NOTE

Fiestaware™ Radiography

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The idea of placing radioactive materials on high-speed instant film for several days was presented at a workshop for science teachers several years ago.[1] Not finding anything written to describe the entire experiment, I present here some guidance and further ideas for unique classroom demonstrations. I also want to encourage teachers to use real radioactive sources in the classroom when discussing nuclear topics, an area that typically lacks good classroom demonstrations. Students learn and remember better when using and touching the real thing, as opposed to computer simulations or analogies like flipping coins to demonstrate the idea of half-life.

This experiment can also be used to demonstrate the difference between a standard radiograph and an autoradiograph. A standard radiograph uses some external radiation source to image an object. The object will attenuate the radiation based on its density and thickness, which produces an image. Typical examples of this are the x-ray films doctors and dentists make. The image in Fig. 1 was made by using a plate of red Fiestaware™ as the source.[2]

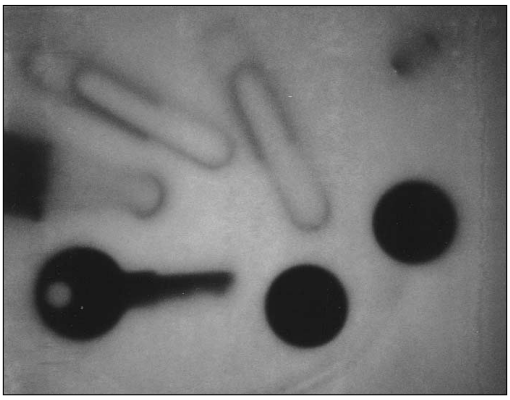

Fig. 1. Radiograph of random office supplies taken by a red Fiestaware™ saucer. Objects include paper clips, a key, two coins, and a plastic push pin (upper right). Exposure time, seven days.

An autoradiograph is an image formed of a radioactive object by itself. For example, a drum of radioactive waste can be placed in front of sensitive film or other radiation detector to form an image of where and how strong the sources are inside the drum. A sample autoradiograph of gas lantern mantles is shown in Fig. 2. In this experiment, strong sources like Fiestaware can be used to take radiographs of other objects. Weaker sources, such as a lantern mantle or a watch painted with radium, can at least be used to form autoradiographs.

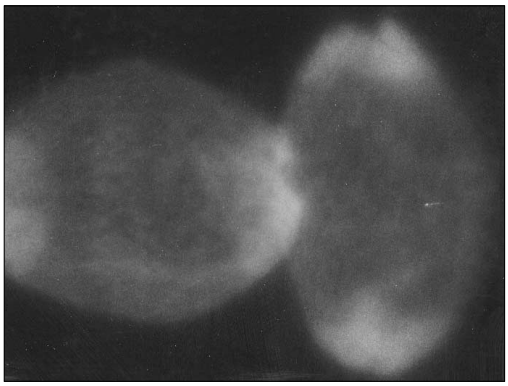

Fig. 2. Autoradiograph of two lantern mantles. One was positioned on the front of the film packet, the other on the back. Radiation penetrates both package and print, so placement doesn't matter. Exposure time, 11 days.

Equipment

To investigate the ability of ionizing radiation to expose camera film, your students will need:

- *Fast instant film* — the fastest (most sensitive) instant film that I have found so far is Polaroid Type 57 black and white film. A box of twenty 9- by 15-cm films can be purchased in a photography store for about $50.
- *Radioactive source* — the higher the activity, the better. Gas lantern mantles, laboratory sources, radium dial watches, and naturally occurring radioactive rocks can all be used. Of the many radioactive consumer products, red Fiestaware dishes such as plates or saucers work well because they cover the entire film. These can be found in antique stores for under $20. (Note: Even though orange in appearance, the official color name used for these plates is "red.")
- *Items to image* — small metal objects found in any desk drawer or around the laboratory will work fine.
- *Roller to develop the film* — Polaroid makes the 545i film holder that can be used to develop the film, but it costs about $175 in camera stores. For this experiment all that is really needed is a soft rubber roller at least 10 cm wide. These are available at art supply stores for about $15.

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Procedure

1. Place the radioactive source on a piece of instant film. If the source is strong enough, like a piece of Fiestaware, place some small metal objects between the film and the source. Make sure that they will not be disturbed or moved during the exposure or blurring will result. Exposures take several days to weeks depending on the strength of the source. As shown in Fig. 3, four days to one week were required to adequately see the outlines of a razor blade using a Fiestaware saucer.
2. After the long exposure time, develop the instant film according to the Polaroid directions. Place the film packet on a smooth, flat surface, and starting at the tapered end, run the rubber roller over the film in a hard, smooth motion, pushing the developer gel over the negative. At room temperature, only 15 to 20 seconds are required for the film to develop.
3. Open the film packet and remove the print. Caution: the developer gel is caustic and can cause alkali burns on the skin and damage clothing.
4. Polaroid recommends coating the print to protect it from scratching and fading. This coating comes with a box of film. Six or eight swipes of the coater across the print will be sufficient. Let the print dry before handling it. Caution: Keep coater fluid away from furniture and clothing. It is also an eye irritant. In case of contact, flush with water.

Discussion

This experiment is so easy that students will be able to think of their own variations and perform them. For example, placing the radioactive source a few inches above the film will make a sharper image because it better approximates a point source, but it also will take longer to expose the film since it is further away.

