POLARIMETRY

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OUTLINE

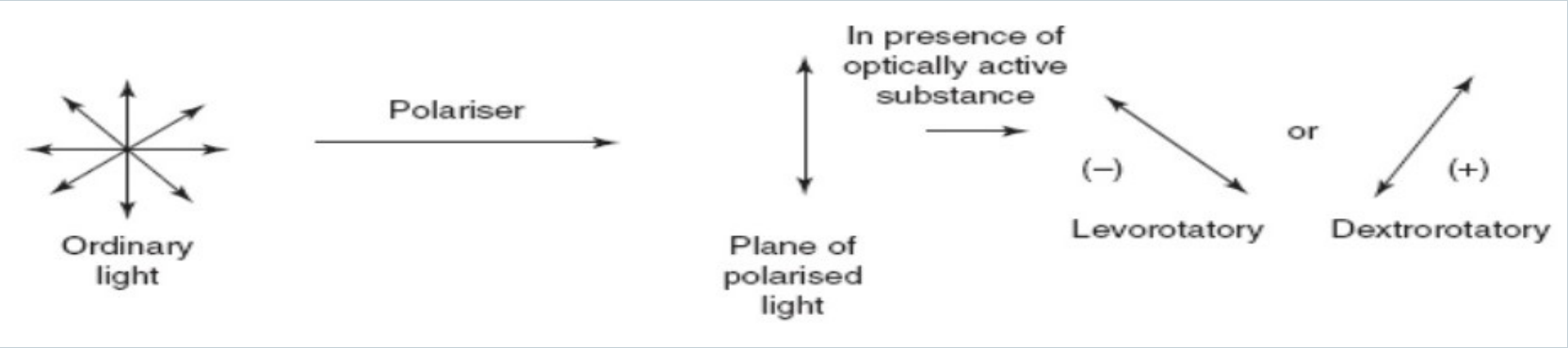
- Introduction
- Optical activity
- Specific Rotation
- Polarimeter
- Applications

INTRODUCTION

- Polarimetry is a type of qualitative and quantitative technique, used for **optically active** compounds
- the tendency of the molecules to **rotate** the plane of plane polarized light (clockwise or anticlockwise) and the **extent of rotation** is measured
- these properties are unique for a molecule, thus polarimetry can be used to **identify** and **estimate** the compounds

DEFINITION

- Polarimetry is one of the important instrumental methods employed in analysis. This measures the rotation of the polarized light as it passes through an optically active compound. This technique involves the measurement of change in the direction of vibration of polarized light when interact with an optically active compound. A substance is said to be optically active if it rotates the plane of the polarized light.



