

Applicant: SynergyX

Inventors: Ajay Singh, Anunay Minj, Abhishek Kumar

Chemical Product Formula: $(C_{10}H_8O_4)_n$

Chemical Product Name: Polyethylene Terephthalate

Process Title:

EHS Summary:

- a. List the wastes generated and their quantity of generation.

Residual MEG:

Residual MEG flow rate = MEG unreacted flow rate in esterification

= 4.816 kmol/hr

= $4.816 \times 62.07 = 298.93$ kg/hr

Residual TPA:

Residual TPA flow rate = TPA unreacted flow rate in esterification

= 2.408 kmol/hr

= $2.408 \times 166.14 = 400.00$ kg/hr

Impure Water produced : Water is also generated as a by-product in esterification.

flow rate of Water produced in esterification = 43.34 kmol/hr

= $43.34 \times 18 = 780.12$ kg/hr

Acetaldehyde: Typically, acetaldehyde is present in the range of 0.01% to 0.05% of the weight of the reactant converted. Considering the conversion efficiency of 92%,

Acetaldehyde production = 0.01% to 0.05% * Conversion efficiency * BHET feed rate

Using the conservative estimate of 0.02%:

Acetaldehyde production = $0.0002 \times 92\% \times 5511.62$ kg/hr = 1.01 kg /hr

Formaldehyde: Similar to acetaldehyde, formaldehyde is present in smaller quantities.

Formaldehyde production = 0.001% to 0.005% * Conversion efficiency * BHET feed rate

Using the conservative estimate of 0.002%:

Formaldehyde production = 0.00002 * 92% * 5511.62 kg/hr = 0.101 kg /hr

Methanol: Methanol is also produced in smaller quantities.

Methanol production = 0.001% to 0.003% * Conversion efficiency * BHET feed rate

Using the conservative estimate of 0.002%:

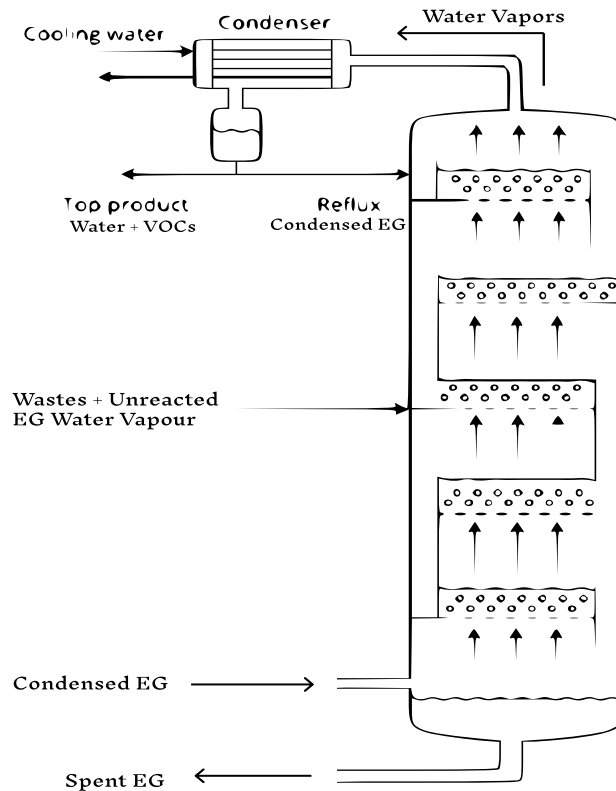
Methanol production = 0.00002 * 92% * 5511.62 kg/hr = 0.101 kg /hr

- b. What are the current regulations for the above waste materials. (Limits to which it can be disposed in the environment)

