Catalytic Decomposition of Hydrogen Peroxide

Decomposition Reactions

FLINN SCIENTIFIC CHEM FAX!

Introduction

Iron(III) chloride catalyzes the decomposition of hydrogen peroxide.

Concepts

- Kinetics
- Catalysis
- Inhibitor
- Decomposition reactions

Materials

Hydrogen peroxide solution, H_2O_2, 30%, 20 mL

Iron(III) chloride solution, $FeCl_3$, 0.1 *M*, 1 mL

Sodium phosphate solution, tribasic, $NaPO_4$, 0.1 *M*, 2 mL (optional)

Demonstration tray

Pipets, Beral-type, 2

Ring stand and buret clamp

Test tube, borosilicate glass, large, 25 × 200 mm

Safety Precautions

Hydrogen peroxide solution is a strong oxidizer and corrosive to eyes and skin. Iron(III) chloride solution is irritating to skin and eyes. Sodium phosphate is moderately toxic by ingestion and a skin and eye irritant. Use only borosilicate glass test tubes for this demonstration. Wear chemical-resistant gloves, chemical splash goggles, and a chemical-resistant apron. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.

Preparation

1. Clamp the test tube in a vertical position using a ring stand and buret clamp. Place the apparatus in the center of the demonstration tray.
2. *Optional:* Prepare 10 mL of 1 M sodium phosphate tribasic solution. Measure 3.8 g of sodium phosphate tribasic solid and mix with 10 mL of distilled or deionized water.

Procedure

1. Pour 20 mL of the hydrogen peroxide solution into the test tube.
2. Using a pipet, dispense several drops (about 1 mL) of the iron(III) chloride solution into the test tube, and observe the dark brown color change and evolution of oxygen gas. The dark brown color is evidence of a reaction intermediate. The reaction is highly exothermic. *Caution:* The reaction is vigorous and exothermic and will froth out of the top of the test tube.
3. When the reaction has proceeded completely, observe as the solution returns to the original yellow color of the iron(III) chloride solution.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures, and review all federal, state and local regulations that may apply, before proceeding. The resulting solutions may be flushed down the drain with excess water, according to Flinn Suggested Disposal Method #26b.

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Tips

- The decomposition reaction is exothermic and the test tube may become very hot. Be sure to let it cool before handling.
- Other substances that catalyze the decomposition reaction of hydrogen peroxide include iodide ions, manganese metal, manganese dioxide, yeast, and even blood.
- Adding 1–2 mL of 0.1 M sodium phosphate solution during the most vigorous part of the reaction will dramatically slow down the rate of decomposition. This is a nice demonstration of the role of an inhibitor.

Discussion

A catalyst is a substance that increases the rate of a reaction without being consumed during the reaction. The decomposition of hydrogen peroxide, H_2O_2, which was demonstrated in this lab, proceeds according to the following equation:

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g) \qquad \textit{Equation 1}$$

The rate of decomposition of hydrogen peroxide is quite slow without the addition of a catalyst. There are two ways to tell if a substance is acting as a catalyst. First, it must speed up the reaction. Second, it is not consumed in the reaction. The same amount of the catalyst can be recovered as was originally added. If it were consumed it would be a reactant and not a catalyst. In this demonstration, iron(III) chloride was used as a catalyst.

However, almost anything will catalyze this reaction, including dust particles or scratches in the glass. To prevent decomposition during shipping and to prolong shelf life, manufacturers of commercially available hydrogen peroxide frequently use an inhibitor, such as phosphate ion, to slow the decomposition process. (That is why laboratory grade hydrogen peroxide appears to be stronger and more active than store-bought hydrogen peroxide.)

When sodium phosphate is added to the catalyzed decomposition reaction in progress, phosphate ions (the inhibitor) remove iron(III) ions from the reaction. Once removed from solution by precipitation, iron(III) ions are no longer available to act as a catalyst.

$$Fe^{3+}(aq) + PO_4^{3-}(aq) \rightarrow FePO_4(s) \qquad \textit{Equation 2}$$

Inhibitors are important chemical substances and are often found in commercial products and biological systems. Antioxidants are frequently added to foods to slow the oxidation process, thus preserving the food and protecting their nutritional value. Many drugs and toxic agents are inhibitors because they block the active sites of enzymes (biological catalysts) and render them inactive.

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

Evidence, models, and explanation

Content Standards: Grades 9–12

Content Standard B: Physical Science, structure and properties of matter, chemical reactions, interactions of energy and matter

Reference

Bilash, B.; Gross, G. R.; Koob, J. K. *A Demo A Day;* Flinn Scientific: Batavia, IL, 1995; p 193.

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Catalytic Decomposition of Hydrogen Peroxide* activity, presented by Jamie Benigna, is available in *Decomposition Reactions* and in *Catalysis*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Catalytic Decomposition of Hydrogen Peroxide* are available from Flinn Scientific, Inc.

Catalog No.	Description
H0037	Hydrogen Peroxide, 30%, 100 mL
F0069	Iron(III) Chloride Solution, 1.0 M, 100 mL
AP1721	Pipets, Beral-type, Graduated
S0101	Sodium Phosphate, Tribasic, 500 g
GP6040	Test Tube, 25 × 200 mm

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