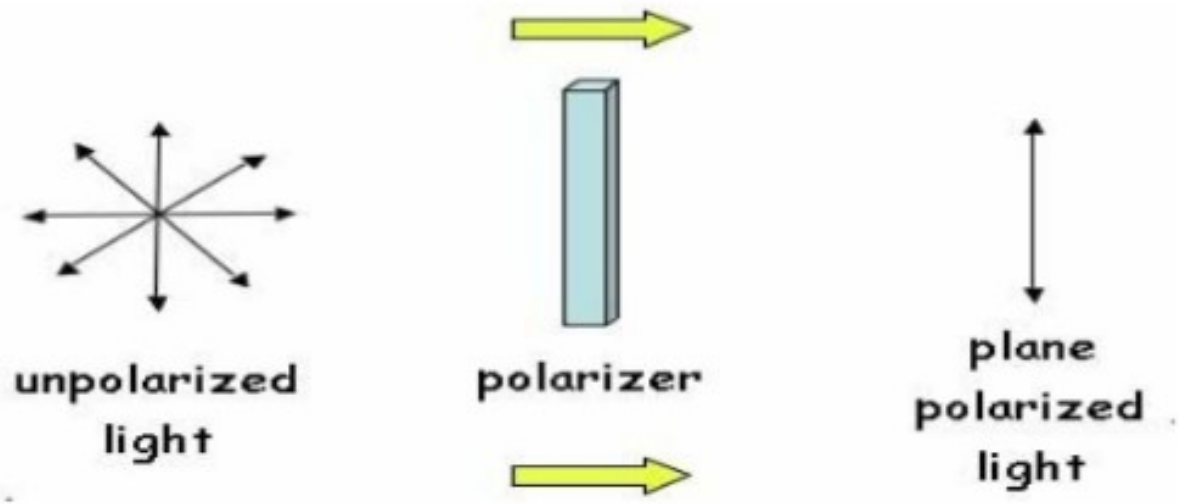
PLANE POLARIZED LIGHT

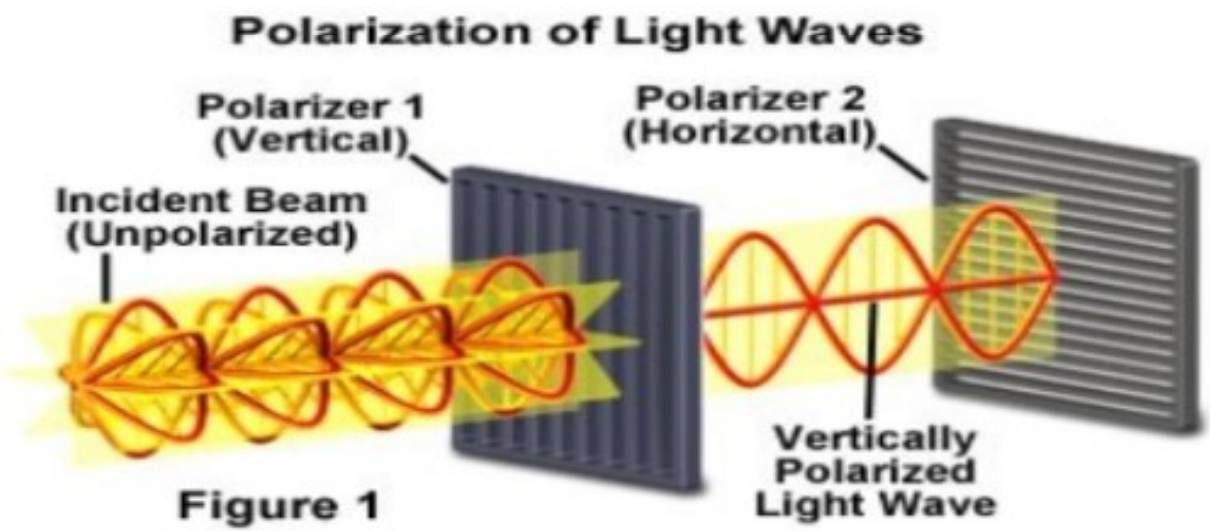
- According to wave theory of light, an ordinary ray light is considered to be vibrating in all planes at right angle to the direction of propagation. If this ordinary ray of light is passed through a Nicol prism, the emergent ray has its vibration only in one plane. This light having wave motion in only one plane is known as Plane Polarised Light.
- NICOL Prism –

➢ Iceland Spar

➢ Calcite ($CaCO_3$ form)

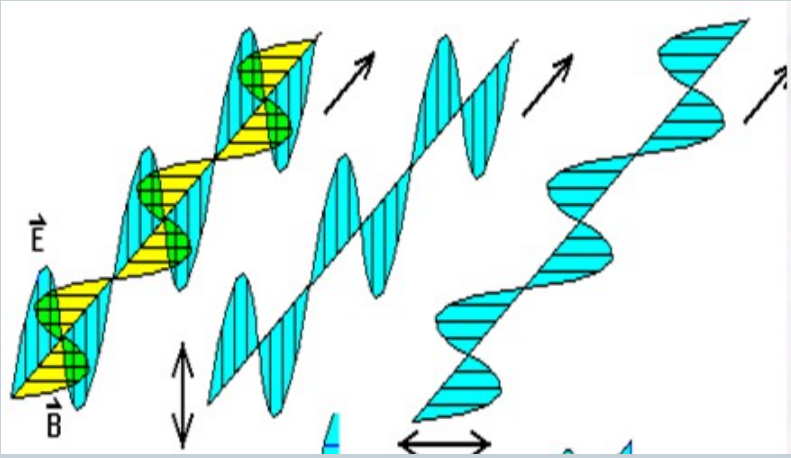
➢ (or) Polaroid

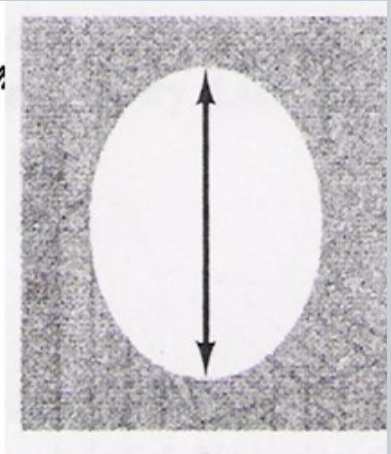

unpolarized light
polarizer
plane polarized light


Polarization of Light Waves
Polarizer 1 (Vertical)
Polarizer 2 (Horizontal)
Incident Beam (Unpolarized)
Vertically Polarized Light Wave
Figure 1