Chemical	Safety Concerns	Exposure Limits	Additional Information
Acetaldehyde	Highly flammable, irritant (eyes, nose, throat)	ACGIH TLV: 25 ppm (not to be exceeded)	Spills: Remove ignition sources, absorb with spill pillow, dispose properly. Can be neutralized with sodium bisulfite solution.
Formaldehyde	Toxic to aquatic life, irritant (eyes, nose, throat, lungs, skin), carcinogen	WHO Indoor Air Guideline (short/long-term): 0.1 mg/m ³ (0.08 ppm)	Formaldehyde is a known human carcinogen.
Methanol	Flammable, toxic by inhalation, ingestion, or skin contact	NIOSH REL: 1 ppm (3.6 mg/m ³) (30-min limit)	Contributes to smog formation in air. Methanol exposure can cause blindness.
Ethylene Glycol (Residual)	Environmental concern (wastewater contamination)	ACGIH TWA: 39 ppm	Disposal regulations vary (1,000-5,000 mg/L). May require treatment before landfill disposal. Odor threshold: 62.5 ppm.
Pure Terephthalic Acid (Residual)	Skin, eye, and respiratory irritation	ACGIH TLV: 1-10 mg/m ³ (8-hour average)	Repeated exposure to Terephthalic Acid may affect the kidneys.

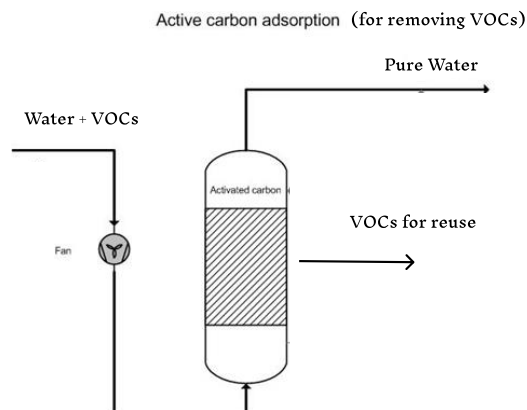
- c. Describe the treatment procedure for wastes with block diagram. Your chemical plant must be a zero liquid discharge plant.

1. Separation of unreacted EG from Water Vapors:



During the esterification process, water vapors and unreacted ethylene glycol (EG) are produced. To recycle the EG, we pass the stream through a distillation column to separate it from other components. Once separated, the EG is reintroduced back into the esterification process for further use.

2. Separation of VOCs from Water Vapor :



Following the distillation of ethylene glycol (EG), we obtain impure water vapor containing volatile organic compounds (VOCs) in minor quantities. These VOCs can be effectively removed by passing the vapor stream through an activated charcoal column. The activated charcoal selectively absorbs the VOCs, allowing for the recycling of pure water.

- d. Are there any safety concerns for the chemicals. Give exposure limits: Time Weighted Average (TWA) for 8 hours and short-term exposure limit (STEL) for 15 minutes.

Chemical	Health Concerns	TWA (ppm)	STEL (ppm)
Acetaldehyde	Irritation of eyes, nose, and throat; respiratory problems; cancer	100	150
Formaldehyde	Severe irritation of eyes, nose, and throat; cancer	0.75	2
Methanol	Headache, nausea, vomiting, blindness; can be fatal	200	250 (Some countries have a lower TWA)
Ethylene Glycol (Residual)	Nausea, vomiting, kidney damage; can be fatal	25	50
Pure Terephthalic Acid (Residual)	Skin, eye, and respiratory irritation	1.472	Not established

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

<https://www.osha.gov/chemicaldata/570>

<https://www.cdc.gov/niosh/pel88/107-21.html>

<https://redox.com/wp-content/sds/1125.pdf>

https://www.ilo.org/dyn/icsc/showcard.display?p_lang=en&p_card_id=0270&p_version=2

<https://www.epa.gov/>

<https://www.niehs.nih.gov/>

<https://www.who.int/about>

<https://www.wef.org/>

<https://www.plasticsconverters.eu/>

<https://www.niehs.nih.gov/>

<https://www.nj.gov/health/eoh/rtkweb/documents/fs/0001.pdf>

<https://nj.gov/health/eoh/rtkweb/documents/fs/0878.pdf>

List the contributions of each author:

- Ajay Singh, Anunay Minj, Abhishek Kumar determined the waste generation quantity.
- Anunay Minj, Ajay Singh, Abhishek Kumar found the current regulations and made the table.
- Ajay Singh, Anunay Minj, Abhishek Kumar found necessary treatment steps and prepared the block diagram.
- Anunay Minj obtained TWA and STEL data and made the table.

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