Pink Catalyst

Catalysis

Introduction

Add a pink cobalt chloride solution to a colorless solution containing potassium sodium tartrate and hydrogen peroxide and watch as a very obvious green-colored complex forms. As the reaction ends, the solution will return to its original pink color—indicating that the cobalt chloride catalyst is not used up in the reaction.

Concepts

- Catalysts
- Kinetics

Materials

Cobalt chloride solution, $CoCl_2 \cdot 6H_2O$, 0.1 M, 12 mL

Hydrogen peroxide solution, 6%, H_2O_2, 40 mL

Potassium sodium tartrate solution, 0.21 M, 100 mL

Beaker, 600-mL

Graduated cylinders, 100-mL and 25-mL

Hot plate/stirrer

Thermometer

Safety Precautions

Cobalt(ous) chloride is toxic by ingestion (LD_{50} 766 mg/kg) and causes blood damage. Hydrogen peroxide is an oxidizer and a skin and eye irritant. Although potassium sodium tartrate solution is considered non-hazardous, do not ingest the material. Avoid body tissue contact with all chemicals. Wear chemical-resistant goggles, chemical-resistant gloves, and a chemical-resistant apron. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.

Procedure

1. Using a graduated cylinder, measure out 100 mL of 0.21 M potassium sodium tartrate solution. Pour it into a 600-mL beaker.
2. Slowly warm the solution to 70 °C on a hot plate.
3. While waiting for the temperature of the solution to increase, measure out 12–14 mL of 0.1 M cobalt chloride solution in a 25-mL graduated cylinder. Show this solution to the class so that the students can note the pink color of the catalyst.
4. When the temperature of the potassium sodium tartrate solution reaches 70 °C, add 40 mL of 6% hydrogen peroxide and the cobalt chloride catalyst to the 600-mL beaker. Stir continuously.
5. The solution will go through a series of color changes as the cobalt chloride begins to catalyze the reaction. The solution will start out pink (the color of cobalt chloride) and then darken to a brown before lightening up to a yellow-orange and finally becoming an olive green color. At this point, the reaction mixture is bubbling vigorously.
6. Once the bubbling subsides, the solution will progress back through the series of colors and return to the original pink color of the cobalt chloride solution.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. Dispose of the final solution according to Flinn Suggested Disposal Method #27d.

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Tips

- If you are going to time the reaction, the use of a hot plate-magnetic stirrer greatly aids the demonstration of this reaction. Otherwise, continuous stirring is necessary.
- Begin timing the reaction upon addition of the hydrogen peroxide and cobalt chloride solution. Complete the timing after the vigorous reaction subsides and the original pink color of the cobalt chloride solution has returned.
- The use of a large beaker is important so that the reaction does not froth over.

Discussion

The solution starts out pink due to the pink color of the cobalt chloride catalyst. The solution turns green forming an intermediate between the catalyst and potassium sodium tartrate. The solution returns to the original pink color of the cobalt chloride solution demonstrating and confirming the fact that a catalyst does not get used up in a chemical reaction.

Based on experimental findings, the following reactions can be suggested as taking place in the Co(II)-H_2O_2-tartaric acid system:

On the action of hydrogen peroxide, the cobalt(II)-tartrate complex becomes oxidized to a green, probably binuclear, Co(III)-tartrate compound. This cobalt(III)-tartrate is reduced both by tartaric acid and hydrogen peroxide to Co(II)-tartrate with a concomitant evolution of CO_2 and O_2, respectively. Since the color of the solution is green throughout the reaction, and most of the cobalt is present as Co(III), then the first step (oxidation) is most likely faster than the reduction of Co(III)-complex. (Toth, 1980).

This demonstration also allows you to demonstrate kinetics—the effect of temperature on the rate of a chemical reaction. For each 10 °C increase in temperature, the reaction rate will approximately double. The reaction may be timed at various temperatures. Suggested temperatures and their corresponding reaction times are:

50 °C—200 seconds

60 °C—90 seconds

70 °C—40 seconds

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Systems, order, and organization
Constancy, change, and measurement
Content Standards: Grades 9–12
Content Standard B: Physical Science, structure and properties of matter, chemical reactions, interactions of energy and matter

Answers to Worksheet Questions

1. Describe what happened in this demonstration. Make sure to name all the chemicals used.

Potassium sodium tartrate solution was heated to 70 °C. Cobalt chloride was dissolved in a small amount of distilled water. Cobalt chloride is pink in color. Once the potassium sodium tartrate had reached 70 °C the cobalt chloride catalyst and hydrogen peroxide were added. The solution became green in color and then it returned to pink.

2. Write a chemical equation for the decomposition of hydrogen peroxide. What evidence is there that this occurred in the reaction?

$2H_2O_2(aq) \rightarrow O_2(g) + 2H_2O(l)$

The products of the decomposition of hydrogen peroxide are oxygen, a gas, and water. The bubbling that occurred in the reaction is probably due to the oxygen bubbles from this decomposition rising through the water and the potassium sodium tartrate solution.

3. What is a catalyst? What ingredient acts as a catalyst in this experiment? What evidence supports that ingredient as a catalyst.

   A catalyst is a substance that increases the reaction rate but is not consumed in the course of the reaction. The cobalt chloride was the catalyst. The pink color of the cobalt chloride appeared again after the reaction had finished, showing that the cobalt chloride had not been consumed during this reaction.

4. Predict what would happen if the catalyst was added to potassium sodium tartrate that was heated to 50 °C instead of 70 °C?

   The reaction rate would likely decrease (take longer).

Acknowledgment

Special thanks to Jim and Julie Ealy, The Peddie School, Hightstown, NJ for bringing this demonstration to our attention.

References

Deroo, Julius, *Sci Teach.*, **1974**, *41*, 44.

Ruda, Paul T., *J. Chem. Educ.*, **1978**, *55*, 652.

Toth, Zoltan, *J. Chem. Educ.*, **1980**, *57*, 464.

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Pink Catalyst* activity, presented by Michael Heinz, is available in *Catalysis*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Pink Catalyst* are available from Flinn Scientific, Inc.

Materials required to perform this activity are available in *The Pink Catalyst—Chemical Demonstration Kit* available from Flinn Scientific. Materials may also be purchased separately.

Catalog No.	Description
AP2084	The Pink Catalyst—Chemical Demonstration Kit
C0242	Cobalt Chloride Solution, 0.1 M, 500 mL
H0028	Hydrogen Peroxide, 6%, 500 mL
P0084	Potassium Sodium Tartrate, 100 g

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.

Pink Catalyst Worksheet

Discussion Questions

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2. Write a chemical equation for the decomposition of hydrogen peroxide. What evidence is there that this occurred in the reaction?

3. What is a catalyst? What ingredient acts as a catalyst in this experiment? What evidence supports that ingredient as a catalyst.

4. Predict what would happen if the catalyst was added to potassium sodium tartrate that was heated to 50 °C instead of 70 °C?