PLANE POLARIZED LIGHT

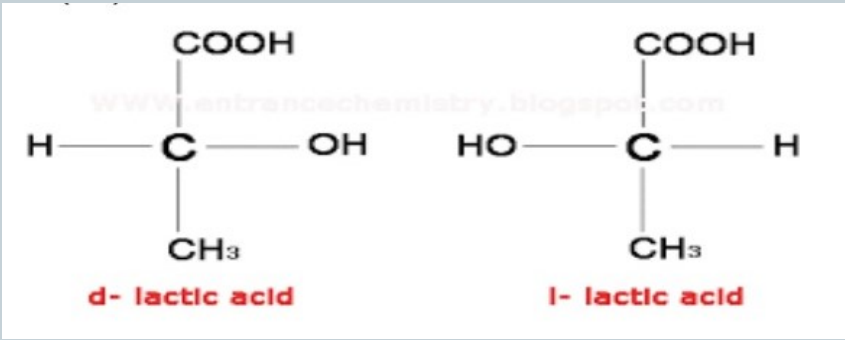
- A plane polarized light consists of two components of fixed magnitude rotating in opposite directions to one another: The right circulatory polarized light and The left circulatory polarized light
- Plane polarized light is the vector sum of these two components





OPTICAL ACTIVITY

- It is the property of a chemical substance to rotate the plane of polarization of plane-polarized light.
- Example: Lactic acid



Dextro= right designated by ‘d’, (+), clockwise

Levo= left designated by ‘l’, (-), counterclockwise

OPTICAL ACTIVITY

- Displayed by solutions of some compounds, notably many sugars.
- The magnitude of rotation depend upon the following factors:

➢ 1. Nature of Substance

➢ 2. Length of liquid column (l) through which light passes.

➢ 3. Concentration of the solution.

➢ 4. Nature of the solvent.

➢ 5. Temperature of the solution (t)

➢ 6. Wavelength of the light used

SPECIFIC ROTATION

- The Rotatory Power of a given solution is generally expressed as <u>specific rotation</u>.
- It is the number of degrees of rotation of plane polarized light produced by one gram of the substance per ml. The measurements is carried out at temp (T) using sodium light (D line). The Specific rotation can be Calculated by the following relation:

$$[\alpha]^t_D = \frac{100 \times \text{observed angle of rotation}}{\text{length in decimeters} \times \text{Grams of substance in 100 ml of solution}}$$

$$[\alpha]^t_D = \frac{100 \times \theta}{l \times c}$$

[α] = specific rotation, T = temperature, λ = wavelength, θ= optical rotation, c = concentration in g/100ml, l = optical path length in dm.

SPECIFIC ROTATION

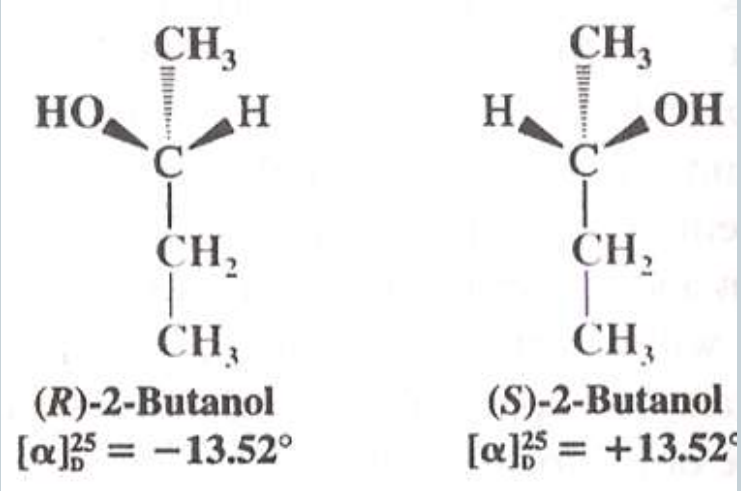
- [α] depends on the temperature and the wavelength of the light used
- These quantities are also incorporated while reporting [α]

$$[\alpha]_D^{25} = +3.12^o$$

- means D line of a sodium lamp (λ=589.6nm) is used for the light at a temperature of 25°C, and that a sample containing 1.00g/ml of the optically active substance, in a 1-dm tube, produces a rotation of 3.12° in a clockwise direction

