West Side Science Club – Event #9 – "The Hydrogel Challenge"

Original Presentation

Date:	23 March 2013	Blogger:	PB
Time:	10 am to 12 pm	Photos:	PB
Site:	West Side Science Club		

Attendance: Mentors – Ben, Paul, Levi, Kim, Bridgett, Emma
Students – Sam, Andres; Daisy, Katherine; Allison, Emily, Diana.

- Alex was present at start but was sent home within first 5 minutes for being disruptive

Brief Description

This lesson plan describes an activity where students are given an array of household objects and the precursors for making edible hydrogels, then challenged to develop ways of fabricating shaped structures of these materials.

Big Questions

Word of the Day: "Hydrogels"

(1) What is a hydrogel?

(2) How can shaped structures of soft materials be made?

Concepts

Concepts to cover from the "Work of CCI Solar" Mind Map:

Level one (concepts): ions, polymers, materials

Level two (skills): problem solving, fabrication, developing creativity

Motivation for this Activity

The idea behind this exercise is to encourage the development of the problem solving and creative skills that are important to progress in scientific research. We don't want every WSSC event to comprise only demonstrations (where the kids just watch mentors perform tasks) and activities in which students must strictly adhere to a set of inflexible instructions. The event planned in this document is an original activity designed to allow students wide latitude to experiment and explore while still maintaining a common theme for the day's work.

Relevant Feedback Provided at the Mini-Retreat and Its Effect on Design Elements for this Activity

- At the mini-retreat, the kids reported that they preferred using everyday materials rather than specialized chemicals brought from Caltech. Sam thought you had to be too careful with the research chemicals.

  This activity uses calcium chloride, sodium alginate, and agar. All of these substances are nontoxic and on the FDA's "Generally Regarded as Safe" list. They can be purchased from online food sellers. The other equipment used in this activity comprises everyday objects.

- The WSSC kids said that they enjoyed activities where you could eat the materials.

  Calcium alginate is edible. It is used in haute cuisine (search "spherification"). Agar is also edible and can be found in candy, like fruit slices.

- The WW mentors voiced a desire to incorporate activities with fewer rigorous instructions. "Activities with complex instructions should be run as demos." We want to go "off-road" from instructions.

  There are only a few general instructions and no specific instructions for this activity. Since the materials are safe and edible, we can be comfortable giving the students wide latitude to explore.

- Ben voiced a desire to incorporate more team-building and problem-solving activities, and more exploratory activities (vs. demonstrations).

  In this activity, students will work in teams to solve a set of challenges we issue to them.

- Levi voiced that we should create more games with our activities

  The students will form teams (by table) to compete with other tables for points. Points will be awarded points based on what structures they each team can fabricate.

Lesson Plan

Student Objectives

- To learn the basic composition of hydrogels and how they are made
- To discover techniques for the fabrication of shaped hydrogel materials

Schedule/Agenda

- Review: Event #8 – "Electroplating" (15 min.)
- Warm-up Demos: The basics of making hydrogels (15 min.)
- Activity: Making shaped hydrogel structures (50 min.)
- Continuation: Sharing results / reproducibility (30 min.)
- Wrap-up: Paul's Dissertation (5 min.)

Materials

Activity: Fabrication of Hydrogel Structures – # of items per box)

- 1 L solution of 1% calcium chloride (Paul)
- 500 mL of 1% solution of sodium alginate (Paul)
- 5 sheets of chromatography paper (Paul)
- 1 bin (Paul)
- 1 star-shaped cookie cutter (Ben)
- 1 roll of Scotch tape (Paul)
- 5 feet of string (Levi)
- 1 small spray bottle/pump (Ben)
- 1 ice tray/mold for making cubes (Ben)
- 1 glue stick (Paul)
- 1 pair of scissors (Ben)
- 4 sheets of transparency film (Paul)
- 4 small plastic cups (Paul)
- 1 50-mL syringe (Paul)
- 1 1-mL syringe
- 1 bottle of food coloring (Ben)
- 2 plastic Easter eggs (Ben)
- 3 drinking straws (Ben)
- 2 200-uL micropipette tips

- 1 hot plate (Levi)
- 50 fruit slices (as prizes; they are made with agar) (Ben)
- Pasteur pipettes and bulbs (Paul)
- 1 copy of Paul's Ph.D. dissertation (Paul)
- duct tape (Paul)

Safety

- Students must wear their eye protection to practice good safety habits for experimental work, even though nothing in this activity is especially dangerous or toxic

Review of Previous Event: Electroplating

- Recall the demo: When a post-1982 penny was cut in half, you could see that most of the penny was composed of a zinc core that is plated with a very thin external layer of copper.

- Recall the activity: We took a battery and applied a current to a nickel coin in a bath of copper ions to form a solid layer of copper on the outside of the coin.

- Recall the second activity: We plated a layer of zinc onto a copper penny. When this "silver" penny was heated, the copper and zinc mixed to form brass, which has a golden color.

Facilitation Questions

- Where did the copper that plated onto the nickel coin copper come from? (It came from the blue solution of Cu^{2+} ions.)

- So, metals can exist in solution (as ions) and as uncharged solid metals. (Yes.)

- What charges do the metals in solution have, + or −? (Positive charges. Electrons, with negative charges, jump onto the positive metal ions.)

