Hydrogel Activity Instructions

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Overview: In this activity, students will create alginate hydrogels to explore drug delivery themes. This activity can be adapted for a middle school, high school, undergraduate, or graduate student audience, depending on the connections drawn in class. This document serves as instructional material for course instructors to prepare items for the activity and run within the classroom. When I last ran this activity, it was for 10 chemical engineering undergraduate and graduate students in a standard classroom (i.e., chairs with desks, chalkboard, projectors, no lab setups). Students worked in groups of 2-3, so I prepared enough materials for 6 groups of students. This resulted in 1 set of materials for me as an instructor at the front of the room, 4 sets of materials for the 4 groups of students, and 1 extra set of materials. I prepared all these materials at home and drove them to class on the day of the activity. To help me transport all the liquids (it's heavy!), I used a small foldable wagon (which, I also use to carry exams 😊).

Materials:

- Food-grade sodium alginate
  - Modernist Pantry, 50g, Amazon Standard Identification Number (ASIN): B00BLPNHLW (quantity = 2)
- Food-grade calcium chloride
  - Modernist Pantry, 50g, Amazon Standard Identification Number (ASIN): B00BLPNJLK (quantity = 2)
- Food dye
  - *Example:* Food Coloring Set (12), Amazon Standard Identification Number (ASIN): B0B6C25MWY
- Glitter
  - *Example:* Fancy Sprinkles Moonstone Iridescent Premium Edible Glitter, Amazon Standard Identification Number (ASIN): B09WZ52R6F
- Clear plastic or white paper cups
  - *Example:* 100 Pcs Paper Ice Cream Cups, Amazon Standard Identification Number (ASIN): B09SM16S3B
- Large clear plastic bowls
  - *Example:* US Acrylic Vista Clear Plastic Salad and Serving 10-inch Bowls, Amazon Standard Identification Number (ASIN): B0B5B33Z1X
- Squeeze bottles (for alginate solution)
  - 12 Pack 8 oz Plastic Squeeze Bottles, Amazon Standard Identification Number (ASIN): B07W5CZZSZ
- Plastic bottles (for calcium chloride solution)
  - Plastic Juice Bottles (48 Pack, 12 oz), Amazon Standard Identification Number (ASIN): B0B8QH3KWT
- Paper towels
- Large trash bags
- Hand mixer, mixing bowl, and spatula
- Water
- Nitrile gloves (to avoid getting food dye on your hands in class)
- Foldable wagon for transport of materials
  - *Example:* Amazon Standard Identification Number (ASIN): B0DHQY5ZMB

Preparing the alginate solution (takes ~24 h):

Note: Do this step for <u>each</u> alginate mixture you will prepare. For the activity I ran in class, I prepared <u>two</u> alginate mixtures – one with light pink food dye, and one with blue food dye + glitter. Each 1000 mL solution filled ~6 squeeze bottles (8 oz) with ~150-200 mL of alginate solution in each. This worked well for creating 6 sets of materials – 1 for me to use up front in the classroom, 4 sets for the 4 student groups, and 1 extra set. Scale according to the number of sets you'll need for running your activity.

1. In a large mixing bowl, add 20 g of sodium alginate powder to 1000 mL of water
2. Using a spatula, spoon, or whisk, mix the alginate powder into the water
    a. Optional: use a hand mixer on a low setting to uniformly mix the alginate powder into the water
3. The alginate powder will remain in clumps in the water, as it needs to dissolve. Let the mixture sit covered overnight at room temperature.
4. The next day, use a spatula, spoon, whisk, or hand mixer to mix the alginate solution, ensuring a smooth consistency, as the alginate should be fully dissolved. The solution will be viscous
5. Add a few drops of food dye and/or glitter (optional) to the mixture and stir in to ensure evening mixed
    a. Note: Use light color food dye to prevent staining on hands and clothing. I typically use light pink. However, for the drug delivery activity, I used dark blue, as I wanted the dye to be dark enough for students to view diffusion of the dye into a surrounding medium to represent small molecule drug delivery.
6. Transfer ~150-200 mL of alginate solution into each squeeze bottle and add the cap
    a. Note: You may want to use a funnel to load the squeeze bottles. I typically use a ladle spoon.
    b. Note: Sometimes the caps feel loose on the squeeze bottles. For transport, I'll sometimes use painter's tape to tape the cap shut to prevent spilling
7. Label the squeeze bottles as "2 wt.% alginate" and move to a box for transport
    a. Note: I recommend a reusable plastic storage container for transport, as if liquid spills, it's a contained mess compared to cardboard boxes (yay secondary containment!)

