Photochemistry and Pinhole Photography: An Interdisciplinary Experiment

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fold here and tear out

perforated

Background

Pinhole camera

Information on the history of photography and the chemistry of black and white photography, references and sources of additional related activities, and student photographs taken with pinhole cameras can be found in supplemental materials for this activity in *JCE Online*, *http://jchemed.chem.wisc.edu/Journal/Issues/1999/Jun/abs736A.html.* Related information can be found on pages 737–746 in Pushing the Rainbow: Frontiers in Color Chemistry; Light and Color in Chemistry: Report on Two ACS Presidential Events.

Integrating the Activity into Your Curriculum

This interdisciplinary activity combines chemistry and art through the construction and use of a pinhole camera. We focused on the chemistry of the black and white photographic process (see the supplemental materials mentioned above for details) as the science component of this activity. The reactions involved are good examples of photochemistry and multiphase chemical reactions, since the light sensitive materials (silver halides) are in the form of a gelatin emulsion of microscopic crystals.

This activity has been used in the Accept the Challenge Program, run by the Merrimack College Urban Resource Institute in collaboration with the Lawrence Public Schools since 1986 to serve the needs of high school and college students from bilingual backgrounds. Through after-school experiences and a summer residency, the program helps these students to succeed in high school and to access higher education. Many of the summer activities stray from the classic lecture or lab content in a discipline to include interdisciplinary projects, such as this pinhole photography chemistry experiment.

About This Activity

In this activity, students use an oatmeal canister to make a pinhole camera, load it with black and white photographic paper, and create a paper negative using the camera. Instructions are included online to allow students to use the negative to make a paper positive. A 42-oz. canister will accommodate an 8 × 10-inch sheet of photographic paper. This size is recommended. If smaller canisters must be used, you may need to cut the photographic paper or use 5 × 7-inch sheets. Some brands of oatmeal come in canisters with metal bottoms. If these canisters must be used, have students cover the interior metal surface with dark cloth or paper to prevent reflections.

Except for the making of a paper positive, this activity can be done without an official darkroom. Any dark room, such as a bathroom or large closet, equipped with a safe light and a table that will hold four trays of chemicals will work.

The instructor will need to prepare developer, stop, and fixer solutions and place them in labeled trays for the students to use. Follow the directions on the package labels. You should include on the tray label the developing time recommended on the package for each solution. If your school has a darkroom, the supplies on hand will probably produce acceptable results. Photographic supplies can be obtained locally at a photography supply store or ordered by mail. One mail order source is Zeff Photo Supply, P.O. Box 311, 11 Brighton St., Belmont, MA 02178; phone: 800/343-5055; email: *zeffphoto@aol.com*.

The following supplies (with recent Zeff Photo Supply prices) are recommended. Similar products may be substituted.

- Ilford Multigrade IV RC Deluxe Photographic Paper: $11.00 for 25 8×10-inch sheets
- Ilford Universal Paper Developer: $4.95, makes about 5 liters
- Kodak Indicator Stop: $4.35 for 16 oz.
- Kodak Rapid Fixer PART A: $7.40 for one gallon (Discard PART B)

Possible problems in developing the paper negative include no light or too much light entering the camera and old or contaminated solutions.

Acknowledgment

The Accept the Challenge Program is run by the Merrimack College Urban Resource Institute which is directed by Patricia Jaysane. The authors thank Scott Gage for the invitation to participate in this program and for supplying the oatmeal canisters and the photographic paper. We also thank the students, Lionel Nunez and Minh Luu, for including their photographs in this activity. See the supplementary materials for larger versions of the pictures.


Paper negative (left) and positive print (right) taken with a pinhole camera by Lionel Nuez.

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Photographs are a common part of life—we see them every day in books, newspapers, advertisements. Cameras can be quite complex and very expensive, but you can easily build a simple camera that focuses images though a pinhole rather than using lenses. To record an image with a pinhole camera you do need light-sensitive photographic paper (or film) and developing solutions. The chemistry involved is fairly simple. The most important reaction is the reduction of silver ions by light to dark silver metal to produce an image on paper. The details of the chemistry of black and white photography are included in supplementary materials for this activity (ask your instructor) and in many other sources.

