A picture containing background pattern

Description automatically generated

**GLOBAL VINYL ESTER**

**RESIN MARKET**

**FORECAST & OPPORTUNITIES, 2030**

Text

Description automatically generated****

**PUBLISHED: September 2021**

**MARKET INTELLIGENCE. CONSULTING**

*Source: TechSci Research*

**4.3. Setup Related Details**

**4.3.1. Target End-Use Applications**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| S. No | Grade | Target Applications | Specifications | | |
| Viscosity 25° C (cps) | Gel Time (min) | Monomer Content (%) |
| 1 | Bisphenol-A Epoxy Resin | Provide Resistance to acid, alkalis, solvents, excellent toughness, and fatigue resistance | 180-800 | 20-32 | 33-45 |
| 2 | Low styrene Monomer Bisphenol-A Resin | Chemical reaction vessels | NA | NA | NA |
| 3 | Novolac Based Epoxy Resin | Excellent thermal, and chemical resistance, resistance to solvents, acids | 300-400 | 20-25 | 36-40 |
| 4 | Brominated Epoxy Resin | High degree of fire retardance, resistance to chemical, tougher and fatigue resistant | 200-500 | 20-35 | 34-39 |
| 5 | Brominated Novolac Epoxy Vinyl Resin | Moderate degree of retardance, application in hot, wet flue gas environment | 300-450 | 20-35 | 36-40 |
| 6 | Elastomer-modified Bisphenol-A Epoxy Vinyl Resin | High impact and fatigue resistance, chemically resistant FRP linings, composites, adhesives, electrical castings, electrical laminates, and fibres | 40-8000 | NA | NA |
| 7 | Urethane Modified Vinyl Ester Resin | Heat, Corrosion and Chemical resistant, application in marine, pultrusion, carbon fibre | NA | NA | NA |
| 8 | Amine Accelerated Vinyl Ester Resins | Composites | 300-500 | 10-15 | 34-41 |
| 9 | Bisphenol A Vinyl ester/ DCPD blend | Hydrolysis resistance, Marine | NA | 27-33 | 60-64 |

*Source: TechSci Research*

**4.3.2. Plant Process Description**

*Source: TechSci Research*

**Manufacturing Process**

# Vinyl Ester Resin (VER) has been manufactured in a batch reactor, traditionally. Initially, the reactor needs to be charged with a mixture of Epoxy resin, Bisphenol-A and should be heated for 4-5 hours to the temperature of 160-170°C. Then, decrease the reactor temperature to 100-120°C and add Methacrylic acid to advance the esterification process. Esterification takes place along the epoxy chain between carboxyl and epoxy group and likewise between carboxyl and hydroxyl group. As the temperature declines to 100° C, additives like Maleic Anhydride and Tri-Ethyl Amine needs to be added as a base catalyst and the mixture is heated for another 4-6 hours.

# After that, Epoxy Resin needs to be withdrawn from the batch reactor and fed to the blender containing Styrene Monomer which is a volatile organic solvent. During polymerization, styrene reacts with vinyl esters to form cross linking at unsaturation points. This cross linking provides high polymerizability and improved resin processability. In addition to this, Styrene Monomer also acts as a diluent to reduce viscosity and improve curing degree leading to excellent mechanical and thermal properties of composite epoxy solution. Further, Blender temperature should be maintained around 70° C. Finally, Water is circulated around blender jacket to gradually cool and reduce the heat to room temperature. Generally, it takes 12-14 hours to process Vinyl Ester Resin. It’s a very critical and temperature sensitive reaction and should be undertaken with utmost caution as a small error can gel the batch immediately.

# As all the raw materials used will be consumed in the process itself, hence there will not be any generation of by-product, Effluent, Gaseous waste, solid waste.

Finally, the finished product is withdrawn from blender and packed in drums.

A picture containing chart

Description automatically generated**Reaction Involved**

Polygon

Description automatically generated with medium confidence

Diagram

Description automatically generated with low confidence

Chart, box and whisker chart

Description automatically generated

A picture containing radar chart

Description automatically generated

Diagram

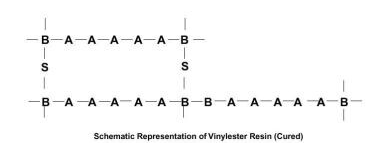
Description automatically generated with medium confidenceDiagram

Description automatically generated

**Curing Of Vinyl Ester Resin**

Vinyl Ester Resins must undergo curing process where low molecular weight liquid resins convert into high molecular weight liquid resulting into cross linked solid three-dimension viscous fluid suitable for the end use applications. Curing process improves the processability and enhances the mechanical properties of composites. Curing is irreversible and exothermic process. One of the important parameters during curing process is gelation time which is defined as the time required to achieve the non-flowing viscous resin from the initial liquid state. Gelation time varies depending upon the use of promoter and catalyst during the curing process.

