



GLOBAL VINYL ESTER RESIN MARKET FORECAST & OPPORTUNITIES, 2030

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MARKET INTELLIGENCE. CONSULTING

TECHSCI RESEARCH
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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

Manufacturing Process

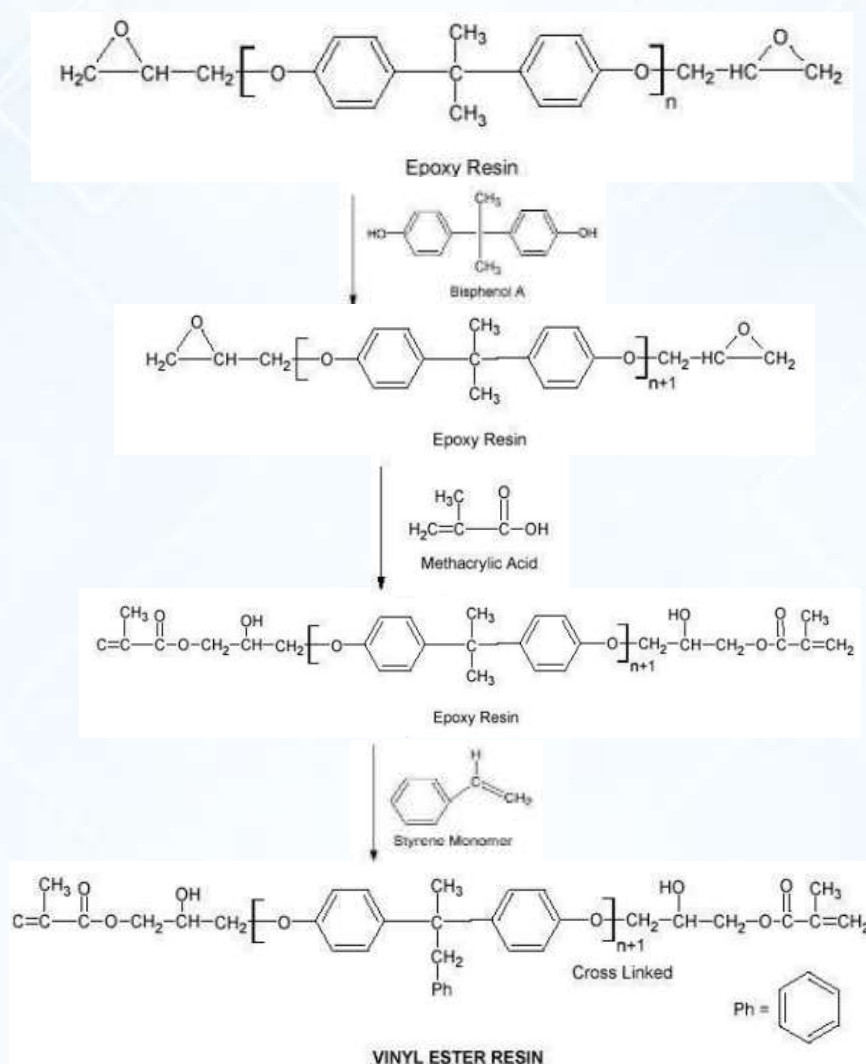
Vinyl Ester Resin (VER) has been manufactured in a batch reactor, traditionally. Initially, the reactor needs to be charged with a mixture of Epoxy resin, Bisphenol-A and should be heated for 4-5 hours at the temperature of 160-170°C. Then, decrease the reactor temperature to 100-120°C and add Methacrylic 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.

Reaction Involved

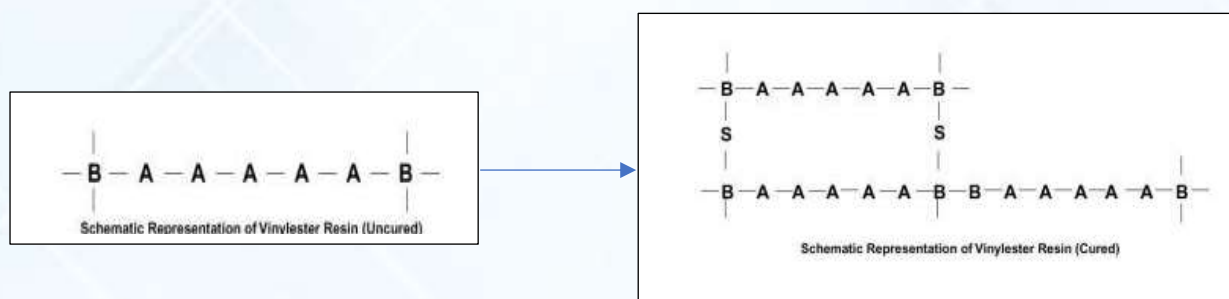


Curing Of Vinyl Ester Resin



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 25 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

