Chemistry 140

The idea of being able to tell the properties of a piece of matter (chemical composition and temperature, to name but two properties) using its interaction with light is called **spectroscopy**.

Please have Parts 1 through 4 ready **before** class on Wednesday, November 15. Note that you may not be able to complete Part 2 until you know what technique you are going to use. For this particular writeup, attach the **abstract** (which should be three sentences long) to the copy of lab book pages; due in class **Monday, November 27.**

Your name, your partner's name, date of experiment

Lab 7: The visible spectrum of dye molecules

The emission and absorption of visible wavelengths of light cause color, as you saw in Exercise 7. In this lab, you will extend that idea and connect it to molecular structure.

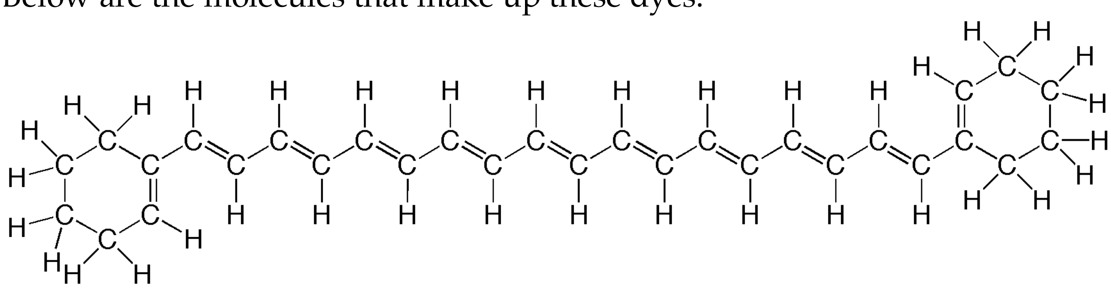
Part 1. Purpose

To determine a qualitative relationship between the structure of a dye molecule and its spectrum.

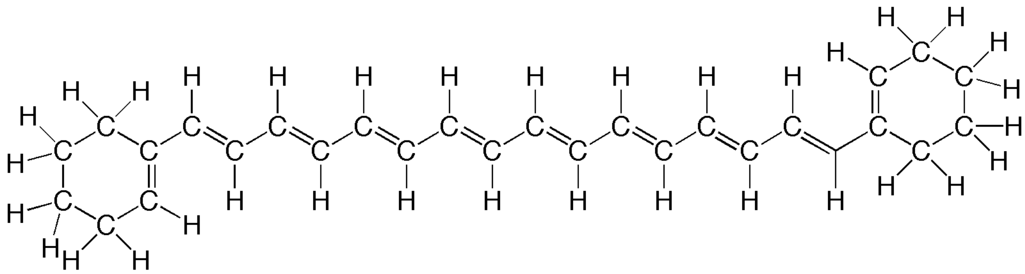
Part 2. Materials and methods

- Spec 20 visible wavelength spectrophotometer
- Laptop computer
- Spec 20D to laptop cable
- a few glass test tubes of the size that fits in the sample chamber
- distilled water (to rinse out the tubes)
- various colored solutions
- disposable plastic pipets

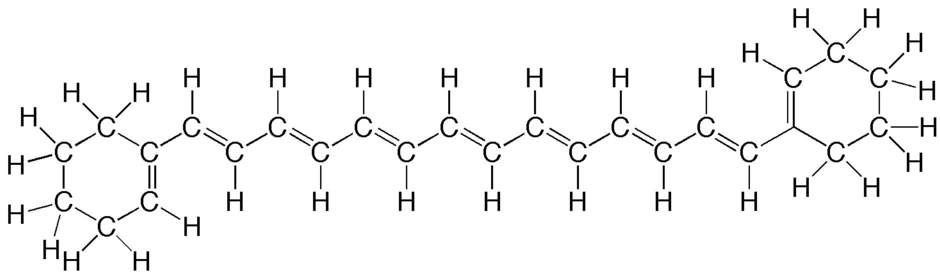
Below are the molecules that make up these dyes:



green dye



blue dye



red dye

Disposal: All waste can go down the sink

Part 3. Procedure

Obtain the spectrophotometer from the instrument room and a laptop computer from the cabinet and plug the cable that connects the two into the appropriate ports. Note that on the display of the console, there is a digital display. Note on the flat part of the console there is a knob that sets the wavelength of light, and a sample chamber (the lid should be closed).

