Appendix A

DIY Spectrometer

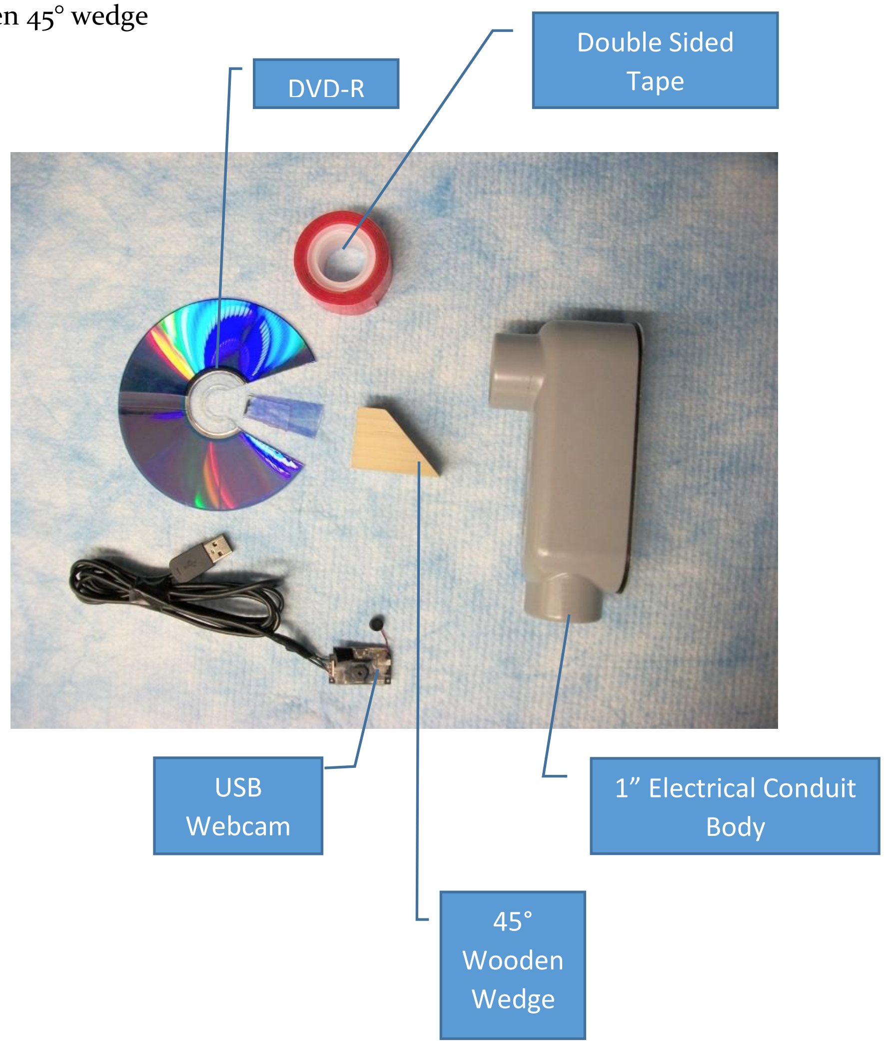
Do-It-Yourself Nitrate Detector

Materials and Methods

A spectrometer is a device that splits light into the various colors it consists of, which we otherwise cannot distinguish with the naked eye. By viewing a substance through a spectrometer, one can distinguish the exact mixture of colors, which correspond to specific wavelengths of light. This can be compared to other spectra to help identify the sample.

The DIY, water-quality spectrometer is a tool made from simple materials:

- A USB webcam
- An unused DVD-R
- Black cardstock paper (not shown)
- A Type-LB conduit body
- Double sided tape
- Wooden 45° wedge



Spectrometer Construction

1) Begin with black cardstock, crease and fold the paper to form a box with one side missing. One side is the imaging slit and opposite side will be the missing side.

