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Microcontroller Based Visible Light Spectrometer

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Abstract : *Visible spectroscopy is working based on the principle of Beer Lambert's Lam. It involves absorbance is directly proportional to intensity of the color and thickness of the medium.*
Visible Light wave length between 400nm to 800nm.

Keywords: *Absorbance, Monocrometer, Spectrophotometer, Spectroscopy, Transmittance.*

I. Introduction

The spectrophotometer has well been called the workhorse of the modern laboratory. Modern spectrophotometers are quick, accurate and reliable and make only small demands on the time and skills of the operator. Visible spectroscopy refers to absorption spectroscopy or reflectance spectroscopy in the visible spectral region. This means it uses light in the visible (near-infrared [NIR]) ranges. The absorption or reflectance in the visible range directly affects the perceived color of the chemicals involved. In this region of the electromagnetic spectrum, molecules undergo electronic transitions.

Visible spectroscopy refers to absorption spectroscopy or reflectance spectroscopy in the visible spectral region. This means it uses light in the visible and adjacent (near-infrared [NIR]) ranges. The absorption or reflectance in the visible range directly affects the perceived color of the chemicals involved. In this region of the electromagnetic spectrum, molecules undergo electronic transitions. This technique is complementary to fluorescence spectroscopy, in that fluorescence deals with transitions from the excited state to the ground state, while absorption measures transitions from the ground state to the excited state.[1]

A spectrophotometer can be either single beam or double beam. In a single beam instrument all of the light passes through the sample cell. *I*o Must be measured by removing the sample. This was the earliest design and is still in common use in both teaching and industrial labs. [2]

The basic parts of a spectrophotometer are a light source, a holder for the sample, a diffraction grating in a monochromator or a prism to separate the different wavelengths of light, and a detector. The radiation source is often a Tungsten filament (300-2500 nm), a deuterium arc lamp, which is continuous over the ultraviolet region (190-400 nm), Xenon arc lamp, which is continuous from 160-2,000 nm; or more recently, light emitting diodes (LED) for the visible wavelengths. The detector is typically a photomultiplier tube, a photodiode, a photodiode array or a charge-coupled device (CCD). Single photodiode detectors and photomultiplier tubes are used with scanning monochromators, which filter the light so that only light of a single wavelength reaches the detector at one time. The scanning monochromator moves the diffraction grating to "step-through" each wavelength so that its intensity may be measured as a function of wavelength. Fixed monochromators are used with CCDs and photodiode arrays. As both of these devices consist of many detectors grouped into one or two dimensional arrays, they are able to collect light of different wavelengths on different pixels or groups of pixels simultaneously. [3]

II. Basic Principle

Visible (Vis) absorption spectroscopy is the measurement of the attenuation of a beam of light after it passes through a sample or after reflection from a sample surface. Absorption measurements can be at a single wavelength or over an extended spectral range. Spectrometer it is instrument which is use to measure the concentration of medium. It involves, absorbance is directly proportional to intensity of the color and thickness of the medium. It measures the light that passes through a liquid sample.

Spectrophotometer gives readings in percent transmission (%T) and in absorbance (A)

2.1 Beer Lambert's Law.

Visible spectroscopy is working based on the principle of Beer Lambert's law**.** The law states that, the amount of light absorbed by a solution (colored) is proportional to the concentration of the absorbing substance and to the thickness of the absorbing material (path length). Absorbance is also called optical density

It is the branch of science that deals with the study of interaction of electromagnetic radiation with matter.

A = abc
Where,
a. a – Molar absorptivity,
b. b –Path length
c. c – Molar concentration

III. System Development

3.1 Block Diagram

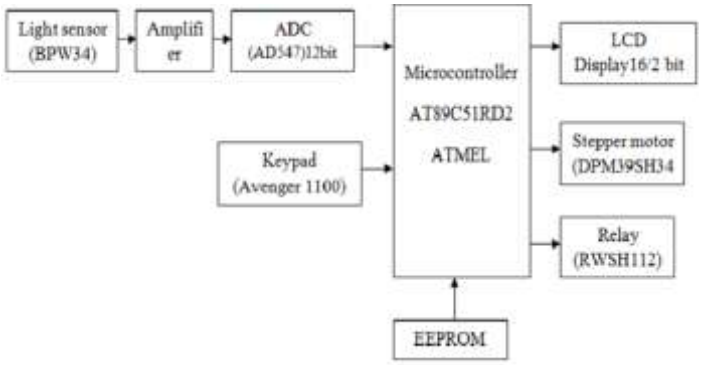

Fig. 1. Block Diagram

Desired wavelength is entered by keypad & set using stepper motor. Light sensor (photodiode) generates the analog signal (mV) proportional to digital intensity. This signal reads through ADC. In spectroscopy reference light signal is measured. When sample placed in path of light & transmit the light. This Light intensity is measured by microcontroller. Microcontroller calculates the percentage transmission.

3.2 Schematic Diagram

3.2.1 Source

It is important that the power of the radiation source does not change abruptly over its wavelength range. The electrical excitation of deuterium or hydrogen at low pressure produces a continuous V spectrum. The mechanism for this involves formation of an excited molecular species, which breaks up to give two atomic species and an ultraviolet photon.

