Making Gel Beads

Levels:
Grades 4-5

Content Areas:
Chemistry; Polymers

Lesson Time:
60 minutes

Next Generation Science Standards:
5-PS1-2; 5-PS1-3;
3-5-ETS1-3

Objectives & Outcomes:
- Students will learn about the key features of polymers and gels.
- Students will make a gel from a polymer
- Students will learn about diffusion

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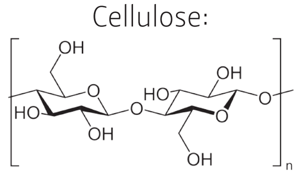
Description:
In this lesson, students learn how to create gels from polymers. Students will learn the chemical background of polymers and gels and some of their uses in every day life. The background materials covers the chemistry of polymers and gels.

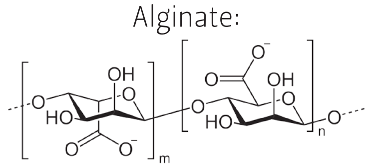
Using This Lesson:
This lesson can be done by individual students. The first part of the lesson is the chemical background of polymers and gels. The second half of the lesson allows students to play with making their own gel beads from two liquid solutions.

Introduction to Gels & Polymers:
A **polymer** is a long chain of repeating molecules, like a long chain of paperclips. Polymers are everywhere from food to electronics. The properties of the polymer depends on what the repeating molecules are. Cellulose, the main component of plants, is a polymer of sugar molecules. Packing peanuts are made from styrofoam, another polymer. This activity will be using the polymer **alginate** - a polymer from seaweed. Look at the structure of these polymers:

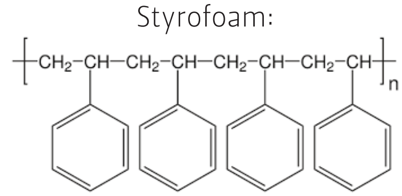
Cellulose:



Alginate:



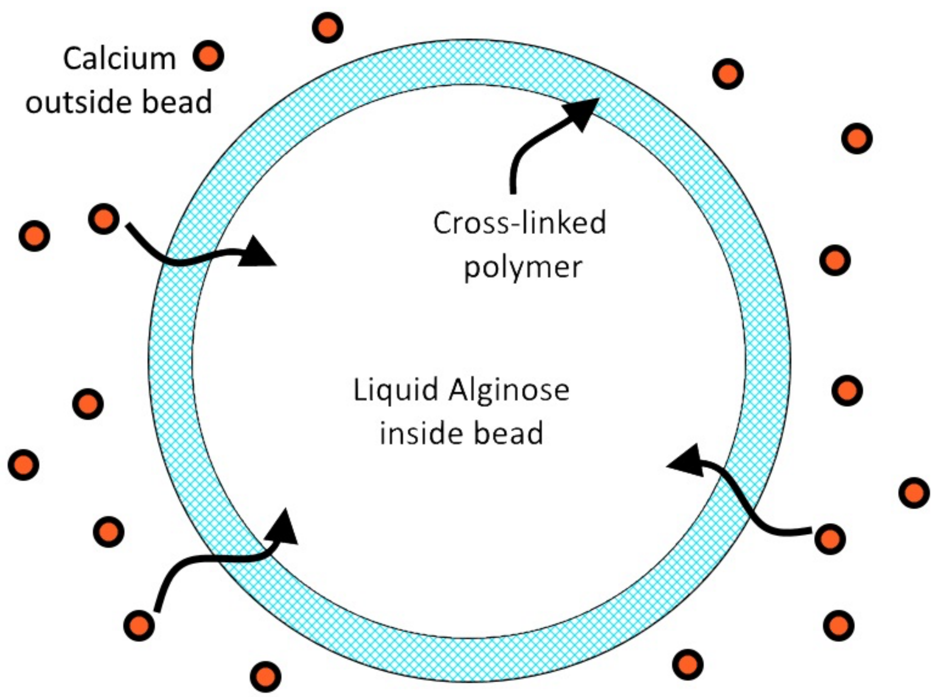
Styrofoam:



The "n" in these depictions means these chemical units will repeat to form long chains sometimes thousands of molecules long.

A **gel** forms when a polymer becomes cross-linked, like tangling a chain of paperclips. Think of a gel like a giant ball of spaghetti covered in sauce. The spaghetti will become tangled and create a net that catches sauce. A gel has qualities of both a solid and a liquid because pockets of fluid get trapped between the polymer chains. Jell-O is a well-known gel made from cross-linked gelatin. If you think about Jell-O, it holds its shape like a solid, but can wiggle more like a liquid.

How is a Gel Bead Formed?



