Facilitator/Educator Guide: Turn Milk into Plastic!

How can plastic be made out of milk? Find out how an acid (in this case, vinegar) along with a measuring cup and teaspoon, a mug, a stirring spoon, and paper towels can turn hot milk into plastic.

Activity's uses:	Classroom demo or small group exploration
Area(s) of science:	Physical Science
Difficulty level:	
Prep time:	<10 minutes
Activity time:	10-20 minutes
Key terms:	plastics, casein, monomers, polymers, chemical reaction, chemistry, food chemistry, acids

Background Information

Plastics are a group of materials that can look or feel different, but can all be molded into many shapes. The similarities and differences between different plastic products come down to the molecules they are made of. Plastics are all similar because they are all made up of molecules that are repeated over and over again in a chain, called a polymer. Polymers can be chains of one type of molecule, or chains of different types of molecules linked together in a regular pattern. In a polymer, a single repeat of the pattern of molecules is called a monomer (even if the polymer is made up of only one type of molecule).

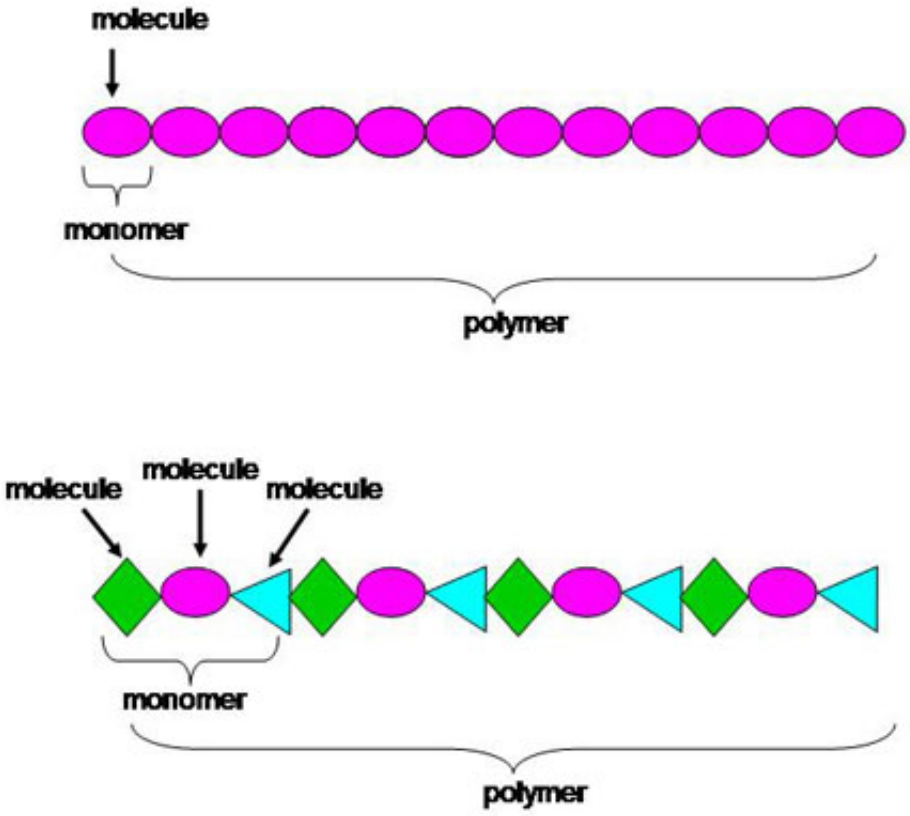

Figure 1. Polymers are made up of repeated patterns of molecules, called monomers. Monomers can be made up of one type of molecule (such as the top polymer) or multiple different molecules (such as the bottom polymer).

Milk contains many molecules of a protein called casein. When milk is heated and combined with an acid, such as vinegar, the casein molecules unfold and reorganize into a long chain. Each casein molecule is a monomer and the chain of casein monomers is a polymer. The polymer can be scooped up and molded, which is why plastic made from milk is called casein plastic. From the early 1900s until about 1945, casein plastic was quite common. Casein plastic has been used to make buttons, decorative buckles, beads and other jewelry, fountain pens, the backings for hand-held mirrors, and fancy comb and brush sets.

In this science activity, students will use hot milk, vinegar, a mug or other heat-resistant cup, paper towels, and a spoon to make their own casein plastic.

For Discussion

This science activity can serve as a starting point for a variety of science and chemistry discussions. Here are a few examples of questions that can be used to start a discussion:

- What different kinds of plastics can you think of? What are some properties of a plastic?
- What is a polymer made up of?
- What do you think will happen when you add an acid, like vinegar, to milk?
- Besides the protein called casein, what else is in milk?
- Do you think that you could make casein plastic out of soy milk? Why or why not?
- Why do you think adding an acid, like vinegar, to the milk will change it?

