

Lab Activity H13

Food Coloring Kinetics

OUTCOMES

After completing this lab activity, the student should be able to:

- explain how the concentration of a reactant affects the reaction rate.
- determine the effect of temperature of a reaction mixture on the reaction rate.
- prepare a reaction mixture which occurs in a specified amount of time.



DISCUSSION

Chemical reactions do not all occur at the same speed (rate). Some reactions, like the explosion of trinitrotoluene (TNT), are extremely fast, while others, like the rusting of iron on an automobile, are quite slow (though it does not always seem that way). Can you think of other examples? There are many other reactions having rates between these examples.

The study of reaction rates is called *kinetics*. Scientists study factors that influence the rates of various reactions in order to get an understanding of how the reaction is occurring and to determine means by which the reaction rate may be controlled. One may want to make certain reactions go faster, like the decomposition of waste materials or the perming of hair. One may also wish to slow certain reactions, like the rusting of iron or the spoilage of food. Scientists spend considerable time and money attempting to control reaction rates.

In order to understand more about reaction rates, one should first have an understanding of the collision theory of chemical reactions. A chemical reaction results from the effective collision of reactant molecules. Molecules are in constant motion and colliding all the time. In an effective collision, the molecules collide with the proper orientation and with some minimum energy, which is determined by the mass and speed of the reactant molecules. Some bonds are broken and other bonds are reformed. Hence, one can affect the reaction rate by finding ways to make effective collisions more frequent.

There are several factors that affect the rate of most reactions. These factors include the concentration of reactants, temperature, catalyst, and surface area of solid reactants. How do these factors affect the reaction rate? Hopefully, the answer to this question will be obtained through experimentation and analysis of results.

The reaction you will be studying is one between the FD&C Blue 1 food coloring and bleach, which is an aqueous solution of sodium hypochlorite. As the dye is oxidized by the bleach, the solution eventually becomes colorless. The molecular structure of FD&C Blue 1 appears in Figure 1 on the next page.

In this lab activity, an attempt will be made to determine experimentally how certain factors affect the reaction rate. The concentration and temperature will be varied in order to observe the effect of these changes. Upon graphing the results, it should be possible to predict the time for a new set of conditions. It should also be possible to predict a set of conditions that will yield a given time.

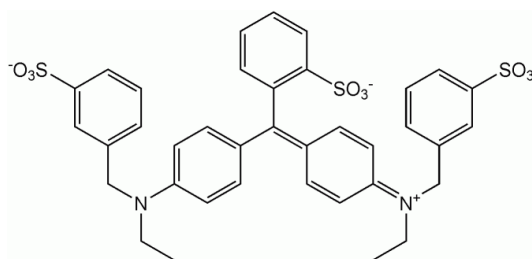


Figure 1. Brilliant Blue FCF (FD&C Blue 1)
http://en.wikipedia.org/wiki/Brilliant_Blue_FCF

Please read the instructions carefully for this lab activity. If you are well organized and have read ahead, you should save a considerable amount of time. Each measurement is fairly short and there will be time to repeat if you make mistakes. Good luck.....

MATERIALS (Provided By Student)

Laundry Bleach – must be fresh **chlorine** bleach,
containing sodium hypochlorite – **not** color-safe
Bowl
Computer with Open USB Port
Distilled Water
Ice

MATERIALS (From Kit)

Blue Food Coloring – must contain
FD&C blue 1
Go! Temp temperature probe with
Logger Lite or *Logger Pro* software
Graduated cylinder, 10 mL
Plastic cup
Portion cups, clear - 3 needed
Safety Goggles/Glasses

PROCEDURE

1. Allow the distilled water and bleach to sit in the same room for several hours to ensure that they are both at the same temperature.

EYE PROTECTION MUST BE WORN AT ALL TIMES DURING THIS EXPERIMENT!

KEEP CHEMICALS USED IN THIS LAB AWAY FROM PETS, FOOD, AND CHILDREN!

IT IS IMPORTANT THAT ALL GLASSWARE IS CLEAN AND THAT THE SOLUTIONS DO NOT BECOME CONTAMINATED BEFORE MIXING!

Part 1. Experiment Preparation

2. Prepare a blue food coloring solution by adding 10 drops of blue food coloring to 200 mL of distilled water in a plastic cup. Mix thoroughly.
3. Plug the Go! Temp temperature probe into a convenient USB port on your computer and launch the *Logger Lite* application that was installed during Lab H1. The temperature probe should automatically be identified by the software and interface.
4. Under the **Experiment** menu, select **Data Collection...** Set the collection mode to “Time Based”, the experiment length to 180 seconds, and the sampling rate to 1 sample/second (1 second/sample). Check the box to take a “Sample at Time Zero”. These should be the default settings, so nothing may need to be changed.
5. From the **Insert** menu, select **Meter**, then **Digital Meter**. Double-click or right-click on the meter and change the “Column” settings to display “Time” on the meter. Drag the meter to a convenient location on the screen, perhaps the lower right portion of the graph or below the data table. Note that all *Logger Lite* windows (graph, data table, meters) may be resized and rearranged as desired.

