Polymer Synthesis from Common Materials

Introduction: Many of the materials we use in our daily lives are polymers, chemicals made of short repeating units (monomers) linked to one another. In the 20th century we learned how to synthesize artificial polymers, or plastics, from fossil fuels, such as oil and natural gas. Today, increased awareness of the environmental effects of mining these fuels has led to the development of plastics that can be synthesized from natural feedstocks, these plastics are referred to as "bioplastics". In today's first activity, you will model common polymer building blocks, and predict the properties of polymeric materials based on your models. In the afternoon, you will synthesize these polymers, and see how well your predictions match with reality!

Learning Goals:

- You will be able to identify some different types of polymers.
- You will be able to define chemical bonds.
- You will be able to describe the molecular structures of polymers.
- You will be able to describe the chemical structure of some polymer monomers.
- You will be able to correlate the structure of polymer monomers with the physical properties of the polymers.

Schedule:

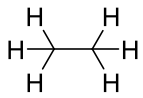
- *11:00-11:15 Cultural connection*
- *11:15-11:45 Introduction to Natural Polymers and the CSMS*
- *11:45-12:30 Activity I – Modeling Polymer Monomers*
- *12:30-1:15 Lunch*
- *1:15-1:30 Predicting Polymer Properties*
- *1:30-2:00 Activity II – Crosslinking: Polymers to Plastics*
- *2:00-2:30 Activity III – Extracting PET strands from Soda Bottles*
- *2:30-2:45 Wrap up*

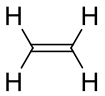
Activity 1 – Modeling Molecular Structures

Materials:

- 1 Model Set

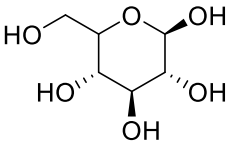
Instructions: Construct each of the following molecules based on their Lewis structure, then try to bend and rotate each bond. Record your observations in the table below. Save your ethane, terephthalic acid, glucose and alanine molecular models. Note that some of the molecules contain common structural motifs.

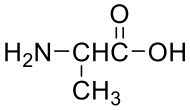

Ethane

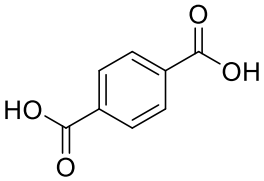

Ethene


Benzene


Cyclohexane


Glucose


Alanine


Terephthalic Acid

Molecule	Observations

Activity 2 – Crosslinking: Polymers to Plastics

Based on "Polymers & Molecular Models: Petretec Industry Example" *Beyond Benign* 2017 Web. 2 May 2018. https://www.beyondbenign.org/lessons/polymers-molecular-models-petretec-industry-example/

Materials:

- Safety Glasses
- Gloves
- 100 mL Guar Gum Solution
- 0.5 mL Borax Solution
- 100 mL of Skim Milk
- 50 mL of Vinegar
- 3 Large Beakers (~200 mL)
- 2 Graduated Cylinders
- 1 Metal Pan
- 1 Small Beaker (~10 mL)
- 1 Disposable Syringe
- 2 Stir Rods
- 1 Hot Plate
- 1 Stopwatch

Instructions:

Predict whether casein or guar gum will make the stronger (harder to deform) plastic when crosslinked: _____

Why do you predict this will be the case? _____

_____

Predict whether the casein or guar gum will make a more durable (harder to break) plastic when crosslinked: _____

Why do you predict this will be the case? _____

_____

Casein-based plastic:

- When you get into the lab, take a pair of gloves and safety glasses and put them on. Do not remove them until you leave the lab area.
- Form groups of 3-4, then have one person from your group collect the materials listed above.
- Add 100 mL of skim milk to a 200 mL beaker.
- Cover your hot plate with aluminum foil.
- Place your metal pan on your hot plate, then place the beaker on the pan.
- Fill the pan with water to just below the level of the milk.
- Begin heating your milk at high heat with constant stirring.
- Record your observations of the milk.
- When the milk begins to simmer, record the time, lower the heat to medium-high and slowly add 10 mL of vinegar to the milk.

- Record your observations of the milk/vinegar solution.
- After 1 minute, add an additional 10 mL of vinegar to the solution and record your observations.
- Continue adding 10 mL of vinegar and making observations until no further changes occur.
- Turn off the heat, remove the beaker and allow your casein product to cool.
- When cool, pour the liquid portion of the product down the drain, and measure and record the properties of your solid casein plastic.

Vinegar Added	Observations
0 mL	
10 mL	
20 mL	

Properties of the casein plastic: _____

Guar gum-based plastic:

- Add 100 mL of the guar gum solution to a 200 mL beaker.
- Place the beaker into your pan of warm water, and set the heat to medium.
- While constantly stirring, slowly add 0.5 mL of the borax solution to the guar gum solution using a syringe.
- Record your observations of the changes that occur as you add the borax.
- Pour out the liquid portion of your product and examine the properties of your guar gum-based plastic.

Observations when adding borax to guar gum: _____

_____

Properties of the guar gum plastic: _____

_____

Activity 3 – Extracting PET Strands from Soda Bottles

Materials:

- Safety glasses
- Gloves
- 1 Hot Plate
- 1 Piece of PET
- 1 Piece of Foil
- 1 Wooden Stick per Person
- 1 Pair of Tweezers or Forceps

Instructions:

- Cut a small piece of plastic out of the soda bottle and place it on the foil on your hotplate (make sure the hotplate has cooled down!). (Ensure the plastic is fully on the foil).
- Set your hotplate to medium high, and wait until the plastic begins to melt.
- Remove the plastic from the foil using your tweezers.
- Use your wooden sticks to try to draw out polymer strands from the molten plastic, see how long a strand you can make!
- Allow the plastic to cool on a piece of foil.
- Try to pull and bend the polymer strands after it has cooled.

Scientific Standards Addressed in this Activity:

MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures.

MS-PS1-3. Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.

HS-PS2-6. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.