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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 has to 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 and analyse its industrial development on a global scale. Various formulated resins have export potential.

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 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**

Unattractive



Highly Attractive

*Source: TechSci Research*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **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** |  |  |  |  |  |  |

**Real GDP Growth Forecast for Major Economies**

|  |  |  |
| --- | --- | --- |
| **Country** | **2023** | **2025** |
| **India** | **7.95%** | **7.52%** |
| China | 5.75% | 5.60% |
| France | 2.32% | 1.76% |
| United Kingdom | 1.94% | 1.67% |
| Germany | 1.87 | 1.22% |
| United States | 2.35% | 1.86% |
| Russia | 2.15% | 1.85% |
| Japan | 1.26% | 0.72% |
| World | 3.84% | 3.56% |

*Source: TechSci Research*

**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 include Bisphenol-A and Bisphenol-F epoxy resin, while specialized epoxy resins include cycloaliphatic epoxy resins, dimer acid modified epoxy resins and multifunctional epoxy resins (Epoxy phenol Novolac resins and Epoxy cresol Novolac resins).

Standard and specialized epoxy resins are classified on the basis of formulation used during the manufacturing process. Standard epoxy resins are formed via traditional routes with conventional use of raw materials including bisphenol A or Novolac, Epichlorohydrin and Caustic Soda and are general purpose in applications. While specialized epoxy resins are highly functional, and characteristics of epoxy resins vary on the type of application.

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, baked 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 leveling.

**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 CPA at 25 degree Celsius.

**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, excellent weathering and electrical performance are required. In India, Cycloaliphatic epoxy resins are mainly used in weather resistant solvent-based coatings for outdoor applications.

**Brominated Epoxy Resins:** 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. Brominated epoxy resins are produced when tetrabrominated bisphenol A is added to the formulation. Fluorinated epoxy resins are used in high performance applications.

**Glycidylamine epoxy resins** are another specialized epoxy resins are heavily used in aerospace composite applications and other 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 glycidylamine epoxy resins around the world.

**2.2. Production Routes and Related Details**

Epoxy resin is usually synthesized by bulk polymerization. The material is available commercially at 98% purity & 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.

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,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 (LMW) epoxides.

**Detailed 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 ECH 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 min 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 (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". High molecular weight epoxides are manufactured by “Advancement” process using Benzyl trimethyl ammonium hydroxide as a catalyst.

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 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 Properties and Applications**

**Properties of all available grades of Epoxy Resin**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **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 EpoxyResin |  | \* |  | \* |  |

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

***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 180 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*

***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.*

***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.*

**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 which may cause adversely impact the 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 when stored in sealed containers. Epoxy resin may crystallize.

**Storage and Handling:** The product need to be stored in a seal pack 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 kept upright to prevent leakage.

**Transportation:** Seal packed containers need to keep 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.

**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**

**2021-2030**

**CAGR**

**5.19% By Volume**

**2015-2020**

**CAGR**

**3.44% By Volume**

*Source: TechSci Research*

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

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Parameters** | **2015** | **2020** | **2021E** | **2025F** | **2030F** |
| **Installed Capacity** | 3766 | 4484 | 4519 | 4588 | 4588 |
| **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 |

*Source: TechSci Research*

**Market Overview (Post Covid)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Demand Scenario** | **2020** | **2021E** | **2024F** | **2028F** | **2030F** |
| **Pessimistic** | **3261** | **3395** | **3718** | **4008** | **4121** |
| **Realistic** | **3261** | **3494** | **4172** | **5055.4** | **5511** |
| **Optimistic** | **3261** | **3576** | **4580** | **6100** | **6974** |

**Global Epoxy Resin Demand Outlook, Realistic,**

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

**Optimistic and Pessimistic, 2021E - 2030F**

Market Leader such as Hexion, Olin, Huntsman and Kukdo are leveraging their market position to benefit from secular growth trends in composite sector

*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.
* 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.

**3.1.1. & 3.1.2. 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 |
| Nan Ya Electronic Material (Kunshan) Co. Ltd. | China | 247 | 247 | 247 | 247 | 247 |
| 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 Co Ltd | China | 210 | 210 | 230 | 230 | 230 |
| 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 |
| Aditya Birla Chemicals Ltd. | 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 |
| Others | Rest of Global | 566 | 653 | 668 | 668 | 668 |
| Total |  | 3766 | 4484 | 4519 | 4588 | 4588 |

*Source: TechSci Research*

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

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, favorable 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.

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

**3.1.4. 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 (Kunshan) Co., Ltd. | 187 | 238 | 258 | 262 | 291 |
| Nan Ya Electronic Material (Kunshan) Co. Ltd. | 201 | 204 | 213 | 210 | 235 |
| Hexion Inc. | 160 | 180 | 196 | 210 | 236 |
| Huntsman Corporation | 144 | 177 | 179 | 188 | 212 |
| Jiangsu Sanmu Group | 137 | 165 | 175 | 172 | 198 |
| Nan Ya Plastics Co Ltd | 158 | 160 | 187 | 196 | 212 |
| The Dow Chemical Company | 149 | 153 | 156 | 162 | 178 |
| Nantong Xincheng Synthetic Material Co Ltd | 99 | 100 | 106 | 101 | 117 |
| Nippon Steel Chemical & Material Co., Ltd. | 82 | 99 | 97 | 106 | 114 |
| Zhuhai Hongchang Electronic Material Co Ltd | 102 | 91 | 98 | 99 | 111 |
| NAMA Chemicals | 91 | 90 | 88 | 94 | 106 |
| Aditya Birla Chemicals (Thailand) Ltd. | 29 | 74 | 81 | 88 | 92 |
| Jiangsu Yangnong Kumho Chemical Co., Ltd. | 61 | 71 | 76 | 74 | 86 |
| Chang Chung Plastics Co Ltd | 37 | 69 | 77 | 80 | 90 |
| 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 |
| Grasim Industries Ltd. | 28 | 49 | 50 | 77 | 81 |
| Anhui Shanfu New Material Technology Co., Ltd. | 45 | 48 | 50 | 49 | 55 |
| Spolchemie A.S. | 44 | 44 | 45 | 48 | 53 |
| Alchemie Ltd. | 44 | 42 | 47 | 49 | 54 |
| Dalian Qihua New Material Co. Ltd. | 41 | 41 | 40 | 39 | 45 |
| Izel Kimya | 31 | 34 | 35 | 36 | 38 |
| Atul Ltd. | 19 | 29 | 32 | 44 | 45 |
| Japan Epoxy Resins | 30 | 28 | 29 | 30 | 34 |
| LEUNA-Harze GmbH | 30 | 24 | 26 | 28 | 31 |
| Ciech Sarzyna | 20 | 20 | 23 | 24 | 26 |
| Hindustan Speciality Chemicals | 0 | 16 | 21 | 25 | 25 |
| SIR Industriale | 15 | 14 | 15 | 16 | 18 |
| Kukdo Chemical India Private Limited | 0 | 0 | 22 | 80 | 85 |
| Meghmani Finechem Ltd | 0 | 0 | 0 | 13 | 21 |
| Others | 390 | 469 | 507 | 519 | 567 |
| Total | 2866 | 3246 | 3485 | 3724 | 4119 |

**3.1.5. Operating Efficiency By Company**

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

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Company | Operating Efficiency (%) | | | | |
| 2015 | 2020 | 2021E | 2025F | 2030F |
| Aditya Birla Chemicals (Thailand) Ltd. | 78 | 74 | 81 | 88 | 92 |
| Alchemie Ltd. | 73 | 70 | 79 | 82 | 90 |
| Anhui Shanfu New Material Technology Co., Ltd. | 77 | 83 | 86 | 85 | 95 |
| Atul Ltd. | 62 | 72 | 80 | 88 | 90 |
| Chang Chung Plastics Co Ltd | 73 | 69 | 77 | 80 | 90 |
| Changchun Chemical (Jiangsu) Co., Ltd. | 86 | 76 | 80 | 78 | 90 |
| Ciech Sarzyna | 65 | 68 | 78 | 80 | 88 |
| Dalian Qihua New Material Co. Ltd. | 83 | 81 | 80 | 78 | 90 |
| Grasim Industries Ltd. | 64 | 75 | 75 | 85 | 90 |
| Hexion Inc. | 77 | 70 | 75 | 81 | 91 |
| Huntsman Corporation | 74 | 67 | 68 | 71 | 80 |
| Izel Kimya | 77 | 85 | 87 | 90 | 95 |
| Japan Epoxy Resins | 74 | 71 | 73 | 75 | 85 |
| Jiangsu Sanmu Group | 80 | 75 | 80 | 78 | 90 |
| Jiangsu Yangnong Kumho Chemical Co., Ltd. | 81 | 75 | 80 | 78 | 90 |
| Kukdo Chemical (Kunshan) Co., Ltd. | 78 | 66 | 72 | 73 | 81 |
| Kukdo Chemical India Private Limited | 0 | 0 | 55 | 80 | 85 |
| Kumho P&B Chemicals | 79 | 72 | 76 | 80 | 88 |
| LEUNA-Harze GmbH | 75 | 59 | 65 | 70 | 78 |
| Meghmani Finechem Ltd | 0 | 0 | 0 | 50 | 85 |
| NAMA Chemicals | 76 | 75 | 73 | 78 | 88 |
| Nan Ya Electronic Material (Kunshan) Co. Ltd. | 81 | 83 | 86 | 85 | 95 |
| Nan Ya Plastics Co Ltd | 75 | 76 | 81 | 85 | 92 |
| Nantong Xincheng Synthetic Material Co Ltd | 83 | 77 | 82 | 78 | 90 |
| Nippon Steel Chemical & Material Co., Ltd. | 82 | 82 | 81 | 88 | 95 |
| Olin Corporation | 75 | 66 | 72 | 80 | 87 |
| Sinopec Baling Petrochemical Co.,Ltd | 86 | 84 | 86 | 85 | 95 |
| SIR Industriale | 73 | 72 | 77 | 80 | 90 |
| Spolchemie A.S. | 74 | 74 | 75 | 80 | 88 |
| The Dow Chemical Company | 74 | 76 | 78 | 81 | 88 |
| Zhuhai Hongchang Electronic Material Co Ltd | 87 | 78 | 84 | 85 | 95 |
| Hindustan Speciality Chemicals | 0 | 53 | 70 | 83 | 83 |
| Others | 69 | 80 | 84 | 81 | 87 |

*Source: TechSci Research*

**3.1.6. Demand By Type**

**Global Epoxy Resin Demand, By Type, 2015–2030F**

*.*

*Source: TechSci Research*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Demand by Type (Thousand Tonnes)** | **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** |

*Source: TechSci Research*

* Bisphenol A (BPA) based Epoxy resins continues to pull strong number in terms of demand by type. 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 market and are likely to maintain a large segment of demand in the coming decade.

**3.1.7. Demand By Grade**

**Global Epoxy Resin Demand, By Grade, 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 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.
* Demand in semi-solid epoxy resin has witnessed a negative growth and will further decline in coming years.