Note on the front of the instrument, there are two knobs. After plugging in the machine, turn the left knob so that you hear a click and the machine's fan starts (someone previous may have left the machine on, in which case, plugging it in should have resulted in that sound).

Turn the left knob a few turns (don't force the knob to go past its natural stop).

Make sure the appropriate button to display "% T" is pushed. Set the wavelength to 400 nm.

Let the lamp in the machine warm up for a few minutes. Afterwards, turn on the laptop, and go to Programs → Instrument Software → Vernier Software → Spectro Pro 1.0. The software may ask you through which port communication should proceed; select "COM4". Select the "New absorbance versus wavelength" option from the File menu. Note that Spectro Pro window has a graph on one side and a table on the other; you will need to print out both to include in your data section. You can change the axes of the display by simply double-clicking within the graph portion and selecting the "Axis options" tab on the window that comes up.

Follow the on-screen instructions to **calibrate** 0% transmittance and 100% transmittance (use a distilled water-filled test tube rather than an empty one, as the instructions suggest) and then to insert the sample itself. The test tube needs to be about two-thirds full in order to get a good spectrum.

You will take spectra of all three color dye molecules. The range of the spectrum will be from 400 to 800 nm in 20 nm increments.

Once you are done with one sample, make sure to print out the graph and the table. You may also save the data file to a flash drive, or e-mail the data file to yourself, if you have paid the computer lab access fee. When printing out the data, make sure you put some kind of identification of yourself and the color of the dye – the data look similar between groups and dyes.

When switching between samples, rinse the tube clean, and shake the tube dry. Make sure there are no water droplets on the exterior of the tube.

Part 4. Original data

Include all three printouts (both graph and table), clearly identifying the color of each dye.

Part 5. Calculated results

Make a table that has three columns (one for each dye) that identifies λ_{max}; that is, the wavelength of maximum absorption for each dye. Note that some dyes may have several such peaks – identify the peak with the largest absorbance (smallest percent transmittance).

Part 6. Group results

No group results for this lab.

Part 7. Questions

1. Is this an **absorption** type of spectroscopy experiment or an **emission** type?

Draw below the "hidden" mechanism of the spectrophotometer to illustrate your point. Your drawing should include the sample chamber, the lamp, the light detector in the proper order so that you will be able to measure the intensity of light that goes through a sample in a test tube. You will also need one other device, placed cunningly, so that you can explain why you see only one color at a time in the sample chamber and how the wavelength knob connects to that.

2. "Zero percent transmittance" has a pretty obvious meaning, as does "100% tramsmittance". "Zero absorbance" is pretty clear, too, but what value is at the other end of the absorbance scale and what does that mean?
3. Why do you have to set 0% transmittance after every wavelength change?

4. Explain the connection between λ_{max} and the actual color of the solution.

5. In the dyes that had two or more potential λ_{max} , how come your eyes did not detect these different colors as the spectrophotometer did?

Part 8. Conclusion (about two paragraphs)

Write a paragraph or so outlining the similarities and differences in the molecular structures of the dye molecules given at the beginning of this handout. Hint: there should be a gross similarity and a subtle similarity. Further hint: look up the word "conjugated" in its chemistry sense.

Write a paragraph or so connecting the difference in maximum absorption wavelengths and the key difference in structure between the dye molecules.

State a general rule between a specific structural difference in these types of dye molecules and the λ_{max} they will exhibit.

Finally, make a prediction about the structure of a dye molecule that would have λ_{max} in the ultraviolet part of the spectrum, and whether this could be tested on the Spec 20D spectrophotometer.