Investigation 7: Reaction Kinetics

Focus Question: *How can we determine the rate law for the reaction between blue dye and bleach?*

Pre-lab required reading

Chemistry: an Atoms-Focused Approach: Sections 13.2 – 13.3

Primers:

- Pseudo-first order reactions: the method of isolation
- Spectrophotometry
- SpectroVis usage
- Using a micropipette
- Volumetric glassware – general
- Volumetric glassware – volumetric flask

Safety and Waste Disposal

- Eye protection should be worn at all times. Bleach is a corrosive oxidizing agent that will react with eyes and skin and can remove color from clothing.
- Gloves should be worn when handling the bleach.
- Dispose of all solutions down the drain with plenty of water.

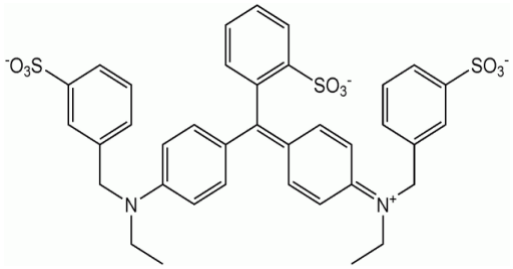
Background

The Reaction

In this experiment we will be studying the reaction between blue food dye #1, erioglaucine, and bleach, $NaOCl_{(aq)}$ in solution. The overall reaction equation is:

$$NaOCl_{(aq)} + \text{FD\&C Blue \#1}_{(aq)} \rightarrow \text{colorless products}_{(aq)} \qquad (1)$$

The structure of aqueous FD&C Blue #1 is shown below:



Observing the reaction

The FD&C Blue#1$_{(aq)}$ ion is colored. Thus a solution of the reactants will be colored. However, the products are not colored and a solution of the products will be colorless. The progress of the oxidation-reduction reaction represented by equation 1 above can be observed by watching the color of the solution disappear. Quantitative information will be obtained by using the absorbance of the solution at the wavelength of maximum absorption for the FD&C Blue#1 ion (630 nm). We will use the SpectraVis spectrometers to record the absorbance as a function of time.

The general rate law for this reaction (1) is

$$\text{Rate} = k[\text{NaOCl}]^x[\text{Blue\#1}]^y \quad (2)$$

The purpose of the experiment is to fully define the rate law shown in equation (2) by determining experimental values for the variables x, y and k. The *method of isolation* will be used with an excess of NaOCl.

Procedure

Part A: Preparation of materials:

Obtain 10-20 mL of Blue#1 Stock solution. Volumetrically prepare 50mL of diluted Blue#1 (concentration of ~1.7×10^{-5} *M* is desired). Be sure to record the exact value of the concentration of solution prepared. Place some of this diluted solution, 20-50mL distilled water, and 10-20mL bleach solution in separate clean, dry, labeled beakers. Record the brand name and label information about the bleach used in your investigation. Use the label information (i.e. 6% NaOCl) to calculate the concentration of NaOCl in your bleach solution. Obtain a clean dry cuvette and three clean micropipettes (with tips) – these will be used to measure all the solutions and also the distilled water. Be careful to keep the micropipette clean and dry by not setting it sidewise on the counter, use the clips provided. Be sure to use the same tip with the appropriate solution at all times so that your solutions do not become contaminated (if not sure – use a new tip!).

Part B: Determining the rate law by the method of isolation:

In order to determine the variables x, y and k, a set of 5 to 6 trials with identical concentrations of blue dye and varying concentrations of NaOCl will need to be investigated. The concentration of NaOCl should always be at least 10 times in excess to the concentration of blue dye in your reaction mixture. The easiest way to design a set of trials is to combine set volumes of each stock solution so that the total volume for each trial is identical. This way, if you add the same volume of stock blue dye solution to a fixed total volume you will always have the same concentration of blue dye in each trial. You can vary the volume of bleach in each trial and make up the difference in volume with water. A good starting point is 850 μL of blue dye solution and 800 μL of bleach solution. Design a set of 5-6 trials decreasing the amount of bleach to 200 μL and adding water to make up the total volume.

To run each trial, add the bleach and water to the clean, dry (as possible) cuvette. Blank the spectrometer before adding the Blue#1. Set up the spectrometer to record the absorbance at 630nm as a function of time. The diluted Blue#1 stock solution should always be added last. After adding the Blue#1 mix the solution by drawing it up into the micropipette tip and releasing it into the cuvette. Click on the "collect" button to record the absorbance as a function of time and click "stop" to stop the trial when the absorbance reaches about 0.03 (about five half-lives from the initial value). Save the data and set up the next trial.

References

Atkins, P.; Jones, L. "Chemical Principles: The Quest for Insight", 5th ed.; Freeman: New York. 2010.

Henary, M.M.; Russell, A.A. *J. Chem. Ed.* 2007, *84*, 3.