**3.1.8. Demand By Sales Channel**

**Global Epoxy Resin Demand, By Sales Channel, 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*

**3.1.9. Demand By Application**

**Global Epoxy Resin Demand, By Application, By Volume, 2015–2030F**

*.*

*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** |

*Source: TechSci Research*

**3.1.10. 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*

**3.1.11. Demand By Region**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Region/Country** | **2015** | **2020** | **2021E** | **2025F** | **2030F** | **CAGR (2015-2020)** | **CAGR (2021E-2030F)** |
| Asia Pacific | 1594.5 | 2040.1 | 2200.4 | 2870.5 | 3675.0 | 5.1% | 5.9% |
| China | 1204.8 | 1558.9 | 1713.7 | 2279.7 | 2924.4 | 5.3% | 6.1% |
| South Korea | 76.8 | 90.6 | 97.0 | 120.5 | 156.4 | 3.3% | 5.4% |
| India | 65.4 | 88.8 | 98.1 | 139.8 | 207.7 | 6.3% | 8.7% |
| Others | 247.4 | 301.8 | 291.6 | 330.4 | 386.4 | 4.1% | 3.2% |
| Global APAC (Percentage Share) | 57.9% | 62.6% | 63.0% | 65.2% | 66.7% |  |  |
| Europe | 506.8 | 550.6 | 582.0 | 675.1 | 821.8 | 1.7% | 3.9% |
| Germany | 131.0 | 153.0 | 161.4 | 191.6 | 226.2 | 3.2% | 3.8% |
| Spain | 29.2 | 31.4 | 33.0 | 38.2 | 44.4 | 1.5% | 3.4% |
| Italy | 68.5 | 65.1 | 68.8 | 80.7 | 94.0 | -1.0% | 3.5% |
| Others | 278.2 | 301.0 | 318.9 | 364.6 | 457.2 | 1.6% | 4.1% |
| Global Europe (Percentage Share) | 18.4% | 16.9% | 16.7% | 15.3% | 14.9% |  |  |
| North America | 298.9 | 316.6 | 334.7 | 397.0 | 465.3 | 1.2% | 3.7% |
| USA | 240.5 | 253.0 | 260.3 | 291.4 | 326.6 | 1.0% | 2.6% |
| Canada | 36.8 | 47.2 | 56.8 | 84.1 | 112.0 | 5.1% | 7.8% |
| Others | 21.5 | 16.4 | 17.6 | 21.6 | 26.7 | -5.2% | 4.7% |
| Global North America (Percentage Share) | 10.9% | 9.7% | 9.6% | 9.0% | 8.4% |  |  |
| South America | 79.6 | 82.9 | 87.6 | 104.7 | 124.0 | 0.8% | 3.9% |
| Brazil | 58.7 | 62.6 | 65.8 | 78.5 | 93.1 | 1.3% | 3.9% |
| Others | 20.9 | 20.3 | 21.8 | 26.2 | 30.9 | -0.6% | 4.0% |
| Global South America (Percentage Share) | 2.9% | 2.5% | 2.5% | 2.4% | 2.2% |  |  |
| Middle East and Africa | 273.9 | 271.0 | 289.2 | 352.5 | 425.3 | -0.2% | 4.4% |
| Saudi Arabia | 54.6 | 60.1 | 63.5 | 80.5 | 107.7 | 1.9% | 6.1% |
| Turkey | 21.2 | 20.5 | 21.3 | 26.0 | 35.3 | -0.7% | 5.8% |
| Others | 198.0 | 190.4 | 204.4 | 246.0 | 282.3 | -0.8% | 3.7% |
| Global MEA (Percentage Share) | 9.9% | 8.3% | 8.3% | 8.0% | 7.7% |  |  |

*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.

**India Demand Supply Scenario 2015 – 2030F**

**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 Virgin 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.

**India Epoxy Resin Demand, By Volume (Thousand Tonnes), 2015-2030F**

*Source: TechSci Research*

**2021-2030F**

**CAGR**

**8.69% By Volume**

**2015-2020**

**CAGR**

**6.31% 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, 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%** | | | |  |

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.

**India Trade Dynamics, By Value (USD million), By Volume (Thousand tonnes), 2019 - 2021**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Imported Country | 2019 | | 2020 | | 2021 | |
|  | Value | Volume | Value | Volume | Value | Volume |
| South Korea | 24.84 | 9.31 | 32.21 | 14.41 | 36.30 | 14.96 |
| China | 8.98 | 2.40 | 8.76 | 2.64 | 5.92 | 2.20 |
| 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 | 32.35 | 8.55 | 30.02 | 8.81 | 28.21 | 8.36 |
| Total | 89.36 | 26.37 | 93.18 | 32.05 | 90.14 | 29.81 |
| Exported Country | 2019 | | 2020 | | 2021 | |
|  | Value | Volume | Value | Volume | Value | Volume |
| Germany | 18.92 | 7.18 | 12.07 | 5.59 | 13.10 | 5.61 |
| Italy | 19.70 | 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 | 24.13 | 7.90 | 20.46 | 7.47 | 16.58 | 5.66 |
| Total | 80.41 | 29.66 | 59.81 | 25.47 | 50.38 | 19.32 |

*Source: DGFT*

**3.2.2.1. Demand By Application**

**India Epoxy Resin Demand, By Application, By Volume, 2015–2030F**

*Others Marine, Defence, Encapsulation etc .*

*Source: TechSci Research*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Demand by Application** | **2015** | **2016** | **2017** | **2018** | **2019E** | **2020F** | **2021F** | **2025F** | **2030F** |
| Paints & Coatings | 26 | 29 | 32 | 35 | 39 | 46 | 40 | 57 | 85 |
| Electrical & Electronics | 15 | 17 | 18 | 20 | 23 | 26 | 23 | 33 | 50 |
| Construction | 7 | 7 | 8 | 9 | 10 | 12 | 10 | 15 | 22 |
| Composite Materials | 5 | 5 | 6 | 7 | 8 | 9 | 8 | 11 | 17 |
| Adhesives | 4 | 4 | 4 | 5 | 6 | 6 | 6 | 8 | 13 |
| Others | 3 | 3 | 3 | 4 | 4 | 4 | 3 | 5 | 6 |
| **Total** | **65** | **72** | **80** | **89** | **103** | **89** | **129** | **193** | **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.

**3.2.2.2. Demand By Grade**

**India Epoxy Resin Demand, By Grade, By Volume, 2015–2030F**

*Source: TechSci Research*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Demand by Grade** | **2015** | **2016** | **2017** | **2018** | **2019E** | **2020F** | **2021F** | **2025F** | **2030F** |
| Liquid | 30 | 33 | 36 | 41 | 47 | 41 | 59 | 90 | 98 |
| Semi-Solid | 4 | 5 | 5 | 6 | 7 | 6 | 8 | 12 | 97 |
| Solid | 31 | 34 | 38 | 43 | 49 | 42 | 61 | 91 | 13 |
| **Total** | **65** | **72** | **80** | **89** | **103** | **89** | **129** | **193** | **208** |

*Source: TechSci Research*

**3.2.2.3. Demand By Type**

**India Epoxy Resin Demand, By Type, By Volume, 2015–2030F**

*Source: TechSci Research*

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Demand by Type** | **2015** | **2016** | | **2017** | | **2018** | | **2019E** | | **2020F** | | **2021F** | | **2025F** | | **2030F** | |
| Bisphenol A Based Resin | 52 | | 57 | | 63 | | 69 | | 78 | | 89 | | 77 | | 110 | | 169 | |
| Bisphenol F Based Resin | 1 | | 1 | | 1 | | 2 | | 2 | | 3 | | 3 | | 4 | | 13 | |
| Epoxy Phenol Novolac Based Resin | 1 | | 1 | | 1 | | 2 | | 2 | | 2 | | 2 | | 3 | | 4 | |
| Cycloaliphatic Epoxy Based Resin | 1 | | 1 | | 1 | | 1 | | 1 | | 1 | | 1 | | 2 | | 3 | |
| Others | 4 | | 5 | | 5 | | 6 | | 7 | | 7 | | 6 | | 10 | | 18 | |
| **Total** | **59** | | **65** | | **72** | | **80** | | **89** | | **103** | | **89** | | **129** | | **208** | |

*Source: TechSci Research*

**3.1.10. Sales By Company**

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

*Source: TechSci Research*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Demand Volume (Thousand Tonnes)** | **2020** | **2021E** |  | **2020** | **2021** |
| Grasim Industries Ltd. | 42.1 | 37.9 |  | 41.27% | 40.34% |
| Atul Ltd. | 23.9 | 21.3 |  | 23.45% | 22.62% |
| Hindustan Specialty Chemicals Ltd | 12.5 | 17.7 |  | 12.26% | 18.78% |
| Kukdo Chemical India Private Limited | 0 | 1.5 |  | 0.00% | 1.57% |
| Others (Nan Ya Plastics, Kukdo Japan, Aditya Birla Thailand, Hexion)\* | 23.5 | 14.7 |  | 23.02% | 15.69% |

\**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.

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**ASIA PACIFIC EPOXY RESIN MARKET OUTLOOK**

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

|  |  |  |  |
| --- | --- | --- | --- |
| Company | 2015 | 2020 | 2030F |
| Kukdo Chemical (Kunshan) Co., Ltd. | 240 | 360 | 360 |
| Nan Ya Electronic Material (Kunshan) Co. Ltd. | 247 | 247 | 247 |
| Jiangsu Sanmu Group | 170 | 220 | 220 |
| Nan Ya Plastics Co Ltd | 210 | 210 | 230 |
| Nantong Xincheng Synthetic Material Co Ltd | 120 | 130 | 130 |
| Others | 1347 | 1689 | 1773 |
| Total | 2334 | 2856 | 2960 |

*Source: TechSci Research*

**3.2.1. Asia Pacific Demand Supply Outlook**

**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*

**3.2.1.2. Operating Efficiency**

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

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

**3.2.1.3. Demand By Application**

**Asia Pacific Epoxy Resin Demand, By Application, 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 | 76 | 77 | 82 | 88 |
| **Total** | **1594** | **1683** | **1864** | **1924** | **2053** | **2040** | **2200** | **2870** | **3675** |

*Source: TechSci Research*

**3.2.1.4. Demand By Type**

**Asia Pacific Epoxy Resin Demand, By Type, By Volume, 2015–2030F**

*Source: TechSci Research*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Demand by Type** | **2015** | **2016** | **2017** | **2018** | **2019E** | **2020F** | **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 | 169 | 173 | 175 | 170 | 187 | 244 | 325 |
| **Total** | **1594** | **1683** | **1864** | **1924** | **2053** | **2040** | **2200** | **2870** | **3675** |

*Source: TechSci Research*

**3.2.1.5. Demand By Grade**

**Asia Pacific Epoxy Resin Demand, By Grade, 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*

**3.2.1.7. Demand By Sales Channel**

**Asia Pacific Epoxy Resin Demand, By Sales Channel, By Volume, 2015–2030F**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Demand by Sales Channel** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** |
| Direct Company Sale | 927 | 984 | 1113 | 1165 | 1255 | 1266 |
| Indirect | 668 | 699 | 751 | 758 | 798 | 774 |
| **Total** | **1594** | **1683** | **1864** | **1924** | **2053** | **2040** |

*Source: TechSci Research*

**3.1.9. 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*

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 having varied characteristics rising from its specific use of raw materials. Building on the growth in consumer electronics, Nan Ya another key player in the APAC has observed significant growth in its epoxy numbers. Market participants will further look to gain from the strengthening construction sector which has been led by infrastructure development and residential buildings.

