A SHORT REVIEW ON ULTRAVIOLET AND VISIBLE SPECTROSCOPY

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ABSTRACT: It is and electronic spectroscopy technique and it is the measurement of electromagnetic radiation which causes changes in energy state from ground to higher. This technique is based on absorption law which is Beer-Lambert's Law. It gives accuracy in their result and used for the analysis of wide variety of sample compounds. It ranges from ultraviolet to visible region. It is very useful technique for the molecular determination, structural elucidation and to determine impurities. The various types of radiation sources are used in this technique to get more accuracy in their result. In this article we discussed about the analytical technique which are widely used in industries.

KEYWORDS: EMR (Electromagnetic radiation), UV (Ultraviolet), Beer-Lambert's Law, Adsorption

INTRODUCTION

Spectroscopy is the technique which measures the Electromagnetic radiations (EMR) which is emitted or absorbed by molecules or atoms or ions of a sample when it moves from one energy state to another energy state and Electromagnetic radiation is a type of energy such as UV rays, Infrared rays, Micro-waves, Radio-waves, X-rays, Gamma rays and visible light etc. EMR is created when a an electron is accelerated by an electric field it cause movement of particles which produces Oscillating electric and magnetic fields which travels at right angles to each other. This technique also deals with the study of interaction between EMR and matter. It is widely used in analytical field for the study of atomic and molecular structures and also used for the analysis of wide varieties of samples. [1]

UV Spectroscopy is also known as electronic spectroscopy; this technique is simple and rapid, and applicable to small quantities of compounds. The fundamental law of spectroscopy techniques that provide the quantitative spectrophotometric analysis which is based on the Beer-Lambert's law. [2-3]

Beer's Law

The intensity of beam of monochromatic light decreases rapidly with the increase in concentration of the absorbing substance or it state the when the light beam is passed through the solution of absorbing substance, the rate of decrease of intensity of radiation with thickness of absorbing solution is proportional to intensity of incident as well as the concentration of solution or Beer's law states that concentration and absorbance is directly proportional to each other. [4-6]

Lambert's Law

When the beam of light from radiation source is allowed to pass through a transparent medium, the rate of decrease of intensity with the thickness of medium is directly proportional to the intensity of light or the rate of decrease of intensity of the Monochromatic light with the thickness of medium is directly proportional to the intensity of incident light. [7-8]

The Beer and Lambert law are normally combined in relation-

$$A = -\log_{10} P/P_0 = abc$$

Where,

A = absorbance / optical density
P = radiant power / intensity
a = absorptivity / extinction coefficient
b = length of the beam in the absorbing medium
c = concentration of the absorbing species [9]

Principle of Ultraviolet and Visible Spectrophotometer

It is based on the principle of absorption of UV & Visible light by chemical compounds, which result in production of different spectra and the spectra arise from the transition of an electron within a molecule from ground state to excited state. When the molecules absorb UV radiation frequency the electron in that molecule undergoes transition from ground level to higher energy level. [10]

Ultraviolet/Visible absorption spectrum is depends on the molecular structure. It is also useful for identification of compound as well as determination of the physicochemical properties such as pka and complexation. The molecules contains the Chromophore which determine that where and in what amount the compound will absorb light in UV-Vis spectrum and it depends on the molecular structure of the compound.[11]

However in pharmaceutical analysis the important application of UV-Vis Spectrophotometer is quantify the drug substances. On the basis of Absorption law of Beer-Lambert qualitative analysis is done by the measurement of absorbance (A) of compound, which may be written as-

$$A = \log\left(\frac{Io}{I}\right) = \varepsilon bc$$

Where,
Io = Intensity of incident light,
I = Intensity of transmitted light,
ε = molar absorption coefficient,
b = the path
c = concentration of light by the absorbing compound[12]

TYPES OF UV/VIS ANALYZER

Selection of analyzer is most important and it is based on the UV/Visible absorption and it is available from very simple to highly sophisticated designs at commercially.
It can be divided into two types-

1. Filter photometric analyzers
- Single Beam
- Dual Wavelength split Beam
- Filter wheel chopper
- Dual Beam

2. Process Spectrophotometer
- Process scanning spectrophotometers
- Process photodiode array spectrophotometers

FILTER PHOTOMETRIC ANALYZERS

It is the most common type of UV-Vis analyzer and the simplest beam (Fig 1). The second type of analyzer is based on the differential measurement at two wavelength (Fig2).[13-14]

