

Colorimetric Determination of Food Dyes in Beverage Mixes

Purpose:

To colorimetrically determine the mass of food dye present in commercial beverage mixes using a prepared calibration curve.

Introduction:

The FDA (food and Drug Administration) is responsible for approving the dyes that can be used in food products for consumption by humans. Currently, there are seven approved dyes for use in food products. These are red 3, red 40, blue 1, blue 2, yellow 5, yellow 6, and green 3, shown in Figure 1. Due to allergic reactions that may occur in humans, certain food dyes (yellow 5, yellow 6, blue 1, red 3, and red 40) must be clearly indicated on all food labels. All seven of these food dyes are rather large compounds that contain a conjugated ring system with alternating single and double carbon to carbon bonds. These types of compounds result in colored molecules and produce a colored solution.

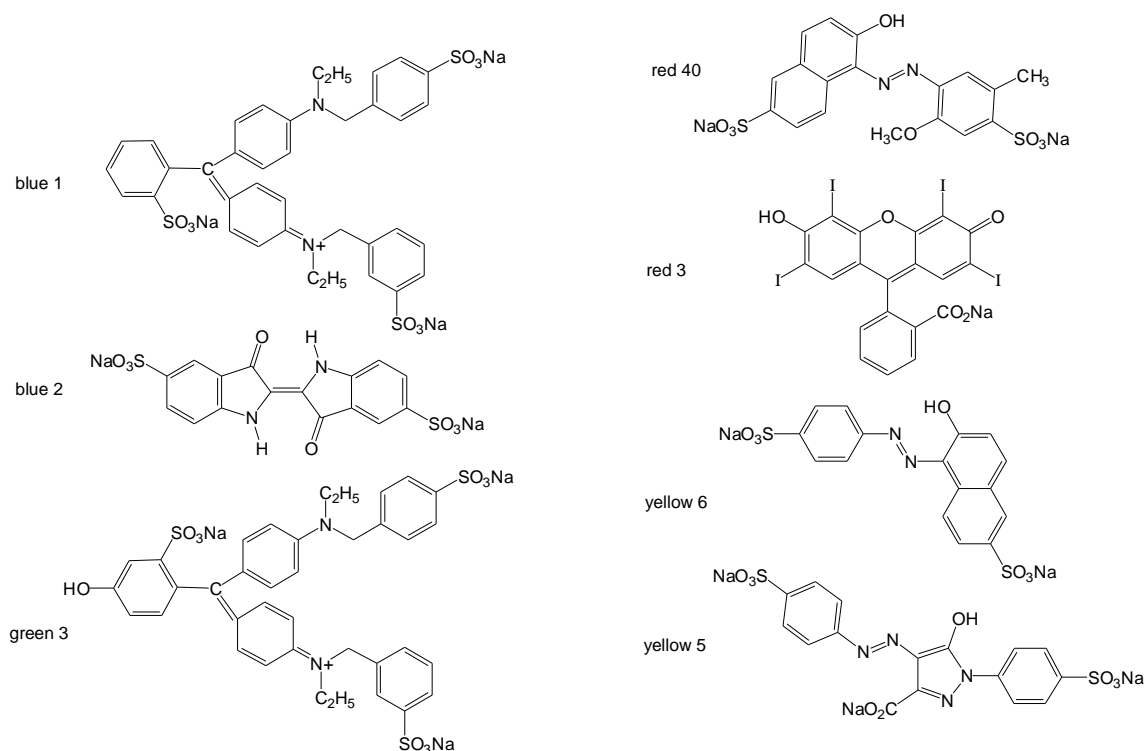


Figure 1: Seven FD&C Food Dyes

Colorimetry is the measurement of the amount of color of a substance. When white light passes through a solution containing the food dye, specific wavelengths will be absorbed which correspond to the energy of the electronic transitions. The electrons being excited are in the alternating double and single bonds.

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Absorbance measurements are performed by comparing the amount of light that enters a chemical sample (I_0) to the amount of light that exits the sample (I). This ratio is better known as the transmittance:

$$T = \frac{I}{I_0} \quad (1)$$

When a chemical sample absorbs radiation, I_0 is greater than I , making T a fraction. A more commonly used value is the absorbance:

$$A = -\log T \quad (2)$$

since this value can be directly related to the concentration of an absorbing species. This relationship is known as Beer's Law:

$$A = bc\varepsilon \quad (3)$$

where b is the path length of the radiation through the sample (typically 1 cm), c is the concentration (in molarity) and ε is the molar absorptivity, a proportionality constant that depends upon both the species and wavelength of light.

