Inhibition of Hydrogen Peroxide

Introduction

The decomposition of hydrogen peroxide is first accelerated by a catalyst and then slowed down by an inhibitor.

Concepts

- Catalysts are used to increase the rate of chemical reactions.
- Inhibitors slow down or stop chemical reactions, frequently by interfering with catalysts.

Materials

Hydrogen peroxide, 30% solution, H_2O_2, 25–50 mL
Iron(III) nitrate, 0.5 M, $Fe(NO_3)_3 \cdot 9H_2O$, 1 mL
Sodium phosphate, tribasic, 0.1 M, $Na_3PO_4 \cdot 12H_2O$, 10 mL
Florence or volumetric flask, 500-mL
Pipet or dropping bottle

Safety Precautions

Hydrogen peroxide is severely corrosive to the skin, eyes and respiratory tract; a very strong oxidant; a dangerous fire and explosion risk. Iron(III) nitrate is a strong oxidizer and a skin and tissue irritant. Sodium phosphate, tribasic is moderately toxic by ingestion and a skin irritant. Wear chemical splash goggles, chemical-resistant gloves and a chemical-resistant apron. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.

Preparation

Prepare 0.5 M iron(III) nitrate (2.0 g/10 mL H_2O) and 0.1 M sodium phosphate, tribasic (3.8 g/100 mL H_2O) solutions.

Procedure

1. Pour 25–50 mL of 30% hydrogen peroxide into a clean Florence or volumetric flask.
2. Add one or two drops of iron(III) nitrate solution to the flask. The solution will quickly turn dark brown.
3. The decomposition reaction will begin to accelerate and produce enough heat to vaporize some of the water in the mixture. At this point, add about 1 mL of sodium phosphate solution. The solution will lighten in color and the reaction will come to a halt.
4. This sequence of adding catalyst [iron(III) nitrate] and inhibitor (sodium phosphate) can be repeated until the hydrogen peroxide has completely decomposed.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. Completely decompose the hydrogen peroxide using iron(III) nitrate before flushing down the drain with excess water.

Connecting to the National Standards

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

Unifying Concepts and Processes: Grades K–12
Evidence, models, and explanation
Constancy, change, and measurement
Content Standards: Grades 9–12
Content Standard A: Science as Inquiry

Publication No. 754
032417

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

Discussion

A catalyst is a substance that increases the rate of a reaction but is not consumed during the reaction. An inhibitor slows down a reaction, frequently by interfering with a catalyst.

In this reaction, hydrogen peroxide decomposes into water and oxygen gas:

$$H_2O_2 \rightarrow H_2O + 1/2O_2$$

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.)

In this demonstration, the iron(III) ion is catalyzing the decomposition of hydrogen peroxide. When the sodium phosphate is added, the phosphate ion (the inhibitor) removes the iron(III) ion from the reaction. Once removed from solution by precipitation, the iron(III) ion is no longer available to act as a catalyst.

$$Fe^{3+}(aq) + PO_4^{3-}(aq) \rightarrow Fe\,PO_4(s)\downarrow$$

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

References

George R. Gross, Union High School, Union, NJ.

Bilash, B. B.; Gross, G. R.; Koob, J. K. *A Demo A Day;* Flinn Scientific: Batavia, IL, 1995; p 192.

Materials for *Inhibition of Hydrogen Peroxide* are available from Flinn Scientific Inc.

Catalog No.	Description
H0037	Hydrogen Peroxide, 30%, 100 mL
H0008	Hydrogen Peroxide, 30%, 500 mL
F0008	Iron(III) nitrate, 100 g
S0101	Sodium Phosphate, Tribasic, 500 g
S0250	Sodium Phosphate, Tribasic Solution, 0.1 M, 500 mL

Consult the Flinn Scientific website for current prices.