Warm-Up Demo: Making Calcium Alginate

Procedure, with Facilitation Questions

1. Take a bottle of 1% sodium alginate and turn it upside down.

    - What do you notice about this liquid, a solution of alginate? (Kids will notice it is gooey. Scientists would describe the solution as "viscous", like pancake syrup).

    - Why are pancake syrup and molasses viscous? (Because they have a lot of sugar inside them)

    - Why do you think this alginate is viscous? (Because it has a lot of sugar inside? Yes! …but it is a different type of sugar from table sugar. It does not taste sweet, but you can eat it. It comes from seaweed.)

    - This particular type of sugar has long stranded molecules with negative charges. Look what happens when we mix it with a solution of calcium metal ions…

- These hydrogels are mostly water (like the solutions they come from), but the water is trapped along with these sugar polymers

2. Pour a small dollop of sodium alginate into a bath of calcium chloride. The dollop will gel into a solid. You can remove it with your fingers after 15 seconds and pass it around. It will feel squishy. (…but squeeze too hard and the un-gelled guts might ooze out.)

Warm-Up Demo: Making Solid Agar

Procedure

1. Take a bottle of xx% agar that has been heated so everything is dissolved. Pour it into a dish.

2. Wait a minute or so.

3. Notice that upon cooling, the solution solidifies into a gel.

Activity: Making Shaped Hydrogel Structures

Now that the kids know the basics for gelation of these two materials, we will present the day's challenge: we want them to use the items in the boxes in front of them to make the structures listed below. They will work in teams (by table) for points, as follows:

Write on board:

Alginate:	spheres	(5 points)
	spaghetti/worms	(10 points)
	ring or donut	(15 points)
	starfish	(20 points)
	interlocking rings	(40 points)
	cube, at least 1×1×1 cm	(100 points)

- +2 bonus points (per class of shape) for being the first table to make one of these structures
- +5 bonus point (one time only) for making a brightly colored calcium alginate object
- To score points, the student must list a recipe/directions in your notebook and have the procedure witnessed by a mentor

Agar:	spheres	(5 points)
	cube, at least 1×1×1 cm	(10 points)
	starfish	(10 points)
	spaghetti	(15 points)
	ring or donut	(20 points)
	interlocking rings	(30 points)

- +2 bonus points (per class of shape) for being the first table to make one of these structures
- +5 bonus point (one time only) for making a brightly colored agar object
- To score points, the student must list a recipe/directions in your notebook and have the procedure witnessed by a mentor

- After the initial fabrication period of ~45 minutes, students may show their notebooks to students at other tables. If the member of the second table can repeat the procedure and make the corresponding structure, the team that provided the directions will score 10 bonus points while the second team (that received the directions) will score the points for making the structure.

- At the end of the day, the team with the most points will be declared the winner. They will receive three fruit slices each, while the second and third place teams will receive two fruit slices per member.

- Fruit slices are made, in part, with agar!

Answers/Solutions

Alginate Spheres (5 points)

1. Fill a syringe with the solution of sodium alginate
2. Slowly depress plunger while holding the syringe over a bath of calcium chloride such that the spherical droplets fall into the bath

Alginate Spaghetti (10 points)

1. Fill a syringe with the solution of sodium alginate
2. Quickly depress plunger while holding the syringe in a bath of calcium chloride such that threads of alginate form by extrusion from the circular orifice.

Alginate Ring or Donut (15 points)

1. Take a piece of chromatography paper and cut it into the shape of a ring
2. Glue it to a solid surface (tray or transparency film)
3. Wet the paper with the solution of calcium chloride
4. Pour the un-cross-linked alginate on top of the ring
5. Wait 30 seconds then wash away any un-cross-linked polymer
6. Carefully peel the ring from the paper

Alginate "Starfish" (20 points)

1. Take a piece of transparency film and cut a star pattern into it
2. Glue it to a piece of chromatography paper
3. Place the paper on a flat surface and wet it with the solution of calcium chloride
4. Pour the un-cross-linked alginate on top of the star
5. Wait 30 seconds then wash away any un-cross-linked polymer
6. Carefully peel the star from the paper

Or…

1. Place a piece of chromatography paper on a flat surface and wet it with calcium alginate
2. Pour the un-cross-linked alginate on top of the paper
3. Wait 30 seconds then wash away any un-cross-linked polymer
4. Use the star-shaped cookie cutter to cut a star-shaped film
5. Carefully peel the film from the paper

Alginate Cube, at least 1×1×1 cm (100 points)

1. I have no idea how to make a nice cube with the materials provided here

Facilitation/Concept Questions

- Mentors should be supportive and talk students through their ideas without giving away the answers
- One mentor might serve as a hot-plate czar to reheat bottles of solidified agar stock
- Remember to get the kids to write out and record their procedures in their notebooks!
- Why do you think it is important to be able to make different shapes of this stuff? What could be the functions of the different shapes? (Many answers possible, just a way to get the kids thinking creatively about designing)

Wrap Up

- Students can present how they made certain structures to the wider group
- Paul can bring along his Ph.D. thesis. A few chapters in it describe procedures for making some of these materials/structures. (Thus, what they were doing today was, very recently, “real”/published scientific research!)

Check for Understanding

- What makes up >95% of hydrogels (Water)
- How do alginate and agar behave differently? Which one gels with ions? Which one gels with changes in temperature?

References