A Silly Polymer Lab: Cross-Linking a Polymer to Create Silly Putty.

Objective:
The objective of this experiment is to cross-link a polymer and observe the changes in the physical properties as a result of this cross-linking. The changes in physical properties of a cross-linked polymer are also studied as the temperature is varied.

Review of Scientific Principles:
If a substance springs back to its original shape after being twisted, pulled, or compressed, it is most likely a type of polymer called an elastomer. The elastomer has elastic properties (i.e., it will recover its original size and shape after being deformed). An example of an elastomer is a rubber band or a car tire.

The liquid latex (Elmer's glue) which you use contains small globules of hydrocarbons suspended in water. The silly putty is formed by joining the globules using sodium borate (a cross-linker). The silly putty is held together by very weak intermolecular bonds that provide flexibility around the bond and rotation about the chain of the cross-linked polymer. If the cross-linked bonds in a polymer are permanent, it is a thermosetting plastic, even if above the glass-transition temperature (T_g). If the bonds are non-permanent, it can be considered either thermoplastic or an elastomer.

Materials and Supplies:
- 55 % Elmer's glue solution in water
- 4 % borax solution (sodium borate)
- Styrofoam cups
- zip lock bags
- food colors

General Safety Guidelines:
- Since borax solid (a bleaching agent) and solution will burn the eyes, goggles and aprons should be worn.
- Hands should always be washed after kneading the silly putty and finishing the experiment.

Procedure:
1. Wear goggles and lab aprons.
2. Pour 20 ml of the Elmer's glue solution into a Styrofoam cup.
3. Add food colouring to the glue and stir.
4. Add 10 ml of the cross-linker (borax solution) to each cup.
5. Immediately begin stirring the solutions together using the wooden stick.
6. After a couple of minutes of mixing, the silly putty should be taken out of the cup and kneaded in the hands. Don't worry about the material sticking to your gloves as these pieces will soon mix with the larger quantity with which you are working. Continue to knead until the desired consistency is reached.
7. Using a ruler to measure, drop the ball from a height of 30 centimeters. To what height does it rebound?
8. Stretch the silly putty slowly from each side.
9. Compress the silly putty back into a ball.
10. Pull the silly putty quickly from each side and compare the results.

11. Place the silly putty on some regular newsprint and press down firmly.
12. Remove the silly putty from the news print and make observations.
13. Repeat the same procedure on a comic section of the newspaper. The silly putty is non-toxic and safe to handle so you can put it in a zip-lock bag and take it home.
14. Follow good laboratory procedure and wash your hands with soap and water when you have finished the experiment.

Data and Analysis:

1. Height of the rebound _____ cm.
2. Observations of pulling the silly putty slowly: _____
3. Observations of pulling the silly putty quickly: _____
4. Observations of the silly putty on newsprint: _____
5. Observations of the silly putty on the comic's section of the newspaper: _____

Questions:

1. How do the physical properties of the glue, water mixture change as a result of adding the sodium borate? _____
2. What would be the effect (your thoughts) of adding more sodium borate solution?

   _____
3. What is the ratio of the height of the drop to that of the rebound distance? _____
4. Who in the class had the ball with the most elasticity? _____
5. How did you come to the conclusion of whose ball was most elastic? _____

   _____
6. At Home:

a) Place your ball in the refrigerator for 10 minutes. Recheck the bouncing portion of this experiment. What are your observations? _____

b) Why do you think this was observed?_____

   _____

c) Now place your ball about 6 inches from a light bulb for about 5 minutes and again recheck the bouncing portion of this experiment. What are your observations?_____

   _____

d) Why do you think this happened?_____

   _____

Slime Lab (Cross-Linking Poly (vinyl alcohol) with Sodium Borate)

Objective:
The objective of this experiment is to explore the change in physical properties of a polymer as a result of cross-linking. The result of adding more cross-linking agents to a polymer is considered and another model of cross-linking is viewed.

Applications:
There are a number of uses of the PVA polymer we are studying:
1. They may be used in sheets to make bags to act as containers for pre-measured soap you simply throw into a washing machine.
2. The PVA sheets may be made into larger bags to be used by hospitals as containers for the cotton cloth used in the operating rooms or to hold the bed linen or clothing of infected patients.

Materials and Supplies:
- 100 ml/group of poly (vinyl alcohol) 4%
- 10 ml of sodium borate 4%
- Styrofoam cups and wooden stir sticks (tongue depressors)
- Zip lock bags or latex gloves (surgical)

General Safety Guidelines:
- Goggles should be worn in this experiment as in all procedures.
- Both the borax and the PVA will burn the eyes. Hands should be washed at the end of the experiment.

Procedure:
1. The polyvinyl alcohol and sodium borate are mixed together in approximately a 10 to 1 ratio.
2. 100 ml of the 4% poly (vinyl alcohol) is added to a Styrofoam cup .
3. Food coloring can be added to the PVA in the cups to make different colors. Simple food coloring is recommended. This coloring should be added before the borax solution is added.
4. Add 10 ml of the 4% cross-linker (sodium borate) to each cup. Begin stirring the mixture immediately with your wooden tongue depressor.
5. Make observations as to what is occurring as the reaction proceeds.
6. Within a couple of minutes the slime will be formed. Lift some of it out with the tongue depressor and make your observations. Record your observations on your data sheet.
7. Take some in your hand and stretch the slime slowly. Record your observations on your data sheet.
8. Repeat the stretching exercise only this time do it rapidly. Record your observations on your data sheet. Compare the results of the two tests. The slime is non toxic and is safe to handle, so you can put it in a Zip-lock bag (or latex glove) and seal it to take home.
9. Follow good laboratory procedure and wash your hands with soap and water. It is recommended that this procedure be followed whenever handling this material. Keep it in the glove or bag until it is discarded. The sodium borate or PVA could burn your eyes.
10. Place a small amount of the PVA on a paper towel and set it off to the side to dry until tomorrow. Upon returning to class the next day, record in the data section your observation of the slime.

Data and Analysis:

1. Observation of the PVA before the sodium borate is added: _____

   _____

2. Observation of the PVA after the sodium borate is added: _____

   _____

3. Observation of stretching the cross-linked PVA slowly: _____

   _____

4. Observation of stretching the cross-linked PVA rapidly: _____

   _____

5. Observation of the cross-linked PVA left out in the air overnight: _____

   _____

Questions:

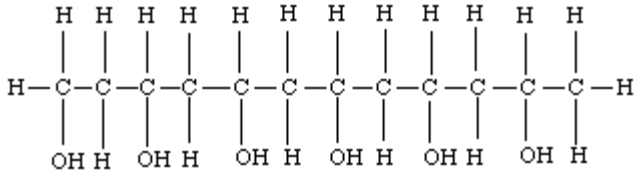
1. What are the physical properties that change as a result of the addition of sodium borate to the poly (vinyl alcohol). _____
2. What would be the effect of adding more sodium borate to your cup (your thoughts only)?

   _____

3. After making the observations on the dried PVA, how does the water affect the elasticity of the polymer? What is elasticity?

   _____

4. Find and circle the repeat unit in the polymer molecule below?



5. What is the formula of the poly (vinyl alcohol) monomer circled above? (Your teacher may want to show you how to alter this slightly after you have drawn the structure.)

   _____

6. In the picture below, circle the boron cross-linking agent.