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**EUROPE**

**EPOXY RESIN MARKET OUTLOOK**

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

*Source: TechSci Research*

|  |  |  |  |
| --- | --- | --- | --- |
| Company | 2015 | 2020 | 2030F |
| Olin Corporation | 190 | 265 | 265 |
| Hexion Inc. | 80 | 132 | 132 |
| Huntsman Corporation | 50 | 120 | 120 |
| Alchemie Ltd. | 60 | 60 | 60 |
| Spolchemie A.S. | 60 | 60 | 60 |
| Others | 301 | 301 | 301 |
| Total | 741 | 938 | 938 |

*Source: TechSci Research*

**3.2.3. Europe Epoxy Resin Demand Supply Outlook**

**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*

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

*Source: Eurostat*

**3.2.3.1. 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 |
| Italy | 9 |

*Source: TechSci Research*

**3.2.3.3. Demand By Application**

**Europe Epoxy Resin Demand, By Application, 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*

**3.2.3.4. Demand By Type**

**Europe Epoxy Resin Demand, By Type, By Volume, 2015–2030F**

*Source: TechSci Research*

**3.2.3.5. Demand By Sales Channel**

**Europe Epoxy Resin Demand, By Sales Channel, By Volume, 2015–2020F**

*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* |

**3.2.2.4. Demand By Grade**

**Europe Epoxy Resin Demand, By Grade, 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*

**3.2.3.7. 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 | 175.11 | 188.92 |  | 24.02% | 24.93% |
| Europe | Huntsman Corporation | 92.80 | 86.92 |  | 12.73% | 11.47% |
| Europe | Hexion Inc. | 76.25 | 85.41 |  | 10.46% | 11.27% |
| Europe | Spolchemie A.S. | 48.70 | 51.76 |  | 6.68% | 6.83% |
| Europe | Alchemie Ltd. | 44.18 | 48.80 |  | 6.06% | 6.44% |
| Europe | Others | 291.96 | 296.00 |  | 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.

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**NORTH AMERICA EPOXY RESIN MARKET OUTLOOK**

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

*Source: TechSci Research*

|  |  |  |  |
| --- | --- | --- | --- |
| Company | 2015 | 2020 | 2030F |
| Hexion Inc. | 127 | 127 | 127 |
| Olin Corporation | 170 | 170 | 170 |
| Huntsman Corporation | 70 | 70 | 70 |
| Dow Chemical | 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.

**3.2.4. North America Demand Supply Outlook**

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

*Source: TechSci Research*

**3.2.4.2. Operating Efficiency**

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

*Source: TechSci Research*

**3.2.4.3. Demand By Application**

**North America Epoxy Resin Demand, By Application, 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 | 14 | 14 | 13 | 13 |
| **Total** | **299** | **309** | **318** | **326** | **337** | **317** | **335** | **397** | **465** |

*Source: TechSci Research*

**3.2.4.4. Demand By Type**

**North America Epoxy Resin Demand, By Type, By Volume, 2015–2030F**

*Source: TechSci Research*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Demand by Type** | **2015** | **2020F** | **2021F** | **2025F** | **2030F** |
| Bisphenol A Based Resin | 5 | 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*

**3.2.4.5. Demand By Sales Channel**

**North America Epoxy Resin Demand, By Sales Channel, By Volume, 2015–2020F**

*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*

**3.2.4.6. Demand By Grade**

**North America Epoxy Resin Demand, By Grade, 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*

Liquid Epoxy resin (LER) is anticipated to be the fastest growing segment due to increased demand for coating and adhesives application. LER based resins are also find its usage in manufacturing of specialized application such as composites and electronics industry. In coming years, solids epoxy resin using liquid epoxy resin will continue to grow. Liquid epoxy resin is also used for tank linings.

**3.2.4.7. 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. | 118.49 | 120.86 |  | 27.81% | 27.51% |
| North America | Olin Corporation | 163.09 | 159.57 |  | 38.28% | 36.32% |
| North America | Dow Chemical | 56.49 | 58.96 |  | 13.26% | 13.42% |
| North America | Huntsman Corporation | 61.69 | 68.14 |  | 14.48% | 15.51% |
| North America | Others | 26.29 | 31.81 |  | 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.

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**SOUTH AMERICA EPOXY RESIN MARKET**

**OUTLOOK**

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

*Source: TechSci Research*

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

*Source: TechSci Research*

**3.2.5. South America Epoxy Resin Demand Supply Outlook**

**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**

**3.2.5.2. Operating Efficiency**

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

*Source: TechSci Research*

**3.2.5.3. Demand By Application**

**South America Epoxy Resin Demand, By Application, 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*

**3.2.5.4. Demand By Type**

**South America Epoxy Resin Demand, By Type, By Volume, 2015–2030F**

*Source: TechSci Research*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Demand by Type** | **2015** | **2016** | **2017** | **2018** | **2019E** | **2020F** | **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*

**3.2.5.5. Demand By Sales Channel**

**South America Epoxy Resin Demand, By Sales Channel, 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** |

**3.2.5.6. Demand By Grade**

*Source: TechSci Research*

**South America Epoxy Resin Demand, By Type, 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*

**3.2.5.7. 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.

A picture containing dome

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**MIDDLE EAST & AFRICA EPOXY RESIN MARKET**

**OUTLOOK**

A picture containing cup, coffee, food, beverage

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

*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 |

*Source: TechSci Research*

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. |

**3.2.6. Middle East & Africa Epoxy Resin Demand Supply Outlook**

**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**

*Source: TechSci Research*

**3.2.6.2. Operating Efficiency**

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

*Source: TechSci Research*

**3.2.6.3. Demand By Application**

**Middle East & Africa Epoxy Resin Demand, By Application, 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 | 12 | 11 | 11 | 12 | 13 | 14 | 15 | 16 |
| **Total** | **274** | **284** | **292** | **277** | **290** | **271** | **289** | **352** | **425** |

*Source: TechSci Research*

**3.2.6.4. Demand By Type**

**Middle East & Africa Epoxy Resin Demand, By Type, By Volume, 2015–2030F**

*Source: TechSci Research*

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Demand by Type** | **2015** | **2016** | **2017** | **2018** | **2019E** | **2020F** | **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** |

*Source: TechSci Research*

**3.2.6.5. Demand By Sales Channel**

**Middle East & Africa Epoxy Resin Demand, By Sales Channel, 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** | **379** | **402** | **436** | **406** | **414** | **366** |

*Source: TechSci Research*

**3.2.6.6. Demand By Grade**

**Middle East & Africa Epoxy Resin Demand, By Grade, 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*

**3.2.6.7. 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 | 114.65 | 129.99 |  | 30.04% | 32.82% |
| MEA | Izel Kimya | 36.30 | 47.85 |  | 9.51% | 12.08% |
| MEA | Olin Corporation | 34.92 | 42.14 |  | 9.15% | 10.64% |
| MEA | Hexion Inc. | 31.79 | 22.38 |  | 8.33% | 5.65% |
| MEA | Others | 164.00 | 153.72 |  | 42.97% | 38.81% |

*Source: TechSci Research*

NAMA Chemicals, Al-Jubail headquartered, Saudi Arabian petrochemical giant 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.

***3.3. MARKET DYNAMICS***

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Green Colour Represent Drivers

Red Colour Represent Challenges

**Rising investment in building & construction sector**

**Government Support and Initiatives**

**Rising Disposable Income & High Living Standards**

**Focus on renewables**

**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***

With increasing population and continuing economic growth, infrastructure, as well as construction sector spending is rising 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. Various government sponsored projects across the globe such as smart cities, AMRUT, freight corridor and urban transport, etc., are expected to provide a huge boost to 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, will also be supporting government’s initiatives across various developing countries, hence giving a big push to the market of epoxy resin such as, ‘Make in India’ initiative by the Government of India. In 2021, per capita consumption of composites in the United States and China was reported to be 11.4 kg and 2.8 kg, respectively. Additionally, the per capita consumption in India stood at 0.36 kg. 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.

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

The demand for advanced and premium quality paints & coatings is increasing across the housing and construction sector due to high living standards across developed nations, including improving disposable income across developing countries and driving the epoxy resin market in the forthcoming years. This is further supported by increasing per capita expenses on premium cars across the globe. Moreover, the disposable income level of the middle-class population across various countries is increasing and has significantly augmented the demand for epoxy-based lightweight coatings and adhesives over the years, further driving the market worldwide.

***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 is driving down the market sales in recent years due to several disruptions caused by the COVID-19 outbreak worldwide. Moreover, rising crude oil prices directly impact the operating cost and profit margins of the industry, and higher transportation costs, adding up the price of epoxy resins in the global market. Inflation of raw material costs drives down the demand for these films, which is emerging as one of the major constraints for the overall market growth worldwide.

**3.4. Market Trends & Developments**

**Epoxy Resin-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 $2710/tonne levels in Oct. over $3500s level in Apr. 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.

**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 fiber and Resin. The cost breakup for CCL is- 30-50%: copper foil, 24-40%: Glass Fiber 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.

***Emerging Applications***

Ban on the usage of Bisphenol A has increased the consumption of Epoxy Resin in various applications, such as producing intermediates, high performance polymers, heat sensitive developers, etc. Recently, BPS has substituted BPA-based epoxy resins which are generally used in food packaging containers. Epoxy resins are also used in aerospace plastics as a binder for reinforcements such as glass, carbon or Kevlar. Growing utilization of epoxy resin in epoxy resins is likely to increase its foothold in the market over coming years. Besides, it is anticipated that Epoxy Resin might replace BPA in the polycarbonate production, which may further boost the demand for Epoxy Resins in the coming years.

**3.5 Technology Evaluation:**

This section aims to provide the different technologies that are available for the third-party licensing. This would provide you with a brief about the process details, process flow diagram and formulated resins description.

Technology 1 is the technology provided by Nippon Steel & Simikin Chemical Co Ltd. (formerly Tohto Kasei Co. Ltd.). It was established in 2010 whereas Technology 2 is the technology provided by Ciba-Geigy AG of Switzerland that was established in 1943.

Other manufacturing companies like Kukdo Chemical Co., Ltd and Olin Corporation have devised and patented their production technology process and are not open for third party licensing.

A brief introduction about the two technologies has been discussed below:

**Technology 1: Nippon Steel & Simikin Chemical Co Ltd. (formerly Tohto Kasei Co. Ltd.) (Japanese firm):**

**Process Details:**

**Pre-reaction Section**

Reaction starts with adding Excessive quantity of Epichlorohydrin (Fresh & recovered) with prescribed quantity of Bisphenol-A by using NaOH as catalyzer. As result of this reaction, Bisphenol-A chlorohydrin intermediate is formed.

Graphical user interface, text, application

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**Reaction Section**

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.

