Sunscreen and Eosin Dye

INTRODUCTION:

After you have convinced your students that Ultraviolet light interacts with everyday things like hi-lighter inks, or even Tonic Water, you can show them that these effects can be useful in a practical laboratory situation. Eosin can be a dramatic indicator of a basic solution (and the inefficiency of mixing) if used in Ultraviolet light. It can also show the remarkable efficiency of sunscreen solutions at preventing UV light from penetrating our skin.

CHEMICAL CONCEPTS:

-acid base indicators
-fluorescence and its dependence on molecular structure
-action of sunscreen materials

MATERIALS:

-Eosin dye (or use fluorescein dye if you don't want to do the acid-base thing)
-Transparent sunscreen spray (eg. Coppertone Sport Spray SPF-15)
-2 L PET bottle
-2 400-mL beakers
-dropper bottles of dilute (0.1M) HCl and (0.1M) NaOH
-1 glass Petrie dish
-1 overhead projector (or a visible light in a "light box")
-1 UV lamp arranged as a "light box"

PROCEDURE:

Construct a "light box" by placing a sheet of clear acrylic plastic (or glass) horizontally on supports that form a tunnel large enough to slip a UV lamp under the clear demonstration surface. Be sure that the sides of the box block out light to the audience. If possible, arrange a tungsten filament light bulb as a "visible" lamp in the same space. (An overhead projector can be used as a "visible light" box.)

Prepare about 2 L of Eosin dye solution by scooping the amount of dye that will rest on the flat end of a toothpick and dropping it into 2 L of distilled water. The solution should appear orange, but not a dark orange. [You can test it by shining a UV lamp across the 2L bottle. The glow should reach to the other side of the solutionÂ… to about the depth of liquid in a filled 400-mL beaker.]

Fill two 400-mL beakers with the dye solution and place them on the light box. Shine visible light up through the beakers in a darkened room. Add one or two drops of acid to one and a few drops of base to the other. Stir and "rave about the differences in the solutions". There will be no visible difference and the class will tell you so.

Turn off the visible light and turn on the UV lamp. The acid solution will be a dull orange and the base solution will glow bright yellow. Stir the "acid beaker" to make the solution rotate slowly and then start dropping in base. Fascinating streamers of yellow will appear in the solution.

The class has just seen a very dramatic example of using UV light and a dye to detect a basic solution. Ask them how they would be sure that all of the dye were cleaned up from an area of a spill. [Rinse the area with base solution and inspect using a UV lamp.] So we are using UV to detect the presence of a chemical.

Sunscreen:

Now place a glowing beaker on the UV light box. Spray transparent sunscreen into the base of a Petrie dish, which has some isopropyl alcohol in it, covering the entire dish surface and quickly place the top on the dish. (Evaporation of the solvent leaves a cloudy surface that blocks the light by physical, not "chemical" means.)

Lift the glowing beaker and slip the Petrie dish under the beaker. The glow will be extinguished. Ask your students what is happening to the energy. (Depending on the ingredients in the sunscreen, the light is converted mainly to infra-red light.)

Reinforce the demonstration by holding up a piece of white paper in the UV light. It will glow with a bright blue light. Spray the sunscreen on the page and observe the dark areas where the sunscreen absorbs the light.

[Note: The action of sunscreen can also be demonstrated if fluorescein dye solution is substituted for eosin.
but it is not sensitive to acid and base environments as Eosin is.]

SAFETY PRECAUTIONS:

With the light box constructed as above, exposure to UV light will be minimal for students, but it IS an issue for the teacher! A simple solution is to apply a good sunscreen to your face, hands and exposed arms. Test your glasses (and safety glasses) for UV absorption by placing them on a piece of white paper. Shine a UV light on the page and look for shadows where the lenses would normally transmit visible light. Ultraviolet detection beads as also a convenient way to check for transmitted UV light. Optometrists have meters that check quantitatively for UV absorption in eyeglass material.

Eosin dye is a mild skin irritant and will stain skin on contact. (The stain is more visible in UV light!)

DISPOSAL:

Transparent Sunscreen is soluble in alcohol.

Dilute Eosin (or Fluorescein) dye can be washed down the sink with plenty of water.

DISCUSSION:

With high school students, I use this as an extension of the theme "We can see more than others if we know how to look". Using UV light is fascinating for students and provides a vehicle to discuss many important topics, especially safety with UV light both in the laboratory and "on the beach".

The Eosin-Y (tetrabromofluorescein) solution has many of the same properties as fluorescein and is quite stable in distilled water. In acid solution, however, it slowly converts to the insoluble Eosinol. This removes the active ingredient from solution and lowers the fluorescence. Thus, the dye solution gradually becomes cloudy in this demonstration and should be discarded after use as an acid-base indicator.

Ultraviolet light can cause chemical reactions in the skin and in sunscreen chemicals. Formulations of these products must take into account the rate of reaction and the safety of the products of reaction with light.

ACKNOWLEDGMENT:

There is an excellent reference URL for the chemistry of dyes and colours at:
http://members.pgonline.com/~bryand/StainsFile/dyes/dyes.htm

Information on sunscreens can be found at www.suncarelab.com

Materials available from Flinn Scientific:

Catalog No. Description

AP4504 Publication #4504
(Introduction to Thin Layer Chromatography has good information about dyes)

E0023 Eosin Y powder
AP9030 Ultraviolet Lamp
FB1147 Ultraviolet Detection Beads