Photonic Phosphorescence

Phosphorescence

FLINN SCIENTIFIC CHEM FAX!

Introduction

Explaining concepts such as the photoelectric effect and the Planck relationship between energy and frequency of photons is made much easier with a concrete demonstration. Here, phosphorescent zinc sulfide is used to demonstrate the energy difference between red and blue photons of light.

Concepts

- Electromagnetic spectrum
- Phosphorescence
- Quantum nature of light
- Photoelectric effect

Materials

Aluminum Foil, ~1' × .5' sheet, 2
Zinc sulfide, phosphorescent, ZnS, ~10-20 g
Water, tap, 20 mL
Compact disk
LED micro light, blue
LED micro light, red
LED micro light, white
Phosphorescent vinyl sheet (optional)
Reaction vials with caps (or test tubes with stoppers), large, 2

Safety Precaution

Although this demonstration poses little hazard, zinc sulfide will produce toxic hydrogen sulfide gas when exposed to acid. 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 two vials or test tubes by measuring approximately 5–10 g of ZnS and placing it in the vial. *Note:* The exact amount is not critical as long as the zinc sulfide is 1–2 cm high.
2. Fill the vial with tap water, and cap tightly.
3. Cover the container in aluminum foil to ensure no light reaches it.

Procedure

1. Show the LED lights to the class and ask them to state which frequency contains more energy.
2. Select two students as volunteers, and turn out the lights.
3. Have each student remove the vial from the foil and simultaneously shine his or her light into the vial for 10–20 seconds. It is important that the amount of time each student illuminates the vial is identical.
4. After time is up, have each student turn off their light and hold up each vial. A marked difference in phosphorescence can be seen.
5. Ask students to predict what will happen if white light is exposed to the vials.
6. Have a student volunteer expose the red LED vial to white light for the same time interval as before. After exposure, remove the light source and observe the increased phosphorescence.
7. Using the CD, successively shine the blue and red LEDs onto the CD-ROM. Notice no dispersion of color from either LED.
8. Shine the white light onto the CD-ROM. The reflective grating properties of the disk will split the white light into its component colors.
9. Optional: In the dark, remove the Phosphorescent Vinyl sheet from its package. Draw on it with first the red and then

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the blue LED micro light, further demonstrating the difference between the energy in red and blue light.

Discussion

The process of light emission, phosphorescence, occurs when electrons in material such as zinc sulfide are promoted to a higher electronic state and then relax at a later time. The primary distinction between phosphorescence and fluorescence depends on this time interval, as fluorescent materials immediately relax after excitation, while phosphorescent materials will relax at a slower rate, allowing the substance to emit photons for a significant time after initial excitation.

A particular energy threshold is needed to excite the phosphorescent material. In this demonstration, the red LED light does not provide enough energy per photon to initiate phosphorescence, while the blue light is well above the excitation threshold. The use of the CD-ROM allows students to see that the red and blue LEDs are not a mixture of colors as these lights emit in a very narrow frequency range. In contrast, the white microlight provides the full spectrum of color, as indicated by the dispersion of the frequencies on the CD grating and the fact it excites the zinc sulfide. This demonstration can provide concrete evidence of the energy dependence on frequency for light and can be used as a method to motivate any experiment that may initially seem counterintuitive using classical light theory. In particular, understanding of the photoelectric effect is immediate, as the results of the experiment are easily explained with this analogy.

Disposal

The vials may be reused from year to year, provided they are wrapped in foil and stored in the dark. Otherwise, filter or decant the zinc sulfide and dispose of according to Flinn Suggested Disposal Method #26a.

Connecting to the National Standards

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

Unifying Concepts and Processes: Grades K–12
- Systems, order, and organization
- Evidence, models, and explanation

Content Standards: Grades 9–12
- Content Standard A: Science as Inquiry
- Content Standard B: Physical Science, structure of atoms, structure and properties of matter, interactions of energy and matter

Acknowledgment

This demonstration was first given by Pamela K. Funjinaka of the Iolani School in Honolulu at a Flinn Foundation Workshop at Texas Wesleyan University in the summer of 2002. She attributes it to a commercial vendor at ChemEd 2001. The addition of the CD and white light source was the idea of Michael Heinz.

Flinn Scientific—Teaching Chemistry ™ eLearning Video Series

A video of the *Photonic Phosphorescence* activity, presented by Michael Heinz, is available in *Phosphorescence*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Photonic Phosphorescence* are available from Flinn Scientific, Inc.

Materials to perform this activity are available from Flinn Scientific, and may be purchased separately.

Catalog No.	Description
Z0015	Zinc Sulfide, Phosphorescent, 25 g
A0019	Aluminum Foil, 12" wide × 25" long Roll
AP9106	Reaction Vials, 2-Dram, Teflon-Lined Caps, Pkg/12
AP4794	Phosphorescent Vinyl Sheet

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