Small is Different: Activity 2

Stained Glass

Au Contraire

I'm Alettie. My friend Yvonne and I live in Chicago, Illinois, and love exploring the city. We visited the Glass Experience exhibit at the **Museum of Science and Industry** and learned that nanoparticles of metals (like gold and silver) are responsible for the red and yellow colors in some old stained glass.

Our question:

How can gold look red and silver look yellow?

We enlisted the help of a nanoscientist at **Northwestern University** who let us make nanoparticles of gold and silver to produce a rainbow of colors! We discovered the size of the particles caused them to behave differently with light and charted how the color changed with size. We even created our own sun catchers from our nanocreations in the lab.

Nano Matters

The behavior of gold and silver at the nanoscale is a perfect example of why scientists are so excited about exploring the nanoworld. The exact same material can exhibit completely different properties at the nanoscale. Metals such as gold and silver change color when nanosized. Although unaware of the nanoscience involved, Medieval artists utilized this color-changing property of metals to create beautiful works of art in stained glass. Scientists today have the tools (such as scanning electron microscopes) necessary to investigate and uncover the nanostructures once hidden in objects of the past. Not only can nanoscientists explore the nanoworld, they can manipulate it and, in the case of gold and silver, have precise control over the size of the particles. Because the size of the particles are on the same order of magnitude as the wavelengths of visible light (400–700 nanometers), small changes in size make observable changes to the color we see.

Icebreaker
Beam me up!

15 minutes

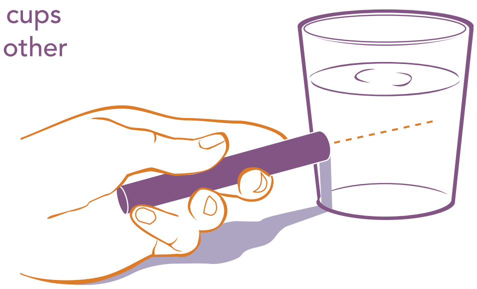
DragonflyTV Skill: Observing

Guide your kids as they

1) Fill 3 clear, clean cups with water.
2) Cup 1 should just contain water. Add a small amount (around 1/8 teaspoon) of flour to cup 2 and a small amount of milk to cup 3. Stir.
3) Predict what will happen when you shine the laser light through the side of each cup.
4) Now test it, being careful not to shine the laser light directly at anyone's eyes. (Testing works best in a darkened room.) What do you observe? Why do you think the light behaves this way? Which two cups behave similarly? Why? Can you brainstorm other places you have seen this effect?

You'll need:

- 3 clear cups
- water
- 1/8 teaspoon measuring spoon
- flour
- milk
- spoon
- laser pointer (e.g., cat toy)



Are you a nano-bit curious?

What you observed is called the "Tyndall effect" and is caused by the scattering of visible light when it hits very small dispersed particles. If cup 1 was clean, it should be free of particles, leaving the beam of light "invisible" through the glass. When the flour was added to the water, suspended particles caused the effect of scattered light. You may have been surprised to see the milk behave in a similar way to the flour. Milk is a colloid—a dispersion of fat particles in water. Mixtures of nanogold and nanosilver scatter light in the exact same way. The particles in the milk (and in the nanogold and nanosilver) are so small—around <1000 nanometers—that they will not settle (like the flour) so it may be hard to tell they are even present without a test such as this. You may have noticed this same effect before: when sunlight through a window hits dust particles in the air, when fog is added to enhance a laser light show or when you flip on your high beams on a foggy night and the light is reflected back into your eyes.

Investigation

Investigate the science of sunblock.

3 hours

You'll need:

- color changing UV beads (SteveSpanglerScience.com)
- snack size zipper lock bags
- black construction paper
- shoebox
- stopwatch
- sunscreen SPF 30 with zinc oxide
- sunscreen SPF 30 with nanoparticles of zinc oxide or titanium dioxide (See Adult Tip for more information.)

Guide your kids as they

1) Discuss nanoproducts. Have you ever heard of the lifeguard nose? Many sunscreens leave a big white streak on your skin, but nanotechnology is helping to make things clearer. Adding nanoparticles of titanium dioxide or zinc oxide (common ingredients in sunscreen that are very effective at absorbing ultra violet (UV) radiation) changes how sunscreens interact with light. Are they as effective as their non-nano counterparts?
2) Place a small dot of each sunscreen on the black construction paper and rub it in.* (Try to use the same amount of each.) Record observations on your data chart, noting which sunscreen disappeared more quickly.
3) Label four zipper lock bags as: control A (no sunscreen), control B (no sunscreen and no light), SPF 30 (white) and SPF 30 nano (clear).
4) Place some UV beads in each bag. Keep the bags in a shoebox or other dark place until you are ready to expose them to the sunlight.
5) Spread sunscreen on the outside of one side of the appropriately labeled bags.
6) Place all bags except control B (no sunscreen and no light) into the sunlight and start the timer. Leave for 5 minutes.
7) Record on a scale of 1 to 5 the degree to which the beads changed color. A rating of 1 would be given to the beads that were not exposed to light (control B) and 5 would be given to the beads exposed to light without sunscreen (control A). Did the sunscreen behave as you expected? Did its clarity relate to how well it blocked UV rays?

*Some people are concerned about the safety of nanoparticles in cosmetics. Although there is no incontravertable evidence suggesting these products are unsafe, there may be children (or parents) who do not want nanosunscreen in contact with their skin. The activity can still be done using Q-tips instead of fingers to spread the sunscreen.

DFTV Adult Tip

In the United States, manufacturers of cosmetics, including sunscreen, are not required to label their products as containing nanoparticles. It may be difficult to distinguish the various types of sunscreens by reading labels. A sunscreen that does NOT contain nanoparticles, usually contains zinc oxide and goes on thick and opaque (e.g., white or neon lifeguard sunscreens). Nanosunscreens, go on clear and contain zinc oxide or titanium dioxide. The Woodrow Wilson Center's Project on Emerging Technology keeps a list of nanoproducts currently on the market that you can search for nanosunscreens. http://www.nanotechproject.org/inventories/consumer/

Are you a nano-bit curious?

There are two main types of UV-blocking ingredients in sunscreens: organic (carbon based) and inorganic (i.e., zinc oxide and titanium dioxide). Organic ingredients are relatively specific as to which wavelengths of light they will absorb. Sunscreens that use organic ingredients, therefore, need to provide the appropriate mixture of several different ingredients to provide adequate coverage. Inorganic blockers absorb a broad spectrum of UV rays, including both UVA and UVB rays, but they are a colloidal suspension of particles in a lotion and scatter sunlight to appear white on your face (see the Icebreaker activity). Nanoscientists have found a way to make the inorganic clusters really small (<100 nanometers) so they no longer scatter visible light and thus go on clear.

DFTV Kids Synthesize

Data and Analysis

Sunscreen	Sunlight time	Observation on black paper	Ranking (1-5) 1 = no color 5 = most color
None	5 minutes		5
SPF 30 non-nano	5 minutes	Hard to make disappear, very white	2
SPF 30 nano	5 minutes	Disappeared quickly, went on clear	2
None	0 minutes		1

Keep Exploring!

Introduce other sunscreens with varying SPF ratings. Is SPF 30 really twice as effective as SPF 15? What about SPF 50? Do spray-on sunscreens work as well as their lotion counterparts?