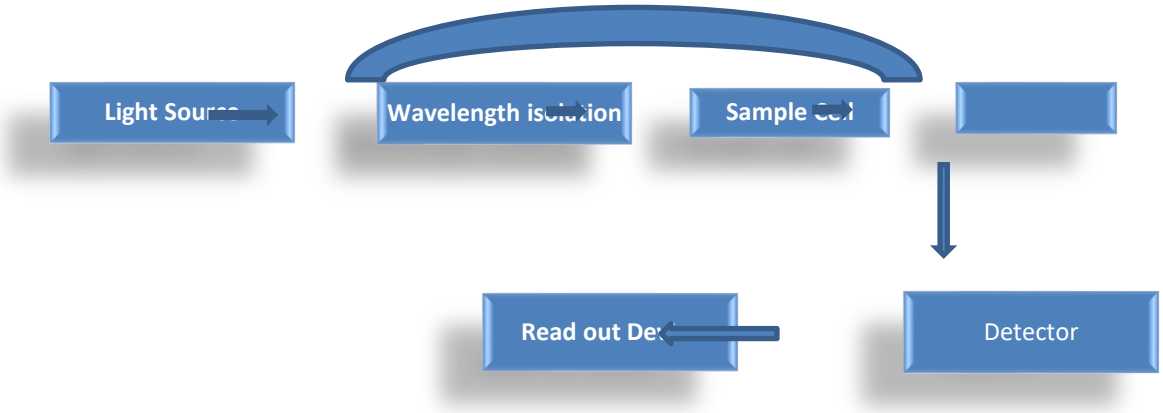


Fig.1 Block Diagram of Absorption Analyzers

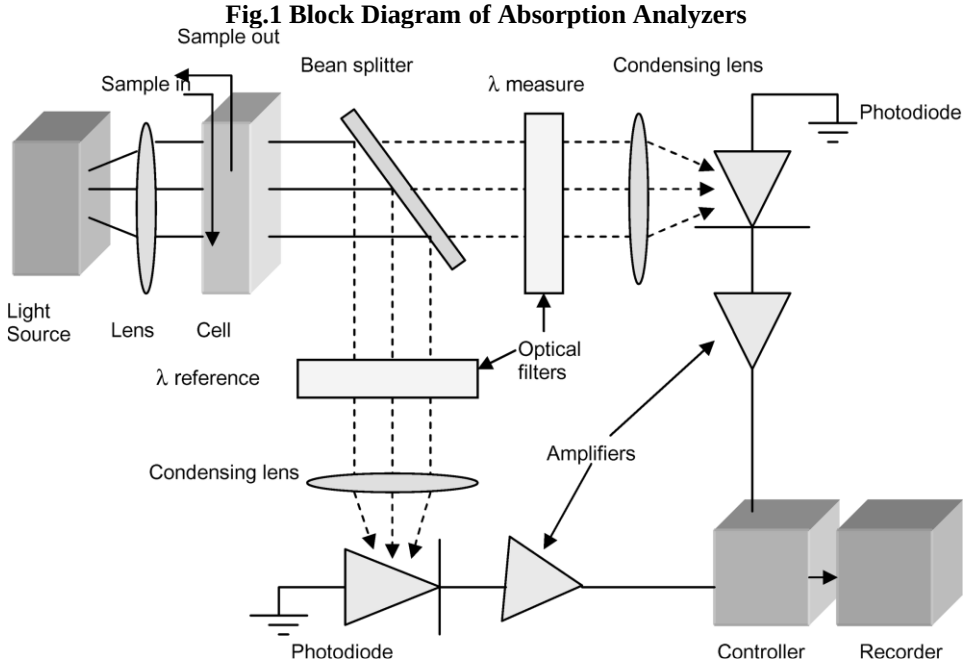
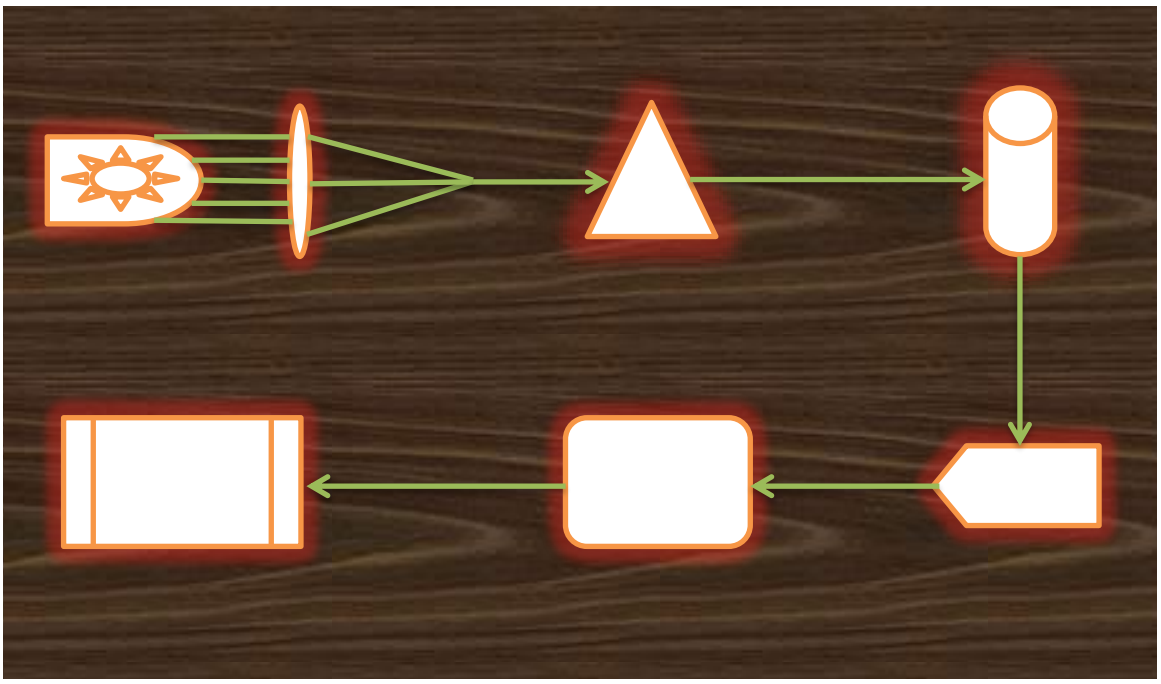


