Chem 106 / Dr. Rusay

POLYMER CHEMISTRY

Nylon, Slime & "Silly Putty"

View the preparation of nylon via the condensation reaction of a diamine with a dicarboxylic acid derivative on YouTube *https://www.youtube.com/watch?v=bNh5hK2f6TM*

You and a partner will prepare either *Slime* or *Silly Putty*. Consult with another team's partners and decide who will prepare *Slime,* and who will prepare *Silly Putty*. Then, follow the respective instructions which follow.

***Slime*:**

1. Obtain a Ziploc bag.
2. Add 50 mL of 4% Polyvinyl Alcohol (PVA) solution to the bag.
3. Add 5 mL of 4% Borax solution ($Na_2B_4O_7 \bullet 10H_2O$) to the bag with a few drops of food coloring if you choose to. *A gel like material will form on adding*.
4. Mix the bag's contents thoroughly being careful not to tear or break the bag. The gel can be kneaded into a ball; use nitrile gloves if you choose to knead the material. *It will stretch if pulled slowly, but shears when quickly twisted*.

Slime @ home: YouTube *https://www.youtube.com/watch?v=emlW5Jh-AHc*

Silly Putty (GAK):

1. Using a graduated cylinder, measure 20 mL of de-ionized H_2O.
2. Pour into a Styrofoam cup and with a pen mark the water level on the cup.
2. Discard the water, and add Elmer's glue up to the mark.
3. Add 20 mL of de-ionized H_2O to the glue and mix well.
4. Add 2 to 3 drops of food coloring of your choice and mix well.
5. Obtain 10 mL of 4% Borax solution, add 5 mL of the solution to the cup all at once (additional solution may be added depending on the consistency desired.) Stir vigorously with a wooden stirrer for 2-3 minutes.
6. When the mixture has stiffened so that you can no longer stir it, wearing nitrile gloves, remove the silly putty from the cup and knead with your hands until the mixture is no longer sticky.
7. Press your silly putty on a piece of newspaper and see if it is the same image that is lifted onto the silly putty.

Silly Putty @ home: YouTube *https://www.youtube.com/watch?v=7KYv5s_yVm0*
https://www.scientificamerican.com/article/bring-science-home-playing-with-polymers/

The preparation of *Slime* and the *Silly Putty* involves a type of polymerization known as ***cross-linking***. Each of these two reactions applies a Borax soap solution as the cross-linking agent. Cross-linking agents bond together many lower molecular weight polymer chains to give a much larger molecular weight polymer. An analogy would be taking many strands of spaghetti and tieing them together with several pieces of string. By doing this, the molecular weight of the polymer is increased, and the physical

/material properties of the polymer developed. *Slime* is prepared by cross-linking polyvinyl alcohol with Borax. *Silly Putty* is prepared by cross-linking Elmer's glue with Borax. To visualize cross-linking, consider polyvinyl alcohol (PVA). A two-dimensional representation of small segments of two adjacent PVA chains are shown in the follwing figure.

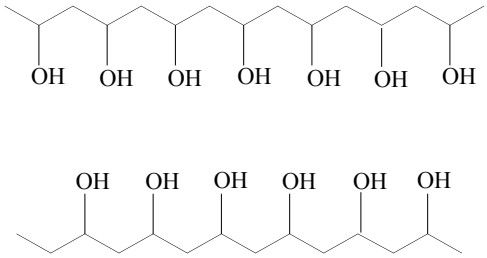

figure #1

When Borax is dissolved in water, the cross-linking agent $B(OH)_4^-$ is formed. The two-dimensional representation of this molecule is shown in figure #2:

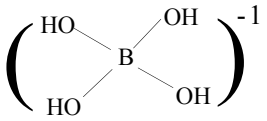

figure #2

Hydrogen bonds form between the Borax and the PVA molecule as shown in figure #3.

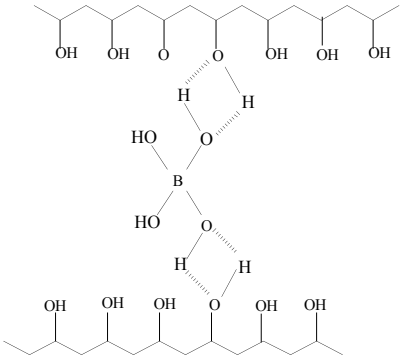

figure #3

Notice how the two polymer chains are connected. This occurs numerous times over the length of one polymer chain, and essentially bonds many polymer chains together, greatly increasing the molecular weight of each