Energetic Light

Chemiluminescence

Introduction

Combine two solutions to produce a beautiful chemiluminescence that lasts approximately 10 minutes. Oxidation of luminol is enhanced by a fluorescent or sensitizer dye that prolongs the light emision.

Concepts

- Chemiluminescence
- Oxidation–reduction

Materials

"Energetic Light" solution, 500 mL*

Hydrogen peroxide solution, H_2O_2, 3%, 50 mL

Potassium ferricyanide solution, $K_3Fe(CN)_6$, 0.6%, 500 mL

**See* Tips.

Beakers, 250-mL, 2

Graduated cylinder, 10-mL

Graduated cylinder, 100-mL

Stirring rod

Safety Precautions

Hydrogen peroxide solution is an oxidizer and a skin and eye irritant. Potassium ferricyanide solution is a mild irritant. Contact with concentrated acids or heating to decomposition may liberate toxic hydrogen cyanide gas; avoid contact of potassium ferricyanide with concentrated acids or heat. 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 0.6% potassium ferricyanide solution by dissolving 0.6 g $K_3Fe(CN)_6$ in 100 mL distilled water. Add 70 mL of the 0.6% potassium ferricyanide solution and 7 mL of 3% hydrogen peroxide solution to one 250-mL beaker. Add 70 mL of the Energetic Light solution to a second 250-mL beaker. *Note:* the Energetic Light solution is very viscous.

Procedure

1. Darken the room completely.
2. While stirring with a stirring rod, add the potassium ferricyanide/hydrogen peroxide solution to the Energetic Light solution.
3. Observe the chemiluminescence. Stir the solution occasionally to prolong the light reaction.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. The resulting solution may be oxidized with household bleach as the final step in the procedure and flushed down the drain with excess water according to Flinn Disposal Method #14.

Tips

- "Energetic Light" solution contains sodium hydroxide, luminol, calcein, and a viscosity additive. Luminol is the oxidizable substrate responsible for the chemical reaction that produces light. Calcein is a fluorescent dye that acts as a sensitizer—it absorbs some of the emitted light and both enhances and prolongs light emission. The viscosity additive increases the thickness of the solution, which also tends to extend the observed chemiluminescence.
- Make sure to stir the energetic light solution while adding the 0.6% potassium ferricyanide solution. This will extend the duration of the chemiluminescence light emission.

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- Chemiluminescence is not a bright light; it is more of a glow. The darker the room, the brighter the glow will appear.

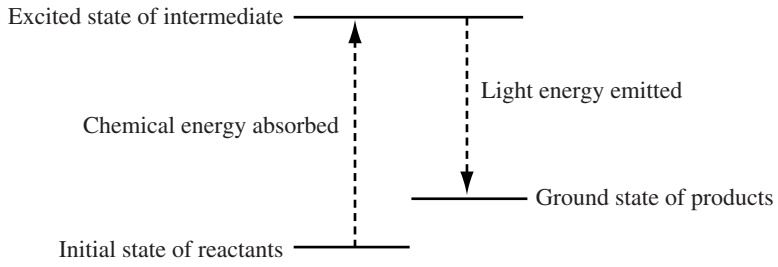
Discussion

Chemical luminescence, or chemiluminescence, is a process by which chemical energy is converted into light energy. The chemical reaction generates a product in an intermediate excited state (the electrons are at a higher energy level than in the ground state). When the electrons fall from that excited state to the more stable ground state, energy is released in the form of light.

$$A + B \rightarrow C + D^*$$

$$D+ \rightarrow D + \text{light}$$

The basic energy diagram for a chemiluminescence reaction is shown below.



Luminol is the most well-known substrate capable of chemiluminescence. Oxidation of luminol by hydrogen peroxide in the presence of an iron catalyst (potassium ferricyanide in the case of the "Energetic Light" reaction) produces the aminophthalate dianion in an excited state. Return of this intermediate to the ground state is accompanied by light emission. A base, sodium hydroxide, is required for the conversion of luminol to an anionic form prior to oxidation, and nitrogen is one of the other products of the oxidation reaction. Calcein or fluorexon present in the Energetic Light solution increases the light intensity and prolongs the light emission.

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

Content Standards: Grades 5–8
Content Standard B: Physical Science, properties and changes of properties in matter, transfer of energy

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.

Two solutions were mixed. The resulting yellow-green mixture glowed for about ten minutes.

2. In chemiluminescence, a molecule in an "excited" state (i.e., electrons are at a high energy level) is produced. The electrons in the molecule then must return to their stable state (i.e., lower energy level). Explain how this is linked to the production of light.

When an electron drops to a lower energy level, energy must be released. This energy is released in the form of light.

3. Define chemiluminescence. Give an example of chemiluminescence found in nature.

Chemiluminescence is a process in which light is produced through a chemical reaction. An example of chemiluminescence found in nature is the firefly.

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Energetic Light* activity, presented by Irene Cesa, is available in *Chemiluminescence*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Energetic Light* are available from Flinn Scientific, Inc.

Materials required to perform this activity are available in the *Energetic Light—Demonstration Kit* available from Flinn Scientific.

Catalog No.	Description
AP8978	Energetic Light—Demonstration Kit

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

Energetic Light Worksheet

Discussion Questions

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