Bioplastics Week 2: Characterization and Degradation of Bioplastic

Water bottles are typically composed of plastics synthesized from molecules derived from fossil fuels and when not recycled they end up in landfills and can take hundreds of years to degrade. There are several fates of plastic water bottles none are good for our environment. When these water bottles find their way into the ocean, marine animals can be killed by accidently ingesting plastic pieces. In addition, you may have heard about chemicals such as bisphenyl- a(BPA) in plastics that could possibly effect brain function. Americans consume about 50 million water bottles per year despite the environmental and potential health consequences of plastic water bottles. To assume that all consumers will use a reusable water bottle is not realistic. Therefore, a bioplastic is a good alternative that degrades in a short amount of time.

Last week you synthesized two bioplastics using common chemicals that are also inexpensive. In this week's lab, you will determine the degradation rate of the bioplastics by measuring the absorbance of yellow food dye over time. You may recall that we added yellow food dye to our bioplastics. Thus, when the bioplastic degrades yellow food dye is released into the surrounding solution and we can monitor the increase in absorbance over time.

In order to determine the average rate of degradation we need to determine the concentration of yellow food dye released into solution over time. Last week you prepared a Beer's law plot for the yellow food dye. Absorbance is directly related to concentration by Beer's Law see Equation 1, where ⍰ is the molar absorptivity in units of $M^{-1}cm^{-1}$; c is the concentration in units of M and path length in units of cm. In most spectrophotometers, a cuvette with a path length of 1 cm is used. The concentration of an unknown sample can be determined using Beer's law.

$A = \varepsilon cl$ (1), where y is absorbance and x is concentration in molar

A Beer's law plot was made last week and can be used to determine the extinction coefficient using the equation of the best fit line. The slope of the line is equal to the extinction coefficient when the path length used is 1 cm. The concentration of an unknown sample can be determined using Beer's law. You can analyze your Beer's law plot from last week to determine the molar absorptivity constant. Knowing this value we can convert the absorbance of yellow food dye to concentration.

Experimental Procedure

Waste Recovery: 1.0 M sodium hydroxide should be collected in the container labeled "1.0 M sodium hydroxide waste" under the waste recovery hood

Degradation Experiments

It is best to do the two bioplastic samples in parallel, one person does the chitosan/alginate bioplastic and one does the starch/glycerol bioplastic

Cut a small piece of the bioplastic (~0.1000 gram) and record the exact mass of the polymer. Determine the absorbance of sodium hydroxide solution plus bioplastic for time zero minutes. Record the absorbance. Place the bioplastic piece in a cuvette and fill the cuvette ~3/4 full with 1.0 M sodium hydroxide. Stir the sample every five minutes for one hour, at the end of one hour take the absorbance of the solution. Record in notebook. *If the absorbance reaches >1.200 before one hour note the time

Cut a second 0.1000 gram sample of bioplastic. Place the bioplastic in a cuvette and fill the cuvette ¾ full with distilled water. Record the absorbance at time zero minutes. Stir the every five minutes for one hour, at the end of the one hour take the absorbance of the solution. Record in notebook. *If the absorbance reaches >1.200 before one hour note the time

Writing your report

Graphs (10 pts)

- Include an image of your Beer's Law Plot from Part 1
- Plot concentration vs. time for each degradation experiment

Calculations (5 pts)

Show how you calculated the molar absorptivity for yellow food dye from your Beer's Law Plot

Calculate the concentration for each of your measured absorbance values for degradation experiments.
Calculate the average rage ([Δdye]/Δtime) over the first thirty minutes of degradation

Results (4 pts)

Report the average degradation rate for each bioplastic sample (make sure to include units!) in water
Report the average degradation rate for each bioplastic sample (make sure to include units!) in sodium hydroxide

Questions (4 pts)

1. Would you expect the rate of degradation for polypropylene to be longer or faster than your bioplastics?
2. What is the relationship between degradation of the bioplastic and absorbance of yellow food dye?

Discussion (8 pts)

- Which bioplastic degraded the faster in 1.0 M NaOH? Reference your results
- How does the degradation rate in 1.0 M NaOH compare to that of the rate in distilled water for each bioplastic?
- Comment on the flexibility of your bioplastics
- Given your results, which bioplastic would be the best choice to replace polymers used in water bottles? Explain