Catch the Wave(length): Spectroscopy Visualized

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HANDS-ON ACTIVITIES

Discover the Wavelength

- Go Direct SpectroVis Plus
- Go Direct Colorimeter

Pivot Interactives

- Beer-Lambert Law: Absorbance *vs*. Concentration

Discover the Wavelength

During experiments that use spectrophotometry to analyze data, it is common to choose a particular wavelength to use throughout the study. How does one decide which wavelength is the best to use?

In this activity, you will experiment with all the wavelengths on your colorimeter to decide which wavelength is the best one to use for experiments involving spectrophotometry. Your teacher will display a full, visible, absorbance spectrum for comparison.

OBJECTIVES

- Compare the function of a spectrophotometer to a colorimeter
- Decide which wavelength is the best to use for an experiment
- Relate wavelengths to the colors of the visible spectrum

MATERIALS

one cuvette
distilled water
colored solution
beral pipette
waste container
lint free tissues (Kimwipes)
cuvette rack

PROCEDURE

1. Obtain and wear goggles.

2. Prepare a blank by filling an empty cuvette ¾ full with distilled water.

3. To correctly use a cuvette, remember:

    - All cuvettes should be wiped clean and dry on the outside with a tissue.
    - Handle cuvettes only by the top edge of the ribbed sides.
    - All solutions should be free of bubbles.
    - Always position the cuvette so the light passes through the clear sides.

4. Calibrate the colorimeter.
   - Place the blank in the cuvette slot of the colorimeter and close the lid.
   - Press the < or > buttons on the colorimeter to set the wavelength to 430 nm.
   - Calibrate by pressing the CAL button on the colorimeter. When the LED stops flashing, the calibration is complete.
5. Empty the cuvette and rinse it with the colored solution then fill it ¾ full of solution.
6. Record the color of your solution in the data section.
7. Place the cuvette of colored solution into the colorimeter.
8. Record your absorbance reading from the meter in the data table.
9. Repeat steps 6–10 with the other three wavelengths on your colorimeter.
10. Record the wavelength of maximum absorbance from the teacher's spectrophotometer.

DATA

Color of your solution: _____ (use: red, orange, yellow, green, blue, indigo, or violet)

Wavelength (nm)	Absorbance
430	
470	
565	
635	

Wavelength (nm)	Color of the LED to the eye
430	
470	
565	
635	

Wavelength of maximum absorbance from teacher's spectrophotometer (nm)	

PROCESSING THE DATA

1. Why is it desirable to use one cuvette instead of two; one for the blank and another for the sample?

2. Complete the "Color of the LED to the eye" column in the data table. You may need to look up the colors on a spectrum chart.

3. Which wavelength on the colorimeter resulted in the highest level of light absorbance for your solution?

4. Looking at the visible light spectrum from the spectrophotometer, what wavelength resulted in the maximum absorbance for your solution?

5. How does the color of your solution compare to the color of the LED creating the light most absorbed by the solution?

6. How does the color of your solution compare to the color that is least absorbed? This is called transmittance.

7. Common experiments in spectroscopy use absorbance to represent concentration of solutions since these two measurements are directly related. For your solution, which wavelength on your colorimeter would be desirable for an experiment in spectroscopy?

8. Looking at the complete absorption spectrum your teacher is showing for the same solution using a spectrophotometer, how does the wavelength of maximum absorbance, λ_{max}, compare to the wavelength you determined in your experiment using your colorimeter?

Discover the Wavelength

Using a class set of colorimeters and one spectrophotometer, you can help your students experience the challenge of deciding which wavelength to use for experiments involving Beer's law and kinetics.

When doing an experiment that involves using absorbance to determine the concentration of a colored solution (Beer's law) or one in which the rate of a reaction is determined by following the change in concentration of a colored solution, an optimal wavelength is required. Once chosen, this wavelength is used for the rest of the experiment. With a spectrophotometer it is easy to examine a complete spectrum and make the best choice by looking for the wavelength corresponding to the highest value of absorbance. When doing similar experiments with colorimeters, it is common to provide the students with the optimal wavelength for their device with little or no discussion why this wavelength is better than the others available on the colorimeter.

In this activity, you use a single spectrophotometer with a whole class of students as they experiment with colorimeters, and you demonstrate with the spectrophotometer.

The students experiment with the four wavelengths on their colorimeters to determine which wavelength would be the best for an experiment in spectroscopy. First have your students perform the activity on the student handout to find the wavelength of maximum absorbance, λ_{max}. Then use your Go Direct SpectroVis Plus spectrophotometer to verify their observations and also discuss when and why other wavelengths might be valid to use.