Part 2. Reference Trial

USE BLEACH WITH CARE! AVOID GETTING ON SKIN OR CLOTHES. CLEAN UP ANY SPILLS IMMEDIATELY. SEE BOTTLE FOR ADDITIONAL PRECAUTIONS.

6. This trial is a practice run that will be used as a reference for subsequent trials. Using a small graduated cylinder, measure 10.0 mL of the food coloring solution into a small clear portion cup. Rinse the graduated cylinder and shake it dry. Add 10.0 mL of bleach to graduated cylinder.
7. Pour the bleach into the portion cup and mix the solutions together by swirling or stirring with the temperature probe for a few seconds. Observe what happens to the color of the mixture. **The color should stop changing in 60 seconds or less. If the color change takes more than 60 seconds, obtain a fresh, unopened bottle of bleach.**

ONCE THE REACTION IS COMPLETE, DO NOT EMPTY THIS PORTION CUP. SET IT ASIDE TO BE USED AS A FINAL COLOR REFERENCE FOR SUBSEQUENT TRIALS.

Part 3. Effect of Concentration on Reaction Time

8. Rinse the graduated cylinder and shake it dry. Use the cylinder to measure 10.0 mL of the food coloring solution into a different, small clear portion cup. Rinse the cylinder and shake it dry. Add 10.0 mL of bleach to the graduated cylinder. Place the temperature probe into the food coloring solution and record the temperature. Remove the probe from the solution.
9. Prepare to make a time measurement with *Logger Lite*. Pour the bleach into the portion cup. Click on the green **Collect** button the instant the solutions come into contact with each other. Mix the solutions together by swirling or stirring with the temperature probe for a few seconds. Remove the probe and dry the tip of the probe with a napkin or paper towel.
10. Set the portion cup next to the reference. When the mixture becomes the same color as the reference mixture, click on the red **Stop** button. Record the reaction time – the time required until the data collection was stopped. If the time is not visible on the digital meter, scroll to the bottom of the *Logger Lite* data table to see the last time that was recorded.
11. Flush the contents of the portion cup down the drain with plenty of water. Rinse the vessel with water and dry it out.
12. If satisfied with the trial, select **Store Latest Run** from the **Experiment** menu, so a new set of data may be graphed. If not satisfied, select **Clear Latest Run** from the **Experiment** menu. Save the file before proceeding to prevent accidental loss of data. If, for whatever reason, the computer were to lock up, the saved set(s) of data may be retrieved.
13. Repeat steps 8-12 and average the results for the two trials.
14. Using a graduated cylinder, measure 10.0 mL of the food coloring solution and pour it into the portion cup. Rinse the graduated cylinder and shake it dry. Add 8.0 mL of bleach to the cylinder and dilute by adding 2.0 mL of water, bringing the total volume to 10.0 mL. Record the temperature of the food coloring with the temperature probe.
15. Prepare to make a time measurement with *Logger Lite*. Pour the contents of the graduated cylinder into the reaction vessel. Click on the **Collect** button the instant the solutions come into contact with each other. Mix the solutions for a few seconds. Remove the probe and dry the tip of the probe.
16. Set the portion cup next to the reference. When the mixture becomes the same color as the reference mixture, click on the **Stop** button. Record the reaction time.
17. Flush the contents of the portion cup down the drain with plenty of water. Rinse the vessel with water and dry it out.

18. If satisfied with the trial, select **Store Latest Run** from the **Experiment** menu. If not satisfied, select **Clear Latest Run** from the **Experiment** menu. Save the file before proceeding.
19. Repeat steps 14-18 and average your results.
20. Repeat step 14-19, using 6.0 mL of bleach diluted with 4.0 mL of water (instead of 8.0 mL of bleach and 2.0 mL water). **REQUIRED PHOTO: Includes your face and/or clearly shows a Picture I.D. (with name), showing the diluted bleach and food coloring solution before the two solutions are mixed.**
21. Repeat step 14-19, using 4.0 mL of bleach diluted with 6.0 mL of water (instead of 8.0 mL of bleach and 2.0 mL water).

Part 4. Preparing a Reaction Mixture with a Known Reaction Time.

22. Answer the questions for Part 4 in the Data and Questions section before proceeding to the next step.
23. Prepare a mixture using the volumes given in your answer to question 3. Using the method for determining the reaction time in part 3 of this experiment, measure and record the reaction **time** in the data table. Repeat the trial, using the same volumes of each solution. How close were you to 60 seconds (or 90 seconds or 120 seconds)? Explain any variation.

Part 5. Effect of Temperature on Reaction Time

24. Answer the questions for Part 5 in the Data and Questions section before proceeding to the next step.
25. Before mixing the solutions together, you may either:
 - a) use an ice-water bath to cool 10.0 mL each of the food coloring solution and the bleach by at least 10°C and react the solutions together.
 - b) use a hot water bath to warm 10.0 mL each of the food coloring solution and the bleach by at least 10°C and react the solutions together.

