Applicant: Cheminova

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Chemical Product Formula: $(C_3H_4O_2)_n$

Chemical Product Name: Polylactic acid

Process Title: Removal of effluents during the production of Polylactic acid

EHS Summary:

a. Wastes generated and their quantity of generation

1. SO_2- 1981 kg/day
2. HCl- 2259.4 kg/day
3. Chloroform- 2000 kg/day
4. Methanol- 782 kg/day

b. Current regulations for the above waste materials. (Limits to which it can be disposed in the environment)

In India, the limit to which SO_2 and HCl can be disposed of in the environment untreated depends on the source and location of the emissions. The Central Pollution Control Board (CPCB), which is the national regulatory agency for environmental pollution in India, sets standards for ambient air quality and regulates industrial emissions of SO_2 and HCl and other pollutants.

- The current NAAQS standard for SO_2 is 50 micrograms per cubic metre (µg/m3) as an annual average and 80 µg/m3 as a 24-hour average.
- The current NAAQS standard for acid mist is 10 micrograms per cubic metre (µg/m3) as an annual average and 100 µg/m3 as a 24-hour average.

Chloroform and Methanol are toxic and hazardous substances, and are strictly regulated in India to protect human health and the environment. The disposal of chloroform and methanol or any other hazardous substance in the environment untreated is prohibited under Indian environmental laws.

- The permissible limit for chloroform in industrial effluent discharge is 0.05 milligrams per litre (mg/L) as per the latest standards published by CPCB.
- The permissible limit for methanol in industrial effluent discharge is 100 milligrams per litre (mg/L) as per the latest standards published by CPCB.

c. Treatment procedure for wastes with block diagram

1. Treatment of SO2 by Flue Gas Desulphurisation

Wet desulfurization scrubber system uses a low-cost alkaline scrubbing reagent (limestone) to produce stable gypsum and high SO2 removal efficiency.

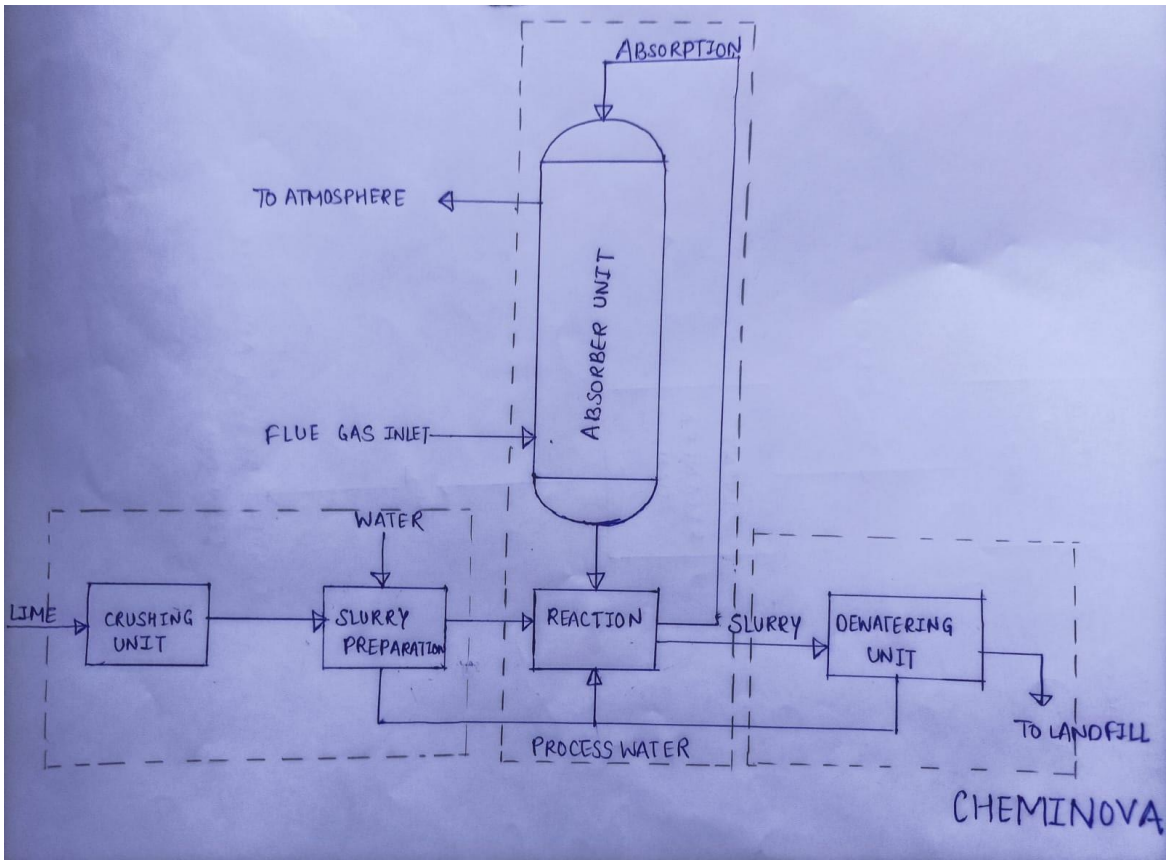
1) SO2 Absorption: SO2 is absorbed when the flue gas is intercepted by tiny droplets of slurry in the absorber. Water in the slurry captures the SO2, changes it into a liquid sulphur-based acid.
   $SO_2 + H_2O \rightarrow H_2SO_3$
   $H_2SO_3 \rightarrow (H)^+ + (HSO_3)^-$