Try This

You will need: large (42-oz.) oatmeal canister, disposable aluminum pie plate, ruler, size 7 hand sewing needle, fine sandpaper, black electrical tape, scissors, mat knife, black garbage bag, large rubber band, small piece of cardboard, photographic paper, developing solutions, tongs, four trays, and a squeegee.

Making a Pinhole Camera

__1. Cut a 1-inch square from the pie pan and place it on top of the cardboard. Put a piece of tape on the eye end of the needle. Hold the needle in the center of the aluminum square and spin the metal so the needle acts like a drill. Continue spinning until the needle point sticks through the metal about 1/8 of an inch. Sand both sides of the metal and spin the needle through the hole again to clean it out.

__2. With a mat knife, cut a 1/2-inch square hole in the center of the side of the oatmeal canister. Make a clean cut. You can use the knife to scrape off extra fibers after you make the cut. Center the aluminum pinhole square over the hole in the canister and tape it onto the outside of the canister using black electrical tape. Place another piece of black tape over the pinhole to act as a shutter.

__3. In a darkroom under red safe lights, load a piece of photographic paper with the smooth (emulsion) light sensitive side facing the pinhole. Cover the top of the canister with a black garbage bag. Do not let the black plastic block the pinhole area. Place the lid on over the black plastic and put a rubber band over the plastic to keep it in place. Make sure the shutter tape covers the pinhole.

Taking a Photograph

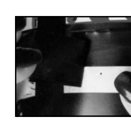
__1. Go outside into the sunlight and find something to photograph. Moving objects do not photograph well.

__2. Position yourself about six feet from your subject.

__3. Put the camera on a table, bench, wall, or the ground to keep it steady. Do not point it directly at the sun.

__4. Remove the shutter tape and time the exposure with a watch—on a sunny day 15–30 seconds will be sufficient, on a cloudy day, 1–3 minutes will be necessary—then cover the pinhole again with the tape. Be careful not to move the camera while opening and closing the shutter.

Developing the Paper Negative



__1. Return to the darkroom. Your instructor should specify the amount of time the paper should be left in each solution. With the safe light on and the door closed, remove the paper from the pinhole camera. Place it in tray 1 (developer) and swirl the solution around the tray with tongs for the time recommended. (If your paper is all white or all black, or you cannot distinguish an image on either side of the paper, ask your instructor for help.) Transfer the paper to tray 2 (stop solution) and swirl for the time recommended. Transfer the paper to tray 3 (fixer) and swirl for the time recommended. Put the paper (no longer light sensitive) in an empty tray.

__2. Leave the darkroom and go to a room with a sink and running water. Fill the tray containing the paper with water and pour it out five times, then continue to rinse the paper under running water for five minutes. Lift it out of the tray and use a squeegee to remove excess water. Hang the paper or lay it out on paper towels, print side up, to dry.

Questions

__1. Use the supplementary materials provided by your instructor (or other references) to write the chemical reactions involved in black and white photography. How do the developing, stop, and fixing solutions work?

__2. Compare the image you obtained with the scene or object photographed. How is it different? Define the terms *negative* and *positive* as they are used in photography.

__3. How could a negative image be converted to a positive image? Devise a procedure for this process. Compare your procedure with the one provided by your instructor. If you have access to the necessary equipment and your instructor approves, make a positive image of your photograph.

Paper negative (top) and positive print (bottom) taken with a pinhole camera by Minh Luu.

Information from the World Wide Web

1. A History of Photography. *http://www.kbnet.co.uk/rleggat/photo/* (accessed Apr 1999).
2. The Penultimate Pinhole Page. *http://www.airtime.co.uk/pinhole/* (accessed Apr 1999).
3. What Is Pinhole Photography? *http://www.pinholeresource.com/* (accessed Apr 1999).
4. The Components of Photographic Material. *http://www.freeyellow.com/members6/glsmyth/photomat.htm* (accessed Apr 1999).