Ritter Ultraviolet Experiment

PURPOSE/OBJECTIVE: To perform a version of the experiment of 1801, in which ultraviolet light was first discovered by Johann Wilhelm Ritter.

BACKGROUND: After learning about William Herschel's discovery of infrared light, which he found beyond the visible red portion of the spectrum in 1800, Johann Ritter began to conduct experiments to see if he could detect invisible light beyond the violet portion of the spectrum as well. In 1801, he was experimenting with silver chloride, which turned black when exposed to light. He had heard that blue light caused a greater reaction in silver chloride than red light did. Ritter decided to measure the rate at which silver chloride reacted to the different colors of light. He directed sunlight through a glass prism to create a spectrum (the rainbow created when light is divided into its colors). He then placed silver chloride in each color of the spectrum and found that it showed little change in the red part of the spectrum, but darkened toward the violet end of the spectrum. Johann Ritter then decided to place silver chloride in the area just beyond the violet end of the spectrum, in a region where no sunlight was visible. To his amazement, this region showed the most intense reaction of all. This showed for the first time that an invisible form of light existed beyond the violet end of the visible spectrum. This new type of light, which Ritter called Chemical Rays, later became known as ultraviolet light or ultraviolet radiation (the word ultra means beyond). Although the procedure for this activity is slightly different than Ritter's original experiment, you should obtain similar results.

MATERIALS: One glass prism, blueprint paper, household ammonia, warm water, one small and shallow square pan, a piece of cardboard slightly larger than the pan, water, a thin black marker, a prism stand or a cardboard box (a photocopier paper box works fine), scissors, a ruler, one blank sheet of white paper, and tape. NOTE: BLUEPRINT PAPER IS EXTREMELY SENSITIVE TO LIGHT - KEEP IT IN A DARK AREA UNTIL IT IS PLACED IN THE SPECTRUM PRODUCED BY THE PRISM IN THE EXPERIMENT!

NOTE: This experiment uses ammonia to develop blueprint paper. The ammonia should handled by an adult only. To reduce the ammonia vapors and increase safety, we conducted a test to determine the amount by which the ammonia could be diluted and still effectively develop the blueprint paper within a reasonably short time. **Click here** to view the details of this test. Our results showed that a mixture of 90% very warm water and 10% ammonia works very well for blueprint paper exposed to its vapors for 90 seconds.

For the best results, read the PREPARATION and PROCEDURE sections carefully before attempting this experiment. Teachers should try this experiment first before having their students perform it.

PREPARATION: This experiment should be conducted outdoors on a sunny day. Variable cloud conditions, such as patchy cumulus clouds or heavy haze will diminish your results. In a very dimly lit area cut out a piece of blueprint paper which is slightly larger than the small, shallow pan and at least 4x4 inches (or 10x10 cm) in area. Keep the piece of blueprint paper out of the light until needed. If you do not have a prism stand (available from science supply stores), the easiest way to mount the prism is to cut out an area from the top edge of the cardboard box. The cutout notch should be able to hold the prism snugly, while permitting its rotation about the prism's long axis (as shown in Figure 2 below). That is, the vertical "side" cuts should be spaced slightly closer than the length of the prism, and the "bottom" cut should be located slightly deeper than the width of the prism. Next, cut out a piece of cardboard which is slightly larger than your piece of blueprint paper.