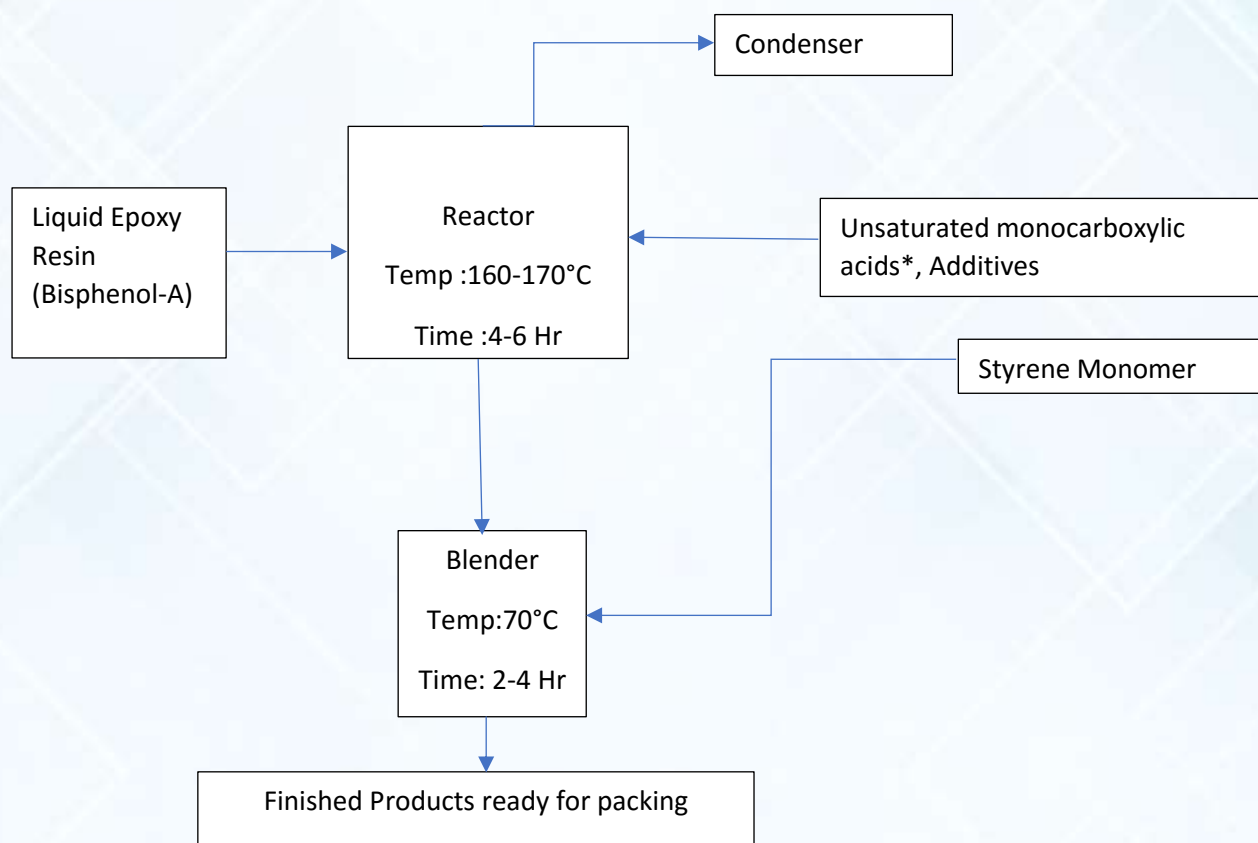
Key Challenges

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.

