Instant Worms & Fruit Caviar

Fun with Polymers in the Kitchen

The University of Toledo Student Chapter of the American Chemical Society

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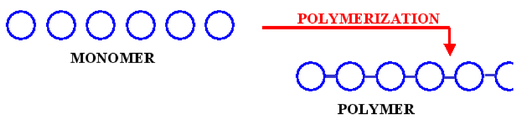
Abstract

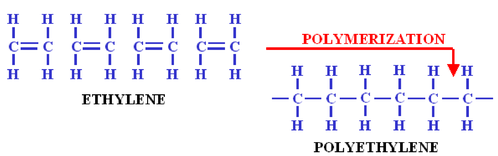
The purpose of this presentation is to provide a demonstration of polymer science that can be performed at home, with ingredients found at a local bakery or grocery store. To show the formation of polymeric materials, a variety of sodium alginate solutions with different additives will be created, each providing a different, fun effect. The addition of the alginate gels to a solution of calcium chloride causes an instantaneous cross-linking effect, creating a gelatinous shell that can be formed into many fun shapes.

This experiment will serve as a bridge between what plastics are and how chemistry can be used in the kitchen, as this is often used to create artificial fruit pieces, artificial caviar, and even the little red pimentos in green olives! This demo includes ways to create fun alginate spheres and "worms", as well as additives for changing color, adding glittery effects, and even make them glow under UV light.

What is a Polymer?

A *polymer* consists of repeating small molecular subunits known as monomers. The monomers can become linked via a number of chemical reactions, and when joined together they create a polymer -"poly" in Latin means "many" and "mer" translates to "parts". These "many-part" compounds are the basic building blocks of life, and are also staples of our daily routines when found as plastics.



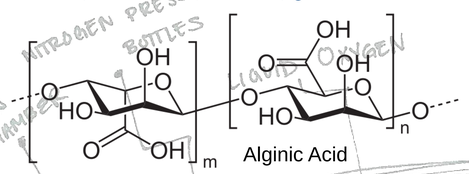


Some examples of polymers range from the mid-sized DNA molecules, with molecular weights ranging from 12,000 to 1 million g/mol, to the incredibly large Ultra-High Molecular Weight Polyethylene (UHMWPE) used in things like body armor. UHMWPE can have molecular weights exceeding 6 million g/mol. Car tires are also a great, recognizable example of polymers.

Theory

What is Sodium Alginate?

Sodium alginate is the sodium salt of alginic acid, a naturally occurring compound that can be extracted from a variety of seaweed and kelp species found in the ocean. It is a simple sugar oligomer, consisting of a variety of linked units of (1-4)-linked β-D-mannuronate (M) and α-L-guluronate (G) residues. When inside the plants, this compound creates a complex polymeric network capable of absorbing over 200 times its own weight in water, which provides a gummy, semi-rigid structure for the plant's cell walls. In a salt form, it is readily soluble in water, and makes a thick, gel-like solution.



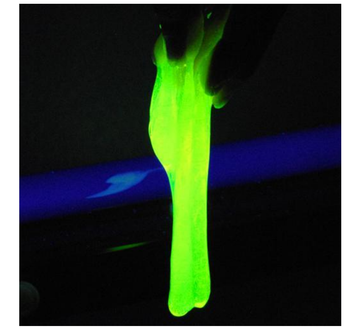
Instant Polymerization!

Sodium alginate is already a polymer. The fun begins when you add it to a solution of divalent ions, such as calcium, which carries a charge of 2+. The sodium ions of the alginate salt allow it to dissociate in water which exposes the negatively charged carboxylate side chains of each sugar molecule. When two of these anions interact with calcium cations, they instantly form two new bonds (instead of the single one with sodium) to create an insoluble complex. This is known as "cross-linking", and thousands of individual alginate monomers form a complex network of oxygen-calcium-oxygen bonds. This reaction is immediately visible as the alginate solution hits the calcium-rich water.

Molecular Gastronomy

Molecular gastronomy is the research of physical and chemical changes during cooking. During "spherification" a chef dissolves some sodium alginate in fruit juice or water-based sauce. The thick gels are then added dropwise to a solution of calcium chloride to make small spheres of caviar-looking fruit juice. The gelled fruit extracts can also be poured into molds and put into a bath of calcium chloride to make gummy shapes that burst with fruit flavor when you bite into them. This is also used to make the fake red pimentos in the green olives you find at the store!

Procedure



Reagents:
- Sodium alginate
- Calcium chloride
- Deionized water
- Highlighter ink
- Food coloring
- Fine craft glitter

Supplies
- Bowl or Beaker
- Ziploc bags
- Paper towels
- Sharpies for labeling
- Empty condiment bottle or plastic pipet
- Tweezers, strainer or slotted spoon
- UV Blacklight

Procedure:

1. Add 2 g sodium alginate to 100 mL distilled water in small portions, stirring vigorously after each addition. A blender might help if you have one!
2. Add several drops of food coloring, highlighter ink, or glitter to the suspension. For best results, prepare the suspension the day before. Combine different additives for fun effects!
3. Add 2 g calcium chloride to a separate 100 mL of distilled water and stir until dissolved.
4. Using a condiment bottle or pipette, add a thin stream of the alginate solution into the calcium chloride solution. This should form worm-like gels. You can add drops to create some fun spheres, or by putting the tip of your pipet into the solution, you can make a huge blob!
5. Remove the worms with tweezers or a strainer/slotted spoon, and shake the excess water off. Play with them and see what happens when you squeeze them open! Worms can be placed in a Ziploc bag to take home.
Note: The bigger your bowl of calcium chloride, and the more alginate you can add in a single stream, and the bigger your worms can be! You can also try adding single drops to make caviar!

Safety:

These chemicals can be irritants to the skin and eyes. Wash skin and eyes with running water. While this is the same procedure for making edible worms and fruit caviar, you should not eat anything that you make in a lab! It is only safe to eat your creations if you make them with clean equipment and chemicals in your kitchen that will only be used for food.

References:

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