Plastics and Polymers: Part 2

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Purpose: To learn about the wide variety of polymers available.

Learning Objectives:
1. To understand that plastics are not the only type of polymers available.
2. The physical and chemical properties of vary based on their composition.

National Science Education Standards (valid 1996-2013):
- Standard B: Physical Science
  - Properties and changes in properties of matter
  - Transfer of energy
- Standard D: Science and Technology
  - Abilities of technological design
  - Understanding about science and technology
- Standard F: Science in Personal and Social Perspectives
  - Science and technology in local, national, and global challenges

Suggested Previous Activity:
*Green Chemistry: Plastics and Polymers: Part 1*

Grade Level: 3-8

Time: 60 minutes

Materials:
- A variety of polymer samples such as:
  - Rubber bands
  - Electric tape, tape
  - Glue
  - Variety of plastic containers
  - Package peanuts
  - Styrofoam
  - Bungee cords
  - Disposable gloves
  - Different types of polymer fabrics like polyester, spandex, nylon, etc.
  - Weighing boats
  - Spatulas
  - Sodium polyacrylate
  - Water absorbing polymer beads
  - Scissors for cutting diapers (optional)
  - Disposable diapers (optional)
- Safety goggles
- Gloves
- Packing peanuts (biodegradable)
- Small cardboard box or container
- Petri Dish
- Pipettes
- Acetone
- Water
- 10% sodium chloride solution* (see preparation instructions)

**Preparation ahead of time:**
Sodium Chloride Solution (if you are doing the Packing Challenge)
Mix 50 grams of sodium chloride with 460 mL of water and stir.

**Introduction:**
Polymers include many types of materials, which have long chain structures with many repeated units. Synthetic polymers are man-made polymers and they can be classified into four main categories when thinking about their utility (these categories are not fixed and some materials can fit into more than one group):

1. Elastomers: are rubbery materials that can be deformed and they return to their original shape.
2. Plastics: materials that can be shaped under specified conditions and will hold their form.
3. Fibers: polymers that can be made into fibers, such as nylon.
4. Adhesives: materials that will bond to a surface.

Polymers are characterized based upon their physical properties. Of importance are the monomer(s) that a polymer is made up of, the monomer arrangement if there is more than one type of monomer present, and the chain length. One change will alter the physical properties of the polymer material. Some properties that vary depending on the identity and the structure of the polymer are: strength, stretchiness, and density. For example, polyethylene with long chains forms a high-density material that is rigid while polyethylene with randomly formed branching long and short chains forms a low-density material that is flexible.

Tell the students that today they are going to learn about other polymers besides common plastics. They will also be exploring some of the physical and chemical properties of different polymers. *Plastics and Polymers: Part 3* will continue the exploration of properties.

**Procedures:**
1. Polymer Examination
   a. Allow students to examine a variety of different polymers.
   b. Students should notice differences and similarities in the different polymers.
   c. Ask them to classify the polymers according to their physical properties. Make sure they write down all their observations on the worksheet.
   d. Make sure they understand plastics are not the only type of polymers.
2. Superabsorbent Polymers
   a. Hand students the water absorbing polymer beads—2-4 in a small Ziploc bag. Ask them if they have seen anything like them.
   b. Ask them what they think will happen if they add water to the beads and make sure they write down their predictions on the worksheet.
   c. Have the students add ~20 mL of water into the Ziploc bag and make sure they close the bags tightly.
   d. Have them write their observations on the worksheet and put the baggies aside for 10-15 minutes.
   e. Hand each student a weighing boat and a spatula.
   f. Tell them to get a small amount of sodium polyacrylate—ONLY THE TIP OF THE SPATULA. Make sure they examine the powder and write down their observations on the worksheet.
   g. Ask them what they think it will happen if they add one drop of water, two drops etc. Let them test their predictions and write down their observations.
   h. Show them a diaper and ask them what makes them absorbent. Cut the diaper open and give students a piece of the center, allow them to examine and test it.
   i. Have students compare the sodium acrylate they tested with the interior of the diaper they experimented with. Explain to them that they are the same material.
   j. Go back and look at the polymer beads. Have they grown? What do all these polymers have in common?

3. Packing Challenge (if time, otherwise this is part of Green Energy: Plastics and Polymers: Part 3)
   a. Have students use rulers to measure the height, length, and width of a packing peanut (biodegradable).
   b. Record the results on the worksheet.
   c. Ask the students if they can make the packing peanuts take up less space. Provide a small box or container and challenge them to fit a specified number of starch packing peanuts (1-3) into the container.
   d. Students are expected to try to tear or smash the packing peanuts so they will fit into the container.
   e. Provide the students with pipets and three different solutions: water, sodium chloride solution and acetone. Put the packing peanuts in a petri dish and allow the students to experiment with dripping the different liquids on them.
   f. If necessary, prompt students to use the water to get the packing peanuts into the container.
   g. Have the students re-measure the size of a packing peanut that has had water dripped on it.

Discussion and Evaluation:
Over a 100 billion pounds of polymers are produced every year in the U.S. (EPA 2006). The polymers produced are not only plastics; there is great variety of polymers that we use on a daily basis and need to be aware of their existence, properties, and recycling ability.
Super absorbent polymers are very common and most students do not think of them as polymer. This group includes a variety of different polymers all having the basic ability to absorb large amounts of water. They soak up water using the process of osmosis (water molecules pass through a barrier from one side to the other). These types of polymers have different physical and chemical properties than those they tested in *Plastics and Polymers: Part 1*.

The packing peanut activity can be used to begin a discussion about how different polymers have different properties, i.e. the starch can be broken down with water while other polymers like a rubber band don’t break down. *Plastics and Polymers: Part 3* continues the discussion of polymer properties.