Graphical user interface, text, application

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**ECH Detachment Section**

After the reaction process is done, excessive quantities of unreacted ECH are separated from the product by increasing the temperature and recovered through a vaporizer, the same is returned to the ECH day tank 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.

**Refining**

In this section washing is done, toluene is added to dissolve resin in it. After continuous stirring, the allowed salt solution is allowed to settle in the gravity settler. The salt solution is then separated from the resin manually by adding water. Again, demineralised water is added to wash the resin and remove the traces of salt from it.

**Filtration**

After refining, filtration is done to remove the impurities, suspended particles and the rest of waste polymer by passing through a multilayer paper filter.

**Product Finishing Section:** Finally, Epoxy resin is filtered to remove suspended filter cake via sparkler filter and is sent to the product tank through mixing tank.

**Dissolvent:** In this section, toluene is recovered via steam stripping at 1200 C. Dissolvent is done to remove the solvent toluene from the resin by passing through falling film thin evaporator & rotary film thin evaporator under vacuum.

**ECH Stripping:** ECH evaporated during reaction contains ECH along with water. The water is stripped off in the distillation unit while recovered pure ECH is recycled for the next batch.

**ECH Distillation:** ECH vapours from the ECH detachment section are recovered and distilled in this section to recover pure ECH which is recycled.

**Process Flow Diagram:**

**Reactor**

**Reactor**

**Distillation**

**1st Stage Distillation**

**2nd Stage Distillation**

**Reactor**

**Washing**

**Distillation**

**Decanter**

**ECH**

**BPA**

**Vent 1**

**Vent 2B**

**Vent 2A**

**Vent 3A**

**Vent 3B**

**H2O**

**To Steam Stripper**

**NaOH**

**Option B**

**Option A**

**DCH**

**Glycerol DCH**

**15% NaOH**

**MIBK**

**H2O**

**Dilute Acid Solution**

**H2O**

**To Steam Stripper**

**Alkaline Brine Solution to steam stripper**

**Vent 4**

**Vent 5**

**Vent 6**

**Packaging**

**Crude DGEBPA**

**Solid Epoxy Resin:**

**Pre-Reaction Section:** In this section, Liquid Epoxy Resin, Bisphenol A & catalyst are added to the reactor (BPA & catalyst are added in 2 Stages then with the progress of the reaction, 2nd lot of BPA & catalyst are added).

**Reaction Section:** Here reaction mixture from the pre-reaction section is added with a solvent in controlled range of pressure (5-7 Bar) & temperature (70-750 C).

**Solidification Section:** Here Epoxy Resin (i.e., formed in the reaction section) is passed through the flaker (with required utilities (chilled water & steam)) & then further pass through the crusher to collect the final solid product.

**Process Flow Diagram:**

**Xylene\***

**Jacketed Reactor.**

**Pre-Reaction Section**

**Reactor2**

**Reaction Section 70°C-80°C, 4 hrs**

**Flaker, 15°C chilled water**

**Crusher**

**Packer**

**Dust Collector**

**180°C -190°C**

**Hot Oil, 220°C**

**Oil, 50°C**

**5-7 Bar**

**Solid Epoxy Resin**

**BPA, Liquid Epoxy Resin, NaOH, Methanol\*, Catalyst**

ss

*\*For the suppression of catalytic reaction, a few amounts of methanol is added in reactor.*

*\*Xylene is added only for the manufacturing of high molecular solvent cut epoxy resin and it is not recovered in the process.*

**Formulated Resins:**

**Mixing:** Different grades of Liquid Epoxy resins are mixed with various types of additives or reactive diluents to meet customer specific applications.

**Technology-2: Ciba-Geigy AG**

**Process Detail:**

**Pre-reaction Section**

Reaction starts with adding Excessive quantity of Epichlorohydrin (Fresh & recovered) with prescribed quantity of Bisphenol-A by using NaOH as catalyzer. As result of this reaction, Bisphenol-A chlorohydrin intermediate is formed.

Graphical user interface, text, application

Description automatically generated

**Reaction Section**

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 the 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 yield.

Graphical user interface, text, application

Description automatically generated

**ECH Stripping & Recovery:** ECH Evaporated during reaction contains ECH and water. Water is stripped off in the distilled unit and pure ECH is recycled for the next batch.

**Refining:** In this section, toluene is added to dissolve resin in it and the salt solution is separated from the resin manually by adding 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, DM water is added to wash the resin and remove the traces of salt from it.

**Dissolvent:** After filtration section, epoxy Resin been sent to reboiler & vacuum distillation column for Toluene recovery.

**Product Finishing Section:** Epoxy resin is finally filtered to remove the traces of impurities.

**Process Flow Diagram:**

**Pre-Reactor**

**Reactor**

**Evaporator**

**Washing/Gravity Separation**

**Condensate with stirrer at 60 RPM**

**Filtration Unit**

**ETP Treatment**

**Sludge**

**Salt Packaging**

**Solid Disposal**

**Packer**

**BPA, ECH, NaOH**

**Unreacted ECH**

**NaOH 48%**

**Dehydrated H2O**

**Toluene**

**Water**

**Steam 100°C**

**Note\*: Process for Solid & Formulated Resin is the same for Technology 2.**

**Technology Evaluation:**

* 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.
* As there are 100’s of grades available in all 3 major types (i.e., solid, liquid & semisolid) for different applications, there is no need for a separate reactor for every grade.
* Technology 1 is newer than Technology 2 in terms of ease of process, therefore preferable.
* There are fewer leading companies having their own technology & related patents, but they don’t share same with anyone outside.

|  |  |  |  |
| --- | --- | --- | --- |
| **Technology** | **Plants** | **Current Capacity** | **Anticipated Capacity** |
| Ciba-Geigy AG | Atul Limited | 40 KTPA | 50 KTPA (By 2024) |
| Hindustan Speciality Chemical Ltd. | 30 KTPA | 30 KTPA |
| Tohto Kasei Co. Ltd. | Grasim Industries Ltd. | 66 KTPA | 90 KTPA (By 2025) |

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 the technology of Ciba-Geigy AG. 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.

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

*Source: TechSci Research*

Chemical and petrochemical sector is leading to a drop in prices of Epoxy Resins along with various other products. Market fundamentals of Epoxy Resin revived significantly in 2017 following a sharp rebound in market activities. However, in 2018 and 2019, prices fluctuated in a stable to narrow range amidst the uncertainty prevailing from stable feedstock and muted

demand patterns from several downstream industries. In 2020, Epoxy Resin witnessed a marginal dive again due to a ground-breaking fall in crude values and a devastating hit on the global economy in the wake of the COVID-19 outbreak. Despite the second wave of COVID-19 in India, prices showcased an appreciable rebound in 2021 due to consistent demand pattern and spillover effect of high international prices.

**3.7 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.

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

**BPA:** Phenol & Acetone

(Mole Ratio 2:1)

**Manufacturer**

**Percentage Margin 26 %**

**Including Transportation charges**

**Direct Sales**

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

Raw Material Cost

(USD 1.67/kg)

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

Caustic Soda Lye (48%)

Current Selling Price (USD 3.09/kg) Direct Sales

Total Cost Incurred (USD 2.39/ kg)

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

**Percentage Margin 29 %**

**In-Direct Sales**

**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

**Epoxy Resin Value Chain**

**Manufacturer**

**Percentage Margin 22.34%**

**Including Transportation charges**

Current Selling Price (USD 3.49/kg) In-Direct Sales

Raw Material Cost (USD 2.05/kg)

**In-Direct Sales**

**Direct Sales**

**Percentage Margin 24.01%**

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

Bisphenol-A

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

Xylene

Catalyst (Recoverable)

Current Selling Price (USD 3.57/kg) Direct Sales

Total Cost Incurred (USD 2.77/Kg)

**Distributor/Retailer**

**End User**

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

BPA: USD 1.4/kg

**Manufacturer**

**Percentage Margin 10.5%**

**Including Transportation charges**

**Percentage Margin 12.36 %**

ECH: USD 1.6/kg

Overhead + Packaging Cost

(USD 0.72/Kg)

Raw Material Cost (USD 2.03/kg)

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

Current Selling Price (USD 3.09/kg) Direct Sales

Total Cost Incurred (USD 2.75/kg)

Current Selling Price

(USD 3.03/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 2.75/kg

**Epoxy Resin Value Chain**

**Manufacturer**

**Percentage Margin 8.3 %**

**Including Transportation charges**

Current Selling Price (USD 3.49/kg) In-Direct Sales

Current Selling Price (USD 3.57/kg) Direct Sales

Raw Material Cost (USD 2.48/kg)

**In-Direct Sales**

**Direct Sales**

**Percentage Margin 10.17%**

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

Bisphenol-A: USD 1.4/kg

Overhead + Packaging Cost (USD 0.72 /kg)

Xylene: USD 0.55/kg

Catalyst (Recoverable)

Total Cost Incurred (USD 3.2/kg)

**Distributor/Retailer**

**End User**

**3.8 Cost of Production**

This section aims to provide you with an overview on the production costs that is the total cost incurred by a manufacturer to produce a specific quantity of a product. It includes fixed cost that consists of repair & maintenance, salaries & wages, research & development, corporate overheads whereas variable costs consist of raw material, packaging materials, catalyst and chemicals and other utilities costs. Variable Costs are subject to variation depending on market conditions and production volume modifications.

Epoxy resin production involves two technologies of production, where both technologies are similar in terms of prices of raw materials as both technologies of production involve identical raw materials application. Bisphenol A, Epichlorohydrin and Caustic soda are used at varied stages of production. Technology 2 requires low cost of packaging material, catalysts and utilities which makes technology 2 slightly cost effective in regard to variable cost in comparison to Technology 1. Fixed cost which includes Repair & Maintenance, Salaries & Wages, Research & Development, and Corporate Overheads has also witnessed similar pattern where Technology 2 edges out Technology 1. In overall cost of production, it has been seen that Technology 2 is marginally cost effective than Technology 1. However, there isn’t much to separate the two as both require same set of raw materials

Table mentioned below provides a comparison between the two technologies and the variations incurred in fixed and variable costs:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **PARAMETERS** | | **COST OF PRODUCTION: Technology 1** | | | **COST OF PRODUCTION: Technology 2** | | |
|  |
|  | | **Quantity** | **Unit Rate** | **Amount** | **Quantity** | **Unit Rate** | **Amount** |  |
| **Tonne** | **USD/Tonne** | **USD** | **Tonne** | **USD/Tonne** | **USD** |  |
| **A** | **VARIABLE COST** |  | | | | | |  |
| 1 | Raw Materials |  |
| BPA | 0.7 | 1400.0 | 974.4 | 0.7 | 1400.0 | 974.4 |  |
| ECH | 0.6 | 1600.0 | 900.6 | 0.6 | 1600.0 | 900.6 |  |
| Caustic Soda | 0.5 | 150.0 | 75.0 | 0.5 | 150.0 | 75.0 |  |
| Sub-Total (1) | **1.8** | **3150.0** | **1950.0** | **1.8** | **3150.0** | **1950.0** |  |
| 2 | Packing Materials, Catalyst & Chemicals, Utilties |  | | 260.0 |  | | 255.0 |  |
|  | **TOTAL VARIABLE COST** | **2210.0** | **2205.0** |  |
|  | |  |  |  |
| **B** | **FIXED COST** |  |
| 1 | Repair & Maintenance | **454.4** | **415.0** |  |
| 2 | Salaries & Wages |  |
| 3 | Research & Development |  |
| 5 | Corporate Overheads |  |
|  | **TOTAL FIXED COST** | **454.4** | **415.0** |  |
|  | |  |  |  |
| **C** | **VARIABLE + FIXED COST** | **2664.4** | **2620.0** |  |
|  | |  |  |  |
| **D** | **INTEREST ON WORKING CAPITAL** | **35.0** | **35.0** |  |
|  | |  |  |  |
| **E** | **CASH MANUFACTURING COST** | **2699.4** | **2655.0** |  |
|  | |  |  |  |
| **F** | **DEPRECIATION (5.28%)** | **52.0** | **52.0** |  |
|  | |  |  |  |
| **G** | **PRODUCTION COST** | **2751.4** | **2707.0** |  |

