



Lesson Plan for “Polymer Fun”

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Introduction

A polymer is a chemical compound consisting of many repeating structural units called monomers. For example, when we connect many paper clips together, the chain of paper clips represents a chain of polymers. Each paper clip is a monomer.

There are two general types of polymers: natural polymers and synthetic polymers (or human-made polymers). Some examples of natural polymers are starch (found in food such as bread, corn, and potatoes) and cellulose (found in plants and trees such as cotton for clothes), DNA and RNA (found in living organisms), chitin (found in seafood; it makes up the shells of crawfish, shrimp, crabs, and lobsters), and many other things. Synthetic polymers: nylon fibers in our clothing, rubber in car tires or shoes, plastics, and paper.

Polymers have many different diverse characteristics. Some are flexible, stretchy, and strong, but some plastics can be very brittle. Polymer chains can get tangled up because these long chains tend to stick to each other. An analogy would be when we eat spaghetti, we often have difficult time trying to separate the noodles. This makes some polymers strong. Polymers are also thermoplastic as they are soft when heated and hard when cooled. This is one way that we make plastics.

Polymers are used widely in our daily life (such as nylon, plastic bags, water bottle, paints, sunglass les, contact lens, DVDs, credit cards, car wheels) and in different fields of engineering. In biomedical engineering applications, polymers are used in controlled drug delivery. A drug delivery device is a polymer combined with a drug so that the diffusion of the drug and the degradation of the polymer are controlled as designed. The device is implanted onto human tissue. Besides that, synthetic polymers for gene therapy provide a safer way of gene delivery. Polymeric materials have been used for biosensors in testing devices and bio-regulation. Moreover, polymers are useful in tissue engineering, artificial organs, dentistry, bone repair, and so on.

In agricultures, hydrogel polymers help reduce water runoff and soil erosion. It increases moisture retention and water conservation by increase water holding capacity in soil so that plants can survive during droughts.

Student Objectives

By the end of this lesson, students should:

1. Have basic concepts about polymers and their properties;
2. Know about applications of polymers in our daily life and also in many different fields of engineering.

Overview of Lesson Process

1. Introduce polymers to students: definition, examples, properties, and applications of polymers. (10 minutes)
2. Activities:
 - Making alginate caviar (15 minutes) & Follow-up discussion (5 minutes)

- Diaper experiment (15 minutes) & Follow-up discussion (5 minutes)
 - Degradation of hydrogel (5 minutes) & Follow-up discussion (5 minutes)
3. Clean up (5 minutes)

Materials

A. Caviar activity:

- Sodium alginate (food grade): ~\$10
- Calcium chloride (food grade): ~\$10
- Fruit juice/water
- Paper bowls + plastic spoons
- Plastic syringe, eyedropper, or baster
- Food coloring (optional)
- Towels

B. Hydrogel activity:

- Pampers Baby Dry Diapers Walmart \$8.97
<http://www.walmart.com/ip/Pampers-Baby-Dry-Diapers-Choose-Your-Size/22866817>
- Stir sticks Officemax Item #: 23219090 \$1.99
- Scissors
- Plastic cups
- Ziploc bags
- Salt

Procedure

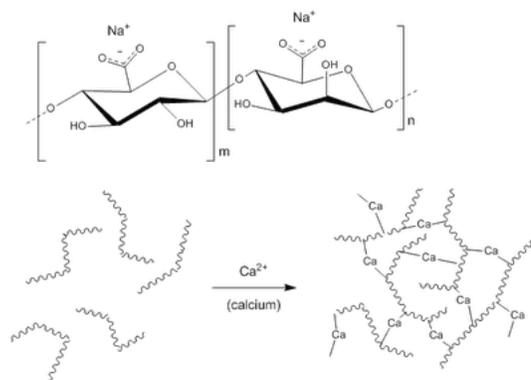
A. Making Alginate Caviar

1. Add about 2 grams of calcium chloride into a bowl and then add about 500 ml of water. Stir to dissolve.
2. In another bowl containing about 2 grams of sodium alginate, add water or fruit juice and stir to dissolve. This will create a thick, gel-like mixture
3. Fill the plastic syringe with the juice mixture above, then gently discharge the mixture to the prepared calcium chloride solution drop by drop. We just made alginate caviar!
4. After a few seconds, gently remove the caviar and place them in a cold water bowl.
5. Remove from water, serve, and enjoy!

☞ Follow-up discussion: What has actually happened?

- ❖ Alginate (or alginic acid) is a natural polymer derived from the cell walls of brown algae. It is commonly used in food products such as ketchup and ice cream to serve as a thickening agent.
- ❖ Alginate can dissolve (are soluble) in water.

Upon adding alginate mixture to the calcium solution, the calcium ions help create cross links between alginate polymer chains, which then creates a gel layer, which is insoluble in calcium solution, on the outside of the water or juice.



Cross linking of polymer chains with Ca²⁺

- ❖ The caviar spheres should be taken out of the bath after less than 1 minute in order to have liquid inside. Longer time will give a more solid center.

