

# Visible Spectra of Commercial Dyes

Light is composed of photons with quantized wavelengths and energies. The longer the wavelength, the lower the energy. Types of light are categorized as: gamma, x-ray, ultraviolet (UV), visible (vis), infrared (IR), microwave, and radio waves, depending on the wavelength of the photon. The light that our eyes can detect, conveniently referred to as the visible region, is a very small section of the light spectrum.

Spectrophotometry is the study of the transmission or absorbance of light through a substance. Transmittance is a measure of the amount of light passing through a substance; absorbance is the amount of light that was captured by a substance. A clear colorless piece of glass has close to 100% transmittance and 0 absorbance of visible light. In colored liquids, for example, the color we see is a result of the different wavelengths absorbed and total amount of light absorbed.

In this experiment, you will use a Vernier Spectrometer (V-SPEC) to identify the dyes found in commercial products. Different dyes absorb at different wavelengths. You will measure the absorbance of food dyes, mixed with water, over the 380 – 950 nm range and compare the spectra of the dyes to the spectra of various commercial products.

## OBJECTIVES

In this experiment, you will

- Measure and analyze the visible light absorbance spectra of various samples of aqueous food dye mixtures to determine the absorbance spectrum for each sample.
- Compare and contrast the spectra of various food dye mixtures.
- Test a sample of a commercial liquid product to identify the food dye(s) in the product.

## MATERIALS

Vernier Spectrometer	food dyes
computer	commercial drink or mouthwash
one cuvette	distilled water
250 mL beakers for food dye samples	stirring rod
100 mL graduated cylinder	tissues (preferably lint-free)
plastic Beral pipets	

## PROCEDURE

1. Obtain and wear goggles.
2. Use a USB cable to connect a Vernier Spectrometer to your computer.
3. Start the Logger *Pro* 3.4.6 program on your computer.
4. Record the type of food dyes that you will be testing (such as Red #40, Blue #1, Yellow #5). Prepare each sample by dissolving 1 drop of a food dye in 100 mL of distilled water.
5. To set up the spectrometer, open the Experiment menu and select Connect Interface → Spectrometer → Scan for Spectrometers.
6. Calibrate the spectrometer.
  - a. Prepare a *blank* by filling an empty cuvette  $\frac{3}{4}$  full with distilled water.
  - b. Open the Experiment menu and select Calibrate → (Spectrometer). The following message appears in the Calibrate dialog box: “Waiting ... seconds for the device to warm up.” After 60 seconds, the message changes to: “Warmup complete.”
  - c. Place the blank in the cuvette holder of the spectrometer. Align the cuvette so that the clear sides are facing the light source of the spectrometer. Click “Finish Calibration”, and then click .
7. Conduct a full spectrum analysis of a food dye sample.
  - a. Empty the blank cuvette and rinse it twice with small amounts of a food dye mixture. Fill the cuvette  $\frac{3}{4}$  full with the food dye mixture and place it in the spectrometer. Align the cuvette so that the clear sides are facing the light source of the spectrometer.
  - b. Click . A full spectrum graph of the food dye sample will be displayed.
  - c. Examine the graph, noting the peak or peaks of very high absorbance or other distinguishing features.
8. To save your graph, select Store Latest Run from the Experiment menu. (Optional) Print a copy of the graph.
9. Repeat Steps 7 and 8 with the remaining food dye samples. Remember to keep a copy of each graph.
10. Obtain a sample of a commercial product containing a dye, such as a mouthwash or a beverage. Repeat Steps 7 and 8 with the commercial product.
11. Select Exit from the File menu to close down Logger *Pro* 3.4.6.

**DATA TABLE**

Trial	Food Dye (or product)	Peaks or unique features of the spectrum
1		
2		
3		
4		

**DATA ANALYSIS**

1. Describe, in detail, the spectrum of each food dye sample. Emphasize the features of each spectrum that distinguishes it from the other food dyes.
  
2. Identify the wavelengths and absorbance values of every peak in the graph of each food dye.
  
3. Identify the food dye or dyes present in the commercial product that you tested. Support your identification with specific information from your testing.

## Teacher Information

1. Grocery store food dyes work well for this experiment. It is wise to avoid the gel-type dyes because they are difficult to dispense a drop at a time and they take longer to mix.
2. In Step 4 of the procedure, the students are instructed to add one drop of food coloring to 100 mL of water. This ratio of food coloring to water works well for most commercial dyes, but you may have to modify it slightly for the dye that you purchase.
3. There are seven dyes that are FDA approved for foods. The table below describes each dye.

Label Name	chemical name	chemical formula
Red 3	erythrosine (tetraiodofluorescein)	$C_{20}H_8I_4O_5$
Red 40	2-naphthalenesulfonic acid (or its sodium salt)	$C_{10}H_8O_3S$
Yellow 5	tartrazine (it is a synthetic yellow azo dye)	$C_{16}H_9N_4Na_3O_9S_2$
Yellow 6	1-p-sulfophenylazo-2-naphthol-6-sulfonic acid, Na salt	$C_{16}H_{10}Na_2O_7S_2$
Blue 1 (Brilliant Blue)	(triarylmethane, sodium salt)	$C_{37}H_{34}N_2Na_2O_9S_3$
Blue 2	indigotine or indigo carmine	$C_{16}H_{10}N_2O_8S_2 \cdot 2Na$
Green 3 (Fast Green)	(acid arylmethane)	$C_{37}H_{34}N_2Na_2O_{10}S_3$

3. Depending on the sports drink or mouthwash that your students test, they may have to dilute their samples to achieve satisfactory absorbance graphs.
4. The cuvette should be  $\sim \frac{3}{4}$  full to get good absorbance measurements and allow enough room to seal the cuvette with a plastic cap.
5. It is good lab technique for each lab team to use a single cuvette to test the liquids in the spectrometer. Because this lab is more qualitative than quantitative, students can prepare their samples in different cuvettes and still achieve good results.
7. We included a few questions in the Data Analysis section of the student version as a generic starting point. Please feel free to edit or replace these questions as best fits the needs of your experiment.
8. As a good way to become familiar with this experiment, you should plan to keep a set of sample data as well as develop an answer key. It is our experience that data can vary, based on many factors, and the sample data that we have collected in testing this experiment may not be representative of your students' results.