



Invisible Rays

Investigating the electromagnetic spectrum using ultraviolet beads.

Try this!

1. The light we see with our eyes is only one small part of the complete range of light (the “electromagnetic spectrum”). Can you guess how we know there are other types of light?

2. Our eyes are only sensitive to visible light. Other things, however, are sensitive to other kinds of light, and we can use those things as tools (“sensors”) to investigate the light we can’t see.
3. Look at the plastic beads inside your classroom. What color are they?

4. Take the beads outside into the sunlight. What color(s) are they now?

5. Something about the beads changed when you put them in the sunlight. The beads are acting as a sensor for a type of light that comes from the sun but doesn’t come from the lights in your classroom, called ultraviolet or UV light. This is the type of light that gives you a suntan, or a sunburn if you aren’t careful.
6. Put the beads in various see-through containers, and use them as sensors to figure out which containers let UV light through and which don’t.

Container	Lets UV Light Through?



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CA Science Content Standards

Grade 7, Standard 6a – electromagnetic spectrum

Grade 7, Standard 6e – how color is perceived

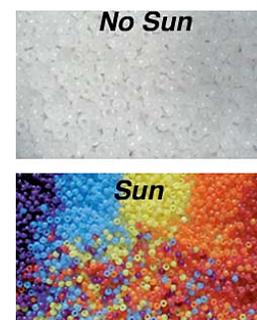
Grade 7, Standard 6f – light can be reflected, refracted, transmitted or absorbed by matter

Materials

- UV beads (or other UV-sensitive materials)
- Various transparent plastic or glass containers (plastic bags, soda bottles, glass jars, etc.)

What's going on?

The UV beads contain different pigments that change color when exposed to ultraviolet light from any source including the sun. The beads are mostly transparent in visible light. In UV light, depending on the pigment added to each bead, you will see different colors. The dye molecules have two branches that are orthogonal to each other, and due to their small size do not absorb visible light. As UV light is added, the two branches align parallel to each other, which creates a structure that absorbs part of the visible light and makes the bead appear colored. Depending on the length of these branches, different colors will be absorbed so the beads appear different colors. When UV light is no longer present, the branches return to their relaxed positions and the beads become transparent again. Each bead will change color about 50,000 times before the pigment will no longer respond to UV light.



The term "light" is often used as a generic word to describe many different forms of light such as incandescent light, fluorescent light, or sunlight, for instance. However, not all light waves carry the same energy. Using UV beads, you will be able to uncover an invisible form of light called ultraviolet light. Just as there are many different colors of wavelengths in the visible spectrum (red, yellow, green, blue, etc.), so are there many wavelengths of ultraviolet light. None of the light in the ultraviolet region of the spectrum is visible to the naked eye.

First, there is long wave ultraviolet light (300 to 400 nanometers), which most of us recognize as "black light" the light that is often used to make decorations glow in discos and theatrical productions. Long wave UV passes easily through plastic and glass.

Short wave ultraviolet light (100 to 300 nm) is used to kill bacteria, hasten chemical reactions (as a catalyst), and is also valuable in the identification of certain fluorescent minerals. Unlike long wave UV, the short wave UV cannot pass through ordinary glass or most plastics. The shortest wavelengths cannot even travel very far through the air before being absorbed by oxygen molecules as they are converted into ozone.

UV beads are the perfect tool for understanding how solar radiation can be harmful and to recognize preventative measures that can be taken to reduce the risks associated with exposure to sunlight. When you expose bare skin to sunlight, your skin will either burn or tan (which doctors warn is still not healthy for your body). UV radiation carries enough energy to break chemical bonds in your skin tissue and with prolonged exposure, your skin may wrinkle or skin cancer may appear. These responses by your skin are a signal that the cells under your skin are being assaulted by UV radiation.



Extensions

You can engage students in further investigations of UV light:

- Ask students to investigate the effects of sunscreen on the beads. Place the beads in several containers that allow UV light to penetrate. Then coat the containers with sunscreens with different sun protection factors (SPF). Students can qualitatively rate the brightness of the bead colors in each container, or quantitatively rate the time until the beads reach their full intensity color. Some sunscreens actually contain zinc or titanium dioxide nanoparticles as sunblocking ingredients. Similar to the pigments in the UV beads, which will absorb a certain color of light, the nanoparticles will absorb the harmful UV light and therefore protect the skin from being burned.
- Ask students to investigate sources of UV light. Use the beads to determine the amount of UV light that is produced by: incandescent bulbs, compact fluorescent bulbs, regular fluorescent bulbs, black lights, candles, Bunsen burners, etc.
- Ask students to investigate whether UV light reaches the Earth on cloudy days. This is an excellent lesson in why it is important to use sunscreen even on cloudy days.
- Ask students to test various pairs of sunglasses for UV protection. Place small piles of beads behind different pairs of sunglasses and see which ones actually protect the bead (and, by extension, your eyes) from UV light.

Credits

The Center for Probing the Nanoscale (CPN) at Stanford University is supported by the NSF under award PHY-0425897. For more information and other activities, visit <http://cpn.stanford.edu>.

What's Going On text adapted from Steve Spangler Science. Retrieved on July 9, 2009 from <http://www.stevespanglerscience.com/content/experiment/00000118>.

Image of UV beads from Educational Innovations, Inc. Retrieved on July 10, 2009 from <http://dwb4.unl.edu/Chem/CHEM869M/CHEM869MMats/UVdetecting.html>.

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