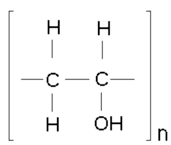
Name:
Period:

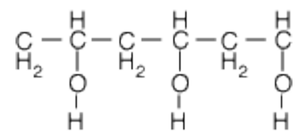
I've Been Slimed!!!

Background: Polymer chains can be linked together to form substances with a variety of properties. While the chains are held together by strong covalent bonds, they are linked to each other by weak hydrogen bonds. The amount of "cross-linking" of these hydrogen bonds determines how resilient the gels or plastics (polymers) are (how much they can be deformed). Gelatin and Kevlar are examples of polymers. Some are called "plastics" because they can be shaped or molded. Most are formed from many monomers linked together (mono = one, poly = many). Polymer chemistry is one of the largest fields in chemistry today.

Polyvinyl alcohol is made of many repeating units of the vinyl alcohol monomer, which doesn't exist by itself. If it did, it would look like this:

In a polymer (polyvinyl alcohol) it looks like this ,and the whole polymer looks like this:





When sodium tetraborate (Borax) forms a borate ion $[B(OH)_4^-]$in solution, the ions form hydrogen bonds with the –OH (hydroxyl) groups of polyvinyl alcohol, linking chains of polyvinyl alcohol to each other. These bonds are called cross-links. In this lab, you'll make a synthetic polymer from polyvinyl alcohol and one from polyvinyl acetate, and compare the two.

Problem: How does cross-linking change the properties of a polymer?

Materials:

Goggles
Apron
Graduated cylinder
2 paper cups
Food coloring
2 wooden splints
Polyvinyl alcohol (4% solution)
Sodium tetraborate (4% solution) (Borax)
Diluted white glue containing polyvinyl acetate

Procedure:

Part A

1. Measure 25 mL of 4% polyvinyl alcohol solution in the graduated cylinder and pour it into one of your paper cups. Add food coloring if you wish, and stir with a wooden splint until the color is evenly mixed. (Up to 5 drops max. or it will not gel.)

2. Add 25 mL of 4% sodium tetraborate solution to the cup. Stir the two solutions together until the solution becomes thick and pulls away from the sides of the cup, then stop stirring. Do not overstir.

3. Remove the polymer gel from the cup, keeping as much gel as possible, and shape into a ball.

4. Repeat steps 1-3, substituting diluted white glue for the polyvinyl alcohol solution. Flush excess liquid down the drain with lots of water.

5. Test each polymer for resiliency and cohesiveness. Try to bounce it, squash it, pull it apart, and so on. Check the polymer gel shear strength by trying to tear it. How easy is it to deform and/or separate it into pieces? (This requires polymer molecules to slip past each other.) Try to deform the polymer slowly, and then rapidly. Record your observations.

6. The polymer gels may be disposed of in the dry waste container or taken home in a baggie. Clean up your work area before leaving the lab.

Observations: (Try pulling it slowly and quickly, bouncing it, letting a ball of it sit for a while on a table, etc…whatever you want to try except for eating it.)

Questions:

1. In each of the comparisons below, say which substance you think has the most cross linking, and explain why.

   a. Liquid epoxy glue / hardened epoxy glue

   b. Silly Putty / a superball

   c. Kevlar / rubber band

2. What does the cross-linking do to the physical state of the substance? What do you think would happen to the state of the substance if you added more Borax?

3. Are the substances produced in this reaction solids or liquids? Explain your answer.

4. Modern life depends on the use of polymers, but there is an environmental cost. How does this statement pertain to the question at nearly every grocery checkout counter today, “paper or plastic?”

5. In some plastics, most of the polymer molecules are aligned in one direction. How does this explain how plastic such as food wrap and tape are easier to tear lengthwise than across?