# TEACHER INSTRUCTIONS

# Water Pods: Bioactive Glass Microbeads Encapsulation

**Objective**

To illustrate the concept of glass beads, biodegradation of glass beads, and the process of drug encapsulation within glass beads for medical applications.

***Figure 1. Water pods produced with both no food dye as well as red food dye, resulting in dramatically different colors. These spheres are great representations of glass encapsulation and formation. (Credit: Ursinus College)***

**Background Information**

Bioactive glass microbeads are a common tool utilized for drug delivery in the pharmaceutical and medical industries. Often consisting of a composition of phosphorus, silica, and other biodegradable and non-toxic components, these glasses are used to deliver medications, provide scaffolding for the formation of bone, and bind to specifically targeted ligands within the body.

From a medical perspective, glass beads are unique in that they have a high potential for surface functionalization, meaning they can be made to interact in very specific ways with the body. Furthermore, their robust nature prevents them from degrading too quickly, increasing their bioavailability and lifespan within the body. Frequently, bioactive glass beads are used to stimulate bone growth in patients with osteo-degeneration or those who have suffered traumatic fractures.

Glass microbeads may be formed in a wide variety of ways. This may include the passive diffusion of medication into pre-fabricated microspheres, the formation of spheres in solutions containing medications, creating porous surfaces that allow liquids to freely enter and exit the sphere, etc.

**Demo Description**

Edible algae-based spheres will be formed in water, creating an “edible water bottle” (Figure 1). This will allow students to observe the formation of spheres, the concept of encapsulation of liquids within spheres, and the ability of said spheres to interact with and break down in the body. Overall, students should gain an appreciation for the applications of these technologies and their applications on the micro-scale.

**Supplemental Link**: https://www.wikihow.com/Make-Edible-Water-Bubbles

**Keywords**

- Porous – The presence of small gaps or holes in the surface of an object, allowing the passage of other substances such as gases and liquids
- Glass microsphere – A general term for any glass composition that is formed into the shape of a sphere, generally measuring between several microns in diameter and several hundred, depending on the application
- Encapsulation – The formation of a sphere around another substance, such as a solubilized drug, encasing it within a shell
- Bio-Active Glass – Referring to a glass composition that includes bioactive materials and are safe for use on living things internally and externally (often these materials are biodegradable)

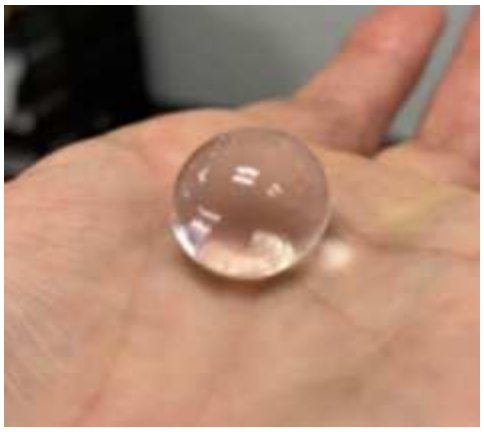

***Figure 2. Water pods are safe to handle, are 100% edible, and are easy to make. Connecting this lesson to others such as optics is easy as well. For example, ask students to consider how light may bend through this sphere, and how its contents could affect this. (Credit: Ursinus College)***

**Materials List**

*Items Provided in the Kit:*

- One bag of Calcium Lactate
- One bag of Sodium Alginate
- Spoon for forming spheres
- Mixing spoon

*Items Provided by Teacher/School:*

- Potable water
- Three small bowls to hold at least 4 cups of water
- Soap for washing hands
- Food coloring

**Safety Precautions**

While all food products are food safe and non-toxic, care should be taken to ensure no products are consumed raw and in large quantities. Furthermore, please ensure that no individuals with known allergies to any ingredients are allowed to interact with or consume the materials. To prevent the spread of illness, it is recommended that any student or instructor interacting with the materials wash their hands thoroughly before touching equipment. All equipment should also be washed before and after use to prevent the spread of illness.