3.2.2 Sources Of Visible Radiation

The tungsten filament lamp is commonly employed as a source of visible light. This type of lamp is used in the wavelength range of 350 - 2500 nm. The energy emitted by a tungsten filament lamp is proportional to the fourth power of the operating voltage.

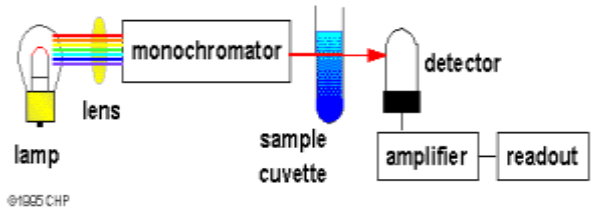

Fig. 2. Schematic Diagram

3.2.3 Wavelength Selector (Monochromatic)

Polychromatic radiation (radiation of more than one wavelength) enters the monochromator through the entrance slit. The beam is collimated, and then strikes the dispersing element at an angle. The beam is split into its component wavelengths by the grating or prism. By moving the dispersing element or the exit slit, radiation of only a particular wavelength leaves the monochromator through the exit slit.

3.2.4 Cuvettes

The containers for the sample and reference solution must be transparent to the radiation which will pass through them. Quartz or fused silica cuvettes are required for spectroscopy in the UV region. These cells are also transparent in the visible region. Silicate glasses can be used for the manufacture of cuvette for use between 350 and 2000 nm.

3.2.5 Detectors

The photomultiplier tube is a commonly used detector in Vis spectroscopy. It consists of a photo emissive cathode (a cathode which emits electrons when struck by photons of radiation), several dynodes (which emit several electrons for each electron striking them) and an anode.

IV. Analysis

If the appropriate wavelength is not selected, the sample will not absorb enough light to make an accurate measurement. To select the best wavelength for measurements, we must find the wavelength of maximum absorption. To do this, we plot wavelength (x-axis) versus absorbance (y-axis) and simply find the wavelength that gives the maximum absorbance. The example below shows a peak absorbance occurring at about 610 nm.

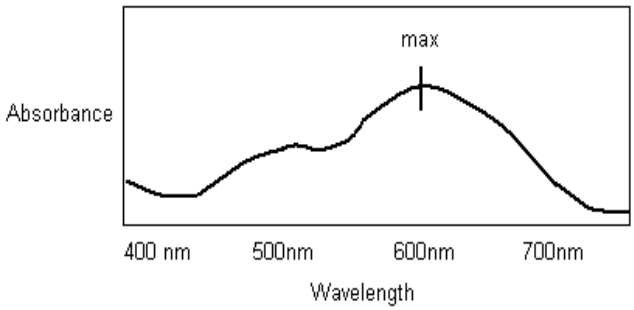

Fig. 3 Absorbance process

Concentration may be expressed in several ways. In this exercise, it is expressed as the milligrams of copper per milliliter of solution (mg/mL). To determine the concentration of an unknown, a series of standards must first be prepared. Standards are made by diluting (adding water to) a stock solution to prepare solutions of known concentrations. The absorbance values and concentrations of these solutions are then graphed, and then the unknown concentration of a solution can be determined from the graph. The relationship between concentration and absorbance can be summarized by using Beer's Law. Mathematically, Beer's Law states that these two quantities are directly (linearly) proportional. A plot of concentration (on the x-axis) versus absorbance (on the y-axis) will produce a linear relationship with a positive slope.

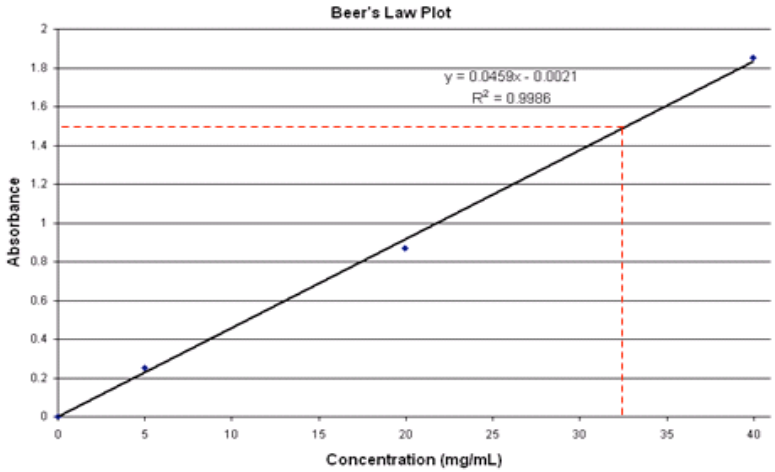

Fig. 4 Beer's law plot

While measuring absorbance, reflectance and transmittance a reference cuvette was used for zeroing

the spectrometer. In order to ascertain the equivalence of the two drugs their absorbance, transmittance and reflectance have to show similar trends. From the results it was seen that both drugs showed presence of a characteristic peak at the same wavelength but the difference was the peak height.

V. Conclusion

Uptil now hardware & software development is completed. Final test results are in process. Almost 75% work of project has been completed. Using this project we measure the concentration of sample.

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