**3.9. Customer Analysis**

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

*Source: TechSci Research*

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

**3.10. 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*

**3.8. Global Demand-Supply Gap**

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

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021E** | **2025F** | **2030F** |
| **Capacity** | 3765.50 | 3795.50 | 4048.00 | 4284.00 | 4419.00 | 4484.00 | 4519.00 | 4648.00 | 4648.00 |
| **Production** | 2866.28 | 2986.35 | 3150.56 | 3328.00 | 3470.41 | 3246.33 | 3485.36 | 3723.96 | 4119.41 |
| **Total Demand** | 2753.56 | 2891.29 | 3110.44 | 3187.00 | 3364.65 | 3261.08 | 3493.88 | 4400.00 | 5511.29 |
| **Demand Supply Gap** |  | | | | | | -8.52 | -675.75 | -1391.88 |

*Source: TechSci Research*

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

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021E** | **2025F** | **2030F** |
| **Capacity** | 2334.5 | 2364.5 | 2607.0 | 2701.0 | 2816.0 | 2856.0 | 2891.0 | 2960.0 | 2960.0 |
| **Production** | 1819.3 | 1908.0 | 2062.0 | 2142.3 | 2261.9 | 2134.8 | 2302.8 | 2444.9 | 2711.9 |
| **Import** | 382.5 | 417.2 | 463.6 | 446.3 | 474.0 | 555.6 |  | | |
| **Export** | 607.3 | 642.2 | 661.9 | 665.0 | 682.9 | 650.3 |
| **Total Demand** | 1594.5 | 1683.0 | 1863.8 | 1923.5 | 2053.0 | 2040.1 | 2200.4 | 2870.5 | 3675.0 |
| **Demand Supply Gap** |  | | | | | | 102.3 | -425.5 | -963.1 |

*Source: TechSci Research*

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

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021E** | **2025F** | **2030F** |
| **Capacity** | 741.0 | 741.0 | 751.0 | 893.0 | 913.0 | 938.0 | 938.0 | 938.0 | 938.0 |
| **Production** | 525.5 | 541.8 | 562.9 | 670.0 | 695.9 | 621.1 | 676.8 | 741.0 | 812.2 |
| **Import** | 241.4 | 261.1 | 273.7 | 199.6 | 213.9 | 200.0 |  | | |
| **Export** | 260.1 | 272.6 | 281.9 | 295.9 | 310.4 | 270.4 |
| **Total Demand** | 506.8 | 530.3 | 554.7 | 573.7 | 599.4 | 550.6 | 582.0 | 675.1 | 821.8 |
| **Demand Supply Gap** |  | | | | | | 94.8 | 66.0 | -9.6 |

*Source: TechSci Research*

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

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021E** | **2025F** | **2030F** |
| **Capacity** | 427.0 | 427.0 | 427.0 | 427.0 | 427.0 | 427.0 | 427.0 | 427.0 | 427.0 |
| **Production** | 321.4 | 325.4 | 318.5 | 311.9 | 320.2 | 287.4 | 299.0 | 319.9 | 356.6 |
| **Import** | 79.5 | 89.4 | 111.4 | 119.5 | 129.3 | 116.2 |  | | |
| **Export** | 102.0 | 105.9 | 111.7 | 105.0 | 112.9 | 86.9 |
| **Total Demand** | 298.9 | 308.9 | 318 | 326.4 | 336.6 | 316.6 | 334.7 | 397.0 | 465.3 |
| **Demand Supply Gap** |  | | | | | | -35.6 | -77.2 | -108.7 |

*Source: TechSci Research*

**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*

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

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021E** | **2025F** | **2030F** |
| **Capacity** | 220.0 | 220.0 | 220.0 | 220.0 | 220.0 | 220.0 | 220.0 | 220.0 | 220.0 |
| **Production** | 166.6 | 175.5 | 172.1 | 169.8 | 159.2 | 171.4 | 173.8 | 183.6 | 200.6 |
| **Import** | 141.5 | 157.1 | 181.8 | 162.7 | 177.1 | 144.1 |  | | |
| **Export** | 34.2 | 48.2 | 62.1 | 55.2 | 45.9 | 44.4 |
| **Total Demand** | 273.9 | 284.4 | 291.7 | 277.3 | 290.4 | 271.0 | 289.2 | 352.5 | 425.3 |
| **Demand Supply Gap** |  | | | | | | **-115.4** | **-168.9** | **-224.7** |

*Source: TechSci Research*

**India Epoxy Resin Market Demand and Gap Analysis, By Volume, 2021, 2024, 2028 and 2030 – Optimistic, Pessimistic and Realistic**

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 natural gas, uncertainties in energy feedstock market outlook adversely impacts the petrochemical market. In lieu of that prospects of epoxy resin also get severely hampered. The series of covid waves through various evolved variants of coronavirus is also considered to be a key market determinant in the long term which may affect the GDP growth rate. Covid in the past have 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. 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 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.

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.

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 augurs well for construction sector in terms of demand growth. Increased inclination towards digitization, India looks to gain traction from Bharat Net and push for complete digital literacy. Indian government has envisioned to make country a manufacturing hub and increasing its GDP share to 25% by 2022, in lieu of that government has taken several initiatives and made various policy changes to attract FDIs as well as promoting domestic manufacturing sector. India is in line with its renewable energy target and will look to consolidate by focusing on renewable sources, particularly wind energy. Advancements in material science present abundant opportunities to explore growth in renewable energy sector through manufacturing of wind turbines and other equipments. Construction industry, electrical and electronics industry along with automotive industry will led demand growth encouraging aggressive capacity expansions throughout the country.

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

**KEY GROWTH FACTORS**

**01**

**02**

**03**

**Rising Disposable**

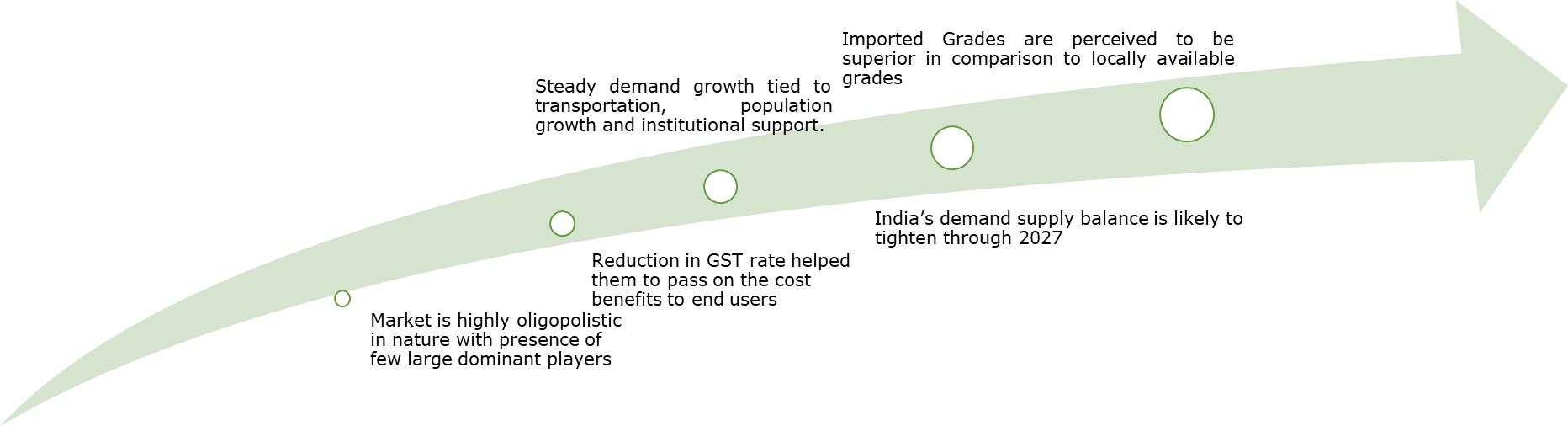
**Income**

**Shorter Repainting Cycle**

**Reduced GST (28 to 18%)**

**04**

**Increasing Focus on Renewable sector**



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

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** | **2025F** | **2030F** |
| **Capacity** | 84.0 | 84.0 | 106.0 | 136.0 | 176.0 | 176.0 | 235.0 | 235.0 | 235.0 |
| **Production** | 55.7 | 68.6 | 89.1 | 89.7 | 101.6 | 93.9 | 119.8 | 193.5 | 210.0 |
| **Import** | 42.1 | 37.5 | 26.4 | 32.1 | 29.8 | 27.5 |  |  |  |
| **Export** | 26.4 | 28.2 | 29.7 | 25.5 | 19.3 | 26.6 |  |  |  |
| **Inventory** | 5.9 | 6.1 | 6.2 | 6.8 | 9.1 | 6.0 |  |  |  |
| **Total Demand** | 65.4 | 71.8 | 79.7 | 89.5 | 103.0 | 88.8 | 98.1 | 139.8 | 208.0 |
| **Demand Supply Gap** |  |  |  |  |  |  | 21.7 | 53.7 | 2.0 |

*Source: TechSci Research*

**3.12 Suggested Capacities (Idea Product Mix and Capacity recommendation)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Demand Scenario** | **2020** | **2021E** | **2024F** | **2028F** | **2030F** |
| **Pessimistic** | **88.83** | **92.09** | **110.92** | **137.53** | **168.44** |
| **Gap** |  | **27.71** | **79.08** | **67.47** | **41.56** |
| **Realistic** | **88.83** | **98.11** | **128.53** | **178.41** | **207.44** |
| **Gap** |  | **21.69** | **61.47** | **26.59** | **2.56** |
| **Optimistic** | **88.83** | **103.25** | **144.75** | **220.08** | **255.62** |
| **Gap** |  | **16.55** | **45.25** | **-15.08** | **-45.62** |

**Salient Features of the Study**

***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, Middle East & North America and deficit in APAC, 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 China, Japan, 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 100 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 also exists, if required. However, exports are not advisable from realization point of view as domestic sale is more lucrative than exports.