Types of molecules analyzed by Polarimetry

Molecule must be Optically active: Optically Active molecule contain asymmetric carbon atom, i.e. ENANTIOMERS

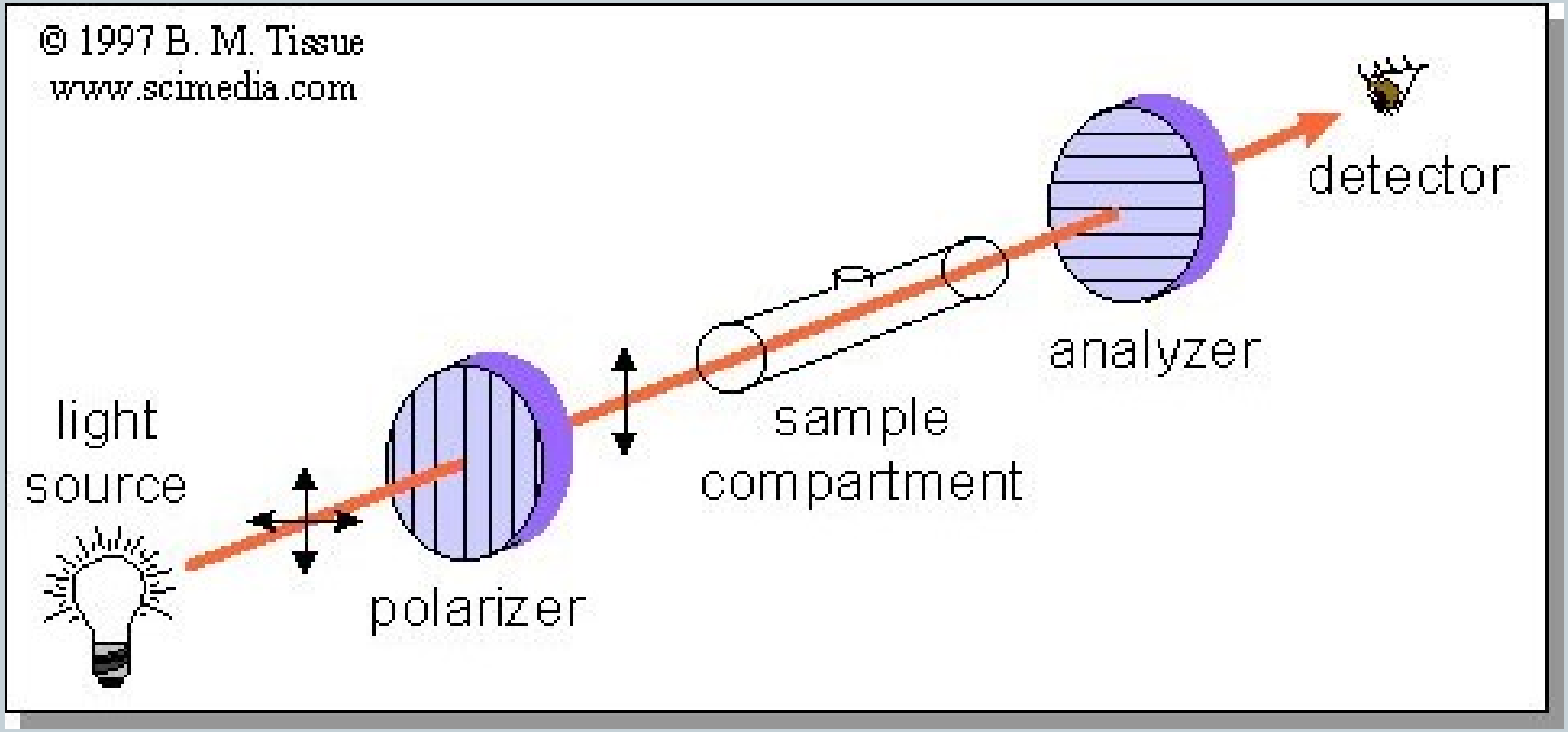


Specific rotation of Enantiomers of 2-butanol

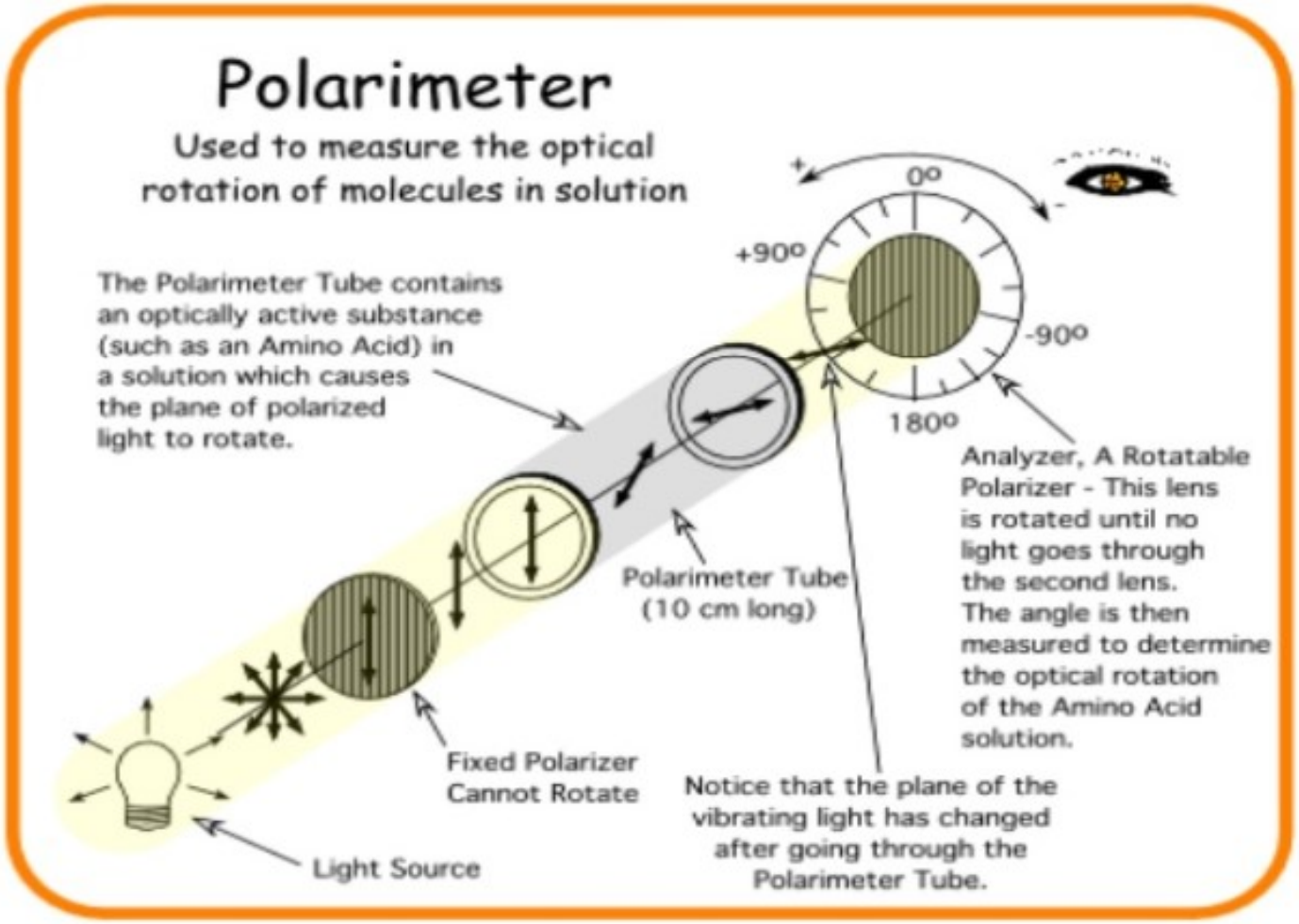
INSTRUMENTATION:POLARIMETER

- The Polarimeter is a device used to measure the effect of plane-polarized light on optically active compounds
- The components of polarimeter are:
- A light source : usually a sodium lamp
- A polarizer: Nicol Prism
- A tube for holding sample in the light beam: sample cell
- An analyzer: Nicol prism aligned to intercept the linearly polarized ray as it emerges from the sample solution , and
- A scale: to measure the rotation of plane polarized light

