Spectrophotometers for Schools

Here we review two spectrophotometers suitable for use in school science labs. Both connect to computers via the USB connection. The models we looked at were the *Red Tide* from Ocean Optics and the *SpectroVis* from Vernier. The Red Tide can also be used with a Pasco Xplorer GLX interface and the SpectroVis can connect to a Vernier LabQuest. These handheld interfaces were reviewed in SSERC Bulletin 226 [1]. They have their own LCD screens and can display tables and graphs without the need to connect the spectrophotometers to a computer.

SpectroVis

Figure 1 - SpectroVis spectrophotometer.

The SpectroVis (Figure 1) is available from Instruments Direct Services Ltd [2]. At the time of writing it cost £382, plus £66 for the optional optical fibre probe (Figure 2). It works with Logger Pro 3 software which is available separately.

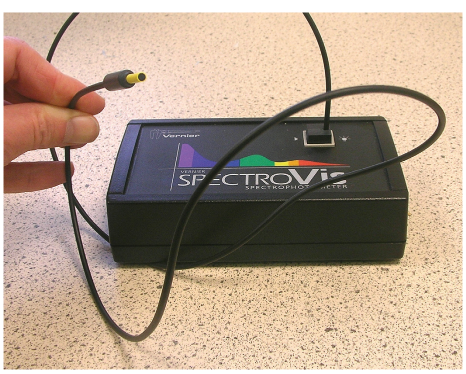

Figure 2 - SpectroVis with optional optical fibre probe.

The manufacturers claim a wavelength range of 400 nm to 725 nm, with a resolution of 3 nm. Our first test was the examination of the spectrum from a sodium lamp. Figure 3 shows the full spectrum whilst Figure 4 is a zoom on the yellow lines at 589.0 nm and 589.6 nm. Neither of the spectrophotometers we tested could resolve the sodium doublet into two discrete peaks. The results agree with the manufacturer's claims.

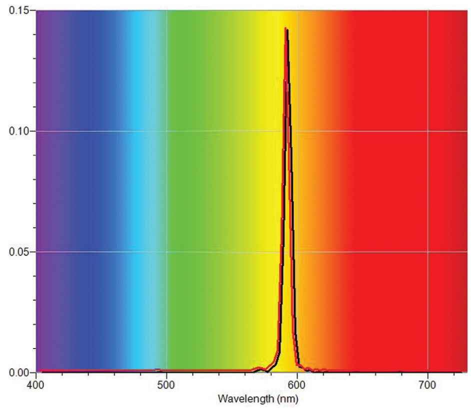

Figure 3 - Spectrum from sodium lamp (SpectroVis).

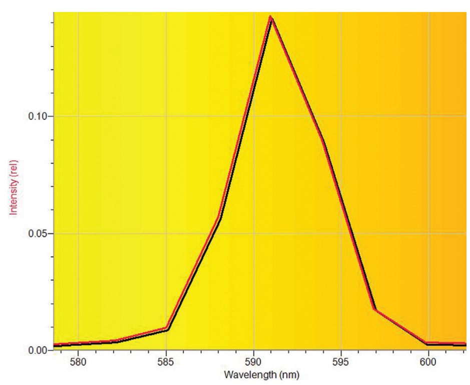

Figure 4 - Zooming in on the sodium yellow line (SpectroVis).

The SpectroVis also has a built-in cuvette holder (Figure 5) and white LED light source.

Figure 5 - Placing a cuvette in the cuvette holder.

This allows for absorbance and transmittance experiments to be carried out. A calibration procedure is described in the manual that comes with the spectrophotometer. We placed two different green food dyes (Figure 6) into cuvettes. Both were made by adding Supercook food colouring to water. This is readily available in supermarkets. In one case, green food colouring was used. In the other, the green colour was made by mixing yellow and blue dye.

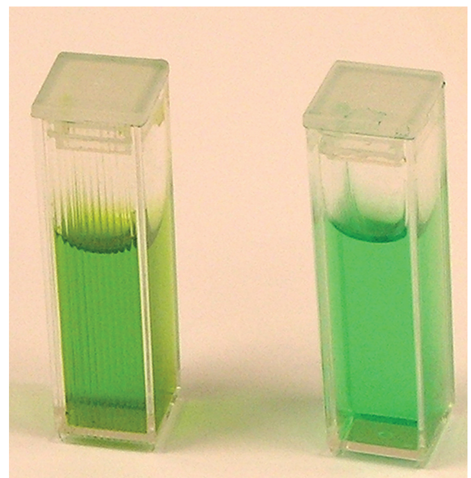

Figure 6 - Food dyes in cuvettes.

The absorbance and transmittance graphs are shown in Figure 7 below.

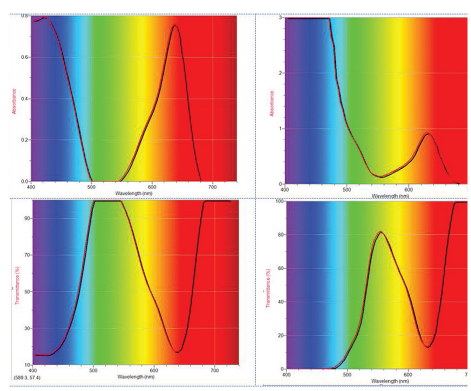

Figure 7 - Absorbance (top) and transmittance graphs for two dyes.

