

Advanced Undergraduate Laboratory, University of Arizona

References

Jenkins and White, Fundamentals of Optics, McGraw-Hill, 1950).

Harrison, Lord, and Loofbourow, Practical Spectroscopy, (Prent.-Hall, 1948), four copies in Science Library (535.84 H3lp)

Introduction

Optical spectroscopy has been and continues to be an important tool of both science and industry. Its importance lies in its being able to report on the huge variety of quantum energy levels of atoms, whether in chemical compounds, stars, solids or whatever. A photographic spectrometer (or "spectrograph") makes use of the powerful technique of photography for recording information. The Bausch & Lomb 1.5 meter grating spectrograph used for this experiment is on loan from the Lunar and Planetary Lab, where it was used as a research instrument.

First familiarize yourself with the spectrometer using the manual in the cabinet in Room 246 to identify its components (and return the manual to the correct file folder in the cabinet!).

Taking off the film holder, one can look into the spectrometer and see the grating. Note its location because a light source must be positioned so that light passing through the slit can fall on the grating. The shutter is opened and closed by moving the bottom end of its handle to the right and left. One can remove the Hartmann slide and the slit to examine them. Each indexed position of the Hartmann slide allows a different narrow horizontal strip of the film to be exposed when the shutter is open.

With the Hartmann slide removed and the shutter open, placing a spectrum tube light source in front of the slit will enable one to look for spectral lines in the film holder opening. (Remember that spectrum tubes operate at high voltage, so turn off or disconnect the power supply whenever changing tubes!) Get a TA to show you how to use the crude, yellow-painted wooden guide to optimize the spectrum tube position. It may be easier to find the lines by using the black eyepiece, which can be slid along the spectrometer opening. By moving the tube's power supply slightly to the left and right while observing a spectral line, you can test whether you understand how to use the guide.

Take off the film holder to examine it. Removing the film cover piece (called a "dark slide" in the manual) by sliding it out of the holder exposes the double slot in the holder. The front slot is for the dark slide; the back slot is for the film. Getting the film and slide into the correct slots in complete darkness in the darkroom is difficult (no safelight is usable with the Tri-X film used for the spectrometer); so practice loading a length of used film and the dark slide a number of times with eyes closed and then see whether you got them in the correct slots.

Notice the lightly scribed line on the back of the dark slide. This line shows how far to pull out the dark slide when the loaded film holder is mounted on the spectrometer. If the slide were pulled completely out of the holder when loaded with film, light would get in from the side. After the slide is pulled to that line, it is not pushed back in until all exposures are made (controlled by the shutter) to avoid the possibility of moving the film in the holder. When the slide is all the way in, the film holder is completely light tight and can be carried from the dark room to the spectrometer or back.

NOTE: Whenever you leave the spectrometer, even for just a few minutes, please push the Hartmann slide all the way in so that it is out of the way as much as possible. We have had a serious problem of damage to it by other students accidentally bumping it while walking by the spectrometer.

Experimental Procedure

To avoid the possibility of a mistake by one student pair damaging the performance of photochemicals used by other pairs, individual bottles of chemicals are reserved for each team doing the experiment. You will use your chemicals week after week until you are done with the experiment.

1. In a drawer inside the west darkroom in Room 246 are some self-stick labels. Take two of them and print "DEVELOPER" and your names and the date on one of them and "FIXER" and your names and the date on the other. Also in that darkroom are some reasonably clean one-pint bottles. Attach your developer label to a brown bottle (developer is slightly photosensitive) and your fixer label to a clear bottle. Use the large bottle marked "MICRODOL-X DEVELOPER" to fill your brown bottle about 3/4 full and the large "FIXER" bottle to fill your fixer bottle a similar amount.

2. The film must not overlap the felt when it is loaded in the holder, so there is a wooden ruler cut to about 11 inches long which is used to measure film in the dark for cutting with a scissors. A plastic film can containing a 35mm cartridge of Tri-X film can be found in one of the glass-door cabinets near the east door of Room 246. You can take off the cap of the plastic can in the light and see the film cartridge which should have about a centimeter of film sticking out of it. Take the cartridge, the spectrometer film holder, the 11 inch ruler and a scissors into the darkroom. Then close the door tightly, turn out all lights, measure and cut a length of film, load the film into the holder and install the dark slide. (Leave about a centimeter sticking out of the film cartridge for getting hold of the next time.)

3. Various exposures are made using the shutter to control the exposure time and the Hartmann slide to control the position on the film. It may be desirable to bracket the exposure time by making exposures of (for example) 1, 5, 20, and 60 seconds.

4. After all exposures are done, the dark slide is returned to the closed position and the holder taken to the darkroom. In the dark, the film is loaded onto the developing tank spool (see instructions on the bookshelf just outside the darkroom) and the tank closed. Developing can then be done in a lighted room. Keep the empty film holder away from the photochemicals and the sink because it rusts easily, especially down in the slots. If liquid gets on it, dry it quickly with a paper towel. For photochemicals, moisten a towel with water and wipe off unseen residue, then use a dry one to dry it thoroughly.

5. Developing and fixing times are on slips on the metal bookshelf just outside the darkroom. Use the plastic funnel to fill the tank with chemical and to put it back into your supply bottle. To eliminate any trapped air, use the plastic handle with a thermometer in it to rotate the film spool in the tank immediately after pouring in a chemical. Use it to stir the chemical in the tank every couple of minutes. After pouring the developer back into its bottle, use a similar procedure with the fixer. The film may be examined after fixing.

6. Check your procedure with a TA before developing.

7. Clean up any spills immediately so they don't get spread around. When done for the day wash the tank components thoroughly in water, wipe off the area and stand the components so they will dry.

Suggested Spectra

1. Mercury. Calibrate the spectrograph using the purple, green and yellow lines of mercury.

2. Hydrogen and another discharge tube (Ne, Ar, He, etc.). Determine wavelengths of strong lines and compare with accepted values.

3. Carbon arc: Examine the film specifically for molecular lines, note the difference from atomic lines and try to understand this difference.

4. An unknown sample obtained from the instructor. Using a 1/16 inch drill spun in your fingertips, drill a hole about 3/32 inch deep into the soft core of a carbon rod held in your other hand, and put some of the unknown in there. Then run that as the vertical carbon rod of the arc. It will be difficult to get a good exposure of the unknown because it will not appear in the arc for a few seconds and may only last a few seconds. Smoke streaming up from the area of the arc or a color change in the light shining from the arc's lens onto the spectrometer shutter indicate a good time to make an exposure.

DANGER:

- 1. The carbon arc has exposed wiring and the carbon rods are at 120 volts when the arc is plugged in; so plug it in only for the time needed to make an exposure; then unplug it and place the plug in plain sight on the bench.**
- 2. Looking at the arc can damage eyesight. Therefore don't let the light from the arc light shine directly onto your eyes or onto the eyes of others.**

12/11/92