2) Limestone Dissolution: $CaCO_3 + H_2O \rightarrow (Ca)^{2+} + (HCO_3)^- + (OH)^-$

3) Oxidation: Through the process of oxidation, sulphite (SO3) is converted to sulphate (SO4). The sulphate by-product, when combined with the calcium, forms calcium sulphate.
   $HSO_3 + O_2 \rightarrow (H)^+ + (SO_4)^{2-}$

4) Precipitation: Precipitation is the process by which a substance separates from a solution due to a chemical change in the solution. The absorbed SO2 reacts with the dissolved limestone to form new products i.e. calcium sulphate (CaSO4), or gypsum
   $(Ca)^{2+} + (SO_4)^{2-} + 2\,H_2O \rightarrow CaSO_4{*}2H_2O$ (Gypsum)

   The said process gives an efficiency of 90% -99% towards neutralization of SO2. Parameters such as boiler load, limestone fineness, Chloride control (Lesser is better), reagent ratio (Ca/S ion), pH & density of absorber tank, etc. affect the performance of FGD process.



BLOCK DIAGRAM OF SULPHUR DIOXIDE TREATMENT

2. Treatment of HCl-

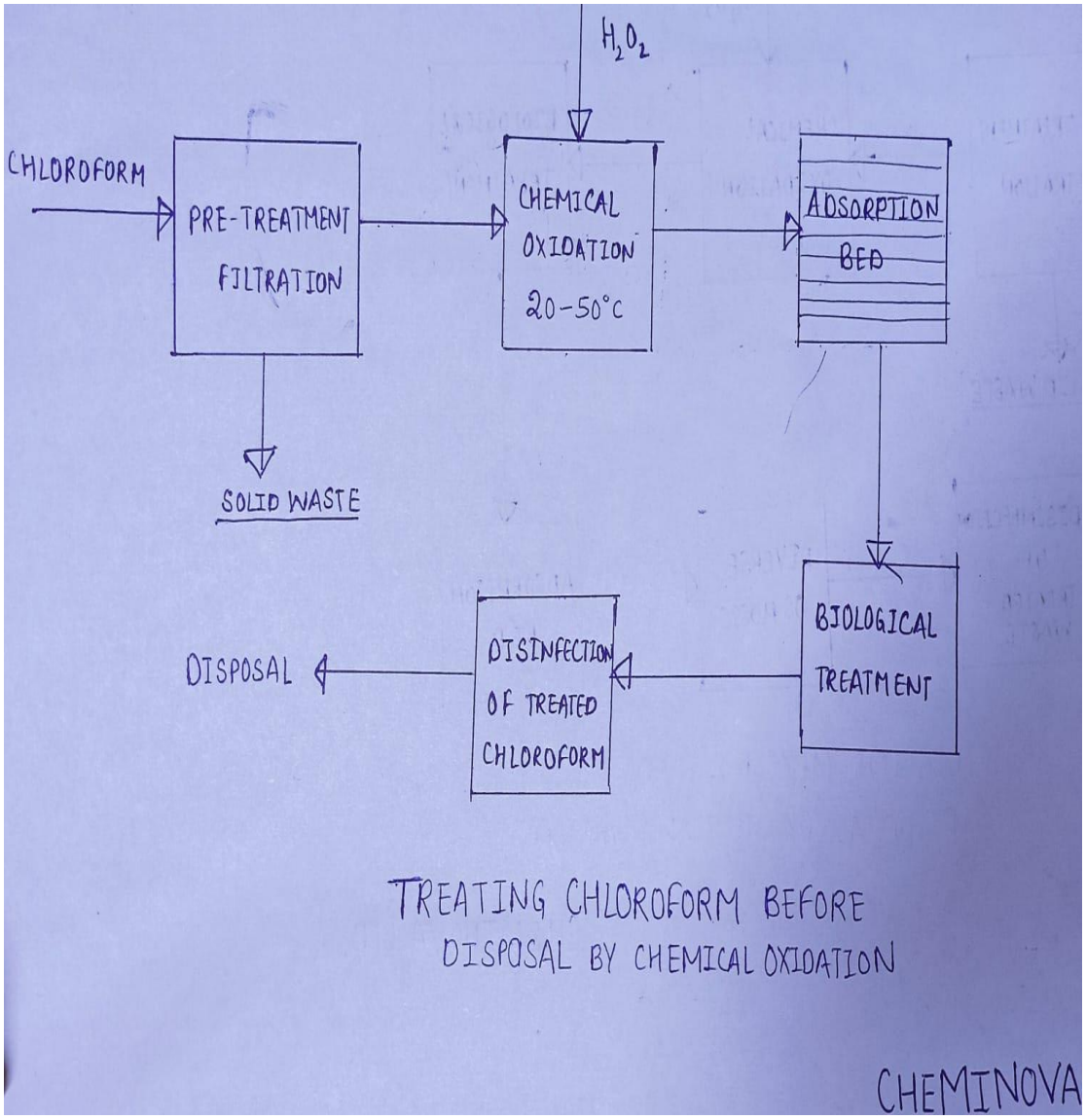
HCl will be made fit for commercial use and sold.