Based on Beer's law, a calibration curve can be prepared using standard solutions (those containing a known concentration of substance). A graph of the absorbance of these solutions vs. concentration should yield a straight line that passes through the origin. One requirement for performing quantitative analyses using calibration curves is that the absorbance of the unknown solution must fall within the absorbance values measured for the standard solution. This is further insurance that Beer's Law is truly being followed.

Above, Beer's Law is defined for the case where concentration is expressed in molarity. In practice, the linear relationship is valid for any concentration unit (e.g. ppm), however the proportionality constant can no longer be called the "molar" absorptivity (since concentration is no longer molar). In the present experiment, concentrations will be expressed in mg/L.

In this experiment the amount of food dye in commercial beverage mixes will be determined by colorimetry. A series of solutions of known concentration will be analyzed and a calibration curve will be prepared. Using the prepared curve and knowledge of dilutions, the mass of food dye in the original package will be determined.

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Procedure:

Preparing the standard solutions

1. Make sure the spectrophotometer is turned on and set the wavelength selector to 503 nm.
2. Obtain approximately 50 mL of stock dye solution; make sure to record its concentration on the data sheet. Fill a buret with this stock solution.
3. Use the volumes of stock solution determined in your pre-lab to prepare 50.0 mL of each standard solution. Round the calculated volumes to the nearest 0.1 mL.
4. Obtain four 50-mL volumetric flasks. Label them **SS1**, **SS2**, **SS3**, **SS4**. Prepare the 0.600×10^{-5} M solution in the flask labeled "SS1" by using the buret to add the volume of stock solution calculated in Step 3 and then diluting to the flask mark with deionized water. Make sure to record exact initial and final volumes from the buret. Repeat this process for the remaining standard solutions using the flasks labeled "SS2", "SS3", and "SS4".
5. Obtain an additional 50-mL volumetric flask and label it **Mix**. Use a volumetric pipette to deliver 10 mL of the prepared beverage mix solution to this flask, then dilute to the mark with deionized water. This is the unknown solution.
6. Obtain 6 clean, dry cuvettes for the spectrophotometer from your instructor. Use a transfer pipette to fill each cuvette with a different solution (**Blank**, **SS1**, **SS2**, **SS3**, **SS4**, **Mix**). The **Blank** solution should be deionized water.
7. Measure the absorbance of each solution by placing the cuvettes in the spectrophotometer with the frosted sides facing you. First, zero the spectrophotometer using the **Blank** solution according to the instrument directions provided. Next, measure the absorbance of each of the standard solutions in order. Finally, measure the **Mix** solution. Record all absorbance values in the appropriate spaces on your data sheet.

Calculations:

1. Calculate the exact concentrations of food dye in each of the prepared standard solutions (**Blank**, **SS1**, **SS2**, **SS3**, **SS4**) using the delivered volumes of stock solution and the dilution equation ($M_1V_1 = M_2V_2$). Enter these values into the appropriate row of the Calibration Curve data table.
2. Prepare a calibration curve by graphing measured absorbance vs. concentration of food dye using the information you entered in Calibration Curve data table.
3. Use the Calibration curve to estimate the concentration of food dye in **Mix** solution.
4. Use the dilution equation and the determined **Mix** solution concentration to calculate the molar concentration of the beverage mix solution provided.
5. Use the listed concentration from the beverage mix solution bottle and the molar mass of the dye analyzed to determine the mass of food dye in the original mix.

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Calculations:

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Data Sheets

Name: _____

Lab Partner: _____

Show work for all calculations on page 4. **Make sure to include units on all values recorded if not provided.**

Beverage mix Flavor: _____

Concentration of Stock food dye solution (mol/L)	
Beverage mix concentration (from bottle, include units)	

Calibration Curve Data:

Flask	Blank	SS1	SS2	SS3	SS4
Volume of stock Food dye solution (mL)					
Concentration of food dye in flask (mol/L)					
Measured absorbance					

Beverage Mix Data:

Absorbance of "Mix" solution	
Concentration of dye in "Mix" solution (mol/L)	
Concentration of dye in stock beverage mix solution (mol/L)	
Mass food dye in beverage mix (mg)	

