Polymer Properties

This lab is a series of small experiments about the properties of polymers. Polymers are long molecules composed of repeating units. The long polymer chains are usually randomly entangled. It is this entanglement that holds the polymer together. Polymer chains can also be chemically crosslinked - in other words chemical bonds may link different chains together. This gives added strength and rigidity to the chain.

As a result of these properties, most polymers have varying amounts of three properties: (1) memory (which leads to elasticity), (2) resistance to flow (which gives appreciable viscosity), and (3) insolubility in water (which makes for a good container for water based liquids). Variations in these properties leads to three major applications of polymers: (1) fibers (clothing), (2) elastomers (rubber bands, etc.), (3) plastics (intermediate properties between fibers and elastomers).

You will investigate and observe variations in these properties and applications in this lab, often with commonly used materials. Most of these activities are based on activities written for our chemistry club outreach into the surrounding public schools and are meant to be enjoyable but thought provoking. Have fun!

We Will Make No Slime Before It's Time

Scientists like to make new substances and find out how they are different and how they can be used. In this activity you will mix two liquids (polyvinyl alcohol and sodium tetraborate) together and get a totally new material. This material has different properties because a chemical reaction has taken place which joins the two old substances. Polyvinyl alcohol is a long molecule called a polymer. The sodium tetraborate links the long molecules together and makes it thicker. Scientists say the new material is more viscous.

Materials
polyvinyl alcohol, sodium tetraborate, plastic cup, plastic spoon, food coloring

Procedure

Mix 30 mL of the polyvinyl alcohol with 10 mL of the sodium tetraborate solution in a plastic cup. (You can color your slime by adding a little food coloring if you wish.) Stir with a plastic spoon. You may stick your fingers into the mixture, but make sure that you wipe them off afterwards.

Questions

1. What is different about the mixture after stirring?

2. This is how scientists make different materials such as plastics harder or softer. Would you want more or less cross-links in order to harden a plastic?

3. The viscosity characteristics of this material are very interesting. What is the difference in the flow properties when stirring slowly and stirring rapidly?

Can you think of any other substance that has the same properties? (It may not be a polymer)

Can you think of substances that have the opposite flow properties?

What's In a Diaper?

Diapers are designed not to leak if possible. Diapers have a white powder (polysodium acrylate – a polymer) in them which absorbs water. We will see how this works.

Materials
Diaper (viewing only), polysodium acrylate, plastic cups, plastic spoon, sugar, salt, water

Procedure

1. Put one level spoonful of the white powder (polysodium acrylate) into a 400 mL beaker. Add about 200 mL of deionized water. Swirl. Turn the beaker upside down. What happens? What does it look like? What does it feel like?

2. Put a spoonful of table salt into your beaker and stir with your spoon. What happens?

3. Repeat the experiment but this time add a spoonful of sugar. Is there a difference?

From your knowledge of the bonding in table salt and sugar explain your results.

4. From your above results would there be a difference in the amount of liquid that can be absorbed if you used regular tap water? What about urine?

Commonly used Polymers

Many of the plastics we use are labeled according to the "Plastic Container Code System". The numbering system is:

1	PETE	polyethylene terephthalate (PET)
2	HDPE	high density polyethylene
3	V or PVC	polyvinyl chloride
4	LDPE	low density polyethylene
5	PP	polypropylene
6	PS	polystyrene
7	Other	All others

Examine some commonly used materials. List and describe the material and give the type of polymer used (write out the entire name).

Item and description	Number code	Name of polymer

1. Which of the above polymers in the container code are condensation and which are addition? What is the chemical difference in how they are made?

2. Why do you think that plastic containers are not being recycled more than they are?

3. Fill in the table:

Name of polymer	Name of Monomer	Structural formula for monomer	General formula for polymer
poly ethylene			
poly ethylene terephthalate			
poly styrene			
poly vinyl chloride			
poly propylene			

Physical Properties of Polymers

The three major types of polymer applications are as fibers, plastics and elastomers. In this activity we will determine the elongation before breaking as well as the general shape of the stress/elongation curve for examples of these types.

Materials

bolts, washers, etc. (preferably constant mass)
a lightweight basket
ring stand, ring
rubber band, grocery bag, sewing thread
meter stick
scissors

Procedure

1. Cut a rubber band (elastomer) and tie one end to the ring.
2. Tie the other end of the rubber band to the basket assembly.
3. Measure the length of the rubber band from the knot at the ring to the tied end at the basket.
4. Add incrementally specific loads (weights – nuts, washers, etc.) to the basket. After each additional load measure the new length. Record the total load added and the total stretched length for each addition.
5. Continue adding until the material breaks.
6. Repeat this procedure using a piece of grocery bag (plastic).
7. Repeat this procedure using a piece of sewing thread (fiber).

Data Table

Elastomer		Plastic		Fiber	
Number of pieces added	Total Length (cm)	Number of pieces added	Total Length (cm)	Number of pieces added	Total length (cm)

Calculations and questions

Graph the number of load pieces added (stress) versus the total length for each polymer. Use graph paper! See if you can explain why the shapes of the graphs are different.