Preparing the calcium chloride ($CaCl_2$) solutions:

1. Prepare low (0.1 wt.%), medium (0.5 wt.%), and high (2 wt.%) $CaCl_2$ solutions
    a. Low: Add 1 g of $CaCl_2$ powder to 1000 mL of water and stir
    b. Medium: Add 5 g of $CaCl_2$ powder to 1000 mL of water and stir
    c. High: Add 20 g of $CaCl_2$ powder to 1000 mL of water and stir
2. Stir with fork for ~5 minutes, or until fully dissolved
3. Add to ~150-200 mL of each solution to a plastic bottle and add the cap
4. Label each bottle with the $CaCl_2$ solution concentration. Place the bottles in a box for transport.
    a. Note: I recommend a reusable plastic storage container for transport, as if liquid spills, it's a contained mess compared to cardboard boxes (yay secondary containment!)

Running the activity in class

Note: **Make sure you have a disposal game plan before deciding to do this activity in your classroom.** When this activity is complete, you'll have a bunch of solid alginate hydrogels, saltwater solutions in bowls, paper cups, and any remaining activity materials. I left 15 minutes at the end of class specifically dedicated to cleanup. Students removed all hydrogels from their cups and combined them into a single small plastic trash bag at the front of the room for disposal through regular trash streams. Students emptied liquid saltwater waste from their cups into a large bowl, which I then took to a restroom for disposal down the sink. I ensured there was no solid hydrogel in the water. Students placed their emptied paper cups into a trash bag at the front of the room for regular trash disposal. Students wiped down all desk and surfaces with paper towels to remove any drips of water. Students recapped bottles with alginate and calcium chloride solutions, and I took them in the foldable wagon back to my car. I stayed after class for 5-10 minutes to ensure the room was completely clean.

1. Make sure you have the following materials with you in the classroom, and arrive at least 15 minutes before class to setup
    a. Alginate solution squeeze bottles
    b. $CaCl_2$ solution bottles
    c. Small cups (white paper or clear plastic)
    d. Large bowls (I recommend at least 3)
    e. Paper towels (multiple rolls, think 1 roll for every ~2 groups)
    f. Trash bags (I used small size, like for a bathroom trashcan)
    g. Original packaging for all products (alginate, calcium chloride, glitter, food dye, etc.)
2. I set up 1 teaching station at the front of the room and 4 group stations throughout the room. Each station consisted of…
    a. 1 pink alginate squeeze bottle
    b. 1 blue/glitter alginate squeeze bottle
    c. 1 low (0.1 wt.%) $CaCl_2$ solution bottle
    d. 1 medium (0.5 wt.%) $CaCl_2$ solution bottle
    e. 1 high (2 wt.%) $CaCl_2$ solution bottle
    f. 6 paper cups
    g. 1 roll of paper towels
        i. I covered the desk with paper towels ahead of time. Plastic table clothes could work as well.
    h. 5 sets of nitrile gloves (size adult large)
3. When students came into the room, I instructed them to sit down at a lab station and divide themselves into groups of 2-3. They pulled up the lab activity worksheet from Canvas and followed along. I did a demo of each activity step upfront in the classroom before they were left to explore. We did a brief safety overview (optional wear gloves, don't eat anything, reviewing food-grade ratings). I had the direct original packaging for all materials used in this activity so that students could review before handling any materials.
4. Students went through the activity and cleaned up at the end of class (see my example cleanup plan above). Make sure to have a cleanup plan in place ahead of the activity! And have twice the amount of paper towels and trash bags you think you'll need.

Let me know if you have any comments or suggestions on this activity, or if you use it in your classes! – Victoria Muir, vmuir@udel.edu