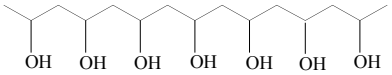
Chem 227 / Dr. Rusay

POLYMER CHEMISTRY

Nylon, Slime & Silly Putty

Observe the preparation of nylon via a condensation reaction of a diamine with a dicarboxylic acid derivative. Then, you and a partner are to prepare *Slime* and *Silly Putty*; instructions follow (*Procedures A & B*).

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 figure #1 below:



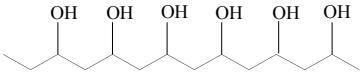


figure #1

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:

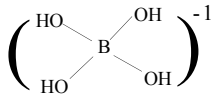


figure #2

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

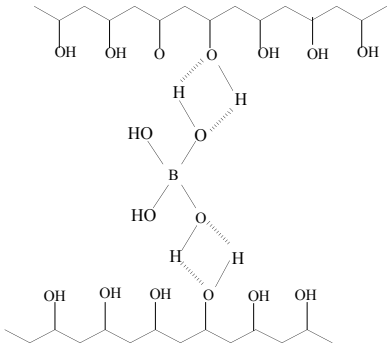


figure #3

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 chain.

Procedures

A. PREPARATION OF *SLIME*:

1. Measure 50mLs of 4% polyvinyl alcohol (PVA) solution using a graduated cylinder and pour it into a Styrofoam cup.
2. Add 2 to 3 drops of the indicator of your choice and mix coloring throughout.
3. Measure 5 mLs of the 4% (Borax) sodium tetraborate solution.
4. Using a spatula or stirring rod, stir the PVA solution quickly and constantly (like you are beating egg whites) while simultaneously adding the 4% Borax solution.
5. Continue to stir the resultant solution vigorously for ~3 minutes until the slime gets to the perfect consistency.
6. If you wish to save your product wrap it in saran wrap in order to prevent the slime from drying out, otherwise, through the product in the trash.

B. PREPARATION OF *SILLY PUTTY*:

1. Using your graduated cylinder, measure 20 mL of de-ionized H_2O into a Styrofoam cup. 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 the indicator of your choice and mix well. You may combine two indicators to achieve a color of your choice.
5. Obtain 10 mL of 4% Borax solution. Add 5 mL at first (more 4% Borax may be added as necessary) and stir vigorously for at least 2 minutes.
6. (Wearing gloves is recommended for this step.) When the mixture has stiffened such that you can no longer stir it, 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 in the front of the classroom and see it the image is lifted onto the putty.

Show the samples of *Silly Putty* and *Slime* to Dr. R. before leaving lab.

Lisa Selchau
Comment: Page: 4
Exploring Chemistry in Today's World; Kathy Tyner, pp. 204

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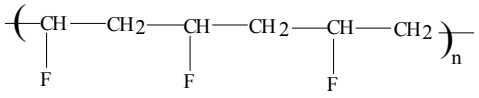
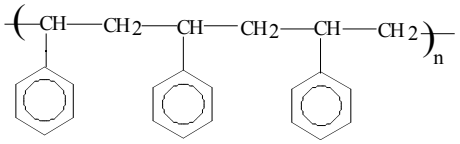
1. Draw the structure of one unit of nylon 6,6 as seen in the videos. Describe the physical characteristics of the nylon observed in the video and briefly explain how the molecular structure relates to its material properties.

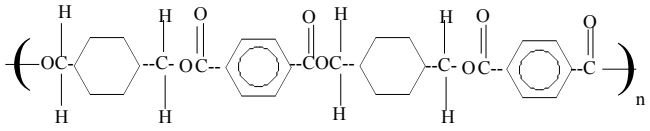
2. Write a mechanism for the polymerization of sebacoyl chloride and 1,6-hexanediamine. (Use structural formulas and one molecule of each reactant to illustrate the mechanism. Show a complete mechanism.)

3. What reactant(s) is/are used to produce the following polymers?

a. 

b. 

c.

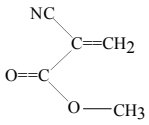


4. Classify each of the polymers in question #3. as either condensation or addition polymers, and if they form from polymerization of *monomers* or from *copolymers*.

   a. _____ b. _____ c. _____

   _____ _____ _____

5. "Super glue" contains methylcyanoacrylate, which readily polymerizes upon exposure to traces of water or alcohols on the surfaces to be bonded together. The polymer provides a strong bond between the two surfaces. Draw the structure of a unit of the polymer formed by methylcyanoacrylate. If you were an emergency room physician, what would you use to "unglue" the super glued fingers of a do-it-yourself home owner?



6. Draw the structure of one unit of *Kevlar*;, which is molecularly similar to nylon but which has dramatically different material properties. Briefly explain the material differences and provide chemical reasoning that would account for the differences.

7. “Fiberglass” is used to make lightweight kayaks that are very expensive and very delicate versus the relatively inexpensive, much heavier, but very durable polyethylene built boats. A German company, Prijon, built a boat from a thermosetting polymer that was intermediate between the two. Describe the chemical and material properties of a thermosetting polymer and how it differs from a thermoplastic polymer.