

## Lesson Plan: Polymer Module

Type: Module-based

### Teaching Plan:

In this session students will learn about different types of plastic. Following this, they will experiment with several different types of plastic in order to understand their properties and uses.

#### Agenda:

1. Introductory Discussion About Polymers – <10 minutes
    - Goal: Teach students about how prevalent polymers are in our environment. Introduce different types of polymers and their chemical structure.
  2. Activity 1: Making a Bouncing Ball – 20 Minutes
    - Goal: Teach students about plastics and their uses. Students will have the opportunity to make a bouncy ball using borax, cornstarch and glue.
  3. Activity 2: Making biodegradable plastic – 20 Minutes
    - Goal: Teach students about the harmful aspects of plastic and the importance of making it environmentally friendly. Students will have the opportunity to make plastic by mixing and heating a solution of cornstarch, oil and glycerin.
- Note: Activities 1 and 2 will be interchanged, where half the class will do one and the other half will do the other simultaneously. When they are finished, they will switch.
4. Activity 3: Hydrogels – 15 Minutes
    - Goal: Teach students about a particular application of polymers – hydrogels and their use in the medical field. Students will have the opportunity to experiment with several different types of hydrogels including diaper innards, hairgel and jello.
  5. Concluding Discussion – <10 Minutes
    - Goal: Discuss the uses of polymers as well as the negative effect they have on the environment.

### Mentors Scientific Background

Polymers: See Mentee Background

Bouncing Balls Chemistry: Glue is made of the polymer polyvinyl acetate (PVA). PVA cross-links to itself when it reacts with borax

Biodegradable Plastic Chemistry: Vinegar ferments corn starch and help create polylactic acid, which is a polymer.

### Hydrogels:

- Hydrogels are a class of polymers that can absorb large amounts of water without dissolving. This is due to the physical or chemical cross linkages of hydrophilic polymer chains. The hydrophilic polymers contain 99% water and are highly flexible.
- Hydrogels mimic many of the properties of natural tissue so they are highly biocompatible.
- Hydrogels can be made porous or dense depending on usage requirements by altering their composition.
- Hydrogels can be prepared from monomers, prepolymers, or existing hydrophilic polymers. These polymers are composed of oxygen, hydrogen, carbon and sometimes nitrogen bonds.
- Note: Other types of absorbent polymers/gels will absorb other liquids.

### Drug Delivery:

- One of the most important applications of hydrogels (in terms of biotechnology) is a controlled drug delivery device.
- A drug delivery device is a polymer (in the case of a hydrogel) combined with a drug in such a way that the drug can be released from the polymer in a predesigned manner.
- The release of the drug is controlled by:
  - o Diffusion and/or
  - o Degradation of the hydrogel
- The release of the drug may be:
  - o constant over a long period,
  - o cyclic over a long period,
  - o triggered by the environment or other external events such as the change in pH.
- These devices are often implanted directly onto the tissue affected by the given disease.
- Hydrogels are great candidates because they are highly biocompatible, flexible and easily manipulated into behaving a certain way. Most importantly, they are biodegradable, so once they are implanted, another surgery is not required to remove them after the drug therapy has been completed.
- Advantages to using a controlled drug delivery system as opposed to systemic delivery (i.e. pills):
  - o Eliminates potential for under- and over-dosing
  - o Targets a specific area
  - o Maintains drug concentration levels within a certain range
  - o Allows consistent drug delivery over a long period of time with fewer invasive administrations
- Disadvantages of using such a system:
  - o Possible toxicity or nonbiocompatibility
  - o Undesirable products of degradation
  - o Surgery required to place and remove implant
  - o Higher cost as compared to traditional methods
- Polymers such as polyacrylamide are currently used in the drug delivery system because it is chemically inert and do not degrade to produce impurities that may be harmful to the human body.

## Introduction for the Mentees.

### What are polymers?

#### Discussion Questions:

1. How many of you know what plastic is? (Show of hands)
2. Can someone explain?
3. Where do you see plastic in this classroom? Write some examples down on your worksheet.

So, plastic is a type of polymer. *Anyone heard that word before?* Polymers are made up of many molecules strung together in a long line like Christmas lights. Polymers can be made of any molecules but most of them contain Carbon, Hydrogen and Oxygen. Usually, a polymer is made up of one or two types of molecules that repeat down the string. Polymers can also have branches and multiple strings. Think about Christmas lights you might hang over your backyard wall – they would look like a fence made up of many squares right? In the same way, polymers are often made of multiple strings connected by branches – these strings can be really long.

