Open Source Portable Spectrophotometer

Elena Ntina, Gerasimos Niforos

1 Introduction

Spectrophotometry deals with the measurement of the interaction of light with materials. Spectrophotometric systems are widely used in studies across many fields. Many of these applications require highly precise and reliable data which often leads to the implementation of complex and expensive spectrophotometric systems. Spectrophotometry is one of the most useful methods of quantitative analysis in various fields such as chemistry, physics, biochemistry, material and chemical engineering and clinical applications.

2 Theory

Spectrophotometry is a method to measure how much a substance absorbs light by measuring the intensity of light as a beam of light passes through a sample solution. The basic principle is that each compound absorbs or transmits light over a certain range of wavelength. This measurement can also be used to measure the amount of a known substance.
Absorption spectrophotometry is based on the ability of a substance to absorb radiation. Measurement of the degree of absorption at various discrete wavelengths yields a pattern of absorbance relative to wavelength — an absorption spectrum — characteristic of the light-absorbing substance. Such absorption spectra may be used to identify or characterize unknown compounds. In addition, the amount of absorbance of monochromatic light is often proportional to the amount of absorbing substance, thus yielding a method for quantitative estimation of the substance. Absorption spectra show the change in absorbance of a sample as a function of the wavelength of incident light. For this purpose it is convinient to intoduce to concept of absorbance A:

$A = -log_{10}(\frac{I}{I_o})$ where I_o is the original intensity of the light beam and I is the intensity of light that reaches the detector. Therefore, absorbance is a direct measure of how much light is absorbed by our sample. The absorbance is linearly proportional to the molar concentration of the sample; which enables the concentration of the sample to be calculated from the absorption spectrum using the Beer-Lambert Law:

$$A = \varepsilon LC$$

where ε is the molar absorptivity, L is the distance covered by the light inside the the sample and C is the concetration of the absorber.
In this work we have chosen to measure the absorbance spectrum of green tea diluted in water and acetone in the visible region of the spectrum.

3 Hardware

To carry out the measurements a C12880MA Spectrometer was used along with a white LED as a light source. The interface with the computer is achieved using a Arduino Uno microcontroller and a USB cable. In the following picture the setup is shown:

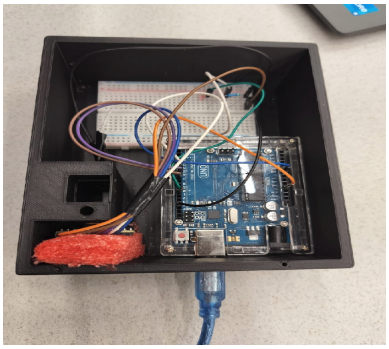

Figure 1: Spectrophotometer setup

4 Measurements

4.1 Spectrophotometer Testing

In order to test our hardware and especially the spectrophotometer's response, we replaced the white LED, that will be used for taking the absorption spectra of our substances, with LEDs of different colours. We chose red, green and blue light LEDs, as in the RGB model. We also measured the ambient light intensity for the room that the measurements were taking place and the spectrophotometer's response when there is no light source at all. Finally, we measured the intensity of the white light coming from the LED that will be used in the experiment.

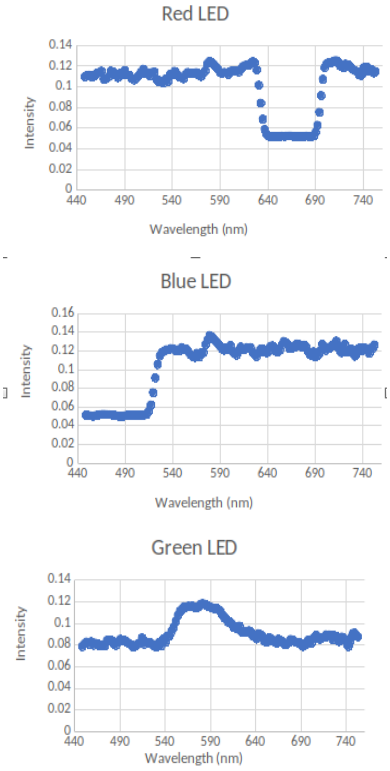

Figure 2: Intensity spectra of red, blue and green LED respectively

Below we find the spectra recorded in total absence of a light source, for the room's ambient light and with the white LED that we are going to use.

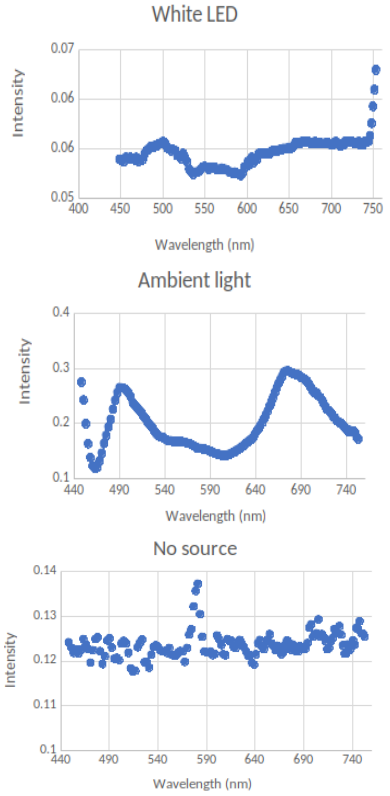

Figure 3: The spectra for the white LED, ambient light and no source (with the setup lid closed)

4.2 Primary Measurements

For our first measurements we created 2 different solutions. In both cases we infused 2 grams of green tea in 20 ml of liquid, in acetone ($(CH_3)_2CO$) and in distilled water, both at room temperature (20^o). For both cases, the teabag remained in the respective solvent for 10 minutes. Following the same philosophy as before, the spectrum of the two solvents was also measured.

5 Conclusions

By comparing the spectra of the green tea in the two different solvents we determine that the green tea-acetone sample is better suited for measurements in the range of the spectrum used. Therefore, our future measurements will concentrate on green tea samples diluted in an acetone solvent. The next step of our experiment is to use different concetrations of green

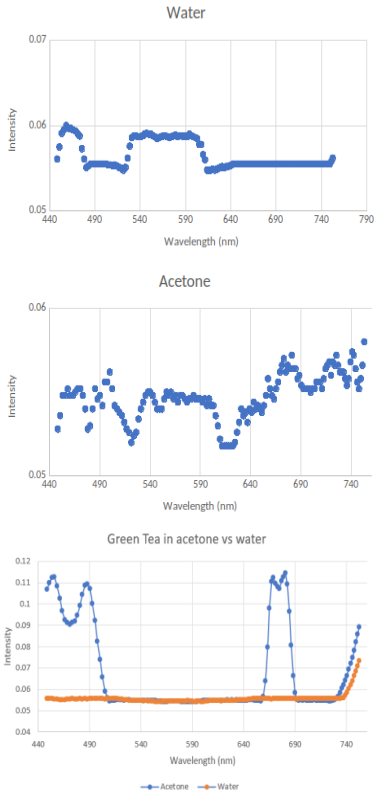

Figure 4: Spectrum water, acetone and of green tea in water and in acetone.

tea as well as different green tea leaves and observe how that effects the peak observed in the spectrum.