Fig. 2 Block Diagram of two wavelengths UV-Vis Analyzer



INSTRUMENTATION of UV SPECTROPHOTOMETER

Fig. 3 Block Diagram of UV Spectrophotometer

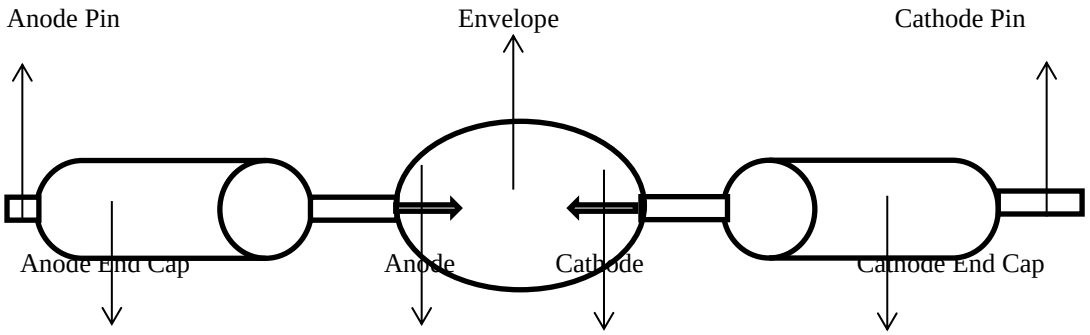


Fig. 3. Xenon Discharge Lamp

Followings are the component of UV Spectrophotometer

1. Radiation Source- The most common type of radiation sources which are used in UV spectrophotometer are Xenon discharge lamp, Hydrogen discharge lamp, Deuterium lamp, Mercury arch lamp, Tungsten lamp. These all types of radiation sources causes excitation by passing electrons through a gas which results in collisions between electrons and gas molecules which result in the production of electronic or vibrational and rotational excitation in the gas molecules.

Properties of Radiation sources: *The radiation sources must be stable and must not allow fluctuations; it must emit light of continuous spectrum of high and uniform intensity over the entire wavelength region in which it is used.*

a) Hydrogen Discharge Lamp: It is used for UV region and it consists of anode and cathode which is enclosed in a glass tube which provided with silica or quartz window for UV radiation to pass and filled with hydrogen gas. When current is passed through this electrode which is maintained at high voltage and discharge of electron occurs which excites the hydrogen molecules which in turn cause emission of UV radiation near region.

b) Xenon Discharge Lamp: It is also known as Xenon arch lamp. It has two tungsten electrodes which is separated by some distance and enclosed in glass tube (with quartz or fused silica) and Xenon gas is filled under pressure within the tube, its intensity is higher than hydrogen discharge lamp.

c) Mercury Arch Lamp: Mercury arch lamp is enclosed with mercury vapour under high pressure and excitation of mercury atoms is done by electric discharge.

2. MONOCHROMATORS-

All types of monochromators have the following component such as an entrance slit and a collimating lens and dispersing device which may be prism or grating or a focusing lens, an exit slit. Monochromator are used to isolate the desired wavelength of radiation from wavelength of continuous spectra.