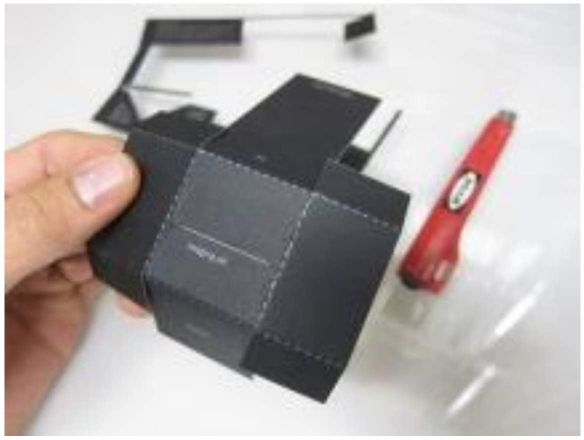


Figure 1-1: Black cardstock with creases and folds. Imaging slit faces outward toward the light source.

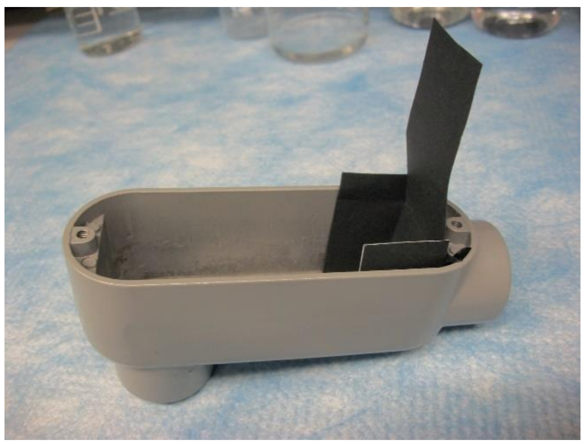


Figure 1-2: Place the folded cardstock box into the conduit body. The long-side portion of the cardstock box faces upward and will be used to conceal the webcam from other light sources when in use.

Figure 1-3: Make sure the imaging slit is orientated correctly as indicated in the photo.

2) Most webcams are encased in a protective plastic shell. It is necessary to remove this shell along with the infrared filter (IR filter) located behind the aperture of the webcam lens. Make sure the webcam will fit properly in the conduit body in the orientation you prefer. Some webcams may produce a vertical spectra gradient, when you want a horizontal gradient. Rotating the webcam may remedy this however, the monochromator must remain in an upright position with respect to the imaging slit.

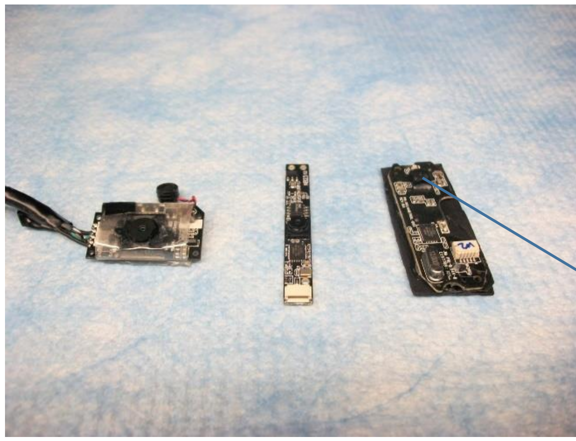


Figure 2-1: There are many different configurations of webcams.

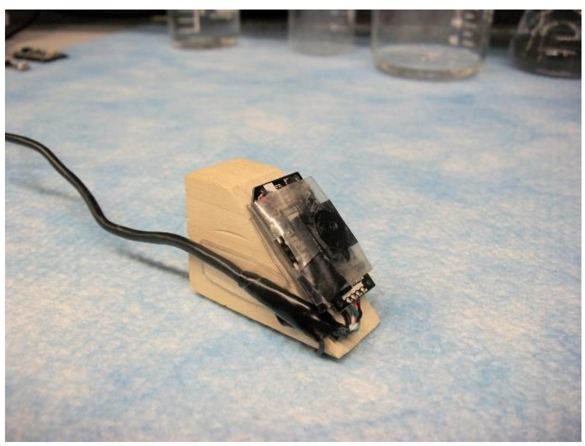


Figure 2-2: Using the 45° wooden wedge and double-sided tape, adhere the webcam approximately half-way up the 45° slope. To ensure the USB cable stays in place, use double-sided tape to secure it to the wooden block.

