

Lab 5 – Absorption

I. Introduction

When a beam of light of an appropriate wavelength is passed through a sample, some or all of that light may be absorbed. In this lab, the light source that will be used will be a helium-neon laser. This laser emits light at a wavelength of 632nm. The sample to be studied is a colored organic food dye. As a result of performing the following experiments, the student will become familiar with the concepts of absorption and how it varies with concentration of the sample.

II. Objective

The purpose of this experiment is

- (1) To introduce a method of quantitatively measuring absorbance of a specific solution.
- (2) To determine from Beer's law, the characteristic absorption coefficient of the organic dye.

III. Procedure

The apparatus must be completely set up according to the attached schematic diagram

PART A:

- (1) Determine that the photodiode used in the experiment is not saturated and is operating in a linear fashion (as per Lab 1). Use neutral density filters to lower the incident intensity. Think about where these filters should be optimally placed to eliminate any unwanted background light.
- (2) Measure the *inner* dimension of the box. Measure the thickness of the plastic wall.
- (3) Place 250ml of *room temperature* water in the plastic box. If cold water is used, water vapor may condensate on the plastic box thereby adding an additional loss of transmitted light.
- (4) Position the box on the electric mixer. Ideally, orient the box such that the incident light is perpendicular to the face of the box. Place a magnetic stir bar in the water and turn on the mixer. Choose a relatively slow mixing speed such that no vortex is generated in the water. Make sure that the height of the laser beam through the plastic box is adjusted such that the laser beam is not effected by either the spinning stir bar or by being too close to the water surface.
- (5) Position a photodetector on an x-z mount and center the photodetector on the transmitted beam.
- (6) Set up the lock-in amplifier and chopper to detect the amount of transmitted light. Optimize the position of the detector. Once you have completed this step **DO NOT TOUCH THE BOX** or you will have to realign **EVERYTHING** from the beginning.

PART B:

- (1) Record the signal observed with only the initial level of water in the box.
- (2) Add 1 drop of dye. If the transmission does not drop to less than 10% of its initial value, add another drop of dye. You will get better results if this initial solution absorbs over 90% of the initial light. Record the signal level with this concentration of dye.
- (3) Without moving your plastic box, dilute your dye solution by adding an additional 100ml of room temperature water. Allow sufficient time for the dye to thoroughly mix in. Using the lock-in, record the new transmitted light level.
- (4) Repeat step (3) four times. Each time you add water, the concentration of the dye is decreased.

III. Data Analysis

The Beer-Lambert Law can be written as

$$I=I_0 e^{-abc}$$

$$\ln(I_0/I)=abc$$

or

$$\ln(V_0/V)=abc$$

$$A=abc$$

Where A=Absorbance, V_0 = Lockin Voltage from unattenuated light, V=lockin voltage from light attenuated by different concentrations of dye in water, a=absorption coefficient of the laser dye, b=path length of the sample, c=concentration of sample solution.

- (1) Using the aquired data, plot the absorbance ($\ln(V_0/V)$) as a function of concentration.
- (2) Fit the data to a linear curve to determine the absorption coefficient of the organic dye. You may use the fundamental unit of dye concentration as "1 drop".

IV. Discussion

- (1) Do your results follow the Beer-Lambert law? Why or Why not?
- (2) What is the absorption coefficient of the organic dye?
- (3) Why is it important not to move the plastic box once you start your measurements?
- (4) In determining the absorption coefficient, do you need to know the reflection coefficient for light from the air/plastic interface? How about the plastic/water interface?
- (5) Why can we neglect the fact that the laser light passes through the plastic wall of the box? (Do we need to include the absorption of the plastic box?)
- (6) What is the absorbance of a single drop of dye? (You may need to estimate the physical size of a single drop.)

