Phosphorescence with LED Micro Lights

Introduction

Use phosphorescent vinyl to demonstrate the difference in energy between the blue and yellow wavelengths of light emitted from LED micro lights.

Concepts

- Phosphorescence
- Energy levels
- LED (Light Emitting Diode)

Materials

Flashlight or other light source
LED micro light, yellow
LED micro light, blue
Phosphorescent vinyl sheet, 12″ × 12″

Safety Precautions

Although this activity is considered nonhazardous, please follow all laboratory safety guidelines. Wash hands thoroughly with soap and water before leaving the laboratory.

Procedure

1. In the dark, remove the phosphorescent vinyl sheet from its package.
2. Shine a flashlight or other light source on the phosphorescent vinyl sheet. Observe the emission of light (phosphorescent glow) induced by visible light, which is all wavelengths or colors.
3. Take the yellow LED micro light and shine it on the sheet. Observe that there is no glow.
4. Take the blue LED micro light and shine it on the sheet. Observe the phosphorescence.
5. Discuss the difference in wavelength and energy between yellow and blue light. Which is higher energy? What is the minimum energy needed for phosphorescence?

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures, and review all federal, state and local regulations that may apply, before proceeding. The materials may be stored for future use or placed in the trash 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
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 Standard E: Science and Technology
Content Standards: Grades 9–12
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, structure and properties of matter, interactions of energy and matter
Content Standard E: Science and Technology

Publication No. 10978
061616

Tips

- Please visit our Web site (www.flinnsci.com) to see video packages from the Flinn Scientific "Teaching Chemistry" eLearning Video Series. *Day in the Dark Demonstrations with Jamie Benigna* and *Phosphorescence* both explore the principles of chemiluminescence as well as use LED lights to demonstrate phosphorescence.
- The phosphorescent vinyl sheet has an adhesive backing and can be used as phosphorescent tape. It can also be easily cut into letters, shapes or smaller pieces with scissors.
- Store the phosphorescent vinyl sheet in a dark envelope or some other container that protects it from light. This will lengthen the life of the phosphorescent material in the sheet.

Discussion

Phosphorescence, also known as "glow-in-the-dark," is the process of light emission that occurs when electrons that have been promoted to a higher energy level or state return ("relax") back down to the ground state at a later time. The time interval between when the electrons are excited and when they relax is the primary difference between phosphorescence and other types of luminescence, such as fluorescence. While fluorescent materials return immediately to the ground state following excitation, phosphorescent materials relax at a slower rate. This allows for light to continue to be emitted even after the exciting source has been removed. This is sometimes referred to as the "afterglow."

In both phosphorescence and fluorescence, a light source is shined on the material, and a photon is absorbed. The energy from the photon is transferred to an electron that makes a transition to an excited electronic state. From this excited state, the electron naturally wants to relax back to its ground state. This relaxation process varies depending on whether the material is fluorescing or phosphorescing. In phosphorescence, the excited electron makes a series of transitions to return to the relaxed ground state. It first makes a slow transition to a second excited state very close in energy to the initial excited state. From this second excited state, the electron makes the transition down to a lower energy level and emits a photon in the process. The characteristic afterglow of phosphorescence is due to the delayed emission that occurs as a result of the slow transition between the first two excited states.

This demonstration uses yellow and blue LED micro lights to show the relationship between the color or wavelength of light and its energy. A minimum light energy is needed to overcome the energy threshold of a material and initiate phosphorescence. The yellow LED has a lower energy and is unable to cause the material to phosphoresce. In contrast, the blue LED has a high enough energy that it is able to cause phosphorescence. A Light Emitting Diode (LED) consists of a negatively charged semiconductor bonded to a positively charged semiconductor. The negative semiconductor has an excess of electrons, whereas the positive semiconductor lacks electrons and has holes where those electrons should be. When a current is applied to the diode by connecting the positive side of a battery to the positively charged semiconductor and the negative side of a battery to the negatively charged semiconductor, the electrons move to fill in the holes on the positively charged semiconductor. When these electrons are freely moving around they are in the conduction band, which is outside the valence band and therefore beyond the electric field of the atom. As the excited electrons move through the conduction band they fall into the holes in the positively charged semiconductor. This drop from the excited conduction band to a lower orbital causes the release of a photon; and the larger the drop, the higher the energy of the photon. A higher energy photon emits a higher frequency of light. According to Planck's Law, the energy of light is directly proportional to the frequency and inversely proportional to the wavelength.

In this demonstration, the blue LED light is an example of higher energy light and the yellow LED light is lower in energy. This means that the distance the electron drops is greater in the blue LED than in the yellow LED, which in turn means that the photons released by the blue LED are at a higher energy level than the yellow. These photons excite the electrons on the phosphorescent vinyl sheet, which then relax at a delayed rate causing the glow we call phosphorescence.

Acknowledgment

Special thanks to Jamie Benigna and Mike Heinz for providing the idea and the instructions for this activity to Flinn Scientific.

Materials for *Phosphorescence with LED Micro Lights* are available from Flinn Scientific, Inc.

Catalog No.	Description
AP7335	LED Micro Light, Yellow
AP7336	LED Micro Light, Blue
AP4794	Phosphorescent Vinyl Sheet, 12″ × 12″

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