**Recommendations**

* RIL may consider setting-up a 100 thousand tonnes Epoxy Resin (base resin, formulated resin, hardener and diluent) unit by the year 2025 as enough scope exists from demand – supply point of view. However, before taking up this decision, RIL should also consider the project from economic viability point of view.
* Considering capacity utilization of 60 percent in first year and 90 percent in second year onwards, 60 percent quantity is likely to be absorbed within the country itself.
* The company can use one third of epoxy resin (liquid and solid) to produce vinyl ester resin.
* RIL needs to explore export market for both standard and specialized epoxy resin.

**Suggested Epoxy Resin plant capacity in MT / Annum**

*Source: TechSci Research*

|  |  |  |
| --- | --- | --- |
| **Name of the Product** | **2025** | **2030** |
| **Liquid Epoxy Resin\*** | 20,000 | 20,000 |
| **Solid and Semi Solid Epoxy Resin\*** | 12,000 | 12,000 |
| **Solvent Based Epoxy Resin** | 5000 | 5000 |
| **Formulated Epoxy Resin** | 5000 | 5000 |
| **Total** | **42,000** | **42,000** |
| **Epoxy System Plant Capacity** | | |
| **Hardeners** | 5000 | 5000 |
| **Reactive diluents** | **3000** | **3000** |
| **Total** | **8000** | **8000** |

**4. Project Description**

**4.3.5 Major Equipment List (List of major equipment in terms of value & importance)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Technology 1:**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | S No | Equipment | Type | Tag No | MOC | | 1 | Caustic Preparation Solution Tank (48% Caustic) | FRP Vessel | V-101 | FRP | | 2 | Caustic transfer pump | Gear Pump | P-101 | FRP/PTFE | | 3 | BPA Storage Vessel Or Hopper (if Solid) |  | V-102 | SS304 | | 4 | BPA Transfer Pump (if Solid, pump is not required) | Centrifugal Pump | P-102 | SS304 | | 5 | ECH Storage Tank |  | V-103 | SS304 | | 6 | ECH Transfer Pump | Centrifugal Pump | P-103 | SS304 | | 7 | Pre-Reactor | Horizontal Reactor | R-101 | SS304 | | 8 | Reaction solution Transfer pump | Gear pump | P-104 | SS304 | | 9 | Reactor |  | R-102 |  | | 10 | Reaction solution Transfer pump 2 |  | P-104-1 |  | | 12 | Distillation Tower | Vacuum Distillation | X-101 | SS304 | | 13 | Solvent Storage Tank (Toluene) |  | V-105 | SS304 | | 14 | Solvent transfer pump | Centrifugal Pump | P-105 | SS304 | | 15 | Washing Tower |  | V-104 | SS304 | | 16 | Gravity Separator |  | Y-01 |  | | 17 | Soln Transfer pump |  | P-106 |  | | 18 | Ditillation Tower | Vaccum Distillation | X-102 |  | | 19 | Soln Transfer pump 2 |  | P-107 |  | | 20 | Sparkler Filter |  | F-101 |  | | 21 | Mixing Tank |  | M-101 |  | | 22 | Product Tank |  | PR-101 |  | | 23 | UF/RO System |  | T-101 |  | | 24 | DG (2 No's) |  | DG-101 & 102 |  | | 25 | Adsorption Column (5 No's) |  |  |  | | 26 | Dust Collector (5 No's) |  |  |  | | 27 | Cooling Tower |  | C-101 |  | |  |  |  |  |  | | **1.2** | **Equipment list for SER** |  |  |  | | 1 | LER Storage tank |  | V-201 |  | | 2 | Pump | Gear Pump | P-201 |  | | 3 | Reactor |  | R-201 |  | | 4 | Hopper |  | H-201 |  | | 5 | Chiller |  | X-201 |  | | 6 | Heat Exchanger | Shell & tube Heat Exchanger | E-201 |  | | 7 | Pump | Centrifugal Pump | P-202 |  | | 8 | Flaker (Hammer Crosser & Hand Crosser Type) |  | S-201 |  |   **Technology 2**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | S No | Equipment | Type | Tag No | MOC | | 1 | Caustic Preparation Solution Tank (48% Caustic) | FRP Vessel | V-301 | FRP | | 2 | Caustic transfer pump | Gear Pump | P-301 | FRP/PTFE | | 3 | BPA Storage Vessel Or Hopper (if Solid) |  | V-302 | SS304 | | 4 | BPA Transfer Pump (if Solid, pump is not required) | Centrifugal Pump | P-302 | SS304 | | 5 | ECH Storage Tank |  | V-303 | SS304 | | 6 | ECH Transfer Pump | Centrifugal Pump | P-303 | SS304 | | 7 | Pre-Reactor | Horizontal Reactor | R-301 | SS304 | | 8 | Reaction solution Transfer pump | Gear pump | P-R-304 | SS304 | | 9 | Reactor |  | R-302 |  | | 10 | Reaction solution Transfer pump 2 |  | P-R-305 |  | | 12 | Distillation Tower | Vacuum Distillation | X-301 | SS304 | | 13 | Solvent Storage Tank (Toluene) |  | V-305 | SS304 | | 14 | Solvent transfer pump | Centrifugal Pump | P-305 | SS304 | | 15 | Dehydration tank |  | V-306 | SS304 | | 16 | Solution transfer pump 3 |  | P-306 |  | | 17 | Gravity Separator |  | Y-301 |  | | 18 | Soln Transfer pump 4 |  | P-Y-106 |  | | 19 | Ditillation Tower | Vaccum Distillation | X-102 |  | | 20 | Soln Transfer pump 5 |  | P-107 |  | | 21 | Washing tank |  | W-101 |  | | 22 | Reboiler |  | M-101 |  | | 24 | UF/RO System |  | T-101 |  | | 25 | DG (2 No's) |  | DG-101 & 102 |  | | 26 | Adsorption Column (5 No's) |  |  |  | | 27 | Dust Collector (5 No's) |  |  |  | | 28 | Cooling Tower |  | C-101 |  | |  |  |  |  |  | | **1.2** | **Equipment list for SER** |  |  |  | | 1 | LER Storage tank |  | V-201 |  | | 2 | Pump | Gear Pump | P-201 |  | | 3 | Reactor |  | R-201 |  | | 4 | Hopper |  | H-201 |  | | 5 | Chiller |  | X-201 |  | | 6 | Heat Exchanger | Shell & tube Heat Exchanger | E-201 |  | | 7 | Pump | Centrifugal Pump | P-202 |  | | 8 | Flaker (Hammer Crosser & Hand Crosser Type) |  | S-201 |  | |