The entrance slit allows to incoming beam of heterochromatic radiation, the dispersing element disperses the radiation into its components wavelength, exit slit allows the nominal wavelength together on either side of it. Various types of monochromatic devices are used which are as follows

1. Filters: *The various types of filters are used such as a) Glass Filter, These are made from pieces of coloured glass which transmit limited wavelength of spectrum wide band width-150nm.b) Gelatin Filter, It consists of mixture of dyes placed in gelatin and band width-25nm. c) Interferometric Filter, It is band width-15nm.*

2. Prism: *Bends monochromatic light amount of deviation depends upon wavelength produces non-linear dispersions.*

3. SAMPLE CONTAINERS OR SAMPLE CELL-

The cells or Cuvette are used for handling liquid samples. The cell may either be rectangular or cylindrical in nature. For study in UV region the cells are prepared from quartz or fused silica whereas fused glass is used for visible region. Thickness of cell is generally 1centimeter.

4. DETECTOR

These are device which converts the light energy into electrical signals that are displayed on read out devices. Transmitted radiation falls on detector which determines intensity of radiation absorbed by the sample. The most common type detectors are used such as Barrier layer cells detector, photo cell detector, Photomultiplier, photovoltaic cells.

5. READ OUT DEVICE OR RECORDER

Recorders are the device which displays all the information which is to be provided by the detector. The resulted information could be a written statement, readings, wavelength chart, table, graph etc. The most common type of recorder is Galvanometer, Ammeter, Digital Read out device.[15]

ELECTRONIC TRANSITIONS

When the organic molecules absorbed energy in the UV region, then it causes transition of valence electrons within the molecules. This transition occurs at different energy level and generally four types of electronic transition are possible which are as follows-

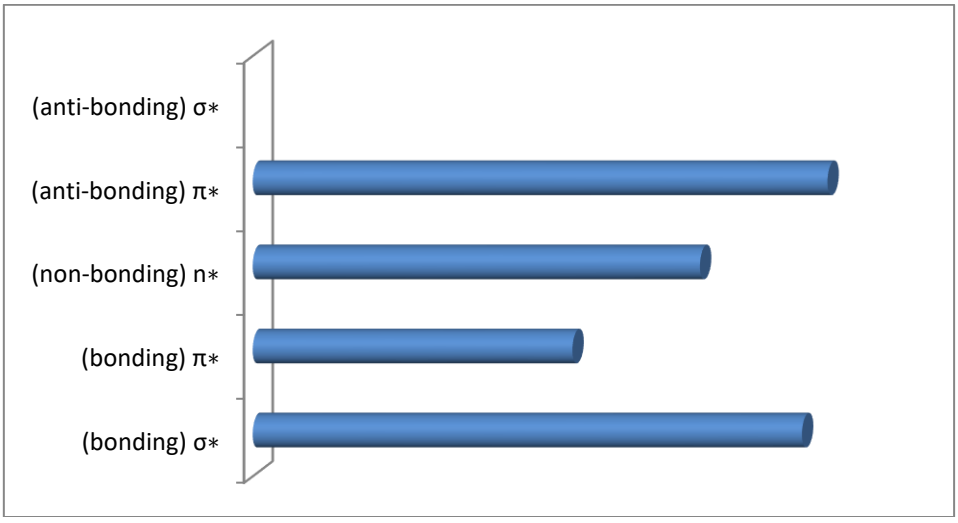


Fig. 4. Electronic Transition of Molecules

1. n → π* Transition- This type of transition occurs in unsaturated molecules which have atoms such as nitrogen, sulphur and oxygen. An electron from non-bonding orbital is promoted to anti-bonding π^* orbital. Compounds containing double bond involving hetero atoms (C=O, N=O, C≡N) undergo such transitions. n → π^* Transition require low energy and show absorption at longer wavelength around 300-350nm.

2. (σ → σ*) Transition- This type of transition occurs in such type of compounds whose all electrons are involved in the single bonds there are no lone pair of electron. σ electron from orbital is excited to corresponding anti-bonding orbital σ^*. The large energy required for this type of transition. E.g. Methane (CH_4) has C-H bond only and can undergo σ → σ^* transition and shows absorbance maxima at 125nm.

3. (n → σ*) Transition- This type of transition occur in saturated compounds like oxygen, nitrogen, sulphur and halogens having loan pair of electrons (non-bonding). It requires less energy than that of σ → σ^* transition. The number of organic functional groups with n → σ^* peaks in UV region is small (150-250nm).

4. π → π* Transition- π electron in a bonding orbital is excited to corresponding anti-bonding orbital π^*. Compound containing multiple double bonds like alkenes, alkynes, carbonyl, nitriles, aromatic compounds undergo π → π^* transition E.g. Alkenes generally absorb in the region 170 to 205nm.[16]

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