3. Treatment of Chloroform and Methanol using Chemical Oxidation

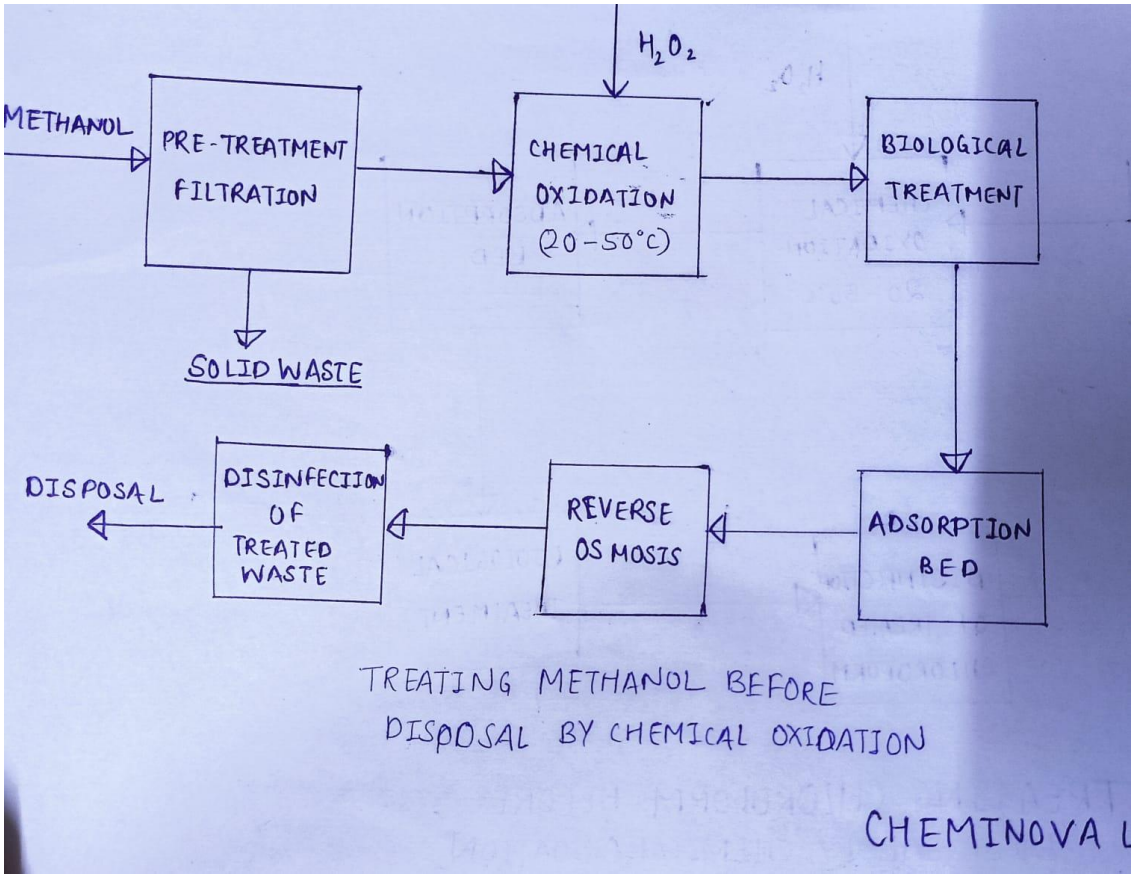
Pre-Treatment: Pre-treatment may include filtration, sedimentation, or other physical separation processes to remove solids and other impurities.

Chemical Oxidation: The waste stream is then treated with hydrogen peroxide (H_2O_2) and a catalyst such as iron (Fe) or copper (Cu) to oxidise the chloroform. This oxidation process produces carbon dioxide (CO_2), water (H_2O), and other byproducts.

Adsorption: The treated waste stream is then sent through an adsorption bed containing activated carbon or other suitable adsorbent material. The adsorbent material adsorbs any remaining chloroform and other volatile organic compounds.



BLOCK DIAGRAM OF CHLOROFORM TREATMENT



BLOCK DIAGRAM OF METHANOL TREATMENT

d. Safety concerns for the chemicals. Exposure limits: Time Weighted Average (TWA) for 8 hours and short-term exposure limit (STEL) for 15 minutes.

Sulphur dioxide (SO2) is a toxic gas that can pose several safety hazards if not handled, stored, and disposed of properly. Some of the safety hazards associated with SO2 are:

- Respiratory hazards: SO2 is a highly irritating and toxic gas that can cause serious respiratory problems when inhaled.
- Corrosive hazards: SO2 is a corrosive gas that can cause severe burns and tissue damage if it comes into contact with the skin, eyes, or mucous membranes.
- Fire and explosion hazards: SO2 is not flammable, but it can react with other chemicals to produce heat, fire, and explosions. It can also form explosive mixtures with air, especially in confined spaces.
- Environmental hazards: SO2 can contribute to acid rain, which can damage crops, forests, and aquatic life. It can also contaminate soil and groundwater, leading to long-term environmental damage.

- Occupational hazards: Workers who are exposed to SO2 in their workplaces, such as in industries that produce or use SO2, are at risk of respiratory, skin, and eye problems, as well as other health problems.

  Time Weighted Average (TWA) for 8 hours: The OSHA permissible exposure limit (PEL) for SO2 is 2 parts per million (ppm) as an 8-hour TWA.