These features allow a number of experiments to be carried out, including investigating Beer's Law and forensic activities.

Some time ago, the senior physicist at SSERC got built for him some ping-pong ball colour mixers based on a design by Gorazd Planinsic of the University of Ljubljana [3]. Figure 8 shows two of them.

Figure 8 - Ping-pong ball colour mixers.

When we examine their output with the spectrophotometer, the results may at first seem surprising (Figure 9).

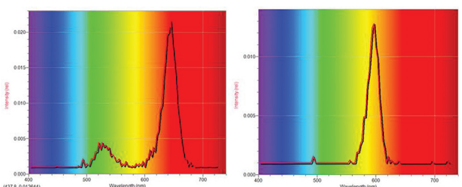

Figure 9 - Examining the light from ping-pong ball sources.

The balls appear to be the same colour, so why are the graphs different? The ball on the right contains yellow LEDs. As expected, there is a corresponding peak in the yellow part of the spectrum. However, the ball on the left contains red, green and blue LEDs but the blue one is off. In other words, we are comparing yellow produced by colour mixing with true yellow. This tells us something fundamental about colour mixing. It does not happen inside or at the surface of the ping-pong ball, or else both outputs would be the same. Rather, it takes place in the brain. *Colour mixing is biology, not physics.* Discuss.

Red Tide

The Ocean Optics Red Tide Spectrophotometer (Figure 10) is available from Feedback Instruments [4], Scientific and Chemical [5] and Timstar [6]. The typical cost is £795 for a "physics set" which consists of the base unit plus an optical fibre, or £1095 for the "chemistry set" which has no optical fibre but does have a light source and cuvette holder. Physics sets can be upgraded to chemistry sets and vice-versa. The range is said to be 350 nm to 1000 nm, with a resolution of 2 nm.

Figure 10 - Red Tide spectrophotometer with optional cuvette holder (chemistry set).

Once again we examined the spectrum from a sodium lamp (Figures 11 and 12).

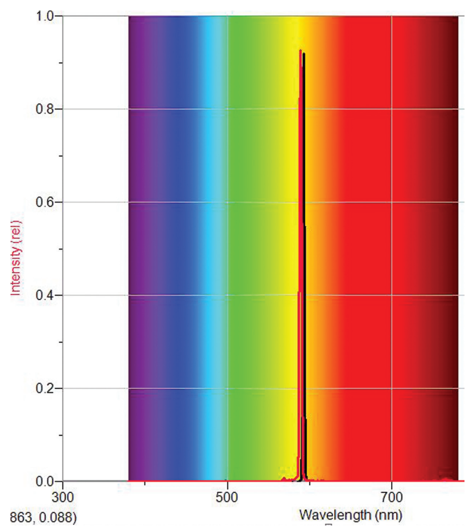

Figure 11 - Sodium emission spectrum captured by Red Tide.

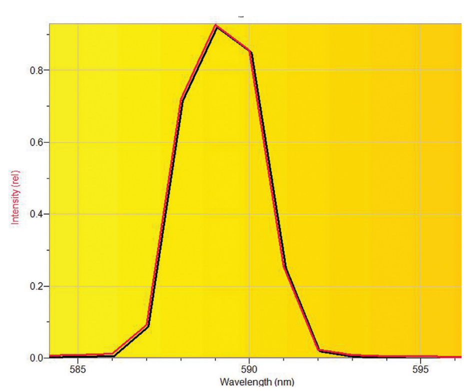

Figure 12 - Zooming in on the sodium yellow line (Red Tide).

The Red Tide works with Logger Pro 3 software but it also comes complete with a package called Spectrasuite. A Spectrasuite screenshot, showing a sodium absorption spectrum, is shown in Figure 13.

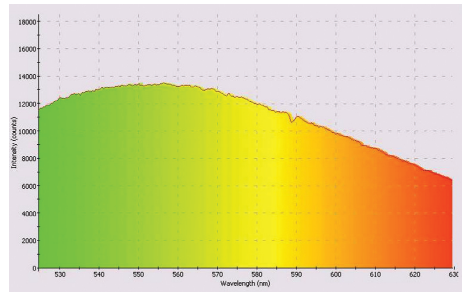

Figure 13 - Sodium absorption spectrum. Note the wee nick in the spectrum at around 589 nm where most absorption takes place.

Conclusion

Comparing the spectra produced by each device, we see that the Red Tide has the greater range and better resolution. It is also considerably more expensive. It is unlikely that many individual school departments could buy either model of spectrophotometer from their annual capital allowance. That said, should biology, chemistry and physics departments pool their resources, buying one becomes much more of a possibility. Since both devices offer possibilities for interesting, innovative practical work in all three sciences, we hope that they do find their way into classrooms.

Appendix

Testing the resolution of a spectrophotometer is not without its problems. The situation is complicated by the fact that no light source, not even a laser, is truly monochromatic. This makes it hard to determine whether the broad peaks we see are due to the measuring instrument, the light source or both. Look at the images below (Figures 14 and 15).

Figure 14 - Spectrum from laser diode module (SpectroVis).