

## Rate of Bleaching Food Coloring – Red Dye #40

### Discussion

This is a kinetics experiment in which we take data (data = measurements) that will allow you to calculate the order of each reactant, the rate of each reaction and then the rate constant of the reaction. The order tells us what effect the concentration of a particular reactant has on the overall rate of the reaction. *Rates* of reactions vary, depending on the reaction conditions; *rate constants* do not vary – hence the word CONSTANT after rate (unless you change the temperature, then all bets are off). We will take measurements (at constant temperature) using a spectrophotometer to determine how quickly the Red Dye #40 molecule reacts with bleach.

Note: When we bleach clothing, bleach doesn't necessarily remove the stain, but it does transform the molecule into something that is colorless. The changed molecule may or may be removed from the clothing in the washing process.

As the Red Dye molecule is transformed, its color changes from red to clear. Recall from Chemistry 1A (see chapter 7) that a solution that looks *red* absorbs light in most any other region of the spectrum, but usually the most intense absorption of light comes from the complementary color to the color we see. We see the color that is not being absorbed, and therefore is being transmitted through the solution. The complementary color of red is green, so the most intense absorption of light should occur near a wavelength corresponding to the color green. We will be looking at the absorbance of light at  $\lambda = 518$  nm. Check your textbook to see in what portion of the visible light spectrum this wavelength corresponds. As the dye molecules in the solution react with the bleach, the red color becomes lighter and lighter, and what this means is that less visible light is being absorbed and so correspondingly more of the light is being transmitted.

The experiment will consist of putting two reactants in a cuvette, inserting the cuvette (as quickly as possible) into the spectrophotometer, and monitoring the amount of light being absorbed as a function of time. This is how we will be able to determine the reaction rate. The rate, in the textbook, has units of Molarity/time. In this situation, the absorbance of the dye molecule is directly proportional to its Molarity.

$$\frac{[\text{Dye}]_t}{[\text{Dye}]_0} = \frac{\text{Absorbance (A)}_t}{\text{Absorbance (A)}_0}$$

where t=the absorbance or concentration at time t

where 0 = the initial absorbance or concentration (or conc. at t=0).

When we have a colorless solution (which is what should happen at the end of the reaction), the molecules aren't absorbing any light in the visible region (which is the region we will be looking at). So **absorption** should approach 0.00% and **transmittance** (the percentage of light in the visible region that is shining through the solution) should approach 100%.

## Procedure

First, obtain about 30 mLs of each reactant solution and place the reactants in separate containers. Cover the flasks containing bleach with stoppers. Label the flasks. Record the temperatures of each reactant before starting the individual experiment. Quickly rinse and dry your thermometer between measurements so that you do not cross-contaminate your reactants.

Flask labels should include your name, the date, the name or chemical formula of the substance in the flask, and (if the substance is a solution) the concentration with its unit. There is colored tape and markers at the instructor's desk for making labels.

The reactant solutions are:

0.010 M Red Dye #40

0.0050 M Red Dye #40

0.035 M NaOCl

0.018 M NaOCl

You will do four unique reactions. In each reaction, use 5.0 mL of the Red Dye and 1.0 mL of the bleach. Write out the four sets of reactants in your pre-lab so that you have different combinations of Molarities in each one. You do not have to write the products.

Next, obtain two cuvettes. [The cuvettes look like test tubes, but are made of a special glass that transmits light better than the test tubes we usually use. You can tell the difference between cuvettes and test tubes in our lab because the cuvettes have a white line and white spot at the top.] Fill one of the cuvettes with DI water. This will be your "Blank". We will use this to ensure that the spectrophotometer is only recording absorbance of light from the molecules of interest (the Red Dye #40) and not from the DI water in which the dye is dissolved.

Set up your spectrophotometer. The professor will guide you through these steps. Once it is ready, you may start your experiment.

For each experiment, the procedure is the same. Using a pipet, measure out 5.0 mLs of the Red Dye into the cuvette for the spectrophotometer. Record the absorbance measurement for the Red Dye alone. Then measure out 1.0 mL of the bleach. Set your time=0 at the moment when you pour the two reactants together. Mix the two together in the cuvette (as quickly and carefully as you can), and immediately place the cuvette into the spectrophotometer and record the absorbance at t=15 seconds, or if you took more time than 15 seconds, take your first reading at whatever time it is. Continue taking absorbance readings every 15 seconds UNTIL the absorbance changes LESS than 0.01 absorbance units for a period of 3 minutes. **This does not mean that you take data for only 3 minutes.** This means that you must continue taking data for a full three minutes AFTER the absorbance has appeared to stop changing significantly. The complete reaction time could take 10-15 minutes. For purposes of your pre-lab, write in the times for at least five minutes, and then leave appropriate space for the times you will have to write it as you go. At the end, you will have completed one trial of the first experiment. Do two trials for each experiment. Between different experiments, empty the cuvettes into the waste bottle, and rinse the cuvettes with the Red Dye solution that you will be using next. You may rinse the cuvette with DI water (do not use tap water) but then use a transfer pipet and rinse the cuvette three times with the Red Dye#40 solution of the Molarity that you will be using next.

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Once the cuvette has been rinsed three times, add the 5.0 mLs of your Red Dye solution for the next experiment.

The cuvettes are ruined if they are scratched. Please do not use a brush to clean them or use an abrasive soap to wash them. Instead, rinse them three or four times with the solution you will be using next, or with DI water if you are finished with them. Do not dry the cuvettes, just return them to the cart and place them upside down in the racks.

**Pre-Lab Information** – Your professor’s preferences may vary from this information. Check with your professor.

- Worth 4 of the 20 points (not a typo, I have just decided to give the pre-lab 20% weight).
- Summarize the procedure in your own words, with enough detail so that you can work out of your lab notebook. Steps, bullets and abbreviations are better than full sentences. Sometimes pictures are more effective so keep that in mind. You only need the procedural steps; theory, calculation information and equipment are not necessary, but if you like to include them, that is fine. The objective is to write with enough detail so that the experiment can be done out of your notebook (photocopying my procedure and stapling it into the notebook is not acceptable). The other objective is that someone else can read and understand what you did, if you were not there to explain it, and if the typed version of the procedure were not available.
- Determine all of the measurements (data) that you need to complete the experiment and then put it in table form.

**Observations and Data** - Your professor’s preferences may vary from this information. Check with your professor.

- Worth 2 of the 20 points
- I will be looking for three things: completeness, data taken to the correct number of significant figures based on the instrument used, and observations of what occurred during the experiment.
- You may ask the question: why do I have to write that the red color goes away, when the procedure has already included this information? The answer to that valid question is that you are being trained as scientists. Your lab notebook becomes the legal document through which (if a company has to go to trial) your work will be examined. If you leave out information because “everyone knows this happens”, that may not convince a jury. In repetitive experiments, you may start to write a notation that says “see Notebook #6” for observation details, if the same things happen over and over again. So, all of you should note color changes as an observation, even if I’ve told you this will happen. Consider that even though it is YOUR notebook, you aren’t keeping it for yourself as much as you are keeping it for people who will take up your work after you have left, or people who need to examine it for legal purposes.

**Report-** Your professor’s preferences may vary from this information. Check with your professor.

- Worth 14 of the 20 points.
- The specific calculations will be posted separately.