Cool Light

Chemiluminescence

Introduction

Chemiluminescence demonstrations are popular with students and teachers alike. When light is produced without heat, that's cool!

Concepts

- Chemiluminescence
- Oxidation–reduction
- Catalyst

Materials

Hydrogen peroxide, H_2O_2, 3%, 15 mL
Luminol, 0.1 g
Potassium ferricyanide, $K_3Fe(CN)_6$, 0.7 g
Sodium hydroxide solution, NaOH, 5%, 50 mL
Water, distilled or deionized, 2000 mL
Erlenmeyer flasks, 1-L, 2
Erlenmeyer flask, 2-L
Funnel, large
Graduated cylinder, 50-mL
Ring stand and ring

Safety Precautions

Hydrogen peroxide is an oxidizer and skin and eye irritant. Sodium hydroxide solution is corrosive, and especially dangerous to eyes; skin burns are possible. Much heat is released when sodium hydroxide is added to water. If heated to decomposition or in contact with concentrated acids, potassium ferricyanide may generate poisonous hydrogen cyanide. 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

1. Prepare Solution A by adding 0.1 g of luminol and 50 mL of 5% sodium hydroxide solution to approximately 800 mL of distilled or deionized (DI) water. Stir to dissolve the luminol. Once dissolved, dilute this solution to a final volume of 1000 mL with DI water.
2. Prepare Solution B by adding 0.7 g of potassium ferricyanide and 15 mL of 3% hydrogen peroxide to approximately 800 mL of DI water. Stir to dissolve the potassium ferricyanide. Once dissolved, dilute this solution to a final volume of 1000 mL with DI water.
3. Set up the demonstration equipment as shown in Figure 1.

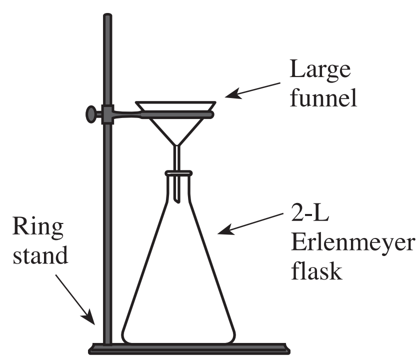

Figure 1.

Procedure

1. Turn down the lights. The room should be as dark as possible.
2. Recruit a volunteer or second presenter. Together, pour Solution A and Solution B into the large funnel simultaneously. As the two solutions mix, chemiluminescence begins.
3. As the reaction progresses, it can be enhanced by adding small amounts of potassium ferricyanide and 5–10 mL of 5% sodium hydroxide solution into the flask.

Disposal

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

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Tips

- This demonstration is especially appealing if it is set up so the students can see the mixture through spiraling clear plastic tubing. Simply follow the directions for setup at the end of these instructions. This type of apparatus gives a large surface area for light to be emitted and also provides a flowing effect along with the luminescence, thus increasing the overall visual impact.
- Another means of displaying luminol's luminescence is to take the two solutions (A and B above), place them in spray bottles, and spray them, creating a luminescent cloud. The key to this procedure is to get the solutions into as fine a mist as possible. *Caution:* Do not spray the solutions toward anyone or in a manner in which they can be easily inhaled.
- Use only distilled or deionized water when preparing the solutions. Hard water and softened water contain high con centrations of ions (such as chloride ions) that may interfere with the excited state of the luminol and prevent chemilu minescence.

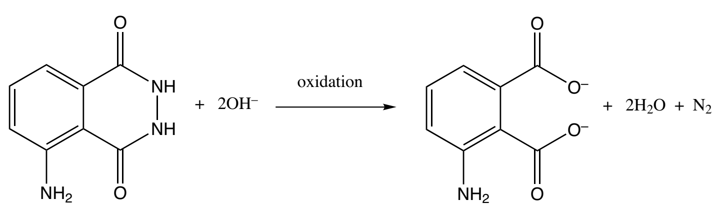
Discussion

Chemiluminescence is defined as the production or emission of light that accompanies a chemical reaction. Light emission results from the conversion of chemical energy into light energy due to changes in the composition of a chemiluminescent material. The "flame test" colors observed when different metal salts are burned in a Bunsen burner flame are examples of a type of chemiluminescence known as pyroluminescence. The glow of solid phosphorus in air is another classic example of chemiluminescence—light, along with some heat, is produced when the phosphorus undergoes an oxidation reaction. The oxidation of luminol (3-aminophthalhydrazide) in this demonstration illustrates a type of "cool light" chemiluminescence in which little or no heat is produced.

The light-producing chemical reactions of luminol were discovered by H.O. Albrecht in 1928. Since that time numerous procedures have been developed to produce light using luminol. Experiments have shown that the following "ingredients" are necessary for luminol to exhibit chemiluminescence—a basic (alkaline) pH, an oxidizing agent, and a catalyst. In this demonstration, the oxidizing agent is hydrogen peroxide, the catalyst is the iron(III) cation in potassium ferricyanide, and sodium hydroxide is used to maintain the basic pH needed for the reaction to occur.

Oxidation of luminol and the resulting chemiluminscence occurs in the following sequence of reactions:

- Sodium hydroxide acts as a base and converts luminol (structure I) into a dianion.
- Hydrogen peroxide oxidizes the dianion form of luminol to the aminophthalate ion (structure II), which is produced in an excited electronic state. Nitrogen gas is also released in this reaction.
- The excited aminophthalate ion decays to a lower energy ground state and gives off light in the process. The emitted light has a wavelength of 425 nm, which is in the blue region of the visible spectrum.



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The "Cool Light" demonstration has value not only for the obvious reason of demonstrating chemiluminescence, but also to show the effects of a catalyst, pH, and temperature on a reaction, as well as how reaction rates are affected by concentration.

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 poured through a large funnel simultaneously. The mixture of the two solutions began to glow.

2. Oxidation is necessary for luminol to luminesce. The chemicals used in this experiment were 5% sodium hydroxide, 3% hydrogen peroxide, and potassium ferricyanide. Which of these do you think served as the oxidizing agent?

   Hydrogen peroxide was the oxidizing agent in this demonstration.

3. 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.

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

   Chemiluminescence is a process in which light is produced through a chemical reactions. An example of this that is found in nature is the firefly.

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

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

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

Materials required to perform this activity are available in the *Cool Light—Demonstration Kit* available from Flinn Scientific. Materials may also be purchased separately.

Catalog No.	Description
AP8627	Cool Light—Demonstration Kit
L0078	Luminol, 5 g
S0074	Sodium Hydroxide, 100 g
P0050	Potassium Ferricyanide, 100 g
H0009	Hydrogen Peroxide, 3%, 500 mL
GP9155	Erlenmeyer Flask, Borosilicate Glass, 2-L

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

Cool Light Worksheet

Discussion Questions

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