BASIC COLORIMETER

Prakash Nawale and P.K.Joshi

Homi Bhabha Centre for science Education, Mumbai.

Published in IAPT bulletin volume 6, October 2014, page 260-261.

Colorimeter is a very essential piece of equipment in the experiments of chemistry and Physics, where light absorption is a key observation/characteristics of an experiment. The absorbance of the light at different wavelengths can be identification characteristics of a given liquid sample. However, for students of class X or XII, a colorimeter is a 'black box' giving results which they can interpret superficially.

While designing experiments for International Junior Science Olympiad (IJSO), we keep in mind the age group of the students and their experience in handling basic laboratory equipments. It has been our effort to use minimum and simplest possible equipment for their laboratory sessions. The equipment used by these students should itself be an object of learning and clarifying concepts of sciences.

In the month of December, 2013, India hosted IJSO in Pune. While designing the experiments the above mentioned idea was a driving force in deciding the experimental task. Thus a very basic "colorimeter" was designed which will help students understand the principles of light emission, absorption and detection. The setup was used as a colorimeter in an experiment to detect the presence of lycopene in tomato puree. However, we soon found usefulness of the same equipment in many other experiments and those will be described in other publications.

Tomatoes contain high levels of beta-carotene, an antioxidant that supports the immune system and helps maintain healthy skin and tissue lining. Tomatoes are packed with antioxidants and vitamin E, both of which are essential for good health, and are also a good source of potassium.

Besides, tomatoes are also the richest source of an exceptionally potent antioxidant called lycopene - the pigment that is responsible for deep red colour. A single lycopene molecule can neutralise up to 13 free radicals which, if allowed to build up, can cause cell damage and trigger cancer – which is nearly two times the radical busting power of beta-carotene.

The amount of lycopene in a tomato varies according to the variety, but deep red tomatoes can contain as much as 50mg of lycopene per kilogram. One of the characteristics of lycopene is

that it absorbs blue light almost completely. So qualitatively, if one can establish a high value of absorbance of blue light in a tomato extract (appropriately prepared) then the presence of lycopene can be established. One of the experiments designed for IJSO-2013 was based on this principle. The tomato puree extract in an extracting solvent (ethanol + pet-ether) was used to get lycopene filterate.

The device designed to work as a colorimeter is shown in the figure below. It has a test-tube holder which can hold the sample. On each side of the test-tube is a holder for fixing a light emitting diode (LED) and a photo-diode to detect light, aligned in a straight line. The LED can be connected to a power source and the sensor can be connected to a current meter to measure the current produced in the sensor proportional to the light incident on it. This arrangement can be see in figure 1.

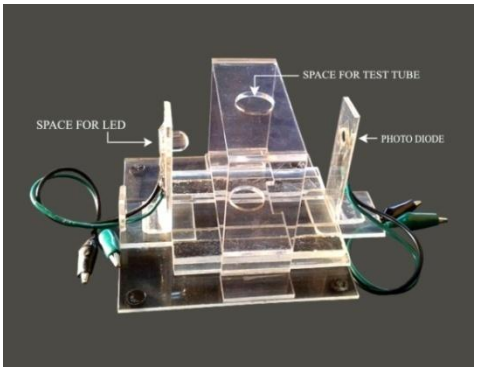

Fig. 1.

The base of the holder is about 11 cm x 11 cm square piece. This can be seen in figure 2. An arrangement is made so that the LED holder is fixed on the base plate but the test tube holder and the sensor holder can slide over the base plate without toppling. The dimensions of the same are given in Figure 2. The LED is powered by a DC adapter of approximately 2.5 volts, and the photo-diodes are soldered to wires to read the output current.

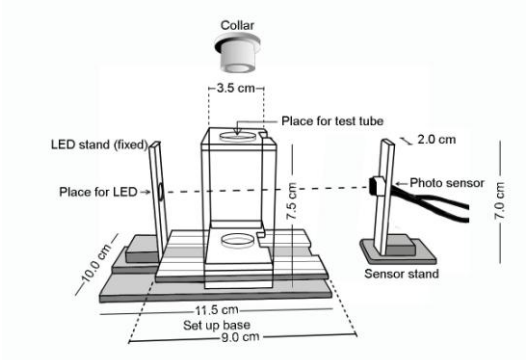

Fig. 2.

A collar is proved at the top to accommodate test tubes of smaller diameters.

In the absence of any sample, the light output from the LED is directly incident on the photo-diode and the output current can be read on a digital multimeter or current meter. When a test tube, filled with water or some similar liquid, is placed in the test tube holder, the liquid acts like a lens and the focusing of light increases the intensity of light incident on the photo-diode/sensor. By moving the sensor holder along the optical axis, one can maximize the current or the light incident on the sensor/photodiode.

The LED holder has the flexibility of replacing white LED with a colored LED to study the optical characteristics of the sample at different lights/wavelengths. In case of lycopene filterate, the intensity of the white light drops to around 50 percent by introduction of the lycopene in the path between white LED and sensor. But in case of blue LED, the current drops to around 2 percent. Thus indicating qualitatively, almost complete absorption of blue light by lycopene filterate.

After several different trials it was decided that acrylic was the most suitable material for this piece of equipment. The pieces were manufactured at TIFR workshop. We are thankful to the members of the TIFR workshop for making around 100 pieces of this equipment with precision.