

# Bay Area Scientists in Schools Presentation Plan

Lesson Name Green Polymers  
Presenter(s) The Sarpong Group

Grade Level 5 Standards Connection(s) chemical reactions to make molecules

**Abstract:** Polymers are an important part of our day to day lives. The presentation explores the construction of polymers from monomers, the properties of polymers, and the degradation of polymers, connecting to green chemistry ideas.

## Vocabulary/Definitions:

- polymer – very large molecules composed of repeating units
- monomer – a single unit that is used to make polymers
- degrade – break down
- molecule—a group of atoms chemically bonded together that act as a unit
- Polymerization reaction—a chemical reaction that link monomers together to form a polymer
- Cross-linking—making chemical bonds between two polymer chains

## Materials

### A. Making Polymers

- 2 oz. Elmer's Glue
- 2 tsp. Borax
- 6 oz. water
- Resealable Plastic Bags
- Food Coloring (opt.)

### B. Properties of Polymers

- Plastic Pipette or Eye Droppers
- Plastic Cups
- Coffee Filters
- Rubber bands
- Distilled water
- Sodium polyacrylate  
0.1 g per eppendorf tube
- Plastic beakers
- Salt

### C. Degradation of Materials

- Legos
- Magic Nuudles or biodegradable packing peanuts
- Styrofoam packing peanuts
- 2 larger beakers

We will bring everything with us, but we will need access to water.

## Classroom Set-up:

We will start and end in a large group, and split into three groups to rotate through the stations.



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## Classroom Visit

### 1. Personal Introduction: \_\_\_\_\_ 2 \_\_\_\_\_ Minutes

Introduce ourselves as graduate students in chemistry from UC Berkeley.

### Topic Introduction: \_\_\_\_\_ 4 \_\_\_\_\_ Minutes

In a polymerization reaction, small molecules called “monomers” react to form “polymers,” which are very large molecules composed of repeating units. Discuss some common polymers (e.g., Teflon, Kevlar, plastics, rubbers, etc.).

Real life analogies:

1. A train, which is composed of boxcars.
2. A wall, which is composed of bricks.

Have everyone join hands in a circle to form a “polymer” of people. Note that in a real polymer, the monomers are the same – like if you cloned one student and made a circle of his clones!

Recycling and green chemistry (everyday life and how the same concepts can be applied to chemistry)

Problems: things don't degrade, need to recycle them or reuse them in current form.

- biodegradability
- what's recyclable, what's not recyclable (cardboard, metals, not Styrofoam)

### 2. Learning Experience(s): \_\_\_\_\_ 40 \_\_\_\_\_ Minutes

#### A. Making Polymers Station

Concepts: polymerization

Key terms: cross-linking, hydrogel

Supplies (per experiment)

- 2 oz. Elmer's Glue
- 2 tsp. Borax
- 6 oz. water
- Resealable Plastic Bags
- Food Coloring (opt.)



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## Lesson Overview

In this module, we will explore the concept that some molecules can be joined together through chemical reactions. Through making a hydrogel, we will observe that exciting materials can be formed through the joining of molecules using chemicals.

As discussed in the introduction, the concept of *crosslinking* will be explored in a laboratory setting using a procedure to make “foam”, a material that consists of Elmer’s glue (polyvinyl acetate) crosslinked by Borax. The students will observe the properties of all the separate compounds before the reaction, and observe that after a chemical reaction, these compounds fused together to make a new material. This should illustrate in a broad overview that molecules can interact with each other and bond together on a macroscopic scale.

## Instructions:

- 1) Dissolve 2 tsp. borax completely in 1/2 cup (4 oz.) water. (2 tsp. of borax will produce a stiff product. If you want slimier, more flexible 'Floam', then try 1 tsp. borax instead.)
- 2) In a separate container, mix 1/4 cup (2 oz.) white glue and 1/4 cup (2 oz.) water. Stir in food coloring (different colors for different groups? Vote on color?.)