**Instructions**

1. Prior to starting the experiment, all utensils should be washed thoroughly. Ensure that all equipment used in this experiment is food-safe, and is not laboratory equipment. Additionally, all individuals who are actively making the spheres should ensure that their hands are clean before beginning.

2. Before beginning, it is recommended that you discuss the concept of drug therapeutics with students, particularly relating to drug delivery in the body. From here, discuss the implementations of bioactive glass beads in medicine, taking care to explain what these beads are, and why they are unique.

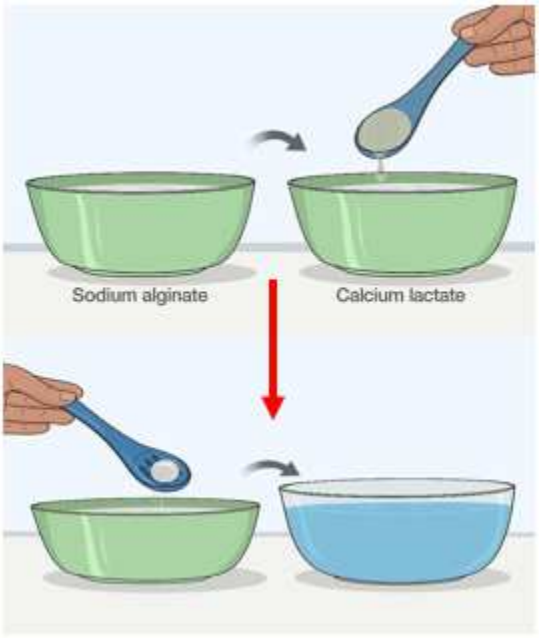


*Figure 3. Mixing can be tricky at first. Attempting smaller drops first is easier. Be sure to allow the alginate to mix in the lactate for about 3 minutes before transferring to water.*

*Figure 4. Beads can be produced in a wide variety of conformations. By changing the size of the dipping spoon, altering the dipping pattern, or using molds, a wide variety of shapes can be made.*

Bioactive glass beads are unique in that they are capable of releasing and delivering large drug molecules to specific points in the body. Their composition allows scientists to functionalize the surface of the beads, which can have a variety of effects, such as allowing them to circulate in the body longer, target specific regions or cells of the body, or bind more effectively to a target. Additionally, glass beads are robust, and can survive for longer periods of time within the body before breaking down. This could allow drugs to circulate longer internally following a single dose.

3. Following this discussion, in one of the bowls, mix 1 gram (approximately ½ tsp) of Sodium Alginate with 1 cup of water. If more is required, simply double or triple the recipe. Be sure to mix thoroughly. If an electric mixer is available, that may be easier, however hand mixing is also acceptable. Most if not all of the Sodium Alginate should be dissolved, and the solution should be viscous.

4. Allow the mixture to sit for at least 15 minutes to allow air bubbles to exit the solution. During this time, it is recommended that you discuss with your students how this procedure will represent the formation of glass beads that are loaded with some specific substance. Real beads that are used for medical therapeutics may be loaded through a variety of ways, however one common technique is to form the beads in the presence of the target compound, trapping the liquid inside. Here, we are replicating this concept with edible components.

5. After the Sodium Alginate has settled, mix 5 grams (approximately 2.5 tsp) of Calcium Lactate into 4 cups of water in a second bowl and mix until completely dissolved. Once dissolved, take the deep spoon for making spheres and dip it into the Sodium Alginate. Transfer this to the Calcium Lactate, dipping the spoon into the solution and then inverting it to release the sphere (Figure 3, top). The sphere should form instantly, however some residual material may stick to the spoon. Allow this to break away. This process can be repeated several times to make multiple spheres. Try to avoid crowding the bowl however, as it could cause spheres to adhere to each other.

6. Allow the spheres to sit in the Calcium Lactate for 3 minutes, agitating gently. Prepare the final bowl with only water. Using a spoon, remove the spheres and transfer them to the third bowl with water to rinse the spheres (Figure 3, bottom).

