

# The Kinetics of a Bleach Reaction **2**

The primary objective of this experiment is to determine the rate law and order of a reaction between food coloring and commercial bleach. You will use a Vernier Spectrometer (V-SPEC) to measure the absorbance of the reaction over time. You will first measure the absorbance of a food coloring solution over the visible light spectrum (380 – 950 nm) and select one or more wavelengths to examine during the reaction. As the reaction proceeds, the food coloring will fade and the absorbance will decrease.

You will determine the order of the reaction and write the rate law based on your analysis of the graph of absorbance *vs.* time.

## OBJECTIVES

In this experiment, you will

- Measure and analyze the visible light absorbance spectrum of a food coloring solution to determine the maximum wavelength(s) of absorbance.
- Measure the absorbance of the reaction between a food coloring solution and bleach.
- Analyze the absorbance *vs.* time graphs to determine the order of the reaction.
- Write the rate law for the reaction.

## MATERIALS

Vernier Spectrometer  
computer  
one cuvette  
250 mL beaker  
50 mL (or 100 mL) beaker  
10 mL graduated cylinder  
100 mL graduated cylinder


food coloring  
commercial bleach (5.25% OCl<sup>-</sup>)  
distilled water  
plastic Beral pipet  
stirring rod  
tissues (preferably lint-free)

## PROCEDURE

1. Obtain and wear goggles.
2. Use a USB cable to connect a Vernier Spectrometer to a computer.
3. Start *Logger Pro* 3.4.6 on your computer.
4. Measure out 100 mL of distilled water into a 250 mL beaker. Add two drops of food coloring to the beaker of distilled water and mix thoroughly. Measure out 10 mL of bleach into a small beaker (50 mL or 100 mL) and set it aside until Step 8.
5. To set up the spectrometer, open the Experiment menu and select Connect Interface → Spectrometer → Scan for Spectrometers.

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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 spectrometer cuvette holder. Align the cuvette so that the clear sides are facing the light source of the spectrometer. Click “Finish Calibration”, and then click .
7. Determine the maximum wavelength for the food colored solution and set up the mode of data collection.
  - a. Empty the blank cuvette and rinse it twice with small amounts of the food colored solution. Fill the cuvette  $\frac{3}{4}$  full with the solution and place it in the spectrometer cuvette holder.
  - b. Click . A full spectrum graph of the solution will be displayed. Note that one area of the graph contains a peak absorbance, and there may be other lesser peaks that characterize this substance. Click  to complete the analysis.
  - c. To save your graph of absorbance vs. wavelength, select Store Latest Run from the Experiment menu.
  - d. Click the Configure Spectrometer Data Collection icon, , on the toolbar. A dialog box will appear.
  - e. Select Absorbance vs. Time under Set Collection Mode. The peak absorbance will be automatically selected. Select a new wavelength, if you wish, by clicking on the graph or checking the box next to the desired wavelength. Click . If you need to start over, click  and select a wavelength (or wavelengths) again.
8. Collect absorbance-time data for the reaction of food colored solution and bleach.
  - a. Remove the cuvette from your spectrometer and pour out the solution.
  - b. **DO THIS QUICKLY:** Add the 10 mL of bleach to the beaker of food coloring solution. Swirl the reaction mixture with a plastic Beral pipet and use the pipet to fill the cuvette  $\frac{3}{4}$  full of the reaction mixture. Place the cuvette in the spectrometer cuvette holder.
  - c. Click . Absorbance data will be plotted every second for 200 seconds.
  - d. Examine the graph of absorbance vs. time, showing a gradual decrease in absorbance. To save your graph, select Store Latest Run from the Experiment menu.
  - e. Discard the cuvette contents as directed.
  - f. Repeat the procedure to conduct a second trial with a new food colored solution and another 10 mL sample of bleach.
9. (optional) Print a copy of your graphs and/or data table.
10. (optional) Select Save As... from the File menu and save your experiment file.
11. Select Exit from the File menu to close down LoggerPro 3.

## **DATA ANALYSIS**

1. Use your results to determine the order of the reaction. Consider the bleach to be in excess.
2. Use the format:  $\text{rate} = k[\text{FC}]^x$  to write a rate law for the reaction. [FC] denotes the molar concentration of the food colored solution. Substitute the appropriate digit for the value of  $x$  in the rate law. Calculate a value for the rate constant,  $k$ .
3. Determine the rate of the reaction during the first ten seconds.
4. How many seconds had passed before the food coloring concentration decreased by half?

## Teacher Information

1. We recommend using regular commercial bleach, 5.25% NaOCl, with no fragrances or other additives. 5.25% bleach is approximately 0.67 M OCl<sup>-</sup>. If you use bleach labeled “ultra”, the NaOCl concentration will be higher, normally 6%. Use less (7-8 mL) “ultra” bleach for the experiment. Do not use bleach labeled “color safe”.
2. In Step 4 of the procedure, students are instructed to make up the food colored water by adding 2 drops of food coloring per 100 mL of water. If you are concerned that your students will work too slowly in Step 8b, where the reaction mixture is prepared, instruct them to add 3 or 4 drops of food coloring in Step 4.
3. Commonly, commercial food coloring is insufficiently pure to evaluate the order of the reaction in any way other than a pseudo-order. Your students should consider this lab as an opportunity to practice the process of analyzing data to learn more about reaction rates and determining the order of a reaction.
4. The cuvette should be ~ ¾ full to get good absorbance measurements and allow enough room to seal the cuvette with a plastic cap.
5. It is important for each student lab team to use a single cuvette to test their liquids in the spectrometer. This will eliminate errors introduced by slight variations in the absorbance of different plastic cuvettes.
6. If you want your students to run this reaction at two different temperatures, we suggest room temperature (~20°C) and cool (~10°C).
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.

### HAZARD ALERT

Sodium hypochlorite solution: Corrosive liquid; causes skin burns; reacts with acid to evolve chlorine gas; evolves chlorine when heated; moderately toxic by ingestion or inhalation; avoid contact with organic material. Hazard code: B—Hazardous.

The hazard information reference is: Flinn Scientific, Inc., *Chemical and Biological Catalog Reference Manual*, P.O. Box 219, Batavia, IL 60510, (800) 452-1261, [www.flinnsci.com](http://www.flinnsci.com).