POLARIMETER: Outline



POLARIMETER: Detailed



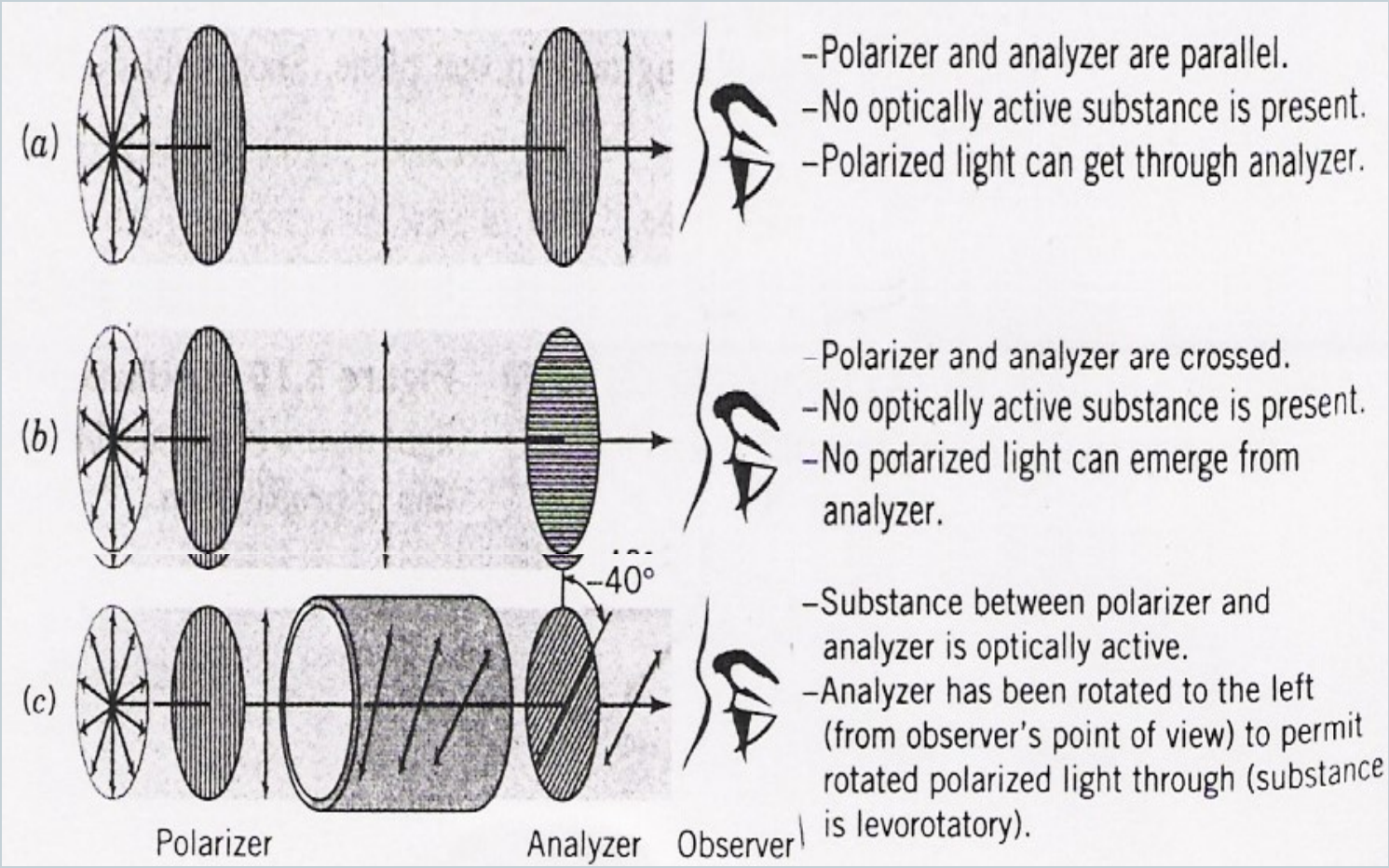
POLARIMETER: Working

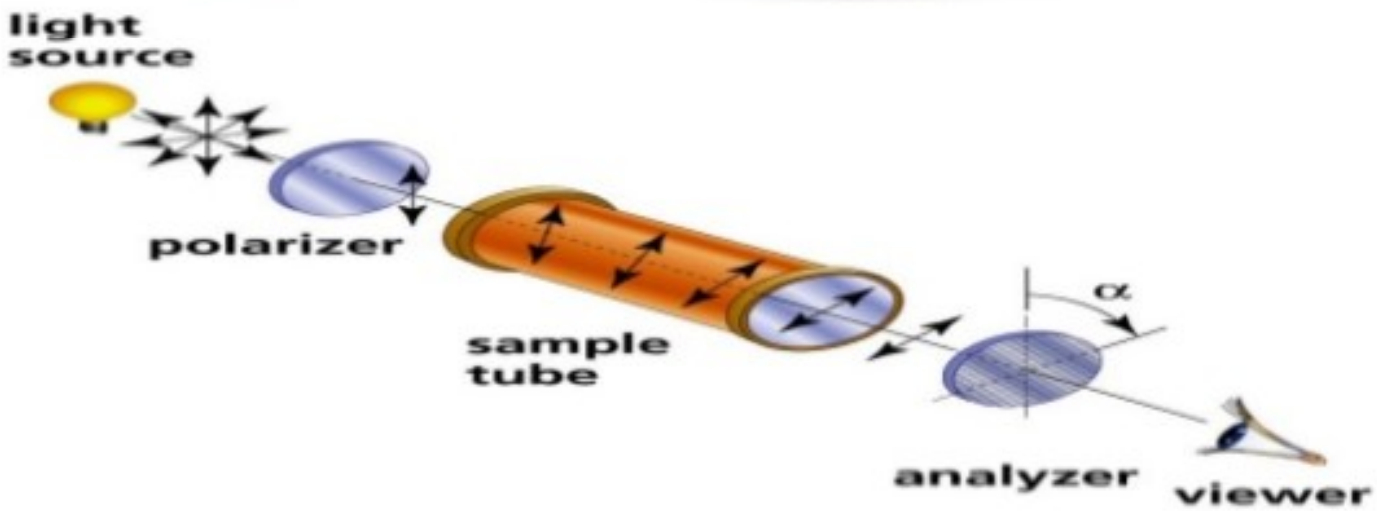
- if no or optically inactive sample is present in the tube and the instrument is reading zero (0°), the axes of plane polarized light and the analyzer is exactly **parallel**
- the observer will detect **maximum amount** (100 % transmittance) of light passing through.
- if the sample is optically active the plane of PPL will be **rotated** as it pass through the tube

POLARIMETER: Working

- in order to detect the maximum brightness of the light (ie. 100% transmittance) observer will have to rotate the axis of the analyzer in either clockwise or counterclockwise direction
- if the analyzer is rotated in a **clockwise direction**, the rotation (**α** in degree) is said to be positive (+), and such substance are c/a **dextrorotatory**
- if the rotation is **counterclockwise**, the α is –ve, and such substances are c/a **levorotatory**

POLARIMETER: Working




light
source
polarizer
sample
tube
α
analyzer
viewer

APPLICATIONS

- polarimetric method is a simple and accurate means for determination of structure in micro analysis of expensive and non-duplicable samples.
- it is employed in quality control, process control and research in the pharmaceutical, chemical, essential oil, flavor and food industries.
