Jelly Beads!

Procedure:

1. Always wear safety goggles.
2. Rinse the beaker, graduated cylinder and petri dish.
3. Measure 20 mL of calcium chloride solution with the graduated cylinder. Add it to the beaker.
4. Add three or four drops of sodium alginate to the beaker.
   What happened?
5. Use the scoop to transfer one or two of the alginate gel beads from the beaker to the petri dish.
   Leave the rest of the beads in the beaker for later.
6. • Rinse the beads in the petri dish with water.
   • Touch the beads.
   • Lightly roll and squeeze them between your fingers.

   What do they feel like? What could you use them for?
7. After at least a minute has passed, use the scoop to transfer another bead or two from the beaker to the petri dish.
8. Rinse these beads, and then feel them.

   Do they feel any different from the beads that you pulled out earlier? Why?
9. When you are finished experimenting, dump the beads and water in the waste container. Clean up for the next person.

How did the alginate drops turn into jelly beads?

How could you use the beads?

A Closer Look:

In this experiment you created a gel out of sodium alginate. A gel is a soft substance that has the properties of both liquids and solids. In this experiment, long chains of repeating molecules in the alginate – called polymers – became tangled into a net or mesh.

How did it work? When you added calcium chloride, the calcium ions in the solution cross-linked the polymers in the alginate, attaching them to each other at many points. This cross-linking created a flexible, soft solid – a gel bead. During the longer soak, more calcium ions were able to move further into the mesh of the gel bead, resulting in more cross-linking and a firmer texture.

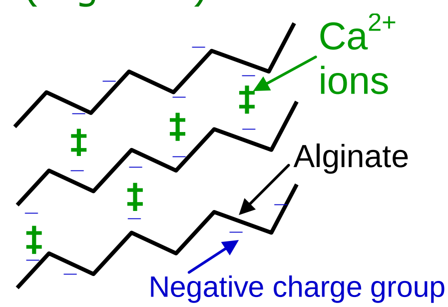
Alginate is made from algae. There are many common gels made from algae that are used in foods, medicine, and other applications. Alginate and the algae-based polymers xanthan gum and carageenan are used to improve the textures of foods such as chicken nuggets and ice cream.

Scientists can also use gel beads to absorb hazardous waste from contaminated solutions. The beads are easy to collect and dispose.

Talking Points:

1. Calcium alginate forms very quickly when sodium alginate reacts with calcium chloride. The other product of the reaction is sodium chloride, or common table salt.

$$Na(Alginate) + CaCl_2 \rightarrow 2\ NaCl + Ca(Alginate)$$



2. Jell-O: Jell-O gets its structure from gelatin, which is a naturally occuring protein (polymer) originally derived from animal tissues (skin, bones, etc.). When cold, individual gelatin molecules are weakly bonded in a triple helix shape, with the bonding sites trapped in the interior of the molecules. However, when hot water is added, the heat energy causes the gelatin molecules to unravel a bit, which exposes bonding sites along the molecular chain, which are then free to attach to other gelatin molecules to form a gel while cooling. This is an example of a reversible cross-link, as “solid” Jell-O can be liquified again with a little added heat.
3. Other examples of polymer gels:
   a. Egg whites: Egg whites, called albumen, are made up mainly of protein and water. Proteins are natural polymers. The proteins can be cross-linked by exposure to heat. When you cook them, the individual polymer proteins unravel and cross-link, similar to the way gelatin does, creating a more solid gel. This won't work as well on the yolk, which, while also protein-rich, has lots of fats and other properties that make it more difficult for it to become hard. You can do something similar when you whisk egg whites: By exerting mechanical energy in the whisking process, you cause the protein bonds to break, and subsequently re-connect. Once these new, strong bonds are formed, the egg stays in that state. The proteins have formed a network of strong, permanent cross-links. A cooked, chemically-altered or well-beaten egg will never go back to its original state. This is an example of a permanent cross-link.
   b. Jelly: Jelly is a gel that gets its structure from a polymer called pectin, which is naturally occurring in most fruits (apples are particularly pectin-rich). Jellies are usually made by applying heat to a sugar-water-pectin mixture, which causes the pectin to cross-link.
   c. Orbitz drinks: This drink was available for a short time in the 1990s. It consisted of a sweet drink with gel beads similar to the ones made in this experiment suspended in it. The beads seemed to defy gravity by floating in the drink and being fairly difficult to get moving. The secret was that the sweet liquid surrounding the beads also contained some polymer ingredients that created a weak mesh that held the beads in place. The drink is no longer made, but it has been spotted on eBay from time to time.
   d. Tapioca, bubble tea, etc.

Extensions:

- Try some additional experimentation with the alginate and calcium chloride. Experiment with creating streamers and shapes: try to make smaller beads, larger beads, “jelly beans”, or “worms” with the alginate. Try it backwards, making a shape out of alginate in the petri dish, and then pouring some calcium chloride solution over it. Squirt the alginate into the $CaCl_2$ bath, or make a shape with alginate in the plastic dish and then pour the curing solution ($CaCl_2$) over it. Deft hands can squirt a little $CaCl_2$ into a bath of alginate and then draw a long streamer up from the interface—but be prepared to unclog the bottle.
- Discuss foods with interesting textures—tapioca, bubble tea, processed meats, Orbitz drinks (those weird drinks with the gel beads in them that were marketed in the 1990s—they were discontinued in 1996, but some bottles are still available on eBay), crunchy chips, cookies, ice cream, and milkshakes. Does texture make a difference in your desire for the food?
- Discuss chemical hygiene and what it would take to make sure a chemical would not hurt people who ate it. We don’t eat chemicals in our lab because it is not safe. To have a food-grade chemical, we would need to be certain that nobody accidentally contaminated it with even a tiny bit of non-food chemicals.
- Discuss sources of chemical compounds, from algae-derived alginates and carrageenan to medicinal extracts. Discuss the difficulty of replicating complex organic molecules and ways to preserve biological resources.