REQUIRED PHOTO: Includes the date clearly shown on a calendar, newspaper, cell phone, or written on a sheet of paper, showing the food coloring solution and bleach either being cooled or warmed. The bottle of bleach should also be visible in the photo.

26. Using the method for determining the reaction time in part 3 of this experiment, measure and record the reaction **time** in the table. Repeat the trial at the same temperature.

Name _____

Lab Section _____

PRELAB QUESTIONS

1. Name several factors that affect the rate of a chemical reaction.
2. Give some everyday examples from **your** experience of chemical reactions that are fast. Give examples of slow reactions.
3. What is the difference between reaction **rate** and reaction **time**?
4. If the reaction **rate** increases, what happens to the reaction **time**?
5. State a hypothesis as to how you believe **increasing** the temperature and concentration will affect the reaction **rate**.
6. Which safety precautions, if any, must be observed during this lab activity?

PHOTOS - Please compress photos and save your file **before** uploading to the dropbox. Photos should come close to filling the boxes below and all required items should be **clearly visible**.

Required Photo 1:

Required Photo 2:

Name _____

Lab Section _____

DATA AND QUESTIONS

Part 3. Effect of Concentration on Reaction Time.

Mixture	Food Coloring Solution (mL)	Bleach (mL)	Water (mL)	Total (mL)	Reaction Time For Trial 1 (sec)	Reaction Time For Trial 2 (sec)	Average Time (sec)	Temp (°C)
1	10.0	10.0	0.0	20.0				
2	10.0	8.0	2.0	20.0				
3	10.0	6.0	4.0	20.0				
4	10.0	4.0	6.0	20.0				

Part 4. Preparing a Reaction Mixture with a Known Reaction Time.

1. Using the graph paper supplied on page H13.11 or Vernier *LoggerPro*, prepare a graph in which the **average reaction time** for each trial is plotted against the **volume of bleach used** in that trial (Note: this volume is related to the overall concentration of bleach in the mixture). Label the axes and draw a best-fit line **or** curve. Utilize graphing fundamentals learned in an earlier lab – place the variables on the correct axis and have the values increase in the proper direction. Please submit the graph with your report.
2. Examine the data and graph that was just prepared. What happens to the reaction **time** as the concentration of bleach increases? What happens to the reaction **rate** as the concentration of bleach increases?

Explain why this should be expected, using **collision theory**.

3. Using your graph, determine the volume of bleach that should be used to yield a reaction time of 60 seconds (*Note: use 90 or 120 seconds if all of your reaction times were greater than 60 seconds – select a time that is **within** your range of data*). Draw dotted lines on the graph (or go to **Analyze > Interpolation Calculator** in *LoggerPro*) to show how the answer was obtained. What volume of water and food coloring solution should be mixed with the bleach to be consistent with Part 3 of this experiment (*Hint: what should be the total volume?*)?

Mixture - circle or highlight the time you tried to match	Food Coloring Solution (mL)	Bleach (mL)	Water (mL)	Total (mL)	Reaction Time For Trial 1 (sec)	Reaction Time For Trial 2 (sec)	Average Time (sec)	Temp (°C)
60, 90, or 120 seconds								

Explain any variation between the predicted time and the observed time.

Part 5. Effect of Temperature on Reaction Time

4. How do you predict an increase in temperature will affect the reaction **time**? A decrease in temperature?
5. In the table below, record the reaction **time** obtained in Part 3 of the experiment, when 10.0 mL of the food coloring solution was mixed with 10.0 mL of bleach.

Mixture	Food Coloring Solution (mL)	Bleach (mL)	Water (mL)	Total (mL)	Reaction Time For Trial 1 (sec)	Reaction Time For Trial 2 (sec)	Average Time (sec)	Temp (°C)
1 (Data from Part 3)	10.0	10.0	0.0	20.0				
1 (At new temp)	10.0	10.0	0.0	20.0				

6. Was your prediction in question 4 correct? Did the reaction **rate** increase or decrease for the trial at the new temperature when compared to the original trial?

Lab Report Submission Checklist

Complete the appropriate checklist and **submit this page** along with your lab activity.

Lab Activity Submitted Via the D2L Dropbox

	Prelab assignment is complete.
	Remainder of lab activity is complete (data, questions, photos. etc.).
	Minimum of two photos of different parts of the procedure included.
	At least one photo shows face or photo I.D. At least one photo clearly shows the date.
	Document filename in format of Lastname Firstname HX .
	File size is no larger than 10 MB.
	Only one document submitted for this lab activity.
	Lab submitted on time.
	If late, this is your first extension.



Lab Activity Submitted Via the US Postal Service or In Person

	Prelab assignment is complete.
	Remainder of lab activity is complete (data, questions, photos. etc.).
	Minimum of two photos (at least one showing face or photo I.D.; at least one shows the date) of different parts of the procedure or a tangible artifact or product from the lab activity is included.
	If return is desired, a self-addressed stamped envelope with sufficient postage is included*.
	Lab submitted on time (postmarked by due date if sent via USPS).
	If late, this is your first extension.

*You may find a postage calculator at <http://postcalc.usps.gov>. Use the balance in your kit to find the weight.