**4.3.8 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 |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **4.3.1 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** | **Viscosity1 @ 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^1 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 | | Tubes, Cans and Coil coatings | 2,381 - 2,941 | 5,000 - 10,000 | 125 - 140 |  |  |  |  | | --- | --- | --- | | **BISPHENOL-F BASED LIQUID EPOXY RESINS** | | | | **Application** | **EEW (g/eg)** | **Viscosity^1 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^1 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^1 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 | | Composites, Electrical and Coating applications. | 167 - 179 | 35,000 - 55,000 | | Composites, Electrical and Coating applications. | 167 - 182 | 25,000 - 35,000 |  |  |  |  |  | | --- | --- | --- | --- | | **GLYCIDYL AMINE BASED MULTIFUNCTIONAL RESINS** | | | | | **Application** | **EEW (g/eg)** | **Viscosity^1 25°C (mPa∙s)** | **HyCl %** | | High Performance Composites (aviation and marine) | 117 - 134 | 7,000 - 11,000^2 @ 50°C | Max 0.10 | | 118 - 134 | 7,000 - 19,000^2 @ 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)** | **Viscosity^1 25°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 |   **4.3.2 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 (BPA) and epichlorohydrin (ECH) in presence of a catalyst (such as a quaternary ammonium salt), the first step by an addition reaction is to form a diphenol-propane chlorohydrin ether as intermediate, and the second step is to be carried out in presence of Caustic, this closed loop reaction produces an Epoxy Resin.  **Production process of solid bisphenol A Epoxy Resin**  **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 ECH 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.  **Cons of Taffy Process**: In this process insoluble polymers are formed, which create handling and disposal problem.  **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.  Diagram  Description automatically generated  **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.)  BisA = EEWi – 1 – EEWf – 1 EEWi – 1 + PEW - 1  where Bis A is mass fraction of bisphenol A in the mixture at initial stage, 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.  **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 hyroxide 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  **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.  The main uses fall in these classes:   * Resin in solvent—coatings varnishes & laminated structure. * Resins in water solutions – adhesive bonding * Solid resin—all types of thermoset molded solid forms.   Phenol  Autoclave Reaction Vessel  Formaldehyde  Caustic Flakes  Stirring & heating up to 600 C  Dilution  Product: Phenol Formaldehyde Resin  Cooling  Vacuum Distillation  Reflux for 30-40 min.  Water  Methanol    **Cycloaliphatic Epoxy Resin:** These epoxy resins are produced by reacting cyclic alkene with a peracid (acid which consist of an acidic -OOH group)  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:   1. triglycidyl para-aminophenol (TGPAP) 2. 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 is resin-based retardant with high bromine content compared to traditional TBBA- based flame retardant, products treated with brominated epoxy resin will have better thermal stability and chemical resistance.  Diagram  Description automatically generated  **4.3.3&4. Process Flow Diagram & Technology Licensor**  **Technology licensor**   * **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 Coorporation 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 following table denotes 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. * 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. * According to the primary research, 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 |   **Synthesis of Epoxy Resin**: The Epoxy Resin has been synthesized by the bulk polymerization by the continuous process of polymerization. The material is available commercially at 98% purity & colourless mobile liquid. Many commercial liquid resin consist essentially of low molecular weight diglycidyl ether of Bis-phenol A (BADGE) together with small quantity of higher mol Wt polymer. During the reaction hydrochloric acid has release. HCl has reacted with caustic & salt has form. As per reaction stoichiometry, the molar ratio of the BPA to ECH is 1:2 i.e., 1 mole of BPA & 2 mole of ECH but in actual practice this ratio is 1:5 or 1:6 of BPA to ECH.  **Technology 1: Nippon Steel & Simikin Chemical Co Ltd. (formerly Tohto Kasei Co. Ltd.) (Japanese firm)**    **Process Detail:**  **Pre-reaction Section**  Reaction starts with adding Excessive quantity of Epichlorohydrin (Fresh & recovered) with prescribed quantity of Bisphenol-A by using NaOH as catalyzer. As result of this reaction, Bisphenol-A chlorohydrin intermediate is formed.  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 minimizes 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  Graphical user interface, application, Word  Description automatically generated  **Resin + 2 NaCl + 2 H2O**  **Evaporator**  After the reaction process done, excessive quantities of unrelated ECH are separated from the product by increasing the temp and recovered through a vaporizer, same is returned to the ECH day tank 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.  **Refining**  In this section washing is done, toluene is added to dissolve resin in it. With continuous stirring & allowed salt solution to settle in the gravity settler, salt solution is separated from the resin manually by adding water. Again, DM water is added to wash the resin and remove the traces of salt from it.  **Filtration**  After refining, filtration is done to remove the impurities, suspended particles and rest of waste polymer by passing through the multilayer paper filter.  **Product Finishing Section:** Finally, Epoxy Resin is filtered to remove suspended filter cake via sparkler filter and is sent to the product tank through mixing tank.  **De solvent:** In this section, dissolvent is done to remove the solvent, toluene from the resin by passing through falling film thin evaporator & Rotary film thin evaporator under vacuum.  **ECH Stripping:** ECH Evaporated during reaction contains ECH along with water,  water is stripped off in the distillation unit, recovered pure ECH is recycled for next batch.  **ECH Distillation:** ECH vapours from the ECH detachment section are recovered and distilled in this section to recover pure ECH which is recycled.  **Process Flow Diagram:**  **Reactor**  **Reactor**  **Distillation**  **1st Stage Distillation**  **2nd Stage Distillation**  **Reactor**  **Washing**  **Distillation**  **Decanter**  **ECH**  **BPA**  **Vent 1**  **Vent 2B**  **Vent 2A**  **Vent 3A**  **Vent 3B**  **H2O**  **To Steam Stripper**  **NaOH**  **Option B**  **Option A**  **DCH**  **Glycerol DCH**  **15% NaOH**  **MIBK**  **H2O**  **Dilute Acid Solution**  **H2O**  **To Steam Stripper**  **Alkaline Brine Solution to steam stripper**  **Vent 4**  **Vent 5**  **Vent 6**  **Packaging**  **Crude DGEBPA**  **Solid Epoxy Resin:**  **Pre-Reaction Section:** In this section, Liquid Epoxy Resin, Bisphenol A & Catalyst is added in to the 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, reactants are added in lots to improve yield.)  **Reaction Section:** 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.  **Solidification Section:** Here Epoxy Resin (i.e. formed in reaction section) is passed through the flaker (with required utilities (chilled water & steam)) & further pass through the crusher to collect the final solid product.  For the suppression of catalytic reaction, a few amount of Methanol is added in reactor.  **Process Flow Diagram:**  **Jacketed Reactor.**  **Pre-Reaction Section**  **Reactor2**  **Reaction Section 70°C-80°C, 4 hrs**  **Flaker, 15°C chilled water**  **Crusher**  **Packer**  **Dust Collector**  **BPA, Liquid Epoxy Resin, NaOH, Methanol, Catalyst**  **180°C -190°C**  **Xylene**  **Hot Oil, 220°C**  **Oil, 50°C**  **5-7 Bar**  **Solid Epoxy Resin**        **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:** As the name suggest, hardener is one who, or that which, hardens. The process is called curing of epoxy resin. 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 resinAdditives: 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: Ciba-Geigy AG**  **Process Detail:**  **Pre-reaction Section**  Reaction starts with adding Excessive quantity of Epichlorohydrin (Fresh & recovered) with prescribed quantity of Bisphenol-A by using NaOH as catalyzer. As result of this reaction, Bisphenol-A chlorohydrin intermediate is formed.  Graphical user interface, text, application  Description automatically generated  **Reaction Section**  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 minimizes 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 yield  Graphical user interface, text, application  Description automatically generated  **ECH Stripping & Recovery:** ECH Evaporated during reaction contains ECH and water, water is stripped off in the distilled unit, pure ECH is recycled for next batch  **Refining:** In this section, toluene is added to dissolve resin in it and salt solution is separated from the resin manually by adding water. There are 3 layers are formed, the resin and toluene stay in the upper layer (called Organic layer) &NaCl water in the lower layer & centre one is unreacted BPA, it is called Emulsion layer. Again, DM water is added to wash the resin and remove the traces of salt from it.  **De-solvent:** After filtration section, Epoxy Resin is sent to reboiler & vacuum distillation column for Toluene recovery.  **Product Finishing Section:** Epoxy Resin is finally filtered to remove traces of impurities  **Process Flow Diagram:**  **Pre-Reactor**  **Reactor**  **Evaporator**  **Washing/Gravity Separation**  **Condensate with stirrer at 60 RPM**  **Filtration Unit**  **ETP Treatment**  **Sludge**  **Salt Packaging**  **Solid Disposal**  **Packer**  **BPA, ECH, NaOH**  **Unreacted ECH**  **NaOH 48%**  **Dehydrated H2O**  **Toluene**  **Water**  **Steam 100°C**  *Note\*: process for Solid & Formulated Resin is same for Technology 2.* | | |
|  | | |
| **43.6. Utilities Overview (Cooling Water System, DM Water Plant, Compressed Air System, power, steam & effluent processing details):**  **For 100 KT Plant (per annum)**  Fresh water requirement will be 923 KLD. 710 KLD treated water after UF/RO system will be reused/recycled  back in process. Water will be sourced from the near water supply system.   |  |  | | --- | --- | | Typical Common Utility to be use | | | 1 | Electricity | | 2 | Gas | | 3 | Fuel Oil | | 4 | Steam | | 5 | Cooling tower Water | | 6 | Process Water | | 7 | Recycled process water | | 8 | Recycled cooling tower water | | 9 | Softened Water | | 10 | Demineralized water | | 11 | Instrumentation Air | | 12 | Inert Gas | | 13 | Nitrogen, purchased | | 14 | Refrigeration |   **Water Consumption:**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Water Consumption in KLD** | | | | | | **S. No.** | **Description** | **Fresh/ Permeate** | **Recycled water** | **Remark** | | 1 | Primary RO | **908** |  |  | | A | RO Permeate | 678 |  | RO permeate water will be used in utility & domestic | | a1 | Domestic | 15 |  |  | | a2 | Cooling Tower | 528 | 530 | 528 KLD Fresh + 530 KLD recycled water after UF/RO system | | a3 | Boiler | 130 | - |  | | a4 | Plant Washing | 5 |  |  | | 2 | Process | 0 | 180 | 180 KLD recycled water after UF/RO system | | 3 | Gardening | **15** |  |  | |  | **Water Required** | **923** | **710** |  | |  | **Total** | **1633** | | **923 KLD Fresh water from GIDC and 710 KLD recycled water after UF/RO System** |   **Detail of Wastewater Generation**   |  |  |  |  | | --- | --- | --- | --- | | **S. No.** | **Description** | **Wastewater Generation in KLD** | **Remark** | | 1 | RO Reject | 230 |  | | 2 | Domestic | 15 |  | | 3 | Cooling Tower | 200 |  | | 4 | Boiler | 117 | To ETP | | 5 | Plant Washing | 5 |  | | 6 | Process | 243 | 304 KLD process effluent will be sent to MEE. From that 61 KLD will convert to Salt and 243 KLD MEE condensate will sent to ETP for further treatment | |  | **Total Wastewater Generation** | **810** | **Treatment in ETP** | |  | Recycled Water | 710 | After treatment in recycling UF and RO system | |  | **Treated Wastewater going to nearest drain/ CETP** | **100** | **RO reject will be disposed off into deep sea via nearest drain/CETP** |   **Nitrogen:** The reaction is carried out in reactor is under ‘nitrogen' blanket' to minimize oxidative degradative reactions.  **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.   |  |  |  |  | | --- | --- | --- | --- | | **S No.** | **Stack Attached to** | **No. of working hrs** | **Type of Fuel used** | |  | |  |  |  | Coal / Biomass or |  | | 1 | Boiler-1 | 24 | Natural Gas |  | | 2 | Thermic Fluid Heater | 24 | Natural Gas |  | | 3 | Boiler-2 | 24 | Coal / Biomass or Natural Gas |  | | 4 | DG Set-1 | As per requirement | Diesel |  | | 5 | DG Set-2 | As per requirement | Diesel |  | | | |
| * + 1. **Waste generation, Management, and disposal:**   Wastewater generation from capacity of 84 KT which includes processes like Badge, Taffy, Advancement and manufacturing of standard and specialized epoxy resin, wastewater generation will be around 700 KLD. From that, 615 KLD will be recycled and 85 KLD will be discharged to CETP after achieving desired norms. Unit will provide 750 KLD capacity of ETP followed by RO & UF. High TDS (Total Dissolved Solids) stream will be treated in MEE/MVR (Multi Effect Evaporator/ Mechanical Vapor Re-compressor).  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.   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | **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 | | |

**5. Economic Evaluation**

**5.1 Estimated Investment:** For the suggested capacity of 84 KPTA, overall investment is USD 10.8 million. The exchange rate is USD 1 = INR 73.30. Considering current volatility in commodity cycles and exchange rate, capital expenditure for the project may increase by 10-12 percent if project is implemented by next year.

**5.2 Fixed Cost & Variable Cost Analysis:**

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 3,93,72,442, as shown in Table 2. In this sense, the total fixed-capital investment reached a value of 3,84,85,675and a working capital value of USD 8,86,767.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **ITEM** |  | **[USD]** |
| **A** | **TOTAL FIXED-CAPITAL INVESTMENT** | **A1** + **A2** | **3,84,85,675** |
| A1 | TOTAL DIRECT PLANT COST | 1 to 9 | 2,73,12,415 |
| 1 | Delivered main equipment (includes auxiliary equipment) | 100% | 88,67,667 |
| 2 | Purchased-equipment installation | 39% | 34,58,390 |
| 3 | Instrumentation and controls (installed) | 26% | 23,05,593 |
| 4 | Piping (installed) | 31% | 27,48,977 |
| 5 | Electrical (installed) | 10% | 8,86,767 |
| 6 | Buildings (including services) | 29% | 25,71,623 |
| 7 | Yard improvements | 12% | 10,64,120 |
| 8 | Service facilities (installed) | 55% | 48,77,217 |
| 9 | Land (purchase is required) | 6% | 5,32,060 |
| **A2** | **TOTAL INDIRECT PLANT COST** | **10 to 14** | **1,11,73,261** |
| 10 | Engineering and supervision | 32% | 28,37,653 |
| 11 | Construction expenses | 34% | 30,15,007 |
| 12 | Legal expenses | 4% | 3,54,707 |
| 13 | Contractor’s fee | 19% | 16,84,857 |
| 14 | Contingency | 37% | 32,81,037 |
| **B** | **WORKING CAPITAL** | **16** | **8,86,767** |
| 16 | Safety and hazard analyses | 10% | 8,86,767 |
|  | **TOTAL CAPITAL INVESTMENT** | **A** + **B** | **3,93,72,442** |

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

The total cost of the equipment is approximately 84.99 million USD 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.