OBJECTIVES

- Compare the function of a spectrophotometer to colorimeter
- Decide which wavelength is the best to use for an experiment
- Relate wavelengths to the colors of the visible spectrum

MATERIALS FOR INSTRUCTOR DEMONSTRATION

Chromebook, computer or mobile device
Vernier Spectral Analysis app
Go Direct SpectroVis Plus
cuvette
distilled water
colored solution(s)
beral pipette
waste container
lint free tissues (Kimwipes)

PROCEDURE

1. Obtain and wear goggles.

2. Make sure your display is seen by your students so they can follow what you are doing.

3. Prepare a blank by filling an empty cuvette ¾ full with distilled water. To correctly use a cuvette, remember:

   - All cuvettes should be wiped clean and dry on the outside with a tissue.
   - Handle cuvettes only by the top edge of the ribbed sides.
   - All solutions should be free of bubbles.
   - Always position the cuvette so the light passes through the clear sides.

4. Launch Spectral Analysis. Connect the Go Direct SpectroVis Plus to your Chromebook, computer, or mobile device. Click or tap Absorbance *vs.* Wavelength.

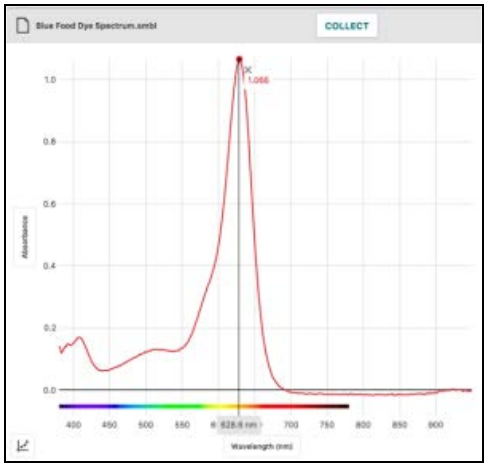
5. To calibrate the spectrometer, place the blank cuvette in the spectrometer and select Finish Calibration. **Note**: If necessary, wait for the spectrometer to warm up before selecting Finish Calibration.

6. Replace the blank with a sample of colored solution. Rinse the cuvette with a little solution and discard. Then fill the cuvette to about ¾ full with solution.

7. Click or tap Collect to start data collection.

8. After the spectrum appears, click or tap Stop.

9. Click or tap on the graph to highlight the wavelength of maximum absorbance.



Wavelength of maximum absorbance selected for a blue food dye solution

10. Have the students compare this wavelength to the one they found for the same solution using the colorimeter.

SAMPLE DATA

Color of your solution: ___Blue___ (use: red, orange, yellow, green, blue, indigo, or violet)

Wavelength (nm)	Absorbance
430	0.09
470	0.07
565	0.22
635	0.71

Wavelength (nm)	Color to the eye
430	violet
470	blue
565	yellow
635	red

Wavelength of maximum absorbance from teacher's spectrophotometer (nm)	629.7 nm

PROCESSING THE DATA

1. Why is it desirable to use one cuvette instead of two; one for the blank and another for the sample?

   Lower chance of optical differences in cuvettes interfering in results

2. Complete the "Color of the LED to the eye" column in the data table. You may need to look up the colors on a spectrum chart.

   see table

3. Which wavelength on the colorimeter resulted in the highest level of light absorbance for your solution?

   635 nm

4. Looking at the visible light spectrum from the spectrophotometer, what wavelength resulted in the maximum absorbance for your solution?

   Maximum absorbance is at 629.7 nm

5. How does the color of your solution compare to the color of the LED creating the light most absorbed by the solution?

   Solution blue, most absorbed red LED, very different colors

6. How does the color of your solution compare the to the color that is least absorbed? This is called transmittance.

   Solution blue, least absorbed blue - same color

7. Common experiments in spectroscopy use absorbance to represent concentration of the solution since these two measurements are directly related. For your solution if you were using a colorimeter, what wavelength would be desirable for an experiment in spectroscopy?

   Best wavelength for blue food dye would be 635 nm

8. Looking at the complete absorption spectrum your teacher is showing for the same solution using a spectrophotometer, how does the wavelength of maximum absorbance compare to the wavelength you determined in your experiment?

   The wavelength of maximum absorbance should be close to one of the wavelengths on the colorimeter. This will vary for different color solutions. For blue food dye the best wavelength on the spectrometer is 629.7 nm and the corresponding one on the colorimeter is 635 nm.

NEXT GENERATION SCIENCE STANDARDS (NGSS)

Disciplinary Core Ideas	Crosscutting Concepts	Science and Engineering Practices
PS4.B: Electromagnetic Radiation PS4.C: Information Technologies and Instrumentation	Influence of Engineering, Technology, and Science on Society and the Natural World Interdependence of Science, Engineering and Technology	Using Mathematics and Computational Thinking Obtaining, Evaluating, and Communicating Information

SOLUTION PREP/TIPS

1. This activity can be done with any Vernier Colorimeter and Vernier LabQuest or Go!Link Interface.

2. The following Vernier spectrophotometers can be used: SpectroVis, SpectroVis Plus, Go Direct SpectroVis Plus, UV-VIS Spectrophotometer, and Fluorescence/UV-VIS Spectrophotometer.

3. Dilute food dye solutions should have a maximum absorbance of just under 1 relative absorbance units.

4. Any color dye can be used for this activity. We used blue food dye for the sample data.