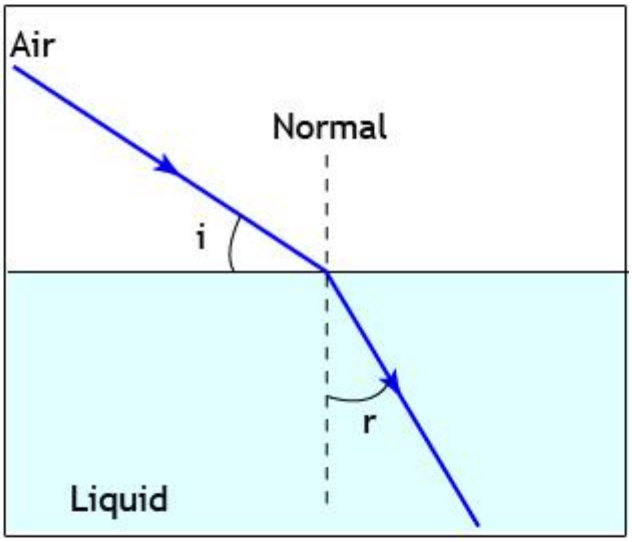
1) REFRACTIVE INDEX



In optics, the refractive index or index of refraction n of a material is a dimensionless number that describes how light propagates through that medium. It is defined as:

$$n = c/v$$

where, c is the speed of light in vacuum and v is the phase velocity of light in the medium. For example, the refractive index of water is 1.333, meaning that light travels 1.333 times faster in a vacuum than it does in water.

The refractive index determines how much light is bent, or refracted, when entering a material. When light moves from one medium to another, it changes its direction, i.e., it is refracted.

If **i** is the angle of incidence of a ray in vacuum and **r** is the angle of refraction, the refractive index n is defined as the ratio of the sine of the angle of incidence to the sine of the angle of refraction.

$$n = \frac{sin\ i}{sin\ r}$$

Determination of Refractive Index

The refractive index of a liquid can be determined with the help of an instrument called **Abbe Refractometer**. A thin film of the liquid is placed between the two prisms. Light from a sodium lamp is made to fall on lower side of the lower prism with the help of a mirror. The hypotenuse surface of the lower prism is ground and, therefore, light enters the liquid at all angles of incidence.

However, no ray can enter the upper prism with greater angle of refraction than the grazing incidence (*i.e.*, at an angle) slightly less than 90ºC. Thus the view in the telescope appears to be divided into two bands, one bright and one dark. The prism assembly is rotated with the help of a side knob till the cross wire of the telescope coincides with the edge of the bright band. A pointer attached to the prism assembly indicates the refractive index on the scale calibrated to read refractive indices directly.

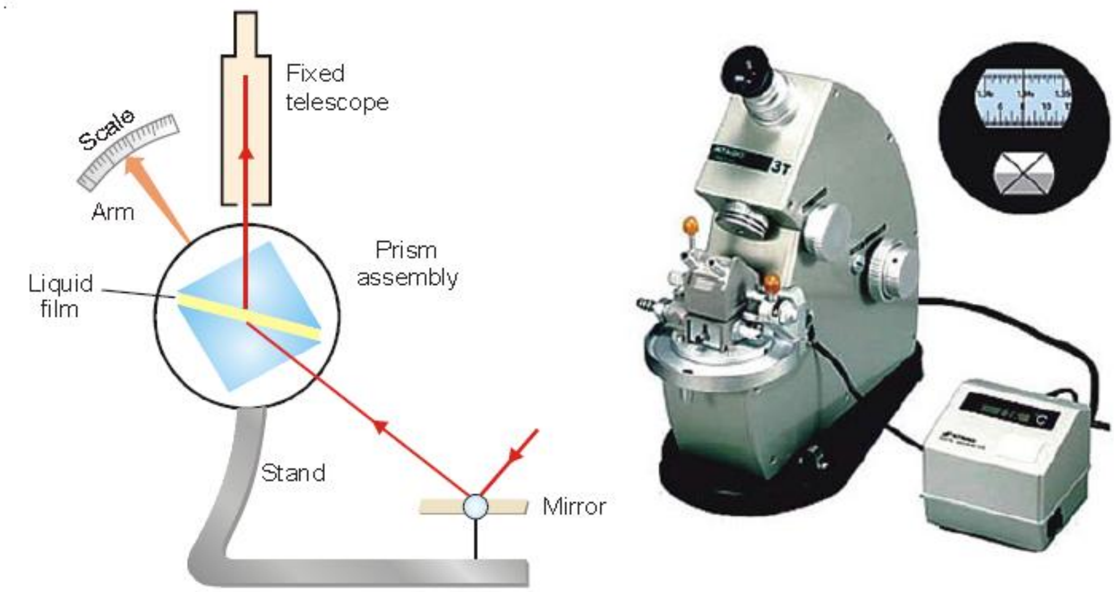


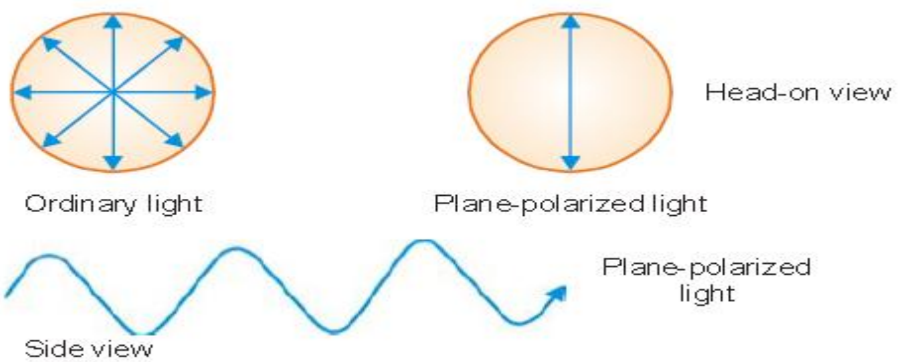
Fig. Abbe Refractometer

Watch video at