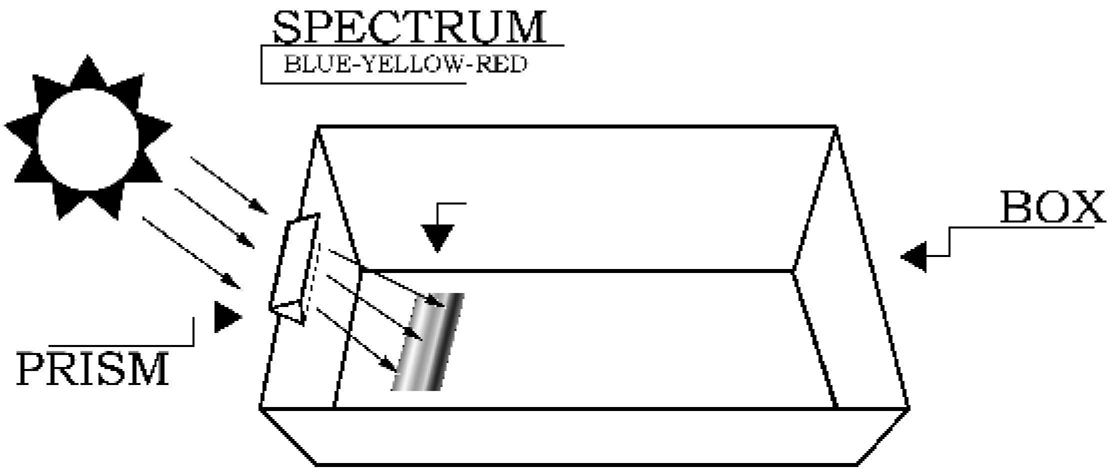

Figure 1

PROCEDURE: The setup for the experiment is depicted in Figure 1. Begin by placing the white sheet of paper flat in the bottom of the cardboard box. This will help you see the colors of the spectrum more clearly. The next step requires you to carefully attach the glass prism near the top (Sun-facing) edge of the box. If you do not have a prism stand, slide the prism into the notch cut from the cardboard box, and rotate the prism until the widest possible spectrum appears on a shaded portion of the white sheet of paper at the bottom of the box. [To see images showing the setup, click here.] The Sun-facing side of the box may have to be elevated (tilted up) to produce a sufficiently wide spectrum.

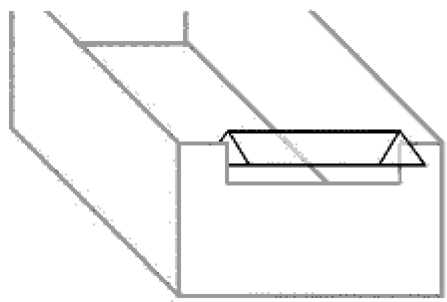

Figure 2

Without exposing the blueprint paper to direct sunlight, quickly place it in the bottom of box, where the spectrum is visible, with the colored side of blueprint paper facing up (exposed to the spectral colors). Be sure to have a large section of the blueprint paper in the area past the blue-violet portion of the spectrum. Tape the paper down at the corners to keep it from moving (this is easier if the tape is already in place on the blueprint paper before placing it in the spectrum). Immediately afterward, while being very careful not to move the box or the blueprint paper, use a thin marker to draw an outline on the blueprint paper around the visible part of the spectrum created by the prism. Label the violet end of the spectrum with a "V". Leave the paper in the box, exposed to the spectrum, for about 30 seconds. Then carefully remove the paper and try not to expose it to sunlight during the process.

Bring the piece of blueprint paper to a well ventilated area. Here pour a mixture of 90% very warm water and 10% ammonia into the pan to a depth of about 1 centimeter. NOTE: The mixing and pouring of the ammonia mixture should be done by a teacher, parent or other adult. Place the blueprint paper across the top of the pan with the colored side of the paper facing the pan and cover it and the entire pan with the piece of cardboard. Do not let any of the ammonia mixture come into contact with the blueprint paper. The cardboard will help contain the ammonia fumes and will decrease the development time. Keep the paper in place above the pan for about 90 seconds.

Once the blueprint paper is developed, move to a location away from the ammonia and study your results. There should be a white (or light-colored) rectangle around the area where the blueprint paper was exposed to the solar spectrum. The white area should be surrounded by a much darker region. You should notice that the area which was exposed to the red end of the spectrum is not as lightly colored as the area exposed to the violet region. Most importantly, you should notice that the light-colored area of the blueprint paper extends far beyond the line marking the violet end of the spectrum. This is the region that was exposed to invisible ultraviolet light.

Using a ruler, measure the marked width of the visible spectrum. Then measure how far the light-colored region of the blueprint paper extends beyond the line marking the violet end of the spectrum. Add these two numbers to compute the total width of the exposed region. Compare your results to those of your classmates and compute average values for the class.

DATA/OBSERVATIONS:

Width of the Visible Spectrum	Width of the Ultraviolet Region	Total Width

CALCULATIONS:

Compute the average widths measured by the class.

	Sum of the Widths (W_{sum})	Total number of observations (N)	Class average (W_{sum}) / N
Width of Visible Spectrum			
Width of Ultraviolet Region			
Total Width			

Compute the percentage of the light-colored region on the blueprint paper that was exposed to visible light and to ultraviolet light.

Percentage of Region Exposed to Visible Light: (Width of Visible Spectrum / Total Width) x 100	Percentage of Region Exposed to Ultraviolet Light: (Width of Ultraviolet Region / Total Width) x 100

QUESTIONS: What happened to the blueprint paper after it was developed? Describe what happened to the area which was exposed to the visible part of the spectrum. Describe what happened to the blueprint paper in the region beyond the violet part of the spectrum - where no visible light could be seen. What do you think exists just beyond the blue part of the spectrum? Do you think that this proves the existence of an invisible form of light? Why or why not? Discuss any other observations or problems.

For further information on the Ritter ultraviolet experiment see: *The Ritter Experiment Main Menu*

If you wish to have your results posted online you may send them to *outreach@ipac.caltech.edu*

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