Name: _____

Science of Slime

Understanding the structure of a material and how it behaves is a large part of what chemists and materials scientists do for a living. Scientists and engineers cannot use new materials to develop new technologies and improve old ones until all of the physical and chemical properties of the material are fully understood. When investigating a new compound, a materials scientist will often need to answer three questions about the compound: What is its structure, how are its properties related to its structure and composition, and finally can its properties be manipulated and enhanced through processing?

In this lab you will begin investigating the physical properties of a rather peculiar substance commonly known as slime. With enough time and equipment, we could thoroughly explore the physical and chemical properties of slime, but that could take years. Today, you will be investigating the consistency of slime and how it reacts when it experiences an external pressure, such as a tug.

What chemicals make up slime?

There is more than one method of making slime. You will be making a version which is often used to manufacture the varieties of slime that can be found in toy stores. The two main ingredients are poly (vinyl alcohol) and a solution of borax, which dissolves to form borate ions. When these two chemicals are combined, they react to form a **cross-linked polymer**.

Poly (vinyl alcohol)

Poly (vinyl alcohol), or PVA, comprises the polymer portion of the chemical reaction. Poly (vinyl alcohol) is manufactured through a process of **addition polymerization**, and the polymer is built on a carbon-chain backbone, with a –OH group on every other carbon (Fig. 1).

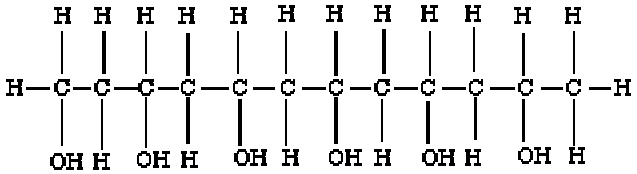

Fig. 1 Structure of poly (vinyl alcohol)

If you recall, addition polymers are formed by consecutively joining monomers to the end of the growing polymer, until the chain is terminated. In the instance of PVA, the chains can reach average molecular weights of over 100,000 grams per mole!

The abundance of –OH groups along each polymer strand allow it to form hydrogen bonds, making poly (vinyl alcohol) very soluble in water. Still, since the molecule is so large and bulky, the dissolving process is quite slow. In lab, your

Support for Cornell Center for Materials Research is provided through NSF Grant DMR-0079992

instructor will be giving you a solution of 4% PVA to speed up your time in lab. The presence of –OH groups also makes it possible for poly (vinyl alcohol) to form hydrogen bonds with other molecules, such as the borate ion, $B(OH)_4^-$. These hydrogen bonds are what give slime its special physical properties.

The borate ion has a tetrahedral structure, as shown below in figure 2.

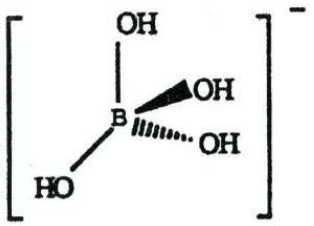

Fig 2. Borate ion

The long, straight strands of poly (vinyl alcohol) begin to twist and turn as hydrogen bonds begin to form between the –OH groups on borate ions and PVA (Fig. 3).

