

NATURES Program - 2016

Lesson Plan: Biobased Materials - Polymers

Prof. Sivaguru Jayaraman

Department of Chemistry and Biochemistry

North Dakota State University. Fargo ND 58108-6050

Introduction:

What makes polymers so fun is that how they act depends on what kinds of molecules they're made up of and how they're put together. Some are rubbery, like a bouncy ball, some are sticky and gooey, and some are hard and tough, like a skateboard

Objectives:

- I. Learn about polymers.
- II. Learn and become familiar with methods of synthesizing polymers

Experiments Summary:

1. Making polymer models with various colored paper clips
2. Condensation polymerization
 - a. Silly/Crazy putty
 - b. Bouncing ball-
3. Biodegradable plastics
4. Polymer synthesis by photoinitiation- Addition polymerization

Experiments:

1. Making polymer models with various colored paper clips

Materials Required:

- Different colored paper clips

Procedure:

Homopolymer: If a polymer consists of only one kind of monomers then it is called a homopolymer.

Alternating polymer: Alternating repeating units of monomers. (A-B-A-B-A-B-A-B-A...)

Block copolymer: Polymer made up of two or more homopolymers (A-A-A-B-B-B-A-A-A-B-B-B-B...)

Random polymer: Polymer that consist of a more than one monomer polymer, which is arranged randomly. (A-B-A-A-B-A-B-B-B-A-A-...)

Graft polymer:

Each paper clip is considered as individual monomer.

1. Make a homopolymer: Take 10 paper clips of one color and attach to one another, which results in the formation of **homopolymer** (A-A-A-A-A-A-A)
2. Make an alternating polymer: Take 5 paper clips of one color (A) and 5 paper clips of a different color (B). Attach paper clip (A) on both ends to 1 paper clip (B). Attach another paper clip (A) to the previous paper clip (B). Continue attaching paper clips in alternating order until you have no more paper clips. This forms an **alternating polymer**. (A-B-A-B-A-B-A-B-A-B-A-B-A)
3. Make a Block Copolymer: Take 5 clips of one color and attach them into a chain (Chain 1). Next, choose 5 units of another color and make them into a chain (Chain 2) . Attach Chain 1 and Chain 2. This forms a **block copolymer**. (A-A-A-A-A-B-B-B-B-B)
4. CHALLENGE- Given the definition above can you make a Graft Polymer?.

Questions

What is the difference between a Graft Polymer and a Homopolymer?

What is the name of the polymer with only one type of monomer arranged linearly?

2. Condensation polymers

a. Bouncing ball

Chemicals required:

- Solid borax
- Elmer's glue
- Water
- Food color
- Corn Starch

Materials required:

- Beakers (2)
- Graduated cylinder
- Stir rods
- Weighing balance
- Gloves
- Scoopula

Procedure¹:

- Acquire two beakers and label the two beakers A and B. Weigh 2 g of Borax in beaker A. Add 20 mL of water to beaker A. Add three (3) drops of food coloring to beaker A. Take 2 mL of the blue solution in beaker A and add to beaker B. Then add 1 plastic spoon full of glue to beaker B. Add 6 g of cornstarch to beaker B. Stir mixture. Continue stirring the mixture for five (5) minutes or until it becomes solid. Take solid mixture into hands and form into a ball. Allow to dry for 5 minutes. Enjoy!

Observations:

Questions

Does the ball bounce?

Compare your ball with those of the other members of the class. How many properties can you compare? (Size, height of bounce, etc)

b. Silly/Crazy putty – Condensation polymerization

Chemicals required:

- 2% borax solution or solid borax
- Elmer's glue, water
- Food color

Materials required:

- Goggles
- Gloves
- Beaker

- Stirring rod

Procedure:

- Acquire two beakers and label the two beakers A and B. Weigh 2g of Borax in beaker A. Add 20ml of water to beaker A. Add three (3) drops of food coloring to beaker B. Then add 1 plastic spoon full of glue to beaker B. Combine beaker A into beaker B. Stir mixture. Continue stirring the mixture for five (5) minutes or until it becomes solid.
- Wearing gloves, take the polymer formed in hands and enjoy.

Principle:

Elmers Glue is made up of polyvinyl acetate, which reacts with water to some extent to replace some of the acetate groups with OH (alcohol) groups. The B-OH groups on the borax molecules react with the acetate groups on the glue molecules (relatively long polymer chains) to eliminate acetic acid and form new bonds between the borax and two glue molecules. The linking of two glue molecules via one borax molecule is called polymer cross-linking and it makes a bigger polymer molecule, which is now less liquid-like and more solid.

Questions:

Observations:

What compound/chemical did we add in the bouncy ball that we did not add in the silly putty?

What are the differences in the silly putty and the bouncy ball?

3. Polymerization of styrene/methylmethacrylate with biomass derived photoinitiator

Chemicals required:

- Styrene
- Biobased Photoinitiator
- Acetonitrile
- Methanol

Materials required:

- Light source

- Pipette
- Plastic bottle and cap

Procedure³:

- Acquire vial with cap. Measure into the vial 1 mL of biobased Photoinitiator, 0.5 mL of thiophenol (coinitiator) and 1 mL of inhibitor free styrene/methyl methacrylate into test tube into the vial.
- Place the samples under suitable light source.
- After 3 hours remove the vial from the light source. add 2 mL of methanol, stir the mixture. Observe the change in the solution.

Principle:

Initiators react with monomers and initiates the polymerization.

Observations:

Questions

1. How do you know the polymer was formed?
2. Can you guess what type of polymer you synthesized (refer paper clip models)

4. Biodegradable Plastic

Chemicals required:

- Corn Starch
- Liquid Glycerin
- Water
- White vinegar
- Food color

Materials required:

- Glass rod (stirring rod)
- 2 Beakers (200 or 400 ml)
- Graduated cylinder
- Hot plate

Procedure²:

- Measure out 15 mL of cold water and half tablespoon of cornstarch into the beaker
- Add (5 mL) of vinegar and 5 mL of glycerin into the mixture.
- Add five (5) drops of food coloring to make it colored
- Place beaker on hot plate and keep on slow heating, 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 beaker.
- Pour some onto a piece of aluminum foil and let it dry, so students can take it home with them at the end of the day
- 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.

Principle: Vinegar ferments cornstarch and help to produce polylactic acid, which is a polymer.

References

1. D. Hurd, M. Silver, A. BornnBacher, C.W. McLaughlin Physical Science Prentice-Hall, Englewood Cliffs, NJ 1988.

Note: All experiments displayed above utilize modified procedures of the references cited.