3) Cut a portion of the DVD-R to be used as the refraction gradient (monochromator). A DVD-R is the preferred choice over CD-R because refraction gradients are more defined in DVD-R's. Starting from the outer edge of the disc, cut two parallel lines about ½" to ¾" wide and 2" long. The outer edge of the DVD-R is used because the refraction gradients are more parallel and produce straighter spectra. The portion of the DVD-R that contains the refracting gradients can be easily separated from the thin reflective layer. Other materials would likely be tested for optimum sprecta brightness.

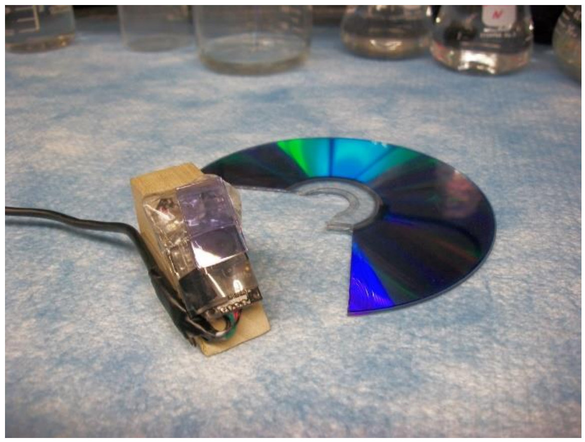


Figure 3-1: Starting from the outer edge of the disc, cut two parallel lines about ½" to ¾" wide and 2" long. Avoid scratching the lens surface!

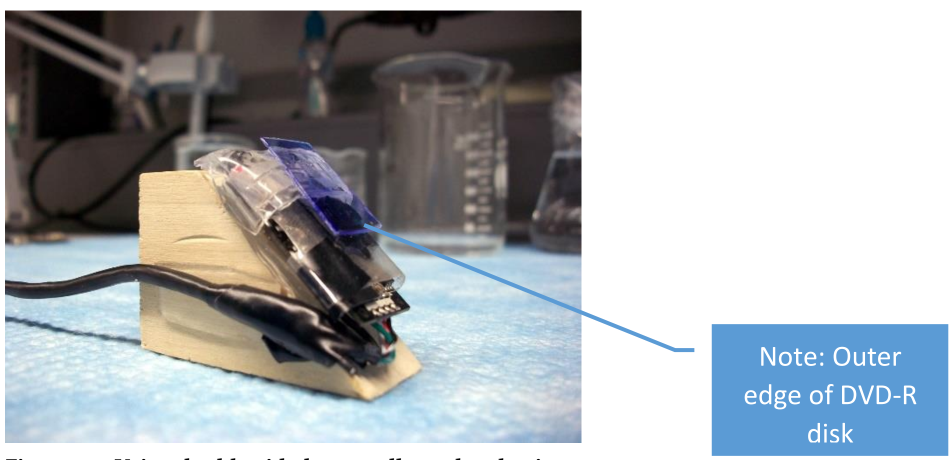


Figure 3-2: Using double-sided tape, adhere the plastic lens to the webcam while keeping the outer-most edge of the disk covering the webcam. Allow for a 1-2 mm gap between the lens and the webcam aperture to prevent distortions. Note: the outer edge of the disk is at the bottom of this picture.

4) Using the webcam afixed to the 45° wooden wedge, place the webcam in the conduit body and ensure the aperture is facing the imaging slit. Firmly adhere with double-sided tape. Now you can fold down the long black tab and close the two side tabs over it, and close the conduit body, screwing it firmly shut.

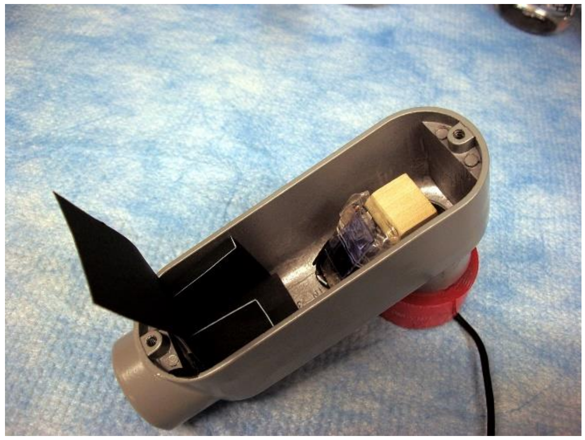


Figure 4-1: Firmly place the webcam and wooden wedge in the center of the conduit body.

