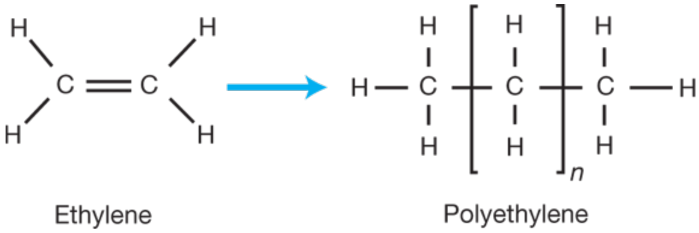
Synthesis of Bioplastics

You may be familiar with common polymers used in plastic containers and water bottles such as high-density polyethylene (HDPE) and low-density polyethylene (LDPE). A polymer is made from building blocks called monomers. For example, consider a molecule of ethylene. In the presence of a catalyst, ethylene monomers will react to form a polymer chain known as polyethylene (Figure 1).



https://www.aiche.org/resources/publications/cep/2015/september/making-plastics-monomer-polymer

Although many plastics are recyclable, it takes hundreds of years for these polymers to degrade. For example, some bottles can take a thousand years to degrade! This long degradation time poses serious consequences for the environment. Thus, recent bioplastics have been synthesized that degrade faster compared to traditional plastics.

Bioplastics use monomers derived from natural products to build a polymer chain. Some commercial water bottles are already use plant derived bioplastics. The Dasani plant bottle uses PET plastic derived from plants. Starch is being considered as one of the molecules to build bioplastics.

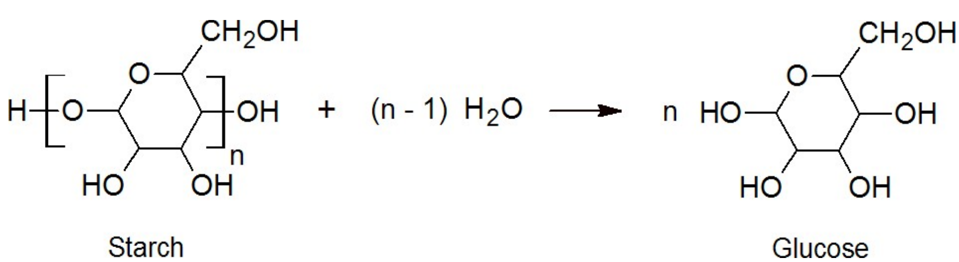


Figure 2: Starch is composed of glucose monomers

Starch is inexpensive, readily available and biodegradable. Starch can break down into glucose, a sugar, monomers thus it is less harmful for the environment (Figure 2). One drawback of using starch is it is brittle, therefore, not an ideal candidate to make a bioplastic. When combined with other molecules known as plasticizers that promote flexibility and reduced brittleness starch makes an excellent polymer. To create the starch/glycerol polymer a dilute solution of acetic acid is used to break down the branching between chains in the starch and glycerol added as a plasticizer. The alcohol groups (-OH) on the glycerol molecule and starch can form a network of hydrogen bonds between alcohol and starch molecules adding flexibility to the polymer (Figure 3).

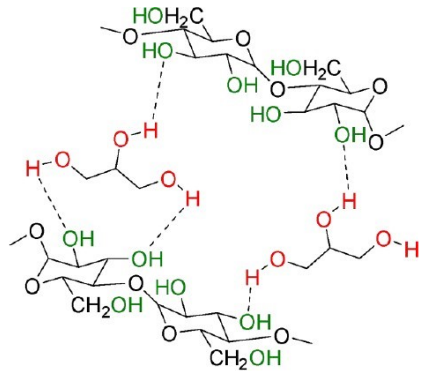


Figure 3 Hydrogen bonds between the amylose molecule in starch (molecule with green -OH groups) with glycerol (molecule with red -OH groups)

In the first week of this lab, you will prepare two different bioplastics one using starch/glycerol and one using chitosan/alginate. The bioplastics will dry for a week until the following lab. To quantitate the amount of dye released into various solutions in week 2 you will prepare a set of standard solutions of yellow food dye and prepare a Beer's law plot. In the second week of lab, you will determine how long it takes each bioplastic to degrade in various solutions by measuring the absorbance of the dye solution over time.

Experimental Procedure

Waste disposal

All excess glycerol, chitosan, alginate and starch solutions are safe to go down the sink. Any solid bioplastic pieces should be disposed of in the trash.

Part A: Synthesis of starch/glycerol bioplastic

Mass 1.0-1.5 grams of glycerol directly into a beaker. Mass 2.0 grams of starch and put into the same beaker. Measure 10.0 mL of distilled water and 1.0 mL of vinegar and add to the same beaker. Heat for ~15 minutes on low heat stirring frequently until the mixture thickens. Remove from heat and add 2 drops of yellow food color. Label an aluminum dish starch/glycerol bioplastic with your group initials. Carefully pour into an aluminum dish and heat on hot plate until translucent. Store in your lab drawer to dry the bioplastic until next week.

Part B: Synthesis of chitosan/alginate bioplastic

Mass 0.3750 grams of chitin and 0.3750 grams of sodium alginate. Mix the powders in the same weigh boat. Add 25.0 mL of distilled water to a 100 mL beaker and add five drops of yellow food dye. While, stirring add the powder slowly making sure to stir well after each addition of the powder mixture. Once all the powder is dissolved stir for an additional ten minutes. Add 25.0 mL of 1% (v/v) of lactic acid to the solution and stir for ~3 minutes until the mixture thickens again. Carefully pour into a dish and slowly add 0.100 M calcium chloride solution to the top of the dish. Let stand at room temperature for one hour. After one hour carefully pour off the calcium chloride solution and keep the dish in your lab drawer to dry the bioplastic until next week.

Part C: Beer's Law plot for yellow food dye

Prepare four standard solutions from the yellow food dye stock solution (8.00×10^{-5}M) . Blank the spectrophotometer with a cuvette filled with water and measure the absorbance for reach standard solution. Record the absorbance in your notebook. Prepare a Beer's law plot of absorbance versus concentration, display the equation and the R^2 on the graph. Save the graph for your report in week 2 and record the molar absorptivity value for the yellow food dye in your notebook to use in week 2.

No lab report for this week but make sure to save your Beer's law plot and record the molar absorptivity value for yellow food dye in your lab notebook.