*At this point, ask the students to make observations of the different compounds. What does the borax solution look like? The glue and water solution? The polystyrene/Styrofoam?*

- 3) Pour the glue solution into a plastic bag. *Notice the properties of the solution.*
- 4) Add borax solution and knead it until it's well mixed. (Use 1 T. of the borax solution for a very fluid Floam, 3 T. for average Floam, and the entire amount for stiff Floam.)

While kneading, explain to the students that Borax is *crosslinking* the molecules of the glue to each other. This is causing the material to stiffen.

When complete label the sandwich bags, and give to the teacher for distribution at the end of the day.

## B. Properties of Polymers Station

Concepts: physical properties (flexibility, hardness, water absorbancy, etc.), control experiment

Key Terms: polyacrylate, control, hydrogel

### Materials:

- Plastic Pipette or Eye Droppers
- Plastic Cups
- Coffee Filters
- Rubber bands
- Distilled water
- Sodium polyacrylate 0.1 g per eppendorf tube
- Plastic beakers
- Salt

### Instructions:

- 1.) Place a coffee filter over the top of a plastic cup and secure it with a rubber band. It is important to pull it tight so that it fits like a drumhead.
- 2.) Using a pipette, slowly drop water to the center of the coffee filter and have the students count how many drops it takes for the water to reach the edge of the cup. (Control Experiment/Demo). Have students record the number of drops on their worksheet.
- 3.) Give a cup, coffee filter and rubber band to each group of 2 students and have them place the filter over the cup.
- 4.) Place ~0.1 g of polymer on each student's coffee filter (pre weighed and in eppendorf tubes). Ask the students to describe what the monomer looks like, have them fill in the space on the worksheet. **BE SURE TO NOT LET THE STUDENTS TOUCH THE POLYMER.** If the students touch the polymer have them wash their hands.
- 5.) Have the students **SLOWLY** drop water on the polymer until the water reaches the edge of the cup counting the number of drops as they go. Have students record number of drops on their worksheet and describe what happened.
- 6.) Once all students are done take one student's polymer and drop salt water on the polymer. (You can make the salt-water solution in front of the students if there is enough time). Explain how the properties of the polymer are changing. Ask for examples of polymers in day to day life. (Diapers, potting soil, heat packs, toys which expand in water, etc.)
- 7.) To clean up, remove the coffee filter from each cup for the student and collect the cups and rubber bands. **DO NOT ALLOW THE STUDENTS TO TOUCH THE POLYMER. IT WILL DRY OUT THEIR SKIN/EYES. HAVE STUDENTS WASH THEIR HANDS WHEN DONE WITH THIS STATION.**



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### C. Degradation of Materials Station

Concepts: degradation, recycling, green chemistry

Key Terms: biodegradable

Materials:

- Legos
- Magic Nuudles or biodegradable packing peanuts
- Styrofoam packing peanuts
- 2 larger beakers

Instructions:

- What is degradation?
  - Ask the students if they have heard this term before and if they know what it means
  - Hands on activity: Have Lego creations built that they can take apart and rebuild. Explain that the Lego creations can be taken apart (degraded) and the individual Lego blocks can be used to make something new
- Do all things degrade?
  - Ask the students for examples of things that breakdown/degrade
  - Hands on activity: Degradable packing materials versus traditional Styrofoam packing peanuts. Student will be giving both type of packing materials and asked what the difference is between the two. Then, they will put the materials in two separate beakers of water and observe.
- What are the advantages/disadvantages to using materials that degrade? Discuss!

### 3. Wrap-up: Sharing Experiences and Building Connections 10 Minutes

*Putting the pieces together – how will students share learning, interpret experience, build vocabulary?*

Summary of the important points from the rest of the demos. The students will be encouraged to think about the cycle of things coming together and breaking apart as they use materials in their everyday lives. They will have the chance to ask us any questions they have and to tell us something that they learned during the whole presentation.

