CRYSTAL VIOLET COLORIMETRY: A BEER'S LAW INVESTIGATION (#2.2)

The CCLI Initiative
Computers in Chemistry Laboratory Instruction

Learning Objectives

The objectives of this exercise are to ...

- illustrate the basic principles of colorimetry.
- demonstrate the components of a colorimeter and how a colorimeter is interfaced to a computer.
- discover the Beer's Law relationship and apply it to the analysis of an unknown solution.

Background

Colorimetry is an instrumental method based on the measurement of light absorption by colored solutions and is widely used for performing chemical analyses. The MicroLAB colorimeter utilizes 10 Light Emitting Diodes (LEDs) ranging from 400 to 644 nanometers, spaced about 35 nanometers apart. They are scanned sequentially and the transmittance or absorbance data is presented as 10 colored bars in a bar graph as shown in Figure 1.

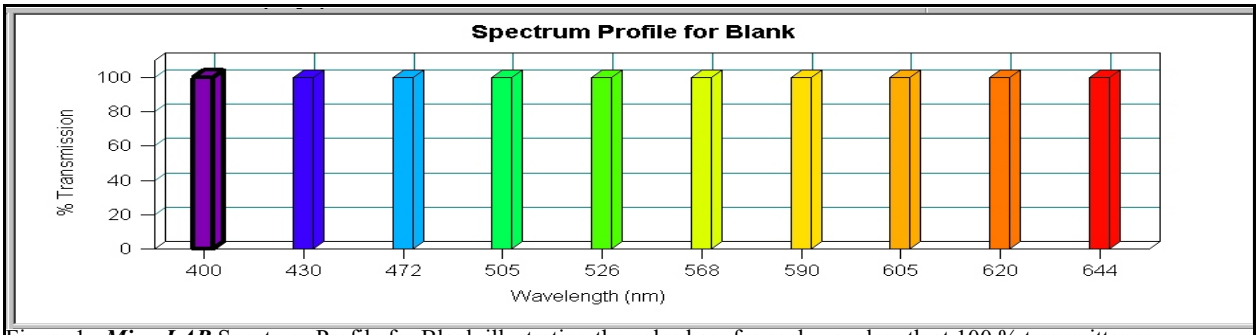

Figure 1. ***MicroLAB*** Spectrum Profile for Blank illustrating the color bars for each wavelength at 100 % transmittance.

Crystal violet (also called methyl violet) is an organic dye. In crystal violet solutions where the pH is greater than 1, the solution is yellow. If pH is less than 1, the solution color is purple. This experiment will involve purple solutions of the dye.

Experiments Performed

Standards Preparation: Students prepare five crystal violet solutions of known concentrations varying from 2.00 x 10^{-6} *M* to 10.0 x 10^{-6} *M*. The Transmittance for each of these *standard* solutions, for a water blank, and for a crystal violet solution of unknown concentration will be measured. The **Transmittance**

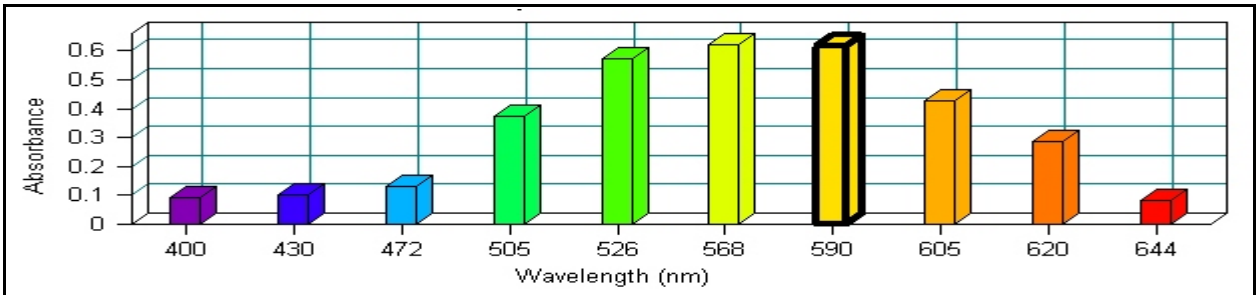

Fig. 2. Absorbance Spectrum Profile for crystal violet. Note that the maximum absorbance occurs at 590 nm.

