Getting Silly with Putty

Modified from lesson by Prof. Chris Ober <http://www.ccmr.cornell.edu/education/lendinglibrary/moreinfo.php?id=30>

**Objectives**:

Students will be introduced to the concept of polymers and their structure, as well as properties associated with them.

**Vocabulary:**

**Molecule**

**Compound**

**Monomer**

**Polymer**

**Materials:**

* All purpose white glue
* Saturated solution of sodium tetraborate (Borax) in water
* Food coloring
* Dixie cup
* Craft stick or spoon
* Eye dropper

**Science Content**

**Polymers** are substances whose molecules have high molar masses and are composed of a large number of repeating units. There are both naturally occurring and synthetic polymers. Among naturally occurring polymers are proteins, starches, cellulose, and latex. Synthetic polymers are produced commercially on a very large scale and have a wide range of properties and uses. The materials commonly called **plastics** are all synthetic polymers.

**Polymers** are formed by chemical reactions in which a large number of molecules called **monomers** are joined sequentially, forming a chain. In many polymers, only one monomer is used. In others, two or three different monomers may be combined. Polymers are classified by the characteristics of the reactions by which they are formed. If all atoms in the monomers are incorporated into the polymer, the polymer is called an *addition polymer.* If some of the atoms of the monomers are released into small molecules, such as water, the polymer is called a *condensation polymer.* Most addition polymers are made from monomers containing a double bond between carbon atoms. Such monomers are called olefins, and most commercial addition polymers are polyeofins. Condensation polymers are made from monomers that have two different groups of atoms which can join together to form, for example, ester or amide links. Polyesters are an important class of commercial polymers, as are polyamides (nylon).

**Preparation:**

Create a super-saturated solution of sodium tetraborate by mixing Borax and water (1 tablespoon of dry Borax per 1 cup of water). Adding more Borax is fine but adding too little means there won’t be enough borax to polymerize the glue molecules.

**Procedure:**

***Engage (~15 minutes)***

Ask students where clothing comes from: cotton, plants and animals. What about metal? *From mined substances, rocks*. Paper products? *From trees, and plants.* What about plastics? Most may not know that plastics are from petroleum products. Explain that chemists design and make molecules with special properties by performing chemical reactions to hook atoms into long chains called polymers. Plastics, therefore, are polymers.

Have several groups of students stand in a straight line and link hands, explain that each student is a molecule and together they form a polymer. Now pretend the Borax is being added, ask the “chains” to move through and under each other’s arms, causing them to tangle. Now, considering that the “molecules” are no longer able to flow like a liquid, ask students to **predict** how the addition of Borax will change the properties of the polymer. Have the students **write down their hypothesis** in their lab notebooks before proceeding.

***Explore (~15 minutes)***

Distribute materials to each student

Ask the students the following questions and have them write down answers in their lab notebooks:

What are the properties of the glue and Borax?

In this lab you will create silly putty to explore the properties associated with polymers.

1. Fill the cup half-way with glue
2. Add one drop of food coloring to the glue solution and stir well with the craft stick (or spoon)
3. Add one dropper full of sodium tetraborate (Borax) into the glue solution. As you do this, pay close attention to the properties of the glue and the Borax both before you combine them and as you stir.
4. Continue adding a dropper full of sodium tetraborate at a time and stirring well after each addition until the glue solution takes on a silly-putty texture (3-6 times). You will need to really stir it for about 2 minutes with the stick.
5. Remove the solid glob and roll it around in your hands to dry it off. It will remain sticky for one or two minutes and then will take on the elastic quality of putty.

Once everyone has made Silly Putty, ask the following questions and have them answer in their lab notebooks:

* How did properties of silly putty compare to properties you wrote down before about the Borax and the glue?
* Can you explain what the reaction of Borax and glue might be doing on a molecular level? (Hint: think about the definition of a polymer)
* How are polymers useful in everyday life? List three products made from them.
* Considering the list you just make as well as your silly putty, describe one difference between different polymers. What do you think caused this difference?

***Explain (~10 minutes)***

Have students present their findings and their answers to lab questions to the class. Time permitting, explain more about polymers with the supplemental material, below.

**Supplemental Information**

* **Polymers:** large molecules, made up of simple repeating untis. The word is derived from
  + *poly* Greek word for “many”
  + *mer Greek word for “part”*
* **Monomer:** simple, repeating unit that makes up a polymer
  + *mono* Greek word for “single”
* Examples of **Natural Polymers:** spider silk, rubber, proteins (DNA) and cellulose (most abundant organic compound on the planet, found in wood and plants)
* Examples of **Synthetic Polymers**: fibers (polyester, nylon), coatings (paint), adhesives (glue), rubber, plastic (polyethylene, polypropylene and polystyrene)
* Expected **Lifetime**: Centuries, except for a few biodegradable ones, which is why **recycling** is so important!