*Can all of you draw what a polymer might look like on your worksheet?*

There are many different types of polymers and they can be either natural or man-made. Some examples of natural polymers you may know are starch and rubber. Some examples of man made polymers include PVC (like PVC pipes) and nylon (like in clothing). Polymers are used in many different things – you pointed out some examples around the classroom. Polymers are everywhere! Erasers, grocery bags, disposable dishes and utensils, shoes, CDs, clothing, car parts – all of these are made of polymers. Polymers are used so often because they have some really cool properties. *Can you think of some properties that make polymers cool? Write them down!*

Polymers can be flexible or stiff depending on what they are made of and how they are made – so, we can change the flexibility of a polymer by changing its ingredients and its branching! Sometimes, we will want flexible polymers so that our product can be stretchy. This ability to stretch is called elasticity. *Can you think of some examples where you would want stretchy polymers?* That's right! When you put polymers in clothes or bags, you would want them to be bendable. *When would you want polymers to be stiff?* Yes, when you want to make tubes or utensils that need to be rigid so that they can stand water pressure or pick things up, you would want stiff polymers.

Polymers can also be really strong. Polymers with flexible chains and branches usually get tangled up, so they can be very difficult to break. They can also stretch really far (think about a rubber band) without breaking because their tangles can be stretched out. Polymers with stiff chains and no branches can line up really close to each other – by doing this, they too become really hard to break. In this case, think about a block of wood which is made up of a polymer called cellulose – is wood easy to pull apart?

Many polymers are also easy to mold, so they can be made into any shape. Finally, polymers are usually leak-proof – because of this, they can be used to hold liquids, food and garbage.

## Environmental Effects of Polymers

### Problems:

1. Natural polymers aren't very abundant, so it's hard to mass produce things using them. They also don't have all the cool properties that man made polymers have.
2. Manmade polymers are usually made from fossil fuels. Do you know why that's bad? Fossil fuels are also scarce and using them adds to the pollution in the air.
3. A lot of plastic is thrown away and ends up in landfills. Plastic bottles make up 11% of our trash! However, man made polymers don't degrade easily – if left outside, they can take hundreds of years to degrade!
4. In order to save space in landfills, people often burn plastic, but this releases a lot of nasty gases in the air that cause pollution and global warming.
5. Plastics also end up in oceans where animals can get stuck in bags or rings and die (think Happy Feet).

### Solution:

1. Reduce, Reuse, Recycle! A lot of energy can be saved and pollution can be prevented if we reduce the amount of plastic we use, reuse as much as we can (grocery bags to trash bags) and recycle what we can't reuse. This way, very little ends up in landfills and oceans and everyone is happy.
2. Make biodegradable plastic that is environmentally friendly and will degrade soon after it has been thrown away. Some examples include utensils made of potato and the plastic you are making out of corn starch. In our case, the corn starch produces polylactic acid, a polyester that decomposes and mineralizes into water and carbon dioxide when composted.

## What are hydrogels?

Hydrogels are a type of polymer that can absorb large amounts of water or another liquid without dissolving. They contain lots of branches and strings, so they can fill up until they are up to 99% water. This is why hydrogels can be used in diapers!

Hydrogels can also be made so that they degrade under certain conditions. For example you can see with the hair gel that it degrades once you add salt to it and lets out water. Other hydrogels can degrade in other settings such as around certain molecules or enzymes.

Because of these properties, hydrogels are also useful in medicine. One important purpose they serve is as drug delivery devices. How many of you have had to take a tablet before? How about an injection? Which was easier? Hydrogel-based drug delivery allows us to put medicine that otherwise has to be injected into tablets that you can take orally.

## Modules/Demos, or Project

- I. Bouncing Ball – in this lesson students will make a bouncing ball out of household items.

