Duration: 110 minutes

MATERIALS

4% Polyvinyl Alcohol solution (PVA)
4% Sodium Borate solution (Borax)
Paper cups (150 ml)
Wooden craft sticks
Food coloring
Plastic baggies
Lab aprons
Safety goggles

RESOURCES

Blueprint For Life/Work Designs – The Quick Reference Guide

INSTRUCTIONAL METHODS

Independent Learning
Laboratory Investigation

LESSON OBJECTIVES

- ✓ Students will understand how society's needs and functions affect supply of goods and services (BP 6.3.2)
- ✓ Students will evaluate the impact of technological and industrial trends on work and learning opportunities (BP 6.3.8)
- ✓ Students will investigate principles involved in the composition, production or functioning of consumer products
- ✓ Students will describe and discuss the impact of the chemical industry on society

BACKGROUND INFORMATION

Professional Engineers and Geoscientists are men and women who use the principles of science to turn ideas into reality. There's an incredible range of career opportunities in professional engineering and geoscience. The many careers available give you the opportunity to shape your future according to your interests and play a role in shaping the future of the world.

Chemical Engineers make our natural resources last longer. Supplies of some of our most important natural resources – oil, natural gas, wood, forests, even water in some areas – are dwindling. With the global population growing, pressure on remaining supplies is increasing. And our environment is being affected by the ways in which we mine, process, use, and dispose of spent resources.

Chemical Engineers are at the forefront of helping to solve many of these critical problems. They apply their expertise in many areas, from developing alternative sources of fuel, to better ways to clean and filter water.

MOTIVATIONAL SET

Most people know that most of the gold used for making jewellery comes from gold mines. Choose an item in your classroom, such as a ballpoint pen. Identify the chemical components of the item, and list the source of each component. How many of these resources are produced in Canada?

For example, a ballpoint pen might be analyzed as follows:

- Plastic barrel – polycarbonate plastic from crude oil
- Plastic plug in the end of the barrel – polyethylene from crude oil
- Plastic ink tube – polyethylene from crude oil
- Metal support for ball – alloy of copper and zinc, both from mines
- Ball – nylon, synthesized from organic acids and alcohols derived from crude oil

Students are to understand that the pen is a result of chemical engineering. By creating various types of chemical products, the pieces can be assembled together to produce a relatively simple device. In all cases the plastic components contained "poly" type plastics. In today's investigation students will become Chemical Engineers and produce polymers of a new plastic.

PROCEDURE

New Slime (Refer to Materials on first page)

Slime is just a fun day with the students right? Now explore what slime can offer in scientific exploration of a variable. PVA is 96% water, Borax solution is 96% water. When mixed together they are still 96% water. Discover the variations students can get by mixing the polymer and the "cross linker" together. Slime will be everything from runny, to hard and brittle. How can this be?

Teach plastic flow vs. elastic behavior. Hydrogen bonding, viscosity, and how this simple polymer demonstration applies to metals, ceramics, and composites. Understanding of chemical bonding will be advantageous.

Safety: Lab aprons and safety goggles must be worn (the Borax and the PVA could burn the eyes). Hands must be washed at the end of the lab.

1. Divide students into 5 groups. Each group will be assigned a different recipe as shown below.

Team No.	PVA Solution	Sodium Borate Solution
1	50 ml	1 ml
2	50 ml	2 ml
3	50 ml	4 ml
4	50 ml	6 ml
5	50 ml	10 ml

2. Add PVA solution to a paper cup.

3. Stir in food coloring if desired.

4. Add Sodium Borate solution to the paper cup, stir quickly and make sure to scrape the sides and bottom of the cup using the wooden craft stick.

5. Pour entire contents of the cup into a plastic baggy and knead.

6. Take slime out of baggy and “investigate” properties.

7. Have groups compare properties of the different slimes:

    - bouncing
    - stretching slowly or quickly
    - letting it “pour” from one hand to another
    - flow rate through a wide mouth funnel

Have students record the appearance and characteristics of the PVA at each step. This method of doing the slime lab allows the students to work as teams and then causes the teams to interact to make comparisons. The students sometimes struggle to find words to describe the slime in step #7 – encourage them to devise some sort of chart or graphic organizer to record their results and conclusions.

DEBRIEF

By having groups use different amounts of sodium borate solution, students will be able to determine the effects of cross-linking on the properties of the polymer. The more sodium borate solution used, the more cross-linking that occurs. Each batch of slime is 96% water, but they do not have the same viscosity. It should be emphasized that the students did not make polymer chains – they were already there (polymer chains are dissolved in the water in the PVA solution). The sodium borate just “ties” the polymer chains together making it a more cohesive mass.

Polymer chains are formed by strong, covalent bonds. In making slime, individual polymer chains are “hooked” together by weak hydrogen bonds. It is evident that this cross-linking is weak because of the ease with which the slime pulls apart. It is sort of like “tying” together strong strands of string with limp strands of cooked spaghetti. Even though this cross-linking is weak, it does alter the properties of the polymer.

Have the students leave some of the slime stretched out on a counter overnight. The water will evaporate and the PVA will become a dry, brittle film that is mostly transparent. Also, pour some PVA solution that has **not** been cross-linked with borax on the counter. It will dry into a more flexible film much like the water soluble laundry bags used by hospitals.

It is possible to mass a sample of each team’s slime both before and after drying and calculate the percentage of water in each. This will provide evidence that each type of slime was indeed 96% water and that the difference in properties was not due to the amount of water, but to the amount of cross-linking.

An observation that the students can make is how cool the slime feels. As the slime is stretched it has more surface area exposed to air and the evaporation rate of the water is increased. What they are feeling is the effect of evaporative cooling.

Discuss the following questions:

1. What was required to convert the liquid plastic into a more solid form?

2. What is the function of the Sodium Borate solution in the production of slime?

3. In order to develop the various components of the pen or item that was examined at the beginning of this lesson, chemical engineers needed to develop plastic materials for various parts of the pen. What do all the "poly" parts of the pen mean? How can knowledge of polymers be used to develop more products for society?

ASSESSMENT / INDICATORS

Students will be able to:

1. Describe the role of Chemical Engineers in society.

2. Discuss the skills and aptitude that are required to be a successful Chemical Engineer.

3. List three new products that have been developed recently that allow more efficient use of our precious natural resources. *The economy of a society functions on the principle of supply and demand – when consumers demand new and different products, companies develop new products to supply the market.*

4. List two new types of careers that have been created in recent years due to changes in technological or industrial trends.