Generally curing of vinyl ester resin is done with the help of cobalt naphthenate (Co 6%) as an accelerator and methyl ethyl ketone peroxide (MEKPO 55%) as a catalyst to initiate the free radical polymerization. When the ambient temperature is around 20° Celsius, appropriate dose of dimethylaniline (DMA) is recommended. The purpose of DMA is to fasten the curing reaction at room temperature and form a cured solid.





*Source: TechSci Research*

**Fig: Schematic representation of Uncured and Cured Vinyl Ester Resin**

**Key Challenges**

One of disadvantages of vinyl ester resin manufacturing process is use of styrene, which is a toxic volatile organic compound. A special care is taken while using styrene monomer during the vinyl ester resin manufacturing process so that it is not exposed to outside environment. Exposure to styrene can cause skin irritation, rash, dryness. It can also irritate eye, nose, and throat. Additionally, prolong exposure can hamper concentration, memory and may affect brain and liver functions. According to Environmental protection Agency (EPA), It is listed under hazardous air pollutant and may be a potential carcinogenic substance as it has been found to cause lung cancer in animals. Studies have been conducted to find substitute of styrene such as vinyl derivatives of benzene and methyl acrylates. Further, efforts have been made to find novel monomers by using renewable feedstocks such as lignin, fatty acids, and carbohydrates.

**4.3.3. Process Flow Diagram**

**Vinyl Ester Resin Manufacturing Process Based on Liquid Epoxy Resin (Bisphenol – A)**

Reactor

Temp :160-170°C

Time :4-6 Hr

Condenser

Unsaturated monocarboxylic acids\*, Additives

Liquid Epoxy Resin (Bisphenol-A)

Styrene Monomer Monomer

Blender

Temp:70°C

Time: 2-4 Hr

Finished Products ready for packing

*Source: TechSci Research*

**Vinyl Ester Resin Manufacturing Process Based on Solid Epoxy Resin (Novolac)**

Reactor

Temp :160-170°C

Time :4-6 Hr

Condenser

Unsaturated monocarboxylic acids \*, Additives

Solid Epoxy Resin (Novolac)

Styrene Monomer Monomer

Blender

Temp:70°C

Time: 2-4 Hr

Finished Products ready for packing

*Source: TechSci Research*

\* *Unsaturated monocarboxylic acids include acrylic acid, methacrylic acid, crotonic acid, monoesters of unsaturated polycarboxylic acids, and monoesters of maleic acid. The unsaturated acids and monoesters may be used singly or as a mixture of two or more of them. The unsaturated monocarboxylic acids can be derived from renewable sources like lignin or soyabean oil therefore, the name bio- based vinyl ester resin is used.*

**Process Flow Diagram**

Raw material storage and handling

Reaction

Blending

Intermediate storage

Finishing

Finished product storage and handling

Bulk

Storage

Finishing

Tank

Storage

Blender

Reactor

Non- bulk

* Tank
* Truck
* IBC
* Drums

*Source: TechSci Research*

*Source: TechSci Research*

Room Temperature

Heating 95°C to 100°C

Heating 35°C to 100°C

**Standard Process**

One mole of bisphenol A was catalytically reacted with two moles of diglycidylether of bisphenol A at 150° C for two hours under atmospheric conditions. This yielded a polyepoxide resin having an epoxide equivalent weight of 500 (gr/eq) which was subsequently cooled to 130° C. Next, two moles of methacrylic acid and 180 ppm of hydroquinone (based on finished product) were added under an air sparge and esterified at 120° C until an acid value less than 10 units was recorded. The vinyl ester resin was then cooled to 110° C and 0.05 moles of maleic anhydride were added. The vinyl ester resin was allowed to continue esterifying for 15 minutes at these conditions before thinning with styrene monomer to 65% non-volatiles and cooling to room temperature. This product is the control.