should decrease with increasing solution concentration while the **Absorbance** should increase with increasing solution concentration. The Spectrum Profile for the absorbance of a CV solution is shown in Figure 2. Note that the maximum absorbance is at the 590 nm wavelength.

Determine the equation for Absorbance: One of the student objectives is to find a mathematical function of **Transmittance** that is directly proportional to sample concentration. Such a function forms the basis for what is known as **Beer's Law**. A graph of this function vs. concentration, which is linear and intersects the origin, is called a Beer's Law plot. To explore this **concentration/Transmittance** relationship, students will first **Hand Enter** some "ideal" simulated data into the spreadsheet program. They will compute and graph several functions (the square, reciprocal, and logarithm and finally the negative logarithm versus concentration) until a function is discovered that has a positive and direct proportionality to concentration.

Construct a Beer's Law Plot and Determining the Concentration of an Unknown: This discovered function is then used for creating a Beer's Law plot from their measured data. Finally, the concentration of an unknown crystal violet solution is obtained directly from this plot.

Data Analysis

Guidelines are given for using the ***MicroLAB*** **Hand Enter** mode to set up the functions as described above and to make a Beer's Law graph and determine the concentration of an unknown.

Instructor Resources Provided

- Sample Report Sheets providing the format to organize the data collection with sample data.
- Questions to consider, answer and turn-in with suggested answers.
- Tips and Traps section to assist the instructor with potential problems and solutions.
- Sample ***MicroLAB*** screen shots and graphs.
- Laboratory preparation per student station.

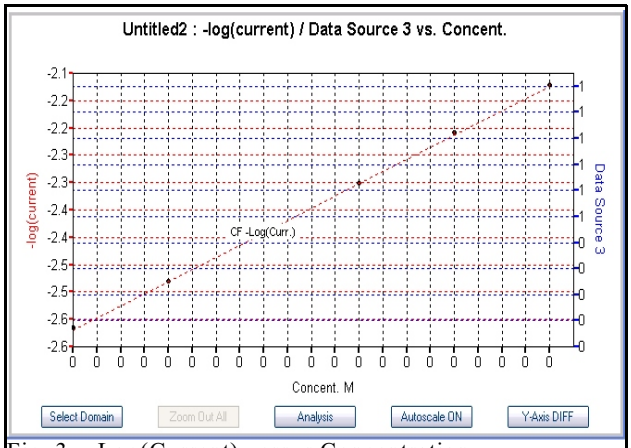

Fig. 3. -Log(Current) versus Concentration.

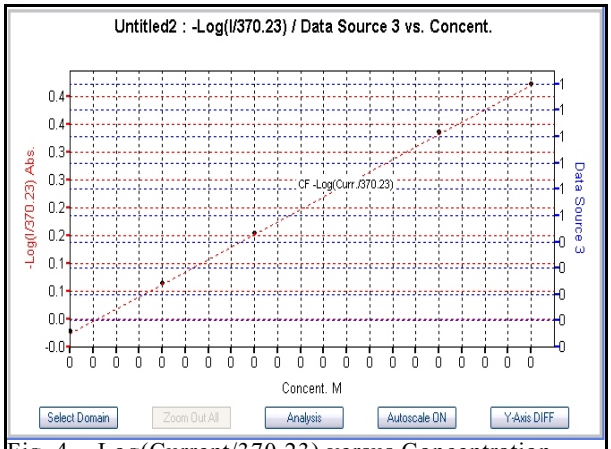

Fig. 4. -Log(Current/370.23) versus Concentration

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