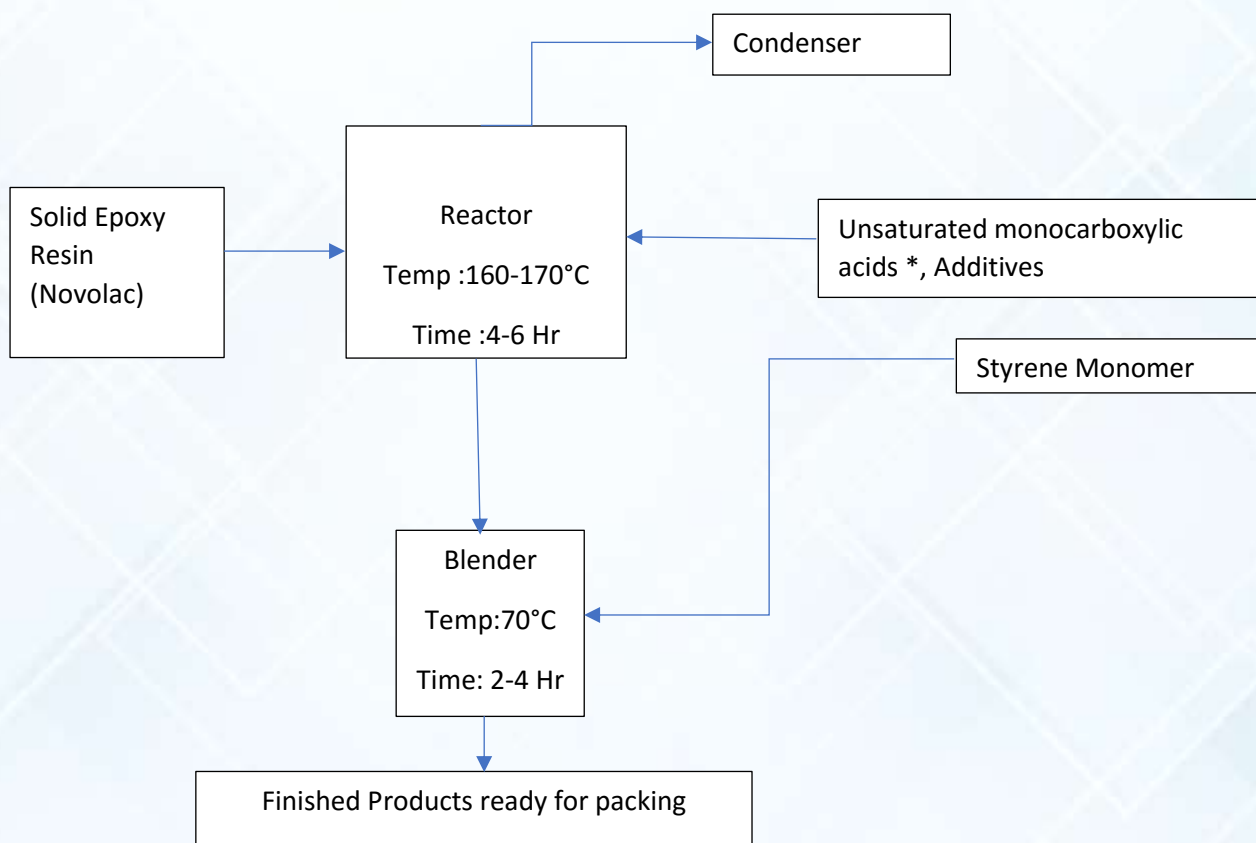
4.3.3. Process Flow Diagram

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



Source: TechSci Research

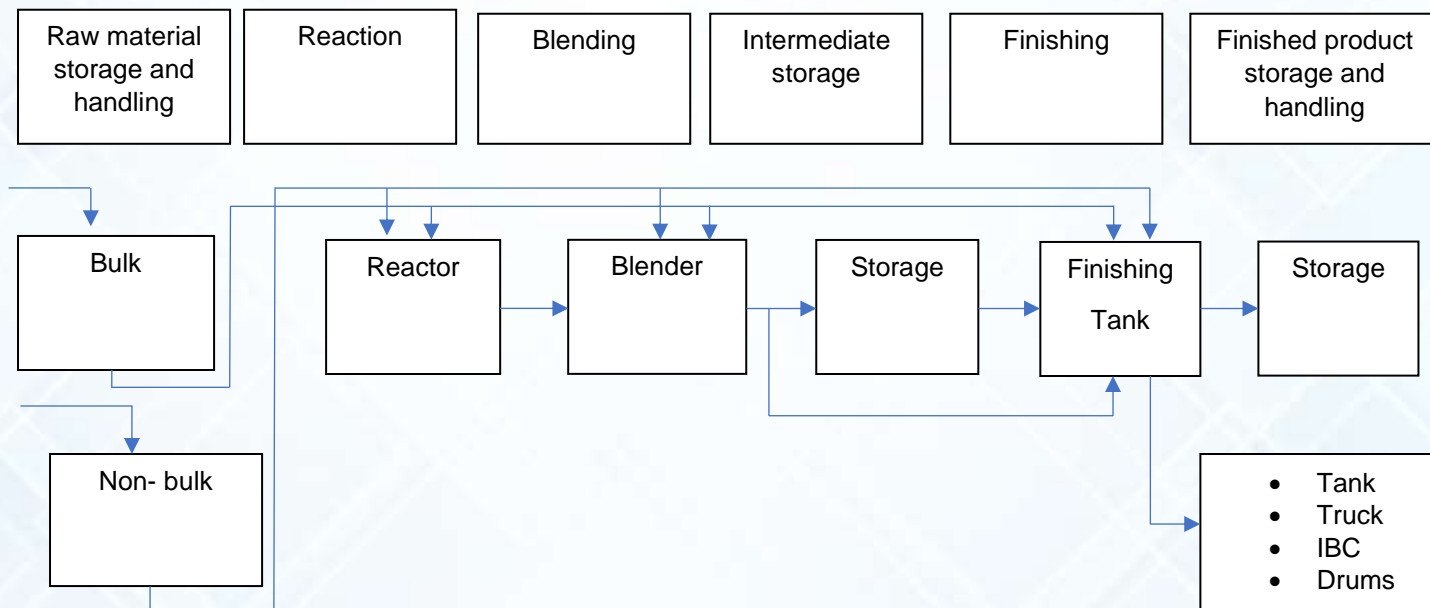
Vinyl Ester Resin Manufacturing Process Based on Solid Epoxy Resin (Novolac)



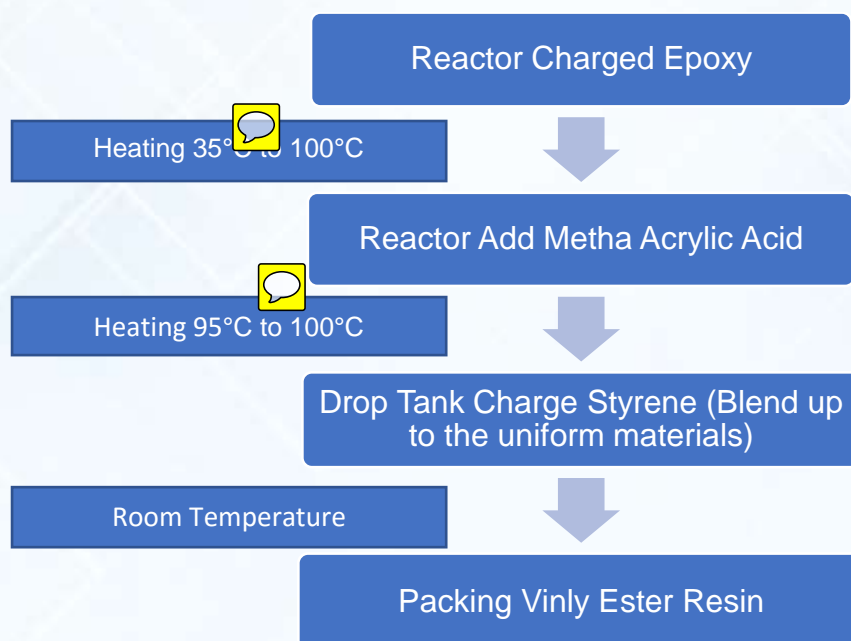
Source: TechSci Research

* 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



Source: TechSci Research



Source: TechSci Research

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 Derakane™. 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 5 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.