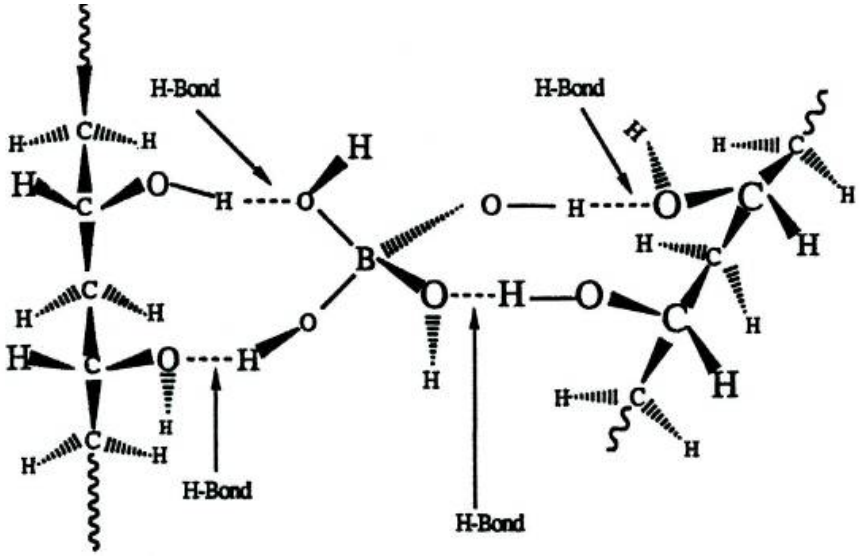

Fig. 3. Borate ion cross-linking with poly (vinyl alcohol) chains

When you are pulling, squeezing, bending and pushing your slime samples in lab, think about what must be happening at the molecular level. (Hint: Think *intermolecular bonds*)

Pre-Lab Questions

1. What is the monomer in poly (vinyl alcohol)?

2. What happens if you add more borax solution to the poly (vinyl alcohol)?

Support for Cornell Center for Materials Research is provided through NSF Grant DMR-0079992

Objective

To learn about the properties of cross-linked polymers, and to devise and carryout a procedure for testing the effect of varying concentrations of either the poly(vinyl alcohol) or the borax solution on your slime.

Materials

90 mL of 4% poly (vinyl alcohol) solution
25 mL of 4% borax solution
200-mL beaker
50-mL beaker
3 Styrofoam cups
Stirring rod
Watch glass
Food coloring
3 cupcake wrappers
Graduated cylinders

Safety

- Laboratory aprons and goggles must be worn at all times.
- Be sure to wash your hands after handling any of the chemicals
- With food coloring involved, be sure to keep the slime off your clothes

Procedure

1. Collect 90 mL of the poly (vinyl alcohol) in a 200-mL beaker and 25 mL of borax solution into a 50-mL beaker and bring them back to your lab bench.

2. For the first trial, add 30 mL of the PVA solution into a Styrofoam cup – remember to record the exact volume in your Data and Observations section.

3. Add 2-3 drops of food coloring into the PVA so you can identify it later (or just so it looks cool!). Make sure you mix the food coloring in well with a glass stirring rod.

4. Add 2 mL of the borax solution to the poly (vinyl alcohol) and begin stirring with the same stirring rod. Within a couple minutes you should have your very own slime!

5. Try pulling some out with your stirring rod and handling it. Record your observations.

Support for Cornell Center for Materials Research is provided through NSF Grant DMR-0079992

6. Try stretching it slowly, and also try stretching it quickly. You can also try examining it on a watch glass, or by some other tests of your own! Just remember to record all of your observations.

7. Place the slime in a small beaker or in a cupcake wrapper to save for later. Wash your stirring rod and the watch glass for the next trial.

8. Now it's your turn. Repeat steps 2 – 7 two more times, only this time change some of the volumes in order to test the effect of concentration on your slime product. In the end you should have three samples of slime.

9. Leave at least one slime sample in a cupcake wrapper and set it aside. Tomorrow you will come in to check on this sample. Any slime you are taking with you must be placed inside a plastic bag, and any unwanted slime should be placed in the waste beaker in the hood.

10. Clean all of your equipment, wipe down your lab area, and be sure to wash your hands.

11. Be sure to answer Question #1 before you leave lab today.

Data and Observations

Trial #1

Data	Observations

Support for Cornell Center for Materials Research is provided through NSF Grant DMR-0079992

Trial #2

Data	Observations

Trial #3

Data	Observations

Questions

1. What will happen to the slime as it sits out overnight?

Support for Cornell Center for Materials Research is provided through NSF Grant DMR-0079992

2. Now that the slime has sat out overnight, what did happen to it? What caused this to happen?

3. What relationship did you determine to exist between the concentrations of poly (vinyl alcohol) and the borax solution and the physical properties of your slime products? Is this what you expected to happen?

4. What do you think would happen if you were to heat up your slime? What if you were to cool it down? What would happen to its physical or chemical properties?

5. Name at least three other tests you could perform on the slime in order to learn more about its physical and chemical properties.

6. What must be happening at the molecular level to allow the slime to bend and stretch without falling apart?

Support for Cornell Center for Materials Research is provided through NSF Grant DMR-0079992