  Short-term Exposure Limit (STEL) for 15 minutes: The OSHA permissible short-term exposure limit (STEL) for SO2 of 5 ppm over a 15-minute period.

  HCl is a highly corrosive and toxic substance that can cause harm if it is not handled, stored, and disposed of properly. Some of the safety concerns associated with HCl release are:

- Corrosive: HCl is highly corrosive and can cause severe burns and tissue damage if it comes into contact with the skin or eyes. It can also corrode metal and other materials, leading to structural damage to buildings and equipment.

- Toxic: HCl is a toxic gas that can cause respiratory problems, such as coughing, wheezing, and shortness of breath. Prolonged exposure to HCl can also cause lung damage and lead to other health problems.

- Environmental pollution: HCl can also cause significant environmental pollution if it is released into the atmosphere or water bodies. It can cause acid rain, which can damage crops, forests, and aquatic life. HCl can also contaminate soil and groundwater, leading to long-term environmental damage.

- Fire and explosion hazard: HCl is a flammable gas that can form explosive mixtures with air. It can also react with other chemicals to produce heat, fire, and explosions.

  Time Weighted Average (TWA) for 8 hours: the permissible exposure limit (PEL) for HCl as per the Occupational Safety and Health Administration (OSHA) is 5 parts per million (ppm) as an 8-hour TWA.

  Short-term Exposure Limit (STEL) for 15 minutes: ACGIH recommend a STEL of 7 ppm for HCl as an average exposure over a 15-minute period.

  Chloroform is a hazardous chemical that poses health risks to human beings, and appropriate safety measures should be taken when handling it.

- Inhalation: Chloroform can be harmful if inhaled. It can cause dizziness, nausea, headaches, fatigue, and even unconsciousness in high concentrations.

- Skin and Eye Contact: Chloroform can be irritating to the skin and eyes, causing redness, irritation, and chemical burns in severe cases.

- Environmental Hazard: Chloroform is a volatile organic compound (VOC) and can contribute to air pollution, and is also toxic to aquatic life.

  Time Weighted Average (TWA) for 8 hours: The OSHA permissible exposure limit (PEL) for chloroform is 50 parts per million (ppm) TWA for an 8-hour workday.

Short-term Exposure Limit (STEL) for 15 minutes: The ACGIH STEL for chloroform is 75 ppm for a 15-minute exposure period.

Methanol is a hazardous chemical that poses health and safety risks to human beings, and appropriate safety measures should be taken when handling it.

- Inhalation: Methanol can be harmful if inhaled. It can cause dizziness, headache, nausea, respiratory irritation, and even unconsciousness in high concentrations.
- Skin and Eye Contact: Methanol can be irritating to the skin and eyes, causing redness, irritation, and chemical burns in severe cases.
- Flammability: Methanol is highly flammable and can ignite easily, presenting a risk of fire and explosion.

Time Weighted Average (TWA) for 8 hours: The OSHA permissible exposure limit (PEL) for methanol is 200 parts per million (ppm) TWA for an 8-hour workday.

Short-term Exposure Limit (STEL) for 15 minutes: The ACGIH STEL for methanol is 250 ppm for a 15-minute exposure period.

References: Provide reference for a material safety data\ sheet/industrial safety report/weblink

https://www.osha.gov/chemical-hazards

https://cpcb.nic.in/uploads/hwmd/Guidelines_HW_5.pdf

https://pubs.acs.org/doi/pdf/10.1021/ja01306a009

List the contributions of each author:

- Author Tanya determined the waste generation quantity for SO2 and HCl while Author Aditi determined the waste generation quantity for Chloroform and Methanol.
- Authors Tanya and Aditi carried out the literature search and found the current regulations.
- Authors Tanya and Aditi found necessary treatment steps and prepared the block diagram.
- Author Tanya obtained TWA and STEL data for SO2 and HCl while Author Aditi obtained TWA and STEL data Chloroform and Methanol.

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