Polymer Synthesis: Bouncy Balls

Objectives

- To gain a general understanding of what polymers are and what characteristics they possess.
- Understand how polymers can be broken down into monomers.
- Understand processes that build and break down polymers.
- Relate polymers and the processes of creating and breaking down polymers to the processes involved in biofuel production.

Skill Level: Middle School and High School	**Class time:** 25 minutes

Materials

- 1 small container
- ½ tsp. of Borax, divided
- 2 tbsp. of White craft glue
- 1 stirring rod
- 1 Ziploc bag
- 1 Marking pen
- Food coloring (optional)

Next Generation Science Standards

Disciplinary Core Idea:
MS-PS1 Matter and Its Interactions

Performance Expectations:

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

HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

Practices	**Crosscutting Concepts**
☐ Asking questions / defining problems	☐ Patterns
☒ Developing / using models	☒ Cause and effect: Mechanism / explanation
☐ Planning / carrying out investigations	☐ Scale, proportion, and quantity
☐ Analyzing / interpreting data	☐ Systems and system models

☐ Math / computational thinking	☒ Energy / matter: Flows, cycles, conservation
☐ Constructing explanations / design solutions	☐ Structure and function
☒ Engaging in argument from evidence	☐ Stability and change
☐ Obtaining / evaluate / communicate	

Background Information

Introduction:

In the production of biofuels, it is important for scientists to understand the chemical structure of these polysaccharides, because the biofuel production process involves breaking these down into glucose monomers, which can then be used to produce biofuels like ethanol. The activity below simulates what plants do when building polymers out of glucose. Students will be taking monomers found in glue, and using borax to create a polymer.

Background:

Biofuels are made by breaking down the glucose found in plants. Glucose is made of polymers, which are long molecular chains composed of repeating chemical units that are linked together. For example, starch is a polymer is made from linked glucose molecules. Plants create another polysaccharide, cellulose, which they use in their cell walls. Plants produce almost one hundred billion tons of cellulose per year. It is the most abundant organic compound on Earth, thus making it an important source of bioenergy.

Polysaccharides are polymers of hundreds to thousands of monosaccharides joined by glycosidic linkages. Cellulose and starch are made up of hundreds of linked glucose monomers. In the production of biofuels, it is important for scientists to understand the chemical structure of these polysaccharides, because the biofuel production process involves breaking these down into glucose monomers, which can then be used to produce biofuels like ethanol. The activity below is analogous to what plants do when building polymers out of glucose.

Engage
Students should be interested to learn about the plant processes that help make bioproducts. These products are made of renewable resources like plants that can be regrown. These products are then used to make things we use everyday, like plastics. This can help make plastic easier to make without being so taxing on our planet.

Explore

Experiment Questions:

- What, if any, of your observations are indicative that a polymer was forming/ formed?
- Why do you think the balls are sticking together? What is holding it together? What conclusions can you draw about the properties of polymers?
- How does knowing about polymers help us understand biofuel creation?
- Could you break the ball back down into its smaller components or to its original form? Why would this be challenging?

Procedure:

1. Draw the polymer chains of glucose, starch, and cellulose for students. Walk them through the carbon structure and answer any questions they may have about the basic chemical bonds of polymers.
2. Pour 1 tablespoon of white glue into the small container.
3. Add ¼ tsp. borax to the dish.
4. Add food coloring (if desired).
5. Wait 15 seconds to allow the ingredients to react.
6. Stir vigorously with a stir stick until the mixture becomes a gummy, solid mass.
7. Roll the ball between the palms of your hands to mold it into a sphere.
8. Once the ball is no longer sticky, go ahead and bounce it!
9. You can store your plastic ball in a sealed ziploc bag when you are finished playing with it.
10. Don't eat the materials used to make the ball or the ball itself.

Explain

- What is the polymer in this situation?
- How easy do you think it would be to break down a polymer?
- What changed the white syrupy liquid into a solid mass?

Elaborate

- Make a list of all the polymers that you see around. Can you recognize which ones are synthetic and which ones are natural?
- The monomers in white glue are human-made and were like synthesized from crude oil. Research the history of white glue and list natural-based glues that would perform the same job.
- Provide a diagram of any one single polymer unit and the polymer chain.
- Write a short discussion summarizing your learning. Please cite any additional resources used in answering questions.

- Design an experiment to compare the properties of two different polymer balls. (Examples: lifetime test, performance test) Starting with fresh materials, redo the procedure and try your experiment.

Resources

Additional Resources:

- Applications of Polymers
- Video: How to Make a Bouncy Ball

Resources Used:

- Energy Education and Workforce Development
- Energy Kids: Renewable Biomass
- National Renewable Energy Laboratory
- Energy.gov