Cup Wars

Theme: Science and Engineering in Society

Introduction

Youth will test how heat affects different types of plastics, exploring how the properties of materials affect its function.

Time needed

- 15-20 minutes

Do & Learn Goal

- Youth will discover that polymers are long chains of repeating units
- Youth will explore how materials & their properties influence their function or purpose

Background Information

Polymers are in almost everything we use in our everyday life. A polymer is a large molecule made up of long chains of repeating units. Each unit, or repeating part, is a **monomer**. The word 'mer' means unit, and 'mono' means one. A **molecule** is the smallest unit of a substance that has all the properties of that substance. For instance, a water molecule is the smallest unit that is still water. A water molecule can be divided into tiny parts called atoms. Each water molecule has two hydrogen atoms and one oxygen atom (thus water is written as H2O).

Materials are the physical substance of which a thing is made or can be made. Wood, plastics, glass, and metal are some examples of materials. The **properties** of polymers reflect what's going on at the ultra-tiny (molecular) level. So, polymers look, feel, and act differently depending on how their atoms and molecules are connected, as well as which molecules they're made up of! This makes polymers a very useful type of material - they can have many different properties and **functions**. Some polymers are stretchy like a rubber band, hard and tough like a skateboard, silky and strong like a parachute, or even bulletproof. While plastics are one common example of polymers, there are many other materials which are also polymers. Examples of natural polymers include rubber (from the sap of rubber trees) and silk (from the cocoons of silkworms). Polymers also include proteins (such as hair, nails, and tortoise shell). Scientists combine monomers into a variety of different polymer arrangements to make synthetic polymers known as plastics. All plastics are polymers. Examples of plastics include polyvinyl chloride (PVC), polystyrene, and polyethylene.

Although all plastics are polymers, not all polymers are plastics. Other examples of synthetic polymers are nylon, polyester, and silly putty.

Do!

Materials:

• One PLA cup (identified as Sample A) – 1 per group of three youth • One PS cup (identified as Sample B) – 1 per group of three youth • One other plastic cup (identified as Sample C) - 1 per group of three youth • Permanent marker, black or blue - 2-3 • Blow dryer - 2-3 • Flip chart paper • Pens/pencils - 1 per group	• Use a permanent marker to label cup samples with A, B, or C on the bottom • Set up equipment (hair dryers, cups); for larger group you may wish to set up three stations (one for testing Cup A, one for B & one for C), and have youth rotate through the stations to conduct their tests • Test sample C prior to the lesson, using the hair dryer test, so you know what will happen; for example, a Solo TM brand cup may show some melting; heating a Dixie TM brand, wax-covered paper cup may cause the wax to soften and become warm; other cups will vary so facilitator should test before using • Put youth in groups of three

Questions:

- What are 3 different containers that you have used for a beverage in the last week? Explain why you chose that type of container.
- If you were having a party and you wanted to serve beverages, what types of containers might you choose?
- What would influence the type of container you'd choose?

Explain the challenge: Your team is challenged to find out which plastic cups can hold a hot
liquid (such as hot tea or hot cocoa).

To ensure safety in this activity, ask the group:

- What are some ways we could test these three cups to see how they withstand heat (like hot liquid)? *Youth will likely say we could pour hot water in them and watch what happens.*
- Would there be any safety concerns with each type of test? *(e.g. burn our hands, have hot water run all over)*
- Emphasize that safety is a key consideration for any experiment. Scientists and engineers have to be sure that any experiment or test they try is safe. To keep us safe, we will be using a hair dryer for the heat source, instead of hot water.

Procedure:

1. Invite youth to examine each type of cup (Samples A, B & C), then answer the following questions, and make brief notes about the cups' appearance (size, texture, color, weight, and other observations) on flip chart paper.
2. Engage in group discussion, using these questions:
    - Based on appearance alone, what is the same and different with the three cups?
    - Do you think these are made of the same material? Why or why not?
    - Based on your observations, predict how each sample will hold up to the heat of the hair dryer.
3. Give a safety demonstration: Show youth how to hold their cups and blow dryer -- the youth can hold the cup right next to the blow dryer, but should keep their fingers out of the hot air. It can help to hold the cup upside down by the lip.
4. Invite each group to move to stations and to blow-dry their sample cups for 30 seconds. (Groups can repeat for another 30 seconds, observing at the end of each 30 second test. They may repeat for up to a total of 120 seconds or 4 sets of 30 seconds each). Guide youth to rotate to all three stations. Ask youth to make notes about their observations using the flip chart paper.

    Facilitator Tip: Sample A "flows" within about 20 seconds. This means the plastic will warp and collapse. Sample B should be impacted only in a minor way (if at all). (The results for Sample C will depend on the type of cup chosen; facilitators will have tested this sample prior to youth trying it so they will know how it reacts to heat).

5. Based on their observations, have youth draw conclusions about the ability of the cups to hold hot water based on how they reacted to the blow dryer test. Ask them to explain their conclusions.

Reflect

- Describe what happened with Sample A? Sample B? Sample C?
- What evidence did you gather through your observations that this cup would or would not hold hot liquid?
- Explain how these reactions are similar. Explain how they are different?
- What do you think causes the cups to react the way that they did?
- What do you notice about the plastic code on the cups we used?
  Facilitator Tip: This may be a good time to discuss what materials plastics are made from: synthetic or "petroleum-based" are still our most common material to make plastics. PLA cups are plant-based plastics.
- Clarify that the word argument in this context is defined as reasons given to support an idea and that in the investigation they just did, the cups are evidence that the plastics are made of different compositions of material.

Learn More!

Tell someone why **you are a scientist** or **teach them a new word** you learned:

- **Function:** The purpose of an object or what it is used for.
- **Material:** A physical substance of which something is made or can be made; wood, plastics, glass, and metal are some examples of materials.
- **Molecule:** The smallest unit of a substance that has all the properties of that substance; made up of two or more atoms.
- **Monomer:** A part or single unit ('mono' means one and 'mer' means unit).
- **Polymer:** Large molecule made of long chains of repeating parts. Each repeating unit is the "monomer," so polymer = many repeating units.
- **Properties:** Characteristics that can be observed or measured; properties include size, shape, density, texture, hardness, color, odor, and other ways something looks or feels.

This activity is part of **Sustainable Polymers: Taking Action to Solve the Challenge of Plastics,** a 4-H STEM curriculum for grades 6-8. Please visit 4hpolymers.org to download the full curriculum.