- it is so well established that the United States Pharmacopoeia and the Food & Drug Administration include **polarimetric specifications** for numerous substances.

RESEARCH APPLICATIONS

- Research applications for polarimetry are found in industry, research institutes and universities as a means of:
- isolating and identifying **unknowns,** crystallized from various solvents or separated by HPLC.
- evaluating and characterizing optically active compounds by measuring their **specific rotation** and comparing this value with the theoretical values found in literature.

RESEARCH APPLICATIONS

- investigating kinetic reactions by measuring optical rotation as a function of time.
- monitoring changes in concentration of an optically active component in a reaction mixture, as in enzymatic cleavage.
- analyzing molecular structure by plotting optical rotatory dispersion (ORD) curves over a wide range of wavelengths.
- distinguishing between optical isomers.

PHARMACEUTICAL APPLICATIONS

- To determine **product purity** by measuring specific rotation and optical rotation of: Amino acids, Amino sugars, Analgesics, Antibiotics Cocaine, Dextrose, Diuretics, Serums, Steroids, Tranquilizers, Vitamins etc.
- For **raw materials inspection** of: Camphors, Citric acid, Glyceric acid Gums Lavender oil, Lemon oil Orange oil Spearmint oil

SUMMARY

- Definition
- Plane Polarized Light
- Optical Rotation
- Specific Rotation
- Polarimeter
- Applications

THANK YOU