Figure 4-2: Close the long black tab, and then close the two side tabs.

5) Now the spectrometer is ready for calibration.Go to http://spectralworkbench.org, follow the instructions and calibrate.

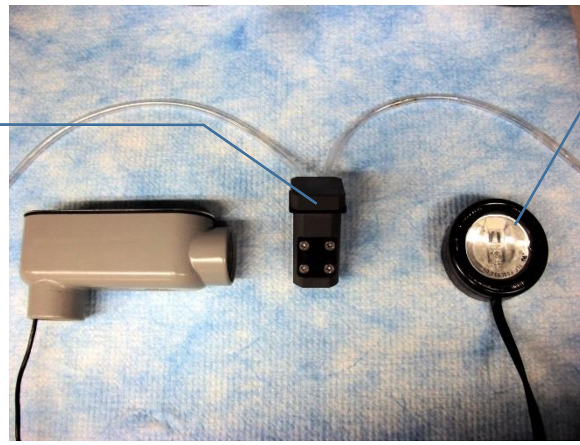


Figure 5-1: Example setup for the determination of nitrate concentration in drinking water with a flow-thru sample cell and a xenon light source. No actual data has been acquired at this time.

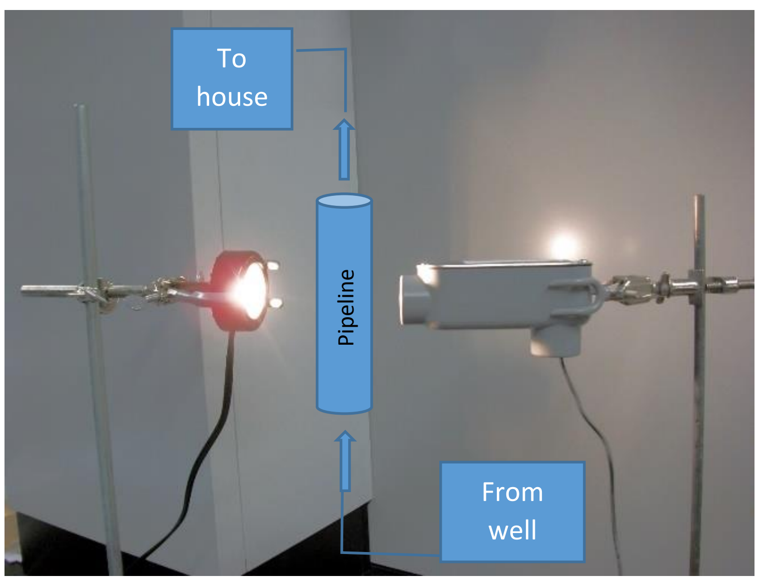


Figure 5-2: The ability of a spectrometer to measure a light source depends on the distance the light source is from the spectrometer. In the flow-thru design, the spectrometer will be placed at a transparent section of pipe, opposite to the light source in-between the well and house.

Results

The spectrometer is first calibrated using the normal CFL (mercury) wavelengths. The calibration is then saved. It is important not to alter the spectroscope arrangement once calibration has been done, otherwise the observations will not be comparable.

