Encouraging **T**omorrow's **C**hemists

Illuminating Chemistry

I. Introduction

Artificial, or man-made, light takes a great many forms depending on its applications. Two of the most important are fire and incandescent light bulbs. Electric light bulbs glow because current flows through the filament, heating it to high temperatures. The filament glows resulting in the emission of light across the entire visible spectrum. This is termed blackbody radiation, which is light produced by heating objects to high temperatures (ex. charcoal briquettes, the sun, candles, etc.)

What sources of light can one think of? Are there any differences in the color or intensity?

Another way to generate light is to do so chemically rather than using heat. This is why most chemical light systems are termed "cool-light" or "cold luminescence." These chemical luminescence systems exist in nature (fireflies, deep-deep sea fish, certain rocks, etc.) Chemists have studied these systems and many can be reproduced in our labs.

This lab will introduce three major ways to generate chemical light: phosphorescence, fluorescence, and chemiluminescence. These chemical light systems require two things in order to work:

1. an energy source
2. a special molecule that accepts the energy (gets excited) and relaxes by giving off that energy as light.

While doing this lab, try to identify what sources of energy are is in each experiment.

II. Objectives

1. See light generated in ways other than by electricity.
2. Recognize that phosphorescence, fluorescence, and chemiluminescence are different and be able to distinguish them.
3. Be able to recognize real life applications of these chemical light systems.

A. Phosphorescence and fluorescence

Most are familiar with phosphorescence from experiences with glow-in-the-dark Frisbees or cereal-box toys or stars on bedroom ceilings. You will see an example of this phenomenon.

Draw a line with pencil to divide the filter paper into two halves. Label one side A, one side B.

Place a few (<3) drops of solution A on the appropriate side. Evaporate the solvent by placing the paper on the hot plate (careful not to burn the paper). Shine the UV lamp on the spot in the dark. *What color is observed? How long those the color persist after removing the UV light?*

Repeat this series of experiments and observations with solution B. *What similarities/differences are observed?*

From these, you should now be able to distinguish between phosphorescence and fluorescence for other compounds.

Quinine is a compound that gives tonic water its bitter taste. Observe tonic water under UV light. Remove the light and note any observations. *Is this phosphorescence or fluorescence?*

Observe tap water under the UV light. Add a single drop of fluorescein to the water and repeat the experiments. *What is observed before UV light, during, and after the UV lamp is removed? Is this phosphorescence or fluorescence?*

What is the energy source for phosphorescence and fluorescence?

B. Chemiluminescence

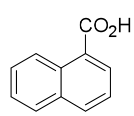
Chemical light can also be produced as a result of a chemical reaction. This phenomenon is used in a number of scientific fields, particularly in the detection of metal in samples (drinking water), antibodies in human fluids, and pollutants in environmental systems. You will observe two of these that are known to occur in the lab.

Luminol is known to react with hydrogen peroxide in basic solutions. Pour the vial of luminol solution (5 mL, buffered pH 12) into the hydrogen peroxide solution (5 mL). *What do you observe?*

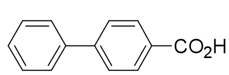
Singlet oxygen is a more excited form of molecular oxygen that can be produced by certain chemical reactions, and it is known to release light. Fill a syringe with about 0.5 mL bleach and add it quickly to the other hydrogen peroxide solution. *What is observed?*

Compare the two chemiluminescence systems that were used (color, intensity, how long the light persists, etc…)

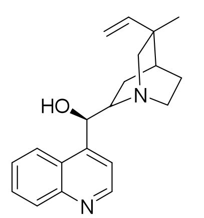
Other examples that they may know about:
"sparks" from wintergreen Lifesavers
blue light when Curad bandage wrappers are peeled apart in a dark room
"glow sticks"



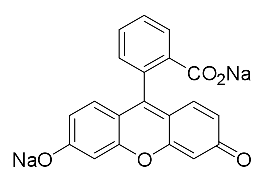
1-Naphthoic acid (**A**)



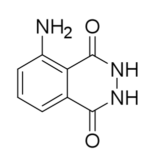
4-Biphenylcarboxylic acid (**B**)



Quinine



Fluorescein



Luminol

Reference: Shakhashiri, B. Z. Chemical Demonstrations: A Handbook for Teachers of Chemistry, Vol. 1, Madison, WI: The University of Wisconsin Press, 1983.

My hints and suggestions:

1. Have them always wear goggles.
2. Be sure that they are careful with the bleach (obvious reasons) and the singlet oxygen H_2O_2 solution. It will burn.
3. The singlet oxygen experiment can actually been done over and over simply by adding more bleach. It can be tough to see, so they can try more than once if needed.