7. Spheres can now be handled and consumed by students. Note that the longer spheres are allowed to sit in Calcium Lactate, the thicker the shells will be (Figure 4). Be sure to encourage students to observe the spheres and handle them.

**Additional Demonstrations**

In order to better observe the formation of the spheres, or to encourage students to think about the formation process and variations that could be performed during encapsulation, food coloring can be used. By adding color to the Sodium Alginate, you can make different colored spheres.

Spheres can also be encapsulated within other spheres, or other liquids could be used in place of water to encapsulate other things, such as juices or soft drinks. Finally, students can even attempt to be artistic with the formation of the edible spheres, by adding streaks of color to the Sodium Alginate, or using different molds to form the spheres when adding the Sodium Alginate to the Calcium Lactate.

**Cleanup and Replacement Parts**

Cleanup can be performed with standard dish soap and water. It is recommended that all solids such as unconsumed or broken spheres be thrown in the trash in order to avoid potential clogging of drains. Replacement ingredients can be purchased at most culinary supply stores, however one recommended supplier is Modernist Pantry® - www.modernistpantry.com Packages are shelf-stable and resealable for long-term use.

TEACHER DISCUSSION QUESTIONS

# Water Pods: Bioactive Glass Microbeads Encapsulation

**Questions for Before the Demonstration**

1. Ask students why are we interested in encapsulating drugs?

*Discussion:* Students should discuss the importance of drug encapsulation as a means of delivering medication to specific regions of the body. Furthermore, encapsulation of drugs can be used to strategically release medications at specific intervals, or in specific environments, limiting off-target effects and promoting efficacy over time, and limited removal from the body.

2. Ask students what are the benefits of encapsulating drugs in medicine?

*Discussion:* Students should discuss the short-term and long-term benefits, ranging from the direct medical applications to the business applications and benefits. Examples include limiting off-target effects, long-term release, strategic release, targeted release, bio-availability retention, surface fowling reduction, variable release times for different applications, cost of administering, etc.

3. Ask students why might glass be beneficial as a drug delivery vehicle?

*Discussion:* Students should discuss the benefits of glass. Ideally, discussions should focus on the robustness of glass as a material, providing shear and tensile strength. Additionally, glass materials are easier and cheaper to produce than alternative coatings, and can be treated to prevent surface adsorption.

**Questions for During the Demonstration**

1. Why do you think we are mixing our ingredients in different solutions? How might this relate to loading medications into glass microbeads?

*Discussion:* Students should understand that encapsulation truly means putting one material into another. The purpose of separating the materials is to allow the “therapeutic” (our water) to enter our pods before and during the formation process.

2. What do you think is happening when the Sodium Alginate is put into the Calcium Lactate?

*Discussion:* Sodium alginate is derived from seaweed algae, and is made up of long strands of carbohydrates, which act as a thickening agent. When calcium ions are present, they arrange themselves between the individual strands of carbohydrates, making the resulting gel we observe here.

**Questions for After the Demonstration**

1. Ask the students about any observations they made about the formation process.

*Discussion:* Students should discuss the sphere formation, the encapsulation process, and should be drawing parallels to how such a technique could be applied to pharmaceutical manufacturing.

2. What differences do you think exist between this experiment and real glass microbeads?

*Discussion:* Students can discuss a wide assortment of differences, however major points should include sterility of conditions, the different heating/melting points of the materials and how that could affect medications, the differing stabilities of medication and their compositions (acidic, basic, reactive, etc.), application of this technique to mass production, etc.

STUDENT QUESTION HANDOUT

# Water Pods: Bioactive Glass Microbeads Encapsulation

1. What are "Bioactive Glass Microbeads”?

2. What are some of the uses of bioactive beads in medicine?

3. What are some ways bioactive beads are made?

4. Why are bioactive glass beads important?

5. What are some other things these beads can be used for?