Final demo – Nylon (see following page)



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## Nylon Demonstration:

### Materials:

- 0.5 M Hexamethylenediamine solution – Prepared by dissolving 3.0 g
  - o hexamethylenediamine and 1.0 g NaOH in 50 mL distilled water. The amine can be dispensed by putting the bottle in hot water until enough has melted (mp is 39-40°C).
- 0.2 M Sebacyl chloride solution – Prepared by mixing 1.5-2.0 mL sebacyl chloride
  - o into 50 mL hexane.
- Gloves
- 250 mL beaker
- Tweezers
- Winding apparatus

### Instructions:

1. Pour the diamine solution into the beaker.
2. Carefully pour the sebacyl solution as a second layer into the beaker, minimizing agitation at the surface by pouring down the side or using a stirring rod.
3. Use the tweezers to pick up the film that has formed at the interface and pull it slowly from the center of the beaker.
4. Wind the thread on a rod, can, or other object.
5. Wash the nylon thoroughly with water before handling.

Disposal: The two solutions must be completely mixed and the resulting nylon washed with water before being disposed of in solid waste. Remaining liquid should be discarded in a solvent waste container or can be neutralized with either sodium carbonate (if acidic) or sodium bisulfate (if basic) and flushed down the drain with water.

Shakhashiri, B. *Chemical Demonstrations: A Handbook for Teachers of Chemistry*, Volume 1, 1983, University of Wisconsin Press.

#### 4. Close:

*Clean-Up. Thanks and goodbye.*

2 Minutes

TOTAL 50 – 60 Minutes



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## Follow-up – After Presentation

Suggest students write a letter explaining “How we learned about polymers and recycling plastics...”

**Gak!** (*BASIS Lesson developed by Chemical Engineering Graduate Students*) - You are given the task of making the best gak. The head scientists have come up with three recipes but they need your help to find the best one. Using concepts of engineering and science, together we will explore the new materials and learn methods to test for which one has the best properties. **(Does not include recipe)**

[http://www.crscience.org/lessonplans/5\\_Gak\\_ChemE\\_10-11.pdf](http://www.crscience.org/lessonplans/5_Gak_ChemE_10-11.pdf)

**Polymer Possibilities** (*BASIS Lesson Developed by Bioengineering Graduate Students*) - We will be introducing kids to the world of polymers. Examples of polymers are all around us whose properties and uses are largely determined by their chemical structure. We will explain how polymers are large molecules consisting of long chains of repeating units. Through activities we will look together at the structure of polymers and their possible properties. **(Includes recipes of various polymers)** [http://www.crscience.org/lessonplans/5\\_PS\\_Polymer\\_Possibilities\\_11-12.pdf](http://www.crscience.org/lessonplans/5_PS_Polymer_Possibilities_11-12.pdf)

**Gum Drop Chains and Shrinky Necklaces** (*Polymer Science Learning Foundation*) - In this activity, learners thread gumdrops together to make a model of a polymer. Then they thread the chains together to mimic crosslinks, and discover how crosslinked polymers act differently than uncrosslinked ones. Use this activity to illustrate about the various structures of polymers.

<http://pslc.ws/macrog/kidsmac/activity/gumdrop.htm>

### **Reading Connections:**

- Janice VanCleave’s Molecules by Janice VanCleave – (Children ages 8-12) Includes 20 simple and fun experiments that allow you to discover the answers to these and other fascinating questions about molecules, plus dozens of additional suggestions for developing your own science fair projects. Learn about the structure of molecules with a simple experiment using gum drops and toothpicks; about molecular motion with a glass, a cup, and food coloring; about crystals using Epsom salts, a soap dish, and a paint brush; and much more. All experiments use inexpensive household materials and involve a minimum of preparation and clean up. <http://www.amazon.com/Janice-VanCleave-Molecules-VanCleave/dp/047155054X/>



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