Fountain of Light

A Two-Color Demonstration of Chemiluminescence

FLINN SCIENTIFIC CHEM FAX!

Introduction

A mixture of solutions first glows red and then amidst vigorous frothing and evolution of heat, an eerie blue glow appears.

Concepts

- Chemiluminescence
- Oxidation reactions

Materials

Sodium hydroxide, NaOH, 0.8 g

Luminol, $C_8H_7N_3O_2$, 0.005 g

Potassium carbonate, K_2CO_3, 25.0 g

Pyrogallol (pyrogallic acid), 1.0 g

Formaldehyde, 37%, 10 mL

Hydrogen peroxide, 30%, 25 mL

Beaker, 250-mL

Graduated cylinder, 250-mL

Graduated cylinder, 100-mL

Graduated cylinder, 10-mL

Shallow pan or 2-L beaker to catch overflow

Gloves (plastic or rubber)

Safety Precautions

Formaldehyde is an alleged carcinogen and a strong irritant. Avoid inhalation of vapors and skin contact. Hydrogen peroxide is a very strong oxidant. Avoid direct skin contact. Sodium hydroxide is a corrosive solid. Pyrogallol is toxic by inhalation, ingestion, and skin absorbtion. Avoid all contact with body tissue. Wear chemical-resistant gloves, chemical splash goggles and a chemical-resistant apron while preparing and performing this demonstration. A fume hood or well-ventilated area is a must. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information.

Flinn strongly recommends against the use of glyoxol or any other formaldehyde alternative as a substitute to formaldehyde in this demonstration. Violent reactions can result.

Preparation

To prepare the Fountain of Light solution, measure 40 mL of distilled water into a 250-mL beaker. In the hood or well-ventilated area, add 0.8 g sodium hydroxide. Stir to dissolve. Add 0.005 g luminol and 1.0 g pyrogallol and stir to dissolve.

Procedure

1. Add 25.0 g potassium carbonate to the Fountain of Light solution. Stir to dissolve.
2. Add 10.0 mL of 37% formaldehyde. Stir. Transfer solution to a 250-mL graduated cylinder.
3. Place the cylinder in a 2-L beaker or shallow pan. *Note:* This demonstration is very messy; clear the surrounding area.
4. To perform the demonstration, turn off the lights. With the room completely darkened, add 25 mL of 30% hydrogen peroxide. Do not stir. Stand back and observe the incredible two-color chemiluminescence!
5. The mixture glows dull red for a few seconds, turns bright blue and then foams vigorously. This is an exothermic 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 disposed of according to Flinn Suggested Disposal Method #26b.

Tips

- Room must be completely dark.
- Dull red color is not visible unless room is completely dark and only appears for 1–2 seconds.

- Make sure both the 30% hydrogen peroxide and luminol is fresh.
- If your balance does not measure 0.005 g, mass out 0.01 g and then divide approximately in half.

Discussion

Chemical luminescence (chemiluminescence) is a process by which the energy of a chemical reaction is converted into light energy. The generation of light is typically associated with thermal reactions such as incandescence or the study of atomic spectra. In cases of chemiluminescence, light is actually a product of the reaction taking place.

Light is produced when electrons drop from an excited or high energy level to a stable, or lower energy level. The wavelength of the light produced is directly related to the energy difference between the two energy levels. Because this is a distinct energy difference, only specific wavelengths are produced by a particular element. In chemiluminscence, a reaction produces a molecule that is in an excited state. As the electrons in this molecule return to their ground state, energy is released in the form of light, usually a characteristic light based on the energy difference.

In this demonstration, two different chemiluminescent processes are occurring. The initial red glow is due to singlet oxygen that is produced during the oxidation of pyrogallol and formaldehyde by the alkaline hydrogen peroxide. Singlet oxygen is oxygen in an excited state due to one of its electrons being in a higher-energy orbital. As this electron drops back down to its ground state, red light is emitted.

The blue glow is caused by the subsequent oxidation of luminol. This reaction does not begin until the red glow from the singlet oxygen has disappeared, and is accompanied by significant frothing. This suggests that the singlet oxygen is not responsible for the oxidation but rather it is caused by some subsequent reaction intermediate. The frothing is caused by production of CO_2, H_2, and O_2 from the initial hydrogen peroxide decomposition and oxidations.

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 A: Science as Inquiry
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, chemical reactions

Reference

Shakhashiri, B. Z. *Chemical Demonstrations: A Handbook for Teachers in Chemistry;* University of Wisconsin: Madison; 1983; Vol. 1, pp 175–179.

Materials for the *Fountain of Light* demonstration are available from Flinn Scientific, Inc.

Catalog No.	Description
F0074	Formaldehyde, 37%, 100 mL
L0031	Luminol, 1 g
P0206	Pyrogallol, 10 g
S0074	Sodium hydroxide, 100 g
H0008	Hydrogen peroxide, 30%, 500 mL
P0038	Potassium carbonate, 500 g
AP8926	Fountain of Light—Chemical Demonstration Kit

Consult the Flinn Scientific website for current prices.