Supplies:

- Borax
- Cornstarch
- White Glue
- Warm Water
- Food Coloring
- Plastic Cups
- Ziploc Bags

Methods:

1. Label one cup 'Borax Solution' and the other cup 'Ball Mixture'.
  2. Pour 1.5 tablespoons warm water and 1/2 teaspoon borax powder into the cup labeled 'Borax Solution'. Stir the mixture to dissolve the borax. For colored balls, add food coloring here.
  3. Pour 1 tablespoon of glue into the cup labeled 'Ball Mixture'.
  4. Add the borax solution you just made and 3/4 tablespoon of cornstarch to the 'Ball Mixture' cup. Do not stir. Allow the ingredients to interact on their own for 10-15 seconds and then stir them together until mixing becomes impossible.
  5. At this point, ensure the consistency of the mixture is correct – it should be goopy and sticky and feel somewhat wet. If this isn't the consistency you see, play around with the ingredients until it is. Then, take it out of the cup and start molding the ball with your hands. Note: The ball will start out sticky, messy and watery but will solidify as you knead it.
  6. Once the ball is mostly dry, go ahead and bounce it! Store the ball in a Ziploc bag.
- II. Biodegradable Plastic – in this experiment, students will have the opportunity to make plastic out of household materials. They will learn about the importance of environmental friendliness while they make the plastic.

Supplies:

- Corn Starch
- Water
- Liquid Glycerin
- White Vinegar
- Food Coloring
- Non stick pan
- Spatula
- Stove Top or Hot Plate
- Aluminum Foil

Methods (Note: On a per student measure):

1. Measure out 6 tablespoons (60 mL) of cold water and 1 tablespoon (10 grams) of cornstarch into the pan
2. Add 1 teaspoon (5 mL) of vinegar and 1 teaspoon of glycerin into the mixture. Note: more glycerin will make it softer and more flexible while less glycerin will make it stiffer.

3. Add about 5 drops of food coloring to make it colored.
  4. Place pan on hot plate and keep the burner on low, constantly stirring. The mixture will start to thicken and become a gooey, opaque substance. Mix until it boils and becomes clear - should be bouncy and should stick to itself rather than the pan.
  5. Pour some onto a piece of aluminum foil and let it dry – the drying process will take 1 day, so students can take it home with them at the end of the day.
- III. Hydrogels – In this experiment, students will learn about hydrogels, a type of polymer that can hold water and other liquids. They will do so by experimenting with diapers, hairgel and jello.

Supplies:

- Diapers
- Water
- Cups
- Jello(premade with added food coloring)
- Warm water (warm if possible)
- Hairgel
- Salt

Methods:

1. Diaper Experiment – How do hydrogels work?
  - a. Grab a diaper and carefully cut through the inside lining. Remove the plastic lining and collect the cotton-like material inside the lining in a plastic bag.
  - b. Seal the plastic bag, blowing in to it so that it fills up with some air. Vigorously shake the bag until you see powder collecting at the bottom.
  - c. Pour the powder into a cup – you may want to use only half of it so that its easier to work with. We've now isolated the secret ingredient.
  - d. Now it's time to mix the powder with water to see what happens. Pour approximately  $\frac{1}{2}$  cup of water into the cup of powder. Add more as necessary!
  - e. After about 30 seconds, observe that the water has changed — it's no longer a liquid... it's a gooey solid!
2. Hairgel Experiment – How can hydrogels stop working?
  - a. Place a blob of hairgel in a cup.
  - b. Add salt to the blob and see it become more liquidy

**Closing Activity and Discussion.**

Discussion Points/Questions:

1. What materials did we work with today?
2. Can you give me some new examples of where you see these polymers in your life?
3. As you heard from your mentor, plastics are a big source of environmental pollution. What are some ways we can reduce this pollution?
  - a. Do you think we should stop using plastics completely?
  - b. If not, how else can we make sure they don't pollute the environment as much?

## Materials

- Borax – 9 g/student
- White Glue – 15 mL/student
- Corn Starch – 20 g/student
- Liquid Glycerin – 5 mL/student
- White Vinegar – 5 mL/student
- Non stick pan – 4/classroom
- Spatula – 4/classroom
- Stove Top or Hot Plate – 2/classroom
- Aluminum Foil – 1 roll/classroom
- Diapers – 1/student
- Hairgel – 1 small tube/classroom
- Salt – 1 tablespoon/student
  
- Water – plenty; (30 mL warm water/student)
- Food Coloring – 1 bottle/classroom
- Plastic Cups – 4/student
- Ziploc Bags – 2/student

## References/Citations

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