This analysis is provided for uninterrupted production process:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Equipment Cost for 100 KT Plant | | | | | | | |
|  | **MAIN PROCESS EQUIPMENTS** | **CAPACITY & MOC** | **Qty** | **In Lacs** | **[USD]** | **Category** | Remarks |
| 1 | Caustic Preparation Solution Tank (48% Caustic) | m3,PP | 1 | 72 | 0.982264666 | Indigenous |  |
| 2 | Caustic transfer pump | m3/hr,PP | 2 | 24 | 0.327421555 | Indigenous | 1 Standby & 1 working |
| 3 | BPA Storage Vessel or Hopper (if Solid) | m3, SS304 | 1 | 24 | 0.327421555 | Indigenous |  |
| 5 | ECH Storage Tank | m3, SS304 | 1 | 120 | 1.637107776 | Indigenous |  |
| 6 | ECH Transfer Pump | m3/hr, SS304 | 2 | 24 | 0.327421555 | Indigenous | 1 Standby & 1 working |
| 7 | Pre-Reactor | m3, SS304 | 1 | 360 | 4.911323329 | Auxiliary |  |
| 8 | Reaction solution Transfer pump | m3/hr, SS304 | 2 | 24 | 0.327421555 | Indigenous | 1 Standby & 1 working |
| 9 | Reactor | m3, SS304 | 1 | 360 | 4.911323329 | Auxiliary | For more no of grade, Reactor will be increased accordingly |
| 10 | Reaction solution Transfer pump 2 | m3/hr, SS304 | 2 | 24 | 0.327421555 | Indigenous | 1 Standby & 1 working |
| 12 | Distillation Tower for ECH | m3, SS304 | 1 | 96 | 1.309686221 | Indigenous |  |
| 13 | Solvent Storage Tank (Toluene) | m3, SS304 | 1 | 120 | 1.637107776 | Indigenous |  |
| 14 | Solvent transfer pump | m3/hr, SS304 | 2 | 12 | 0.163710778 | Indigenous | 1 Standby & 1 working |
| 15 | Washing Tower | m3, SS304 | 1 | 72 | 0.982264666 | Indigenous |  |
| 16 | Gravity Separator | m3, SS304 | 1 | 120 | 1.64 | Indigenous |  |
| 17 | Soln Transfer pump | m3/hr, SS304 | 2 | 12 | 0.16 | Indigenous | 1 Standby & 1 working |
| 18 | Ditillation Tower for Toluene Recovery | m3, SS304 | 1 | 96 | 1.31 | Indigenous |  |
| 19 | Soln Transfer pump 2 | m3/hr, SS304 | 2 | 24 | 0.33 | Indigenous | 1 Standby & 1 working |
| 20 | Sparkler Filter | m3, SS304 | 1 | 120 | 1.64 | Indigenous |  |
| 21 | Mixing Tank | m3, SS304 | 1 | 144 | 1.96 | Indigenous |  |
| 22 | Feed Pump | m3/hr, SS304 | 2 | 24 | 0.33 |  | 1 Standby & 1 working |
| 23 | Product Tank | m3, SS304 | 1 | 180 | 2.46 | Indigenous |  |
| 24 | UF/RO System | m3/hr, SS304 | 1 | 120 | 1.64 | Indigenous |  |
| 25 | Evaporator (Thin Evaporator & Rotary film thin evaporator) | m3, SS304 | 1 | 36 | 0.49 | Indigenous |  |
| 26 | Cooling Tower | m2, SS304 | 1 | 72 | 0.98 | Indigenous |  |
| 27 | DG’s, Generator’s | 400 KV | 2 | 96 | 1.31 | Indigenous |  |
| 28 | DCS System (Instrumentation Item) |  | 1 | 360 | 4.91 | Indigenous |  |
| **1.2** | Equipment list for SER |  | 1 | 2736 | 37.33 |  |  |
| 1 | LER Storage tank | 375m3, SS304 | 2 | 240 | 3.27 | Indigenous |  |
| 2 | Xylene Storage Tank | 110m3, SS304 | 1 | 108 | 1.47 | Indigenous |  |
| 3 | Condenser | 7m2, SS304 | 1 | 30 | 0.41 | Indigenous |  |
| 4 | Feed Pump | 18m3/hr, SS304 | 4 | 14.4 | 0.20 | Indigenous | 2 Process pump & 2 Standby |
| 5 | Weighing Tank | 14m3, SS304 | 1 | 30 | 0.41 | Indigenous |  |
| 6 | Hoist | 3-4 Ton/hr, SS304 | 1 | 18 | 0.25 | Indigenous |  |
| 7 | BPA Hopper | 08-12m3, SS304 | 1 | 14.4 | 0.20 | Indigenous |  |
| 8 | Reactor | 15 m3, SS304/CS | 1 | 360 | 4.91 | Indigenous |  |
| 9 | Resin Hopper | 1.2m3, SS304 | 1 | 14.4 | 0.20 | Indigenous |  |
| 10 | Condenser | 7.5m2, SS304 | 1 | 24 | 0.33 | Indigenous |  |
| 11 | Reactor | 15m3, SS304 | 1 | 360 | 4.91 | Auxiliary |  |
| 12 | Condenser | 7.5m2, SS304 | 1 | 36 | 0.49 | Indigenous |  |
| 13 | Raw material Hopper | 0.2m3, SS304 | 1 | 2.4 | 0.03 | Indigenous |  |
| 14 | BPA Dust Collector | 25m3, CS | 1 | 12 | 0.16 | Indigenous |  |
| 15 | Reactor | 16m3, SS304 | 1 | 360 | 4.91 | Auxiliary |  |
| 16 | Resin hopper | 1.2m3, SS304 | 1 | 3.6 | 0.05 | Indigenous |  |
| 17 | Condenser | 7.5m2, SS304 | 1 | 36 | 0.49 | Indigenous |  |
| 18 | Dust Collector | 25m3, CS | 1 | 12 | 0.16 | Indigenous |  |
| 19 | Cut Tank | 17m3, SS304 | 1 | 240 | 3.27 | Auxiliary |  |
| 20 | Condenser | 25m2, SS304 | 1 | 48 | 0.65 | Indigenous |  |
| 21 | Product filter | 15m3/hr, SS304 | 1 | 12 | 0.16 | Indigenous |  |
| 22 | Flaker | 6m3/hr | 1 | 480 | 6.55 | Auxiliary | Vendor: SANDVIK |
| 23 | Flaker hopper | 4,000kg/hr, SS 304 | 1 | 24 | 0.33 | Indigenous |  |
| 24 | Circle Feeder | 7.5 ton/hr, SS 304 | 1 | 48 | 0.65 | Indigenous |  |
| 25 | Crusher | 4500kg/hr, SS304 | 1 | 96 | 1.31 | Indigenous |  |
| 26 | Packer (25 Kg, 100 Kg, 200Kg, 500 Kg /bag,) | SS 304 | 4 | 72 | 0.98 | Indigenous |  |
| 27 | Product Dust Collector | 40m3/hr, SS314 | 1 | 18 | 0.25 | Indigenous |  |
| 28 | Product Tank | 150m3, SS304 | 4 | 512 | 6.98 | Indigenous |  |
| 29 | Vent Condenser | 6m2, SS304 | 4 | 72 | 0.98 | Indigenous |  |
| 30 | Product Filter | 15m3/hr, SS304 | 4 | 57.6 | 0.79 | Indigenous |  |
|  | Feed Pump | 18m3/hr, SS304 | 5 | 60 | 0.82 | Indigenous |  |
|  | Total |  |  | 3415 | 46.59 | Indigenous |  |
| 1.3 | ETP Plant | 800 KD |  | 350 | 4.77 |  |  |
|  | Final Total |  |  | 6501 | 88.69 |  |  |

**5.4. Annual Cost of Production.**

Concerning the base case, the annual cost of raw materials reached a value of **16,38,00,000** per year for 84 KT/Annum plant capacity. Main Raw Material considered BPA, ECH & NaOH with % per ton of epoxy are 0.7, 0.6 & 0.5. Estimated utility Cost Utility Cost per ton of Epoxy is 5600/ ton of epoxy resin production (taken from secondary cost)

|  |  |  |  |
| --- | --- | --- | --- |
|  | **ITEM** |  | **[USD]** |
| **C** | **MANUFACTURING COST** | **C1** + **C2** + **C3+ C4** | **19,13,07,760** |
| **C1** | **Raw materials** |  | **16,38,00,000** |
| 1 | Raw materials | - | 16,38,00,000 |
| **C2** | **Labour** |  | **23,09,580** |
| 2 | Operating labor | - | 19,65,600 |
| 3 | Direct supervisory and clerical labor (17.5% of operating labor) | 17.50% | 3,43,980 |
| **C3** | **Variable Overheads** |  | **1,76,26,028** |
| 4 | Packaging Cost (6% of Manufacturing cost) | 6.00% | 11598197.38 |
| 5 | Utilities (calculated) | - | 60,27,831 |
| **C4** | **Fixed Overheads** | **14 to 16** | **75,72,152** |
| 6 | Maintenance and repairs (5% of fixed-capital investment) | 5.00% | 19,68,622 |
| 7 | Operating supplies (15% of cost for maintenance and repairs) | 15.00% | 2,95,293 |
| 8 | Laboratory charges (15% of operating labor) | 15.00% | 2,94,840 |
| 9 | PLANT-OVERHEAD COSTS (55% of 2 + 3 + 5) | 55.00% | 45,85,576 |
| 10 | Administrative costs (10% of 2 + 3 + 5) | 10.00% | 4,27,820 |
| **D** | **Selling Overhaeds** | **14 to 16** | **3,99,82,699** |
| 11 | Patents and royalties |  | 7001778.437 |
| 12 | Distribution and selling costs (11% of manufacturing cost) | 11.00% | 2,15,02,455 |
| 13 | Research and development costs (7% of manufacturing cost) | 6.00% | 1,14,78,466 |
|  | **Total Production Cost** | **C** + **D** | **23,12,90,459** |

**5.5. Payback Period:**

|  |  |
| --- | --- |
| **PROFITABILITY PARAMETER** | |
|  | **Value (USD Million)** |
| **NPV @ 10%** | 94.27 |
| **Internal Rate Of Return (%)**  ***On Total Capital -*** ***Before Taxes*** | 37.62% |
| **Payback Period, Years** | 3.62 |
| Simple |  |
| Discounted @ 12% |  |

**5.6. Project Sensitivity Analysis:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ***NPV in USD Million*** | | | | | |
|  | BASE CASE | 90.00% | 95.00% | 105.00% | 110.00% |
|  | **CAPITAL COST** | | | | |
| IRR% | 37.62% | 37.09% | 37.35% | 37.88% | 38.15% |
| NPV | 94.3 | 92.6 | 93.4 | 95.1 | 96 |
|  | **REVENUE** | | | | |
| IRR% | 37.62% | 16.76% | 28.01% | 46.33% | 54.50% |
| NPV | 94.3 | 18.8 | 56.5 | 132 | 169.7 |
|  | **RAW MATERIALS COST** | | | | |
| IRR% | 37.62% | 48.29% | 43.06% | 31.89% | 25.77% |
| NPV | 94.3 | 139.5 | 116.9 | 71.7 | 49.1 |

**5.7. Project Schedule:**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Phase 1** | | | | | **Phase 2** | | | | |
|  | **2024** | **2025** | **2026** | **2027** | **2028** | **2029** | **2030** | **2031** | **2032** | **2033** |
| **Operating Rate** | 60% | 80% | 90% | 95% | 77% | 88% | 95% | 95% | 95% | 95% |
| **Operating Revenue** | 76.4 | 103.3 | 118.0 | 126.4 | 208.0 | 241.3 | 264.4 | 268.4 | 272.4 | 276.5 |
| **Quantity Produced** | 25.2 | 33.6 | 37.8 | 39.9 | 64.68 | 73.92 | 79.8 | 79.8 | 79.8 | 79.8 |