Plastic Polymer Lab

Objectives:

Students will understand important characteristics about plastics and how these properties affect the fate of plastic as marine debris. They will connect their personal use of plastics with the problems of marine debris.

Concept:

Plastics are a unique and relatively recent technology created by linking monomers together. A variety of polymers and chemical additives are used to make a range of plastics with diverse characteristics. Different types of plastics have different properties that affect the likelihood that the plastic will end up as marine debris and also how the plastic may affect the marine environment. Individuals have great power as plastic users to change their own consumption and disposal habits and influence others to minimize plastic waste.

Materials:

- Science notebooks
- Pencils
- Handout: Estimated Life Span of Plastic Products
- Handout: Polymer Lab
- Elmer's Glue (1 cup for every 2-4 students)
- Borax (1 teaspoon for every 2-4 students)
- Food coloring (optional)
- Mixing bowls (1 for every 2-4 students)
- Mixing cups (1 for every 2-4 students)
- Spoons (1 for every 2-4 students)
- Ziploc bags
- Gum drops (optional)
- Toothpicks (optional)
- Laptop/computer and projector or SmartBoard

Preparation:

Set up computer and projector or SmartBoard to show the "How It's Made – Plastic Bags" video by the Discovery Channel on YouTube (https://www.youtube.com/watch?v=8CfL5xl2N1Q). This video on YouTube sometime begins with advertisements, so play through these during your preparation.

Prepare a sample polymer by mixing 1 cup white Elmer's glue with 1 cup warm water, and a drop or two of food coloring, if you'd like. Combine 1 teaspoon of borax powder with ½ cup warm water. Mix well and then pour into glue mixture, stirring well with a spoon. Once the molecules start to link up, forming a polymer, use your hands to knead it.

Arrange these ingredients, mixing bowls, and measuring spoons and cups on a back table for students to use themselves during the lesson.

Introduction:

Show "How It's Made – Plastic Bags" – a YouTube video by the Discovery Channel.

Ask students to write down questions and comments in their science notebooks during the video.

Discuss their questions and comments, as well as overall reactions to the video, afterwards.

Procedures & Activities:

Explain that the plastic production process often begins by treating components of crude oil or natural gas in a "cracking process."

Plastic Polymer Lab *Continued*

This process creates hydrocarbon monomers such as ethylene and propylene. The monomers are then chemically bonded together to form chains called polymers. In the video, the polyethylene is a polymer made of ethylene monomers.

Simply put, polymers are chemicals made of many repeating units. Explain that polymers are a very important part of our lives. Natural polymers include rubber, silk, plant cellulose & starches, DNA, and proteins such as keratin (wool, hair, feathers) and gelatin (like in jello). There are hundreds of synthetic polymers including glue and plastics such as:

- o Bags and food wraps
- o Polystyrene foam cups, plates, and takeout containers
- o Bottles (soda, juice, milk, water, etc.)
- o Nylon rope and fishing line
- o Clothing (synthetic fleece, spandex, nylon, etc.)
- o Neoprene wet suits
- o PVC plastic pipes
- o Teflon pots and pans
- o Credit and ID cards
- o Absorbent part of disposable diapers

Brainstorm with the class why polymers are useful (*they are strong and can be flexible*), and have students write at least three important uses for polymers in their science notebooks.

Next, reveal your sample polymer and explain to students that they will make their own polymer using borax and glue.

In fact, the glue is actually already a simple polymer, but the borax crosslinks the polymers in the glue to create a more complex polymer … a type of plastic!

Divide students into groups of 2-4 people.

After making a polymer, explain more about how plastic polymers interact with the natural world. Because of their hardy molecular structures, plastics take a long time to break down. They are not biodegradable. If you bury plastic in the ground and come back in any number of years, it will be intact. Biological organisms, like bacteria and worms cannot decompose it.

However, plastics are photodegradable. When exposed to sunlight for prolonged periods of time, the chains that form plastic polymers begin to change. Sometimes the bonds between the polymers break or oxidize. Where the bonds are changed, the polymer can break. Other times the opposite happens and additional cross-linking occurs between the polymers. Because this can make the plastic less flexible, it can also actually lead to more breakage. As more photodegradation takes place, plastics break into smaller and smaller pieces.

