Think Outside the Trash: Chemical Recycling of Plastic Polymer

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Introduction & Objective

- Polyethylene terephthalate (PET) is used in textile and packaging industries.
- PET accounts for 29% of all the plastic waste generated. According to EPA's Advancing Sustainable Materials Management Fact Sheet 2020, out of 35.68 Millions of tons of plastic waste generated 3.09 million tons were recycled and 75.5 % of the plastic waste ended up in landfills.
- Chemical recycling is identified as the best way to recycle plastic. It is the process where the plastic polymers are converted into smaller units called monomers.

How can we recover PET from this?

Solution is Research in the labs!

United Nations Sustainable Goals

This research aligns with the UN sustainable Goal # 12.

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

Current Research

4 different methods.

PET Chemical Recycling

- **Glycolysis** BHET and Oligomers
- **Mathanolysis** DMT and EG
- **Hydrolysis** TPA and EG
- **Other Processes** Aminolysis, Ammonolysis

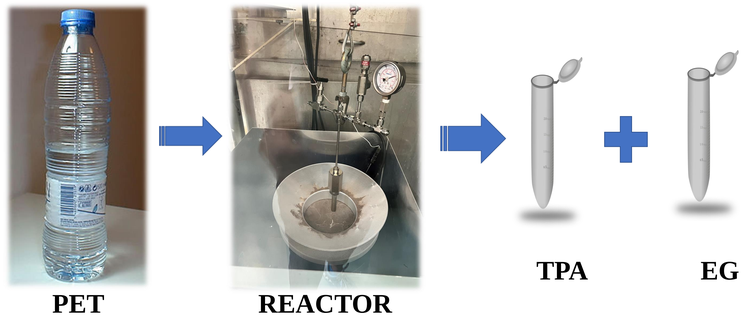
4 different products

The Reaction

(1) PET → (NaOH, H_2O) → disodium terephthalate (Na_2TP) + ethylene glycol (EG)

(2) terephthalic acid (TPA) + NaCl

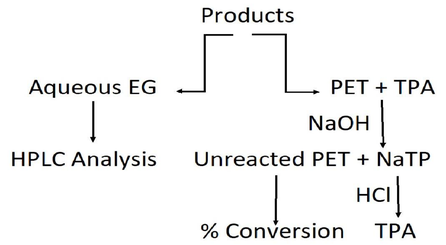
PET to Products



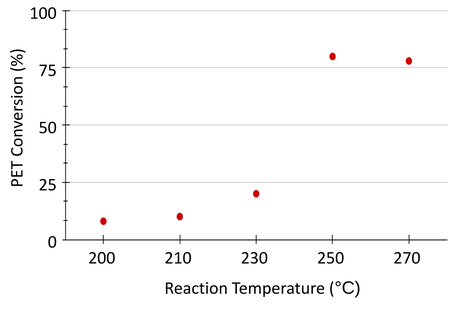
PET **REACTOR** **TPA** **EG**

Post Run Analysis

- Extraction process includes centrifuging to separate solid residues from aqueous fractions.
- After separating ethylene glycol, remaining residue contains PET and TPA.
- Terephthalic acid is converted into a soluble sodium salt to separate it from unreacted PET.



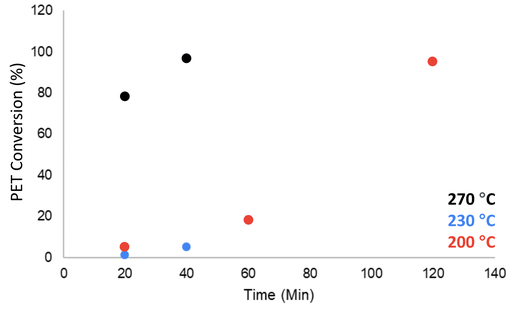
PET Hydrolysis as function of Temperature



- Figure (left) PET conversion at varying temperatures
- Low conversions observed at temperatures less than 250 °C
- Similar conversions at temperatures ≥250 °C

Time vs. Yield at 3 different temperatures

- Figure (right) PET conversion at varying times
- Longer durations at 200 °C reach near complete conversion of PET
- Increased temperatures reduce time required for full conversion



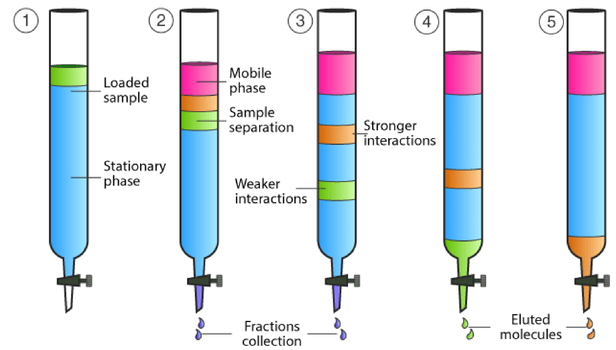
Classroom Connections

Some transferable skills I would like for my students to acquire from my RET PD are:

- Accuracy and Precision skills in measurements and recording data
- Safety protocols in setting up experiments and timing the experiments
- Analyzing data using excel

MA STD HS-PS 1.11 : Design strategies to identify and separate the components of a mixture based on relevant chemical and physical properties.

Lesson Plan includes that students research to learn about different separation methods like chromatography, distillation, centrifuging methods to apply in real life mixture separation. For example – An oil spill clean-up, household chemical mix-up, contaminants in water, muddy rain water to potable water.



- **Image (above):** example column chromatography hands-on lab experiment to separate organic dyes in food coloring

Image souce: https://byjus.com/chemistry/column-chromatography/

Conclusions & Future Work

- During my short experience in this research work I have learned that % conversion of PET into Ethylene glycol and Terephthalic acid increases with more Reaction time and Reaction temperature.
- In future I would like to run hydrolysis of PET under wider temperature and time ranges. I would also like to run the hydrolysis with an environmentally friendly catalyst to see if the % conversion is higher.

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