Calcium moving into the bead causes liquid alginose inside of the bead to cross-link, causing the gel wall to thinken

The gel beads in this activity are made by dropping 2 wt% sodium alginate into a 1 wt% calcium chloride solution. **Weight percent** (wt%) corresponds to the grams of something dissolved in 100 mL of water. This means that a 2 wt% solution of sodium alginate contains 2 grams of sodium alginate in 100 mL of water.

In this experiment, calcium causes alginate to cross-link and trap water. Beads form because the sodium alginate drops are round and begin to crosslink once they hit the calcium chloride solution. A gel shell forms around the bead and thickens when the bead is left in solution. This happens because of **diffusion**. Diffusion is the movement of molecules from high concentration to low concentration. Calcium diffuses through the alginate gel layer. When the calcium reaches the inside of the bead, it will cause the alginate there to crosslink and become a gel. This is how the gel shell thickens. After about 5-10 minutes, the bead will be entirely gel and may even bounce. **Remember - the gel beads are 98% water!**

Making Gel Beads

Solution Preparation:

1. Make all solutions prior to class. Use food grade products to reduce risks of accidential ingestion, although this is not encouraged or recommended. All solutions can be poured down the dran.
2. Sodium alginate: Add 20 g of sodium alginate to 1 L of water. Makes plenty of gel beads for 30 students. Use blender or electric mixer to mix sodium alginate in water. Mixture should be smooth when done. Store in refrigerator in class.
3. Calcium chloride: Add 20 g of calcium chloride to 2 L of water. Mix until all powder goes into solution. Does not need to be refrigerated.

Making Gel Beads:

1. Pour the 2 wt% sodium alginate solution into small cups. Add food coloring and stir. Put a few pipettes into each container of 2 wt% sodium alginate. Set-up one container of each color of 2 wt% sodium alginate solution per group of students.
2. Give each student a small cup of 1 wt% calcium chloride solution (approximately ½ inch of liquid per cup). Students can use pipettes to drop the 2 wt% sodium alginate solution into the 1 wt% calcium chloride to make gel beads or other shapes.
3. Beads will quickly gel on the outside while remaining liquid on the inside. Students can reach into the cup and pick out beads to observe the gel shell. Have students experiment with leaving the beads in solution for different lengths of time.
4. Students can take their gel beads home. Use fingers or a small strainer to harvest beads and place them in a plastic bag. Do not store in water or calcium chloride solution because the food coloring will leach out. The beads keep well in the refrigerator or a cool dry place.

Materials:

Expendable:

- 20 g Sodium alginate powder
- 20 g Calcium chloride powder
- Water
- Food coloring (optional)
- Zip-top bags (optional)
- Small droppers
- Small cups (1/student)

Reusable:

- Blender or electric mixer
- Balance
- 2L bottles (count 2)
- Small strainers (optional)

Experiment Questions:

Below are basic and advanced level questions and activity enhancements.

BASIC LEVEL

1. Do all beads form equally? What determines their size and shape?
2. How does the time for the bead to completely gel change with bead size?
3. Does the mass or density of the bead change as calcium moves into the bead? If so, how?

ADVANCED LEVEL

1. What happens once the bead is removed from the calcium solution? Does the crosslinking stop immediately or continue over time?
2. Why does the outer gel form so quickly, but it takes so long for the middle to solidify?

Next Generation Science Standards

DISCIPLINARY CORE IDEAS:
PS1.A: Structure and Properties of Matter
ETS1.B: Developing Possible Solutions

PERFORMANCE EXPECTATIONS:
5-PS1-2: Measure and graph quatities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mizing substances, the total weight of matter is conserved.

5-PS1-3: Make observations and measurements to identify materials based on their properties.

3-5-ETSI-3: Plan and carry out fair tests in which variables are controlled and failure points considered to identify aspects of a model or prototype that can be improved.

PRACTICES:
3. Planning/carrying out investigations.
6. Constructing explanations/ design solutions.

CROSSCUTTING CONCEPTS
1. Patterns
2. Cause and effect: mechanism and explanation
6. Structure and function

Resources:

The Gel Bead Process, Mock, Lyman-Holt, & Rochefort (February 2005) College of Engineering, Oregon State University. Retrieved from http://engineering.oregonstate.edu/momentum/k12/feb05/M!_GelBeads_final021405.pdf

Activity: Gel Beads, Rochefort (2009) Chemical Engineering Department, Oregon State Univeristy. Retrieved from http://people.oregonstate.edu/~rochefow/K-12%20Outreach%20Activities/Gel%20Bead%20Teacher%20Packet/GelBead_TeachEngineeringActivity.docx

Everyday Polymers (2013) CHIP GK-12 Project, Department of Electrical and Computer Engineering, Colorado State University. Retrieved from https://www.teachengineering.org/view_lesson.php?url=collection/csu_/lessons/csu_polymer/csu_polymer_lesson01.xml