Ask students to think of times they have seen photodegraded plastic -- maybe they've left a plastic bag in the sun too long or seen the cracked dashboard of an old car.

Pass out "Estimated Life Span of Plastic Products" to students. Although we have estimates as to how long this process takes based on current rates of degradation, no one is really sure because plastics haven't been part of the world long enough to know.

Because it takes so long to breakdown, plastic isn't like other kinds of trash. When it ends up in our landfills and in our oceans, it doesn't just go away.

Have students write in their science notebooks three ways it is beneficial that plastics don't biodegrade and three ways it is harmful that

Plastic Polymer Lab *Continued*

plastics don't biodegrade.

Wrap-Up:

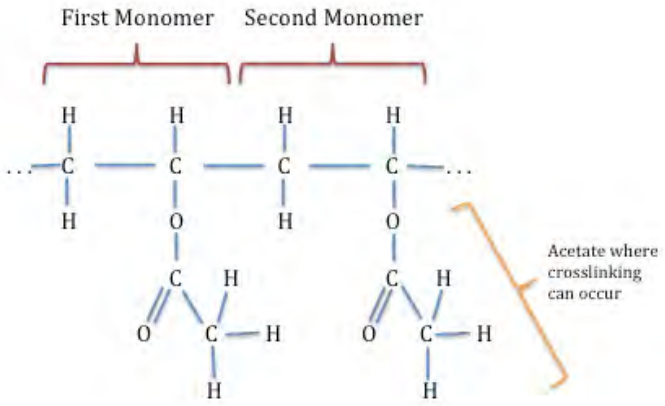
Ask students to make a list of all the polymers they use in their lives and prioritize them from most to least important.

Identify which of these polymers come from petroleum products (hint: pretty much all plastic products!).

Discuss ways to reduce, reuse, and recycle these things. Could any of the plastic polymer products they use be replaced with something that is more sustainable?
Challenge students to identify at least one plastic polymer product that they will cut out of their "diet" for the next week.

Extensions & Lesson Connections:

Extend this lesson by teaching students more about the chemistry of a polymer. Explain to students that white Elmer's glue is already primarily composed of the polymers polyvinyl acetate and polyvinyl alcohol. In this experiment they used borax (sodium borate) to crosslink these chain polymers to create a different polymer. The chain polymer is made up mostly of monomers of polyvinyl acetate ($C_4H_6O_2$) linked together. Provide each group with gum drops in three colors and toothpicks, as well as a diagram of the molecular structure of a chain of polyvinyl acetate. Ask them to create a molecular model using the gumdrops and toothpicks. Each color of gumdrop can be a different element (Carbon, Hydrogen, and Oxygen) and the toothpicks represent the bonds between them. Below is a diagram of the molecular structure of polyvinyl acetate. Since it is a polymer, after all, the smaller monomers repeat over and over again. The diagram below has two molecules of the monomer $C_4H_6O_2$ linked together:



Once each group has created their basic polyvinyl acetate model with gumdrops, explain that the borax (sodium borate) crosslinks these polymers at the acetate groups ($C_2H_3O_2$) that "hang off" the polymer. This results in the long chains of polyvinyl acetate being linked together, which reduces the viscosity of the compound, making it more solid and "bouncy."

This lab pairs well with the "Plastics in Society" lesson.

Evaluation:

Observe student participation during group work. The successful creation of polymer slime can be used as a measure of cooperation, student understanding, and ability to follow multi-step directions and measure ingredients. Review student science notebook entries, including uses of polymers, and the pros and cons of plastic not biodegrading. Evaluate these entries for completeness, effort, and understanding of the concepts.

Polymer Lab

1. You will need 1 mixing bowl and 1 mixing cup and a spoon.

2. Go back to the table to measure 1 cup of glue and 1 cup warm water into your mixing bowl.

3. Mix ½ cup warm water and 1 teaspoon of borax into your mixing cup.

4. Return to your desks.

5. Mix the borax mixture into the glue mixture and stir well.

6. When you notice your slime starting to take shape as monomers link into polymers, remove the slime from the leftover water and knead with your hands.

7. Play with and observe your completed polymer for a couple minutes

8. Split the polymer among each member of your group and store in Ziploc baggies.

9. Clean up your lab station.