Materials

Needed for preparing ahead:

- Measuring cup (1)
- Milk (1 cup per demo or small group)
- Stovetop oven and pan (1) or microwave and microwaveable container (1)
- Thermos (1)
- Mug or other heat-resistant cup (1 per demo or small group)
- Set of measuring spoons (1)
- White vinegar (4 tsp. per demo or small group)

Needed for each demo or small group at the time of the science activity:

- Hot milk (1 cup)
- Mug or other heat-resistant cup with 4 tsp. of vinegar (1)
- Paper towels (6)
- Spoon for stirring (1)
- Optional: Cookie cutters, glitter, food coloring, markers

Figure 2. You need only a few simple household materials to do this fun science activity. You can use a stovetop oven and pan or a microwave and microwaveable container.

What to Do

Prepare Ahead (<10 minutes)

1. Heat 1 cup of milk for each classroom demo or small group. Heat the milk in a pan on a stovetop until the milk is

steaming. Alternatively, you can microwave the milk in a microwaveable container by warming it at 50% power for 5 minutes and watching to make sure it does not overflow. It should be about the same temperature as you would want milk to be for making hot cocoa. If it is not heated enough, microwave it for 2 minutes at 50% power and repeat this until the milk is hot.
2. Store the hot milk in a thermos until it is needed.
3. Right before doing the classroom demo or small group exploration, add 4 teaspoons (tsp.) of white vinegar to a mug. Each demo or group should have one mug with vinegar.

Science Activity (10-20 minutes)

1. Each classroom demo or small group should have 1 cup of hot milk, one mug with vinegar, paper towels, and a stirring spoon.
2. Help students measure out 1 cup of hot milk from the thermos and add the hot milk to the mug or other heat-resistant cup with vinegar. When the hot milk is added to the vinegar, the milk should form white clumps (curds). Have students mix the mug of hot milk and vinegar slowly with a spoon for a few seconds. Ask them to write down their observations.

Figure 3. When the hot milk is added to the vinegar, the milk should form white clumps (curds).

3. Stack four layers of paper towels on a surface that is safe to get damp.
4. Once the milk and vinegar mixture has cooled a bit, have students use a spoon to scoop out the curds. Direct them to tilt the spoon against the inside of the mug to let excess liquid drain out while retaining the curds in the spoon. Have them collect as many curds as they can in this way and put the curds on top of the paper towel stack.

Figure 4. Have students collect and drain the curds from the mug using a spoon, and then put the curds on top of a stack of paper towels.

5. Direct students to fold the edges of the paper towel stack over the curds and press down on them to absorb excess liquid from the curds. Two more paper towels can be pressed down on top of the curds to soak up the rest of the extra liquid.
6. Have students knead all of the curds together in a ball of dough. This is the casein plastic.

Figure 5. Direct students to press down on the curds with the paper towels to soak up all of the extra liquid. Students should then knead the curds together to make a ball of dough, which is the casein plastic.

7. If students want to make the casein plastic into something, they can color, shape, or mold it now (within an hour of making the plastic dough) and leave it to dry on paper towels for at least 48 hours. To shape the plastic, students must knead the dough well before shaping it. Molds and cooking cutters work well, or, with more patience, the dough can be sculpted. Food coloring, glitter, or other decorative bits can be added to the wet casein plastic dough, and dried casein plastic can be painted or colored with markers. Once it has dried, the casein plastic will be hard. Drying time varies depending on the thickness of the final item (thicker pieces take longer), but plan on at least two days.

Figure 6. Students can mold and decorate the casein plastic within an hour of making it. It will take at least 48 hours to dry completely.

Expected Results

When you add the hot milk to the vinegar, small, white chunks should become visible in the mixture. This is because adding an acid, such as vinegar, to the milk changes the pH of the milk and makes the casein molecules unfold and reorganize into a long chain, curdling the milk. The white chunks are curds. Students should be able to use a spoon to separate the curds from most of the liquid, and additional drying of the curds with the paper towels should make the curds ready to knead into a ball and use as casein plastic. The casein plastic can be molded and decorated.

For Further Exploration

This science activity can be expanded or modified in a number of ways. Here are a few options:

- How does the amount of vinegar used affect the yield of casein plastic? You can have students repeat this activity, but in addition to testing 4 tsp. of white vinegar with 1 cup of hot milk, try also testing 1 tsp., 2 tsp., or 8 tsp. of white vinegar, each with 1 cup of hot milk. To collect more of the curds and get a better idea of the yield of the casein plastic, instead of scooping out the curds with a spoon, you can have students pour the vinegar and milk mixture through a piece of cotton cloth (such as an old T-shirt) secured with rubber bands on top of a cup.
- How does the temperature of the milk affect how much casein plastic you can produce? You can have students do this activity again, testing milk heated to different temperatures.
- In addition to vinegar, there are a lot of other acids that we encounter in the kitchen all the time, such as lemon juice, orange juice, soda pop, and tomato juice. Do some of these acids work better than others to make casein plastic?

Downloads and Links

- Turn Milk Into Plastic! Facilitator / Educator Guide
- Turn Milk Into Plastic! Student Guide web page (http://www.sciencebuddies.org/science-fair-projects/Classroom_Activity_Student_MilkPlastic.shtml)

Credits

Teisha Rowland, PhD, Science Buddies