**Specialised Process (Low Epoxy Value)**

This vinyl ester resin was prepared the same way as standard process, except that 2.26 moles of methacrylic acid were used and the vinyl ester resin was esterified to an epoxy value less than two units before cooling to 110° C and adding maleic anhydride. This product was thinned in styrene monomer to 65% non-volatiles and cooled to room temperature.

**Low Styrene Emission Vinyl Ester Resin**

The production of low styrene emission vinyl ester resin includes paraffin as a styrene emission inhibitor and a drying oil as an adhesion promoter for fibre-reinforced applications. It has been found that due to paraffin wax additives there is a substantial loss in the adhesive properties of the vinyl ester resin therefore adhesion promoter in the form of a drying oil is added.

**India Scenario of Vinyl Ester Process**

The standard process is majorly used in the country as the demand of the product is project based in which only blending is done in the reactor which involves no technology licensor. Indian Companies manufactures vinyl ester of INEOS’s quality like DerakaneTM. The specialized process is mainly used by western companies as they produce low epoxy and styrene free vinyl ester resin.

**4.3.4. Technology Licensor**

* Vinyl ester resins are downstream product of Epoxy Resin. Mostly manufacturing companies have their in-house technology and R&D facilities to make formulations.
* Major reactions are carried out with the help of batch reactor and blender which can be outsourced.
* Generally, manufacturing process involves mixing of feedstock material in batch reactor and blending with organic solvent such as styrene monomer.
* There is no technology licensor for the product. Indian manufacturing company Atul limited has vertically integrated Epoxy resin capacity and downstream integrated Vinyl Ester Resin capacity while other Indian players such as Innovative Resins, Satyen Polymers, Mechemco Resins among others have In-house batch reactor set up. However, they import feedstocks Epoxy resin, Bisphenol-A, and other additives from the domestic or international market.

**4.3.6. Utilities Overview**

**Energy/power Requirements**

* Total connected load is 1000 KW which is sufficient to carry out proposed vinyl ester resin manufacturing activity.

**Fuel**

* LDO will be used as fuel in Thermic Oil Heater with quantity 352 Lit./Hr. Electricity will be used in reactors.
* Diesel will be used to run the D.G. set, if needed.

**Water Requirement**

* Total water requirement will be 8 KL/day for the vinyl ester resin plant which will be used in cooling. There is no use of any water in vinyl ester resin manufacturing process.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sr. No.** | **Usage** | **Water consumption (KL/Day)** | **Wastewater generation (KL/day)** | **Disposal of wastewater** |
| 1. | Processing | 0 | 30 | To Primary ETP followed by Evaporation |
| 2. | Cooling | 5 | 0 |
|  | **Total** | **5** | **30** |  |

*Source: TechSci Research*

**Effluent Processing Details**

* 3.5 KL/day of effluent will generate from processing. The effluent will be treated in ETP having various treatment units like collection cum neutralization tank and finally evaporated in evaporator.

**Estimated cost towards Environment Management Proposals**

The proposed environmental protection, control and mitigation measures will incur a capital investment of about ₹ 80 lakhs which will include APC (Air Pollution Control) system, water pollution control system, environmental monitoring, statutory compliance, disposal of solid waste etc. and an additional of about ₹ 35 lakhs will be utilized for maintenance.

**4.3.7. Waste Generation, Management, and Disposal**

**Hazardous Waste Management**

The proposed plant will generate the following hazardous wastes

|  |  |  |  |
| --- | --- | --- | --- |
| **Sr. No.** | **Name of the Waste** | **Source** | **Mode of Disposal** |
| 1 | Process Waste/Residue | Process | Reuse and Nonreusable disposed to CHWIF Site. |
| 2 | ETP Sludge/Evaporation Residue | ETP/ Evaporator | TSDF Site |
| 3 | Used Oil | Lubrication/ D.G.set | Reuse as Lubricant within premises. |
| 4 | Discarded drums/bags | Stores | Sold To Recycler |

*Source: TechSci Research*

ETP (Effluent Treatment Plant) sludge serves as the main source of hazardous waste generation from proposed activity. The other sources of hazardous waste generation from proposed activity includes spent or used oil generation from plant machinery and discarded barrel or containers from handling and storage of raw materials.

A dedicated storage area will be provided in the unit for the hazardous storage within premises having waterproof floor and roof cover.