NREL/MK-6A42-76590
April 2020

NRELEd: To Fluoresce or Not to Fluoresce: That is the Question!

Developed by Melissa Gish, NREL SERF, Ann Greenaway, NREL SERF, Meghan Pearson, NREL Education Center

Background

Consider the rainbow for a second. It is a beautiful arc of colors in the sky that appears when there is both sunshine and rain, but why does it happen? It turns out, every time scientists try to understand light, they are often left with more questions. Isaac Newton tried to understand light and why people see color. Albert Einstein discovered that light acts as both a wave and a particle. Jan Ingenhousz discovered that plants need light for a reaction called photosynthesis.

All objects are constantly absorbing and reflecting light. Reflected light allows us to see colors. For example, we can see the difference between a red car and a blue car because a red car reflects back red light and a blue car reflects back blue light. However, not all light is reflected. If every object reflected all the colors, everything would look white! This lab actually explores the colors that are absorbed. Even though we cannot see absorbed colors, these light-wave particles still do a lot of work on the object they are hitting. Some objects have special properties that allow us to see that work!

Photons, Fluorescence, and Having Fun!

*Have you ever wondered what makes highlighters so bright? Why does a yellow highlighter look different on a page than a yellow marker? It's all about **fluorescence**. Fluorescence occurs when an object or substance absorbs a shorter wavelength (high energy) and emits a longer wavelength (lower energy).*

What You Need:

- Highlighters* (the more colors, the more options)
- A clear drinking glass for each highlighter
- Red, green, and blue laser pointers
- Water
- Protective goggles (optional)

*This activity will ruin the highlighters, so do not choose your favorites.

Procedure

1. Fill each glass with water and place the highlighter, tip down, to soak overnight.
2. Choose the blue laser. Shine it through each of the highlighter-water glasses, one at a time. Look down through the top of the glass.

What do you notice? What colors do you see? Does the blue laser look the same in each of the glasses?

3. Repeat the process with the green and red laser.

What did you notice with the green laser? What did you notice with the red laser?

The Science:

Before NREL was a national lab, it was SERI, the Solar Energy Research Institute. As the name suggests, the lab focused on solar energy. Many of the buildings on NREL's campus still focus on solar energy and how to better capture that energy. These buildings include the Solar Energy Research Facility (SERF), the Solar Radiation Research Laboratory (SRRL), the Science and Technology Facility (S&TF), the Outdoor Test Facility (OTF), and others. Melissa Gish and Ann Greenaway are researchers in the SERF. One area of focus for solar research is what happens when electrons become excited in a solar cell, and how all the energy can be captured.

What is an atom?

An atom is the basic building block of elements. These elements form together in different compounds to make up everything we can see. For example, humans are mostly made up of the elements carbon, hydrogen, oxygen, nitrogen, sulfur, and phosphorous. There are many other elements that exist in our bodies, but those are the main six. We are made up of sextillions of these atoms.

Atoms are also made up of smaller parts called subatomic particles. These particles are the proton, the neutron, and the electron. The proton and the neutron are relativity large and exist in the center of the atom, called the nucleus. The electrons, however, are very small. They travel outside the nucleus in an unpredictable path. Because they are so small, it is easy for them to be knocked off course by the energy of light.

The Electromagnetic Spectrum

Light comes in many different forms, some of which you might not have known were light. In science, we use the electromagnetic spectrum to describe all the different types of light, in order of wavelength. Humans can only see a very small part of the electromagnetic spectrum, called visible light. These visible light wavelengths are also what we use in solar panels.

While humans can only see the visible light portion of the spectrum, some living organisms, for example butterflies, can see more colors and further into the spectrum, including infrared wavelengths and ultraviolet wavelengths.

What is a LASER?

LASER is an acronym for
Light
Amplification by
Stimulated
Emission of
Radiation

Despite what you may have seen in movies like Star Wars (you know, pew-pew lasers!), lasers are an important tool for scientists to use in identifying unknown or new chemicals. Lasers produce a narrow band of light at a specific wavelength (a single color of light) where the light waves travel in phase with one another. Laser light is collimated, which means it focuses to one small point. Scientists are not the only people who use lasers. CD and DVD players use a laser to play your favorite songs and movies, and barcode scanners at grocery stores use lasers to tell us the price of our favorite snacks.

Because these lasers have only one wavelength, they produce a predictable amount of energy. That energy either travels as a wave or a particle (remember Einstein's idea about duality). The particles of light energy, or photons, collide with electrons, giving the electron its energy. This causes the electrons to become excited.

Electron Excitation

There are two different ways an electron can lose its extra energy. The first one is to give off all the extra energy in the form of heat. This is what most electrons do, and it is what a yellow marker does. Once the electron has given off enough heat, it returns to the ground state.

However, sometimes, the electron can actually give off light to get rid of extra energy. This is what is happening in this experiment. You can observe different colors when the laser is pointed through the water because the electrons in the dye are absorbing the energy, and then they give off heat and light to get rid of some of it. In the diagram example, the electron absorbs violet light to become excited and then emits heat and green light to lose the energy.