Potassium chloride salt substitute will also work for making standard radiographs. An 11-ounce container of NoSalt™ placed in a sandwich bag will produce a very faint outline of razor blades and paper clips after a two-week exposure time. This might make a good long-term experiment, taking four to eight weeks to produce a clear image.

To save on equipment costs, we tried an ordinary kitchen rolling pin instead of a purchased film holder or rubber roller. This did not work; streaks of undeveloped areas remained across the final print. The soft rubber roller molds to the surface better and pushes the developer gel out in a more uniform manner.

With upper-level classes, include some discussion and investigation into the type and energy of the sources. For example, Fiestaware is both a beta and a gamma source. Whether the betas or the gammas are responsible for the image is determined by the energy of the particles, the thickness of the outer covering of the film packet, and the active thick-

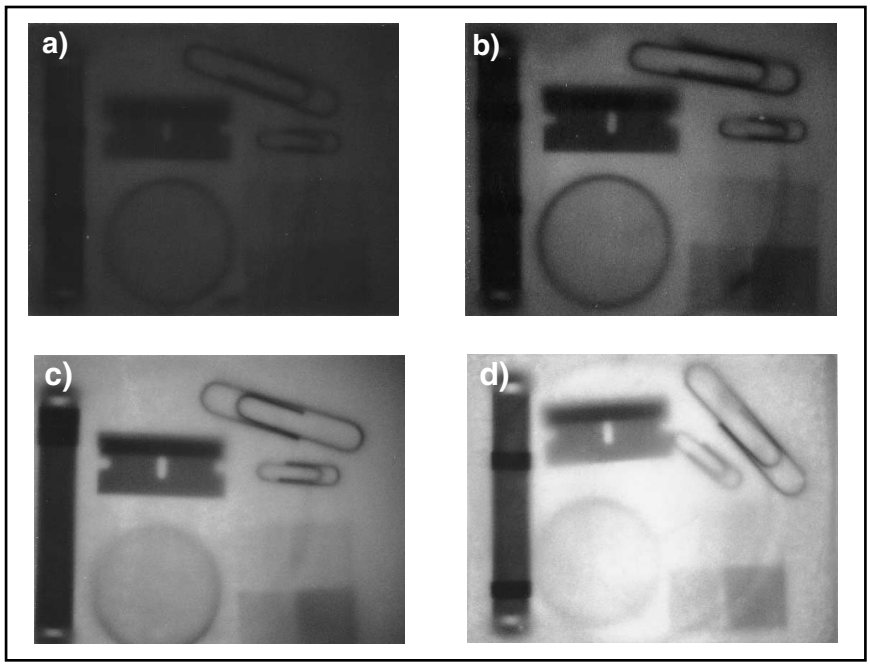

Fig. 3. More random office supplies imaged with a Fiestaware™ saucer: (clockwise from left) a binder strip, a razor blade, paper clips, aluminum foil squares, and a paper tag with metal ring. Exposure times are (a) two days (b) four days (c) eight days (d) two weeks.

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ness of the film negative. Using a standard set of sealed laboratory sources can offer some experimental confirmation of the relative exposure of different radiation types and energies.

Comment

As described here, this inexpensive, easy, and fun demonstration or laboratory experiment shows one of the many uses of ionizing radiation. Students at any level are able to investigate the relative strength of different radioactive sources and are able to experiment with various absorbers. After seeing "real-life" demonstrations, students do not soon forget classroom discussions about radiation.

References

1. Michael A. Mocherman, "Radiation Education for Everyone," American Nuclear Society Teacher Workshop, North Carolina State University, Raleigh, 1992.
2. Jack G. Couch and Kelly L. Vaughn, "Radioactive consumer products in the classroom," *Phys. Teach.* **33**, 18 (1995). That article included the following explanatory note on the history and discontinuation of Fiesta red dishes:

   Brightly colored Fiestaware was first introduced by the Homer Laughlin China Company (HLC) of Newell, West Virginia in 1936. Dishes were originally available in five colors including the popular brilliant orange-red known as "Fiesta red." Various dish styles were offered in the uranium-bearing Fiesta red until midway through World War II when the government assumed control of uranium oxide and the color was dropped temporarily. According to the company, "Fiesta red went to war." Fiesta red returned to the marketplace in 1959 when the Atomic Energy Commission licensed HLC to again buy uranium—this time depleted. The manufacturer explains:

   Before 1943 the colorant, 14% by weight of the glaze covering the ware [was] uranium oxide U_3O_8 with the uranium content being made up of about 0. 7% U-235 and the remainder U-238...the colorant now used is depleted technical grade U_3O_8 with the uranium content being made up of about 0.2% U-235 and the remainder U-238.

   HLC eliminated the color in 1972 and dropped the Fiestaware line in 1973. (Fiestaware was reintroduced in 1986 on the occasion of its fiftieth anniversary, but the favorite Fiesta red was not restored.)

Physics Trick of the Month

Reverse Jack's Profile

There are two "one-eyed" jacks in a deck of cards, the Jack of Hearts and the Jack of Spades. Hold either one behind a glass of water. If you press the jack against the side of the glass and view him through the water, he will face in his normal direction. Move the card slowly away from the glass. You'll see Jack turn around and face the other way!

Transparent glass or plastic rods, such as those used for stirring drinks, have the same refraction property. Hold such a rod slightly above the following sentence:

bob KICKED POP

You'll see what happens next!

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