B. Diaper Experiment

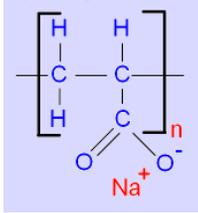
1. Place a new diaper on a piece of newspaper. Cut through the inner lining carefully. Take out the cotton-like material and put all the material into a Ziploc bag. Pour all the material that may have spilled onto the newspaper into the Ziploc bag.
2. Blow air into it so that it fills up with air like a pillow. Seal the Ziploc bag. Shake the bag vigorously until you can see powder at the bottom.
3. Remove the stuffing from the bag and pour the powder you just extracted at the bottom into a plastic cup. (It may be easier to work with only half of it at a time) We have now isolated the major ingredient.
4. Add 1/2 cup of water to the cup containing the ingredient. Observe what happens to the powder. Try to shake the cup a little bit to mix the ingredients. Add more water if necessary until you see a transformation.
5. After 30 seconds, observe that the water has changed from liquid to sticky and soft solid. Turn the cup upside-down and see how it has solidified.
6. Do step 1 to 4 again but adding more water into the cup containing the powder to test how much water the powder can absorb.



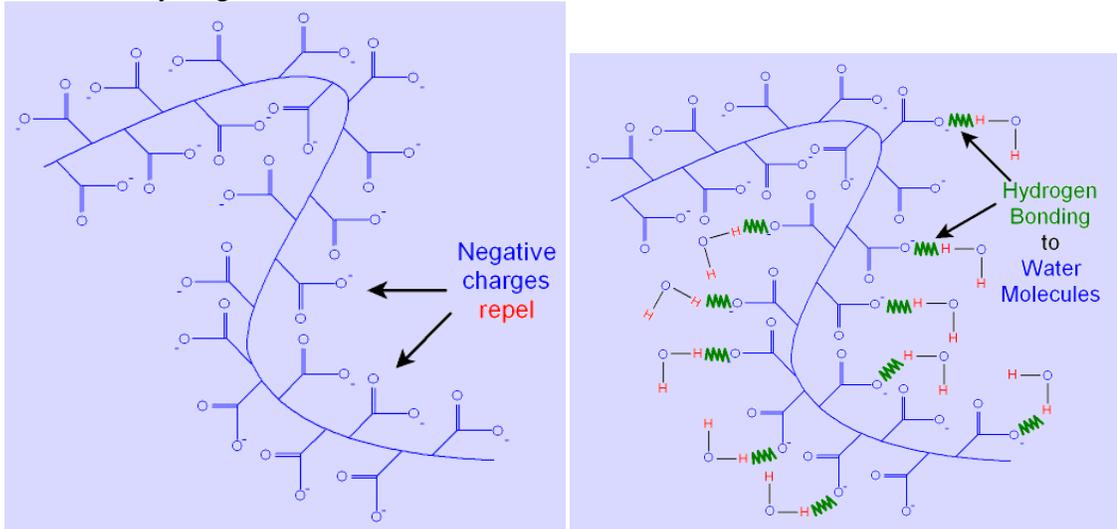
☞ Follow-up discussion: What has actually happened? Why did the mixture begin to thicken when added water into the cup? What do you think it is made of?

- ❖ The powder is hydrogels. Hydrogels polymers are long cross-linked molecule chains made up of repeating units and have hydrophilic groups that grab onto water molecules. This characteristic makes them a great solution for soaking up water.

- ❖ Hydrogels can be made of sodium polyacrylate with the carboxylic group.



- ❖ In the absence of Na^+ ions, the negative charges on the oxide ions along the polymer chain repel each other. The chains uncoil as in the picture.
- ❖ Water molecules are attracted to the negative charges to make hydrogen bonding. Therefore, hydrogels can absorb a lot of water



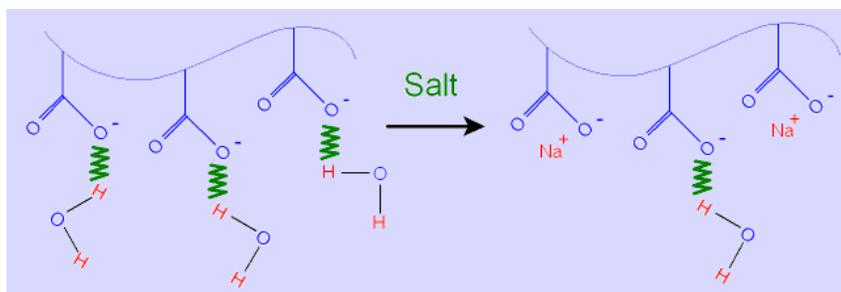
- ❖ The cotton-like fibers that you removed from the diaper and isolated from powder help to spread out the hydrogens and water so that baby would not have to sit on a water-filled gel.

C. Degradation of Hydrogels

1. Add a spoonful of salt into the solid mixture. Stir the mixture until you notice a change
2. Observe that the solid compound has dissociated back into water and the powder since hydrogels loses its ability to store water

☞ Follow-up discussion: What has actually happened?

- ❖ When salt is added to hydrogels, the positive sodium ions take up places next to the negative oxide ions, leading to less places for water molecules. Consequently, hydrogels lose the water-holding abilities.



- ❖ The chains also start to change their shape since the negative charges along the chain repel each other less in the presence of sodium ions, making the chains coiled up. This also squeezes out water from the hydrogel.

Resources

1. Idea of lesson:

<http://beam.berkeley.edu/sites/default/files/BEAM%20Fall%202011%20Lesson%20Plan%20-%20Polymer%20Chemistry.pdf>

2. Natural polymers:

<http://pslc.ws/macrog/natupoly.htm>

3. Use of polymers in daily life:

<http://www.stevespanglerscience.com/experiment/helpful-hydrogels>

4. Pictures of diaper experiment:

<http://www.stevespanglerscience.com/content/experiment/diaper-secret>

5. Follow-up discussion of diaper experiment and degradation of hydrogels:

<http://www.gcscience.com/o71.htm>

6. Application of polymers:

<http://cmbi.bjmu.edu.cn/2001/nano/pdf/8.pdf>