** | | **Lit/Hr** | **Litre/Hour** | | **KL/day** | **Kilolitre/day** | | **ETP** | **Effluent Treatment Plant** | | **LER** | **Liquid Epoxy Resin** | | **NPV** | **Net Present Value** | | **IRR** | **Internal Rate of Return** | | **UPR** | **Unsaturated Polyester Resin** | | **IDC** | **Interest during construction** | |

**Annexure- 1 (Reference Links)**

1. <https://epoxy-europe.eu/wp-content/uploads/2016/09/epoxy_erc_bpa_whitepapers_summarypaper.pdf>
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11. <https://patents.justia.com/patent/8461286>
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14. <http://nopr.niscair.res.in/bitstream/123456789/22741/1/IJCT%2010%283%29%20257-264.pdf>
15. <https://www.chemeurope.com/en/encyclopedia/Epoxy.html>
16. <https://www.tri-iso.com/documents/Epoxy_Chemistry_and_Application_Overview.pdf>
17. <https://krayden.com/pdf/hunt_epoxy_resin_handling_guide.pdf>
18. <https://krayden.com/pdf/hunt_epoxy_resin_handling_guide.pdf>
19. <https://dd7pmep5szm19.cloudfront.net/1548/0000074303-21-000019.pdf>
20. <https://olinepoxy.com/wp-content/uploads/2019/01/Epoxy_Resins_Stewardship_Manual.pdf>
21. <http://www.kukdo.com/en/invest/financialHighlight.do>
22. <http://www.kukdo.com/en/business/epoxy.do>
23. <http://environmentclearance.nic.in/writereaddata/FormB/EC/Risk_Assessment/14112018I1V10Q4RRHDocument.pdf>
24. <http://www.environmentclearance.nic.in/DownloadPfdFile.aspx?FileName=varl86rdGM35Gx6hlrIz3hiQqKOE4fdnSSWVvZTkWBbNC1200aAJ6p1zVn7QLuvY&FilePath=93ZZBm8LWEXfg+HAlQix2fE2t8z/pgnoBhDlYdZCxzVPEh4a7F53Cae7tleKGoXIDiA7chYePNgRJpehWx3dLsaLaee8RS5VxBvVdCAnIMg=>
25. <https://www.grasim.com/Upload/PDF/vilayat-epoxy-env-report-2232012.pdf>
26. <https://www.pcimag.com/articles/88393-dow-epoxy-receives-eia-approvals-for-shanghai-plants>

**Historical Prices of key raw material in India July 2018 onwards (USD/tonne)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Year | Month | Bisphenol A CFR JNPT | Epichlorohydrin CFR JNPT | Caustic Soda Lye Ex-JNPT |
|  |  | Prices in USD/Tonne | | |
| 2018 | July | 1095.81 | 1839.45 | 429.30 |
| 2018 | August | 1102.10 | 1792.08 | 435.81 |
| 2018 | September | 1069.65 | 1706.79 | 442.76 |
| 2018 | October | 1056.51 | 1620.22 | 470.53 |
| 2018 | November | 1098.49 | 1588.78 | 443.88 |
| 2018 | December | 1127.71 | 1582.69 | 444.67 |
| 2019 | January | 1143.07 | 1646.92 | 426.71 |
| 2019 | February | 1154.64 | 1699.17 | 426.06 |
| 2019 | March | 1202.75 | 1675.79 | 439.66 |
| 2019 | April | 1213.09 | 1682.77 | 415.22 |
| 2019 | May | 1184.65 | 1671.68 | 412.98 |
| 2019 | June | 1179.63 | 1629.30 | 409.49 |
| 2019 | July | 1210.15 | 1652.32 | 406.54 |
| 2019 | August | 1206.89 | 1562.36 | 392.28 |
| 2019 | September | 1208.69 | 1610.66 | 373.25 |
| 2019 | October | 1233.80 | 1547.28 | 380.91 |
| 2019 | November | 1245.28 | 1511.12 | 369.39 |
| 2019 | December | 1269.25 | 1401.45 | 392.08 |
| 2020 | January | 1268.07 | 1442.01 | 386.73 |
| 2020 | February | 1282.32 | 1477.82 | 369.03 |
| 2020 | March | 1218.63 | 1468.47 | 348.20 |
| 2020 | April | 1173.09 | 1393.90 | 301.77 |
| 2020 | May | 1211.38 | 1416.60 | 283.58 |
| 2020 | June | 1236.11 | 1389.31 | 299.78 |
| 2020 | July | 1259.97 | 1409.46 | 304.31 |
| 2020 | August | 1257.45 | 1402.23 | 337.82 |
| 2020 | September | 1284.92 | 1433.13 | 349.17 |
| 2020 | October | 1271.49 | 1449.64 | 343.78 |
| 2020 | November | 1306.99 | 1447.12 | 288.75 |
| 2020 | December | 1351.30 | 1474.89 | 280.72 |
| 2021 | January | 1602.16 | 1558.26 | 274.89 |
| 2021 | February | 1874.93 | 1755.97 | 306.17 |
| 2021 | March | 2240.72 | 1771.10 | 324.48 |
| 2021 | April | 2446.89 | 2154.71 | 331.83 |
| 2021 | May | 2535.05 | 2561.55 | 301.60 |
| 2021 | June | 2579.94 | 2593.66 | 290.31 |
| 2021 | July | 2697.67 | 2591.54 | 383.58 |
| 2021 | August | 3201.64 | 3084.00 | 432.92 |
| 2021 | September | 3739.56 | 3135.11 | 460.29 |
| 2021 | October | 3762.32 | 3228.66 | 697.63 |
| 2021 | November | 3820.15 | 3786.58 | 966.11 |