Auto Accelerator

A Self-Catalyzed Reaction

Introduction

This demonstration is a rare example of auto-catalysis; that is, a catalyst for the reaction is actually one of the products of the reaction!

Concepts

- Auto-catalysis and kinetics
- Oxidation–reduction

Materials

Manganous sulfate solution, 0.1 M, $MnSO_4 \cdot H_2O$, 1 mL
Potassium permanganate solution, 0.01 M, $KMnO_4$, 100 mL
Sodium oxalate solution, 0.05 M, $Na_2C_2O_4$, 100 mL
Sulfuric acid solution, 9 M, H_2SO_4, 30 mL
Beakers, 250-mL, 2
Graduated cylinders, 100-mL, 3

Safety Precautions

Sulfuric acid solutions are severely corrosive to eyes, skin, and other tissue; considerable heat of dilution with water; even very dilute solutions are harmful to eyes and skin. Potassium permanganate solution may be a skin irritant. Sodium oxalate solution is toxic by ingestion. Manganous sulfate solution may be a tissue 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 or purchase the following solutions:

- Sulfuric acid solution, 9 M: Dilute concentrated (18 M) sulfuric acid, H_2SO_4, in a 1:1 ratio with distilled or deionized water. *Note:* Always add acid to water. This dilution generates much heat; it is recommended that it be performed in an ice bath.
- Potassium permanganate solution, 0.01 M: Dissolve 1.58 g of potassium permanganate, $KMnO_4$, in 1 L of distilled or deionized water.
- Sodium oxalate solution, 0.05 M: Dissolve 6.7 g of sodium oxalate, $Na_2C_2O_4$, in 1 L of distilled or deionized water.
- Manganous sulfate solution, 0.1 M: Dissolve 16.9 g of manganous sulfate, $MnSO_4 \cdot H_2O$, in 1 L of solution distilled or deionized water.

Procedure

1. Add 50 mL of 0.01 M $KMnO_4$ to each of two 100-mL graduated cylinders.
2. Using the third 100-mL graduated cylinder, measure out 100 mL of 0.05 M $Na_2C_2O_4$ solution into one of the 250-mL beakers. Add 30 mL of 9 M H_2SO_4 to this sodium oxalate solution. Stir to mix.
3. Divide the $Na_2C_2O_4/H_2SO_4$ solution equally into the two 250-mL beakers. (Measure using the 250-mL graduated cylinder.)
4. Add 4 drops 0.1 M $MnSO_4$ solution to one of the beakers containing the $Na_2C_2O_4/H_2SO_4$ solution.
5. Carefully pour the solutions from the beakers into the 100-mL graduated cylinders containing the $KMnO_4$ (pour one beaker into each cylinder). There will be 115 mL of liquid in each cylinder. The cylinder should be able to accommodate this volume of liquid. If in doubt, use 250-mL beakers instead of graduated cylinders.
6. Observe the reaction. The purple permanganate solution will turn clear as the permanganate ion, MnO_4^-, is reduced to the manganous ion, Mn^{2+}. Note the time needed for each reaction to occur. The catalyzed reaction, containing the

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manganous sulfate, $MnSO_4$ solution, should change color within 2–3 minutes, and the uncatalyzed reaction should take almost twice as long to change color.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. The products of this reaction can be disposed of according to Flinn Suggested Disposal Method #26b.

Connecting to the National Standards

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

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

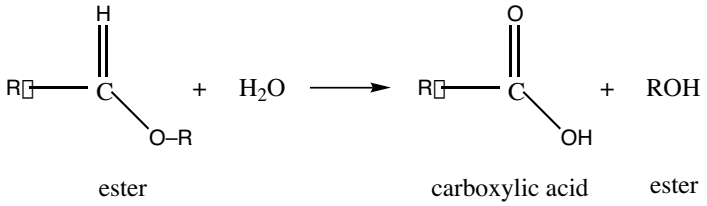
Discussion

The manganous ion, Mn^{2+}, is a catalyst for the reaction between permanganate and oxalate ions:

$$2\ MnO_4^-(aq) + 5C_2O_4^{2-}(aq) + 16H^+(aq) \rightarrow 10CO_2(g) + 2Mn^{2+}(aq) + 8H_2O(l)$$

In this reaction, the concentration of the catalyst actually increases, because the catalyst, Mn^{2+}, is one of the reaction products. This phenomenon is known as auto-catalysis.

Other examples of auto-catalysis are the hydrolysis of an ester by water, where the liberated acid acts as the catalyst, and the drying of oil-based paints, where excess oil is added to accelerate drying.



References

Bilash B.; Gross, G. R.; Koob, S. K. *A Demo a Day;* Flinn Scientific: Batavia, IL, 1995; p 235.

Summerlin, L. R., Ealy, J. L. *Chemical Demonstrations;* American Chemical Society: Washington, D.C., 1988; Vol. 2, p 156.

Materials for *Auto Accelerator—A Self-Catalyzed Reaction* are available from Flinn Scientific, Inc.

Catalog No.	Description
S0413	Sulfuric Acid Solution, H_2SO_4, 9 M, 500 mL
P0176	Potassium Permanganate Solution, $KMnO_4$, 0.01 M, 500 mL
S0094	Sodium Oxalate, $Na_2C_2O_4$, 100 g
M0149	Manganous Sulfate Solution,$MnSO_4zH_2O$, 0.1 M, 500 mL

Consult the Flinn Scientific website for current prices.