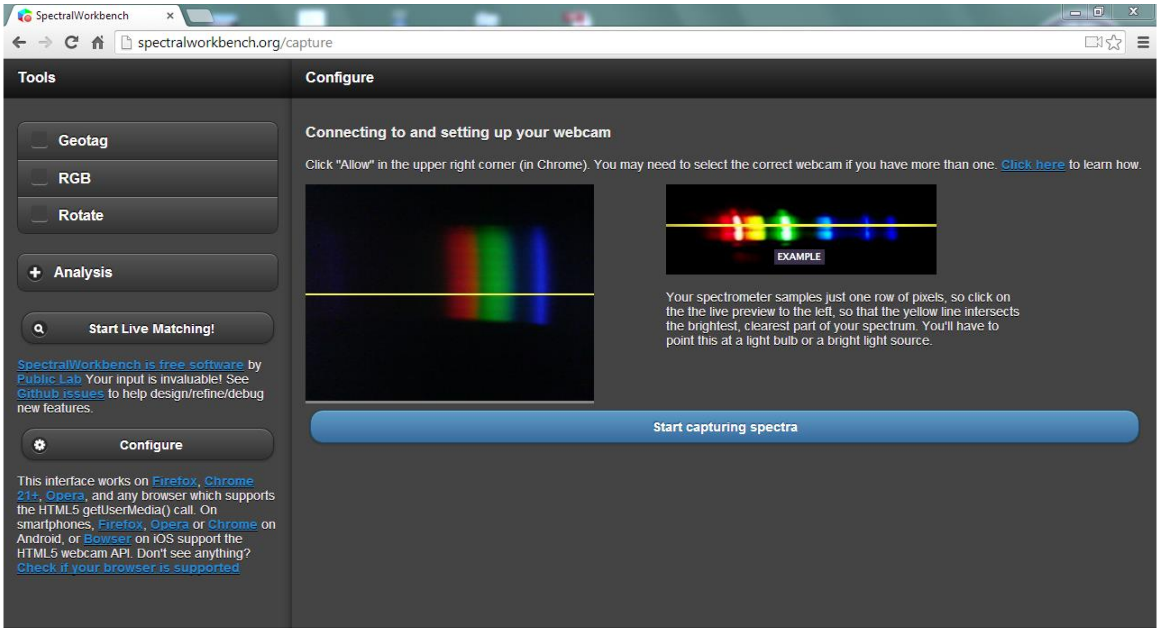


Figure R-1: First step in using SpectralWorkBench is configuring the spectrometer. The yellow line designates the spectrum line to be analyzed. This spectrum is of a white LED.

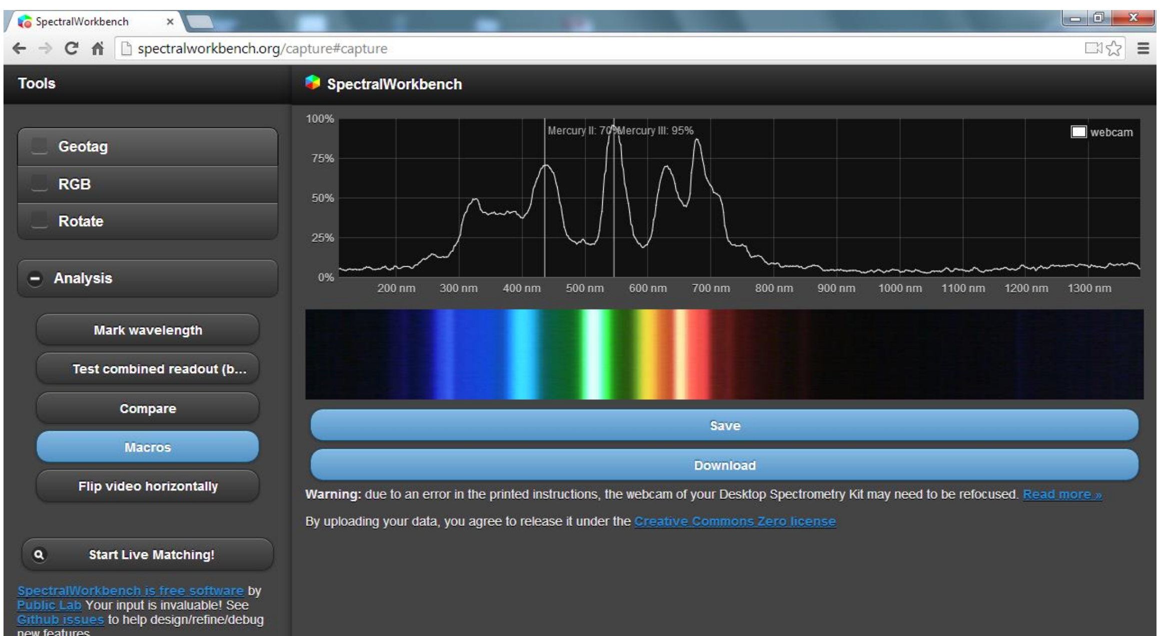


Figure R-2: The CFL spectrum contains Mercury II (436 nm) and Mercury III (546 nm). Observe the spectrum flip from Figure R-1 which is part of the configuration setup.