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Invisible rays: our extraterrestrial enemies?

Detecting UV radiation in our environment

AIM

Detect exposure levels to environmental UV-radiation, identify factors that influence it and how to reduce UV exposure.

EQUIPMENT AND MATERIALS

Required by each student or working group:

UV sensitive beads

Other suggested materials:

Sunscreen
Cardboard box and empty milk carton (or other reflective surface)
Assorted glass and plastic plates or containers, sunglasses
Assorted household light bulbs (incandescent, fluorescent, etc)
Black light source
Digital camera
Different color clothes

INTRODUCTION

The sun radiates energy over a broad spectrum of wavelengths. The human eye is sensitive to wavelengths of light from about 400 nanometers, or nm (violet light) to about 700 nm (red light). Light with a wavelength shorter than 400 nm is called ultraviolet light or ultraviolet radiation and is invisible to our eyes. However, UV radiation is responsible for sunburn and other adverse health effects, which range from premature aging of the skin, to serious eye damage and cancer. Fortunately for life on Earth, our atmosphere's stratospheric ozone layer shields us from most UV radiation. What gets through the ozone layer, however, can still cause problems, particularly for people who spend substantial time outdoors. Because of these serious health effects, you should protect yourself when outdoors and limit your exposure to this invisible enemy.

Photochromism is defined as the reversible interconversion of a chemical species between two states with different absorption spectra. This change is usually brought about by absorption of light, in particular UV light. One of the mechanisms of

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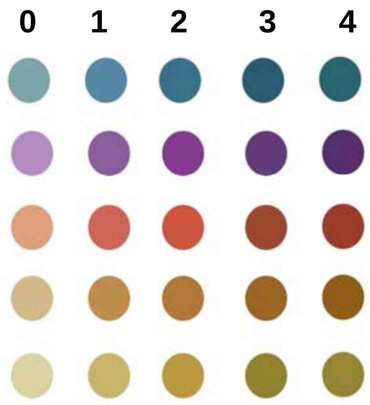
photochromism is reversible photodimerization. Photochromic molecules can belong to various classes: triarylmethanes, stilbenes, azastilbenes, nitrones, fulgides, spiropyrans, naphthopyrans, spiro-oxazines, and others. For example, the spiro form of an oxazine is a colorless dye. After irradiation with UV light, a carbon-oxygen molecular bond within this compound is interrupted leading to the formation of a conjugated system, with ability to absorb photons of visible radiation, and therefore appear colorful. When the UV source is removed, the molecules gradually relax to their ground state, the carbon-oxygen bond renews and the molecule returns to its colorless state. Photochromic dyes usually have the appearance of a crystalline powder and can be incorporated into a polymer matrix with a stabilizer, resulting in the production of a UV sensitive material. Usually, four basic photochromic colors (magenta, cyan, yellow, black) are available commercially and other colors can be made by their combinations. The rate of change upon exposure to UV varies by color. Photochromic dyes can cycle thousands of times between the colorless and colored form depending upon the application. One of the most famous reversible photochromic applications is color changing lenses for sunglasses, as found in Transitions® eye-glasses. In this procedure, we use the reversible photochromics properties of commercially available plastic beads to explore the levels of the invisible UV rays in our environment and identify substances that can filter them. Note that the UV beads are extremely sensitive to all UV wavelengths, including UVA radiation (315-400 nm) such as the one emitted by black light bulbs and some lamp bulbs, which do not have any significant health effects.



PROCEDURE

1. If required, mount the experimental setup (see suggestions below). Each student may arrange his/her beads in a bracelet to perform all experiments.
2. Expose your UV beads to sunlight or other radiation source for 5 minutes.
3. Register the color change observed from 0 to 5 by using the color guide provided below or by taking a picture. Results can be plotted in a graph for better visualization.
4. Discuss the results obtained.

Suggested experimental setups

I. Sun, shadow and reflection

- expose the beads to direct sunlight or in the shadow and register color intensity; set up different shadow conditions using plain cardboard or cardboard coated with a reflective surface;

II. UVs throughout the day

- expose the beads to direct sunlight at different hours of the day and register color intensity;

III. Filtering UVs

- expose the beads to sunlight through different glass, plastic or other materials (like T-shirts with different colors) and register bead color intensity;

IV. Sunscreen

- place the beads in a plastic bag and spray with different sunscreen lotions; expose the beads to direct sunlight and register color intensity;

V. Domestic UV light sources

- expose the beads to different household lamps and register color intensity;

SAFETY GUIDELINES

This protocol poses no safety concerns.

PREPARATION AND TIMING

This procedure does not require any beforehand preparation by the teacher. Experimental set ups and observations can be performed in few minutes in a classroom setting or independently by the students, if they are allowed to take their bead bracelets home. However, important information will be gained by repeating experimental observations at different times of the day or on different days.

SCOPE FOR OPEN-ENDED INVESTIGATIONS

In this procedure some experimental settings to explore environmental UV radiation levels and UV filtering are suggested, but many more may be performed – students should be stimulated to formulate their own questions and design adequate experimental settings to perform them. For example: do UV levels change throughout the year? Do they differ with latitude? (suggest online collaboration between students from schools in Southern and Northern Europe); etc

ETHICAL AND OTHER CONCERNS

This protocol poses no ethical or other concerns.

SUPPLIERS

Beads can be acquired online from several science education material suppliers such as www.hos.se , www.stevespanglerscience.com or http://www.sciencekit.com/default.asp.

STORAGE OF MATERIALS

UV sensitive beads should be stored in the dark. Beads retain the ability to change color about 50 000 times.

WEBSITES:

http://www.epa.gov/sunwise/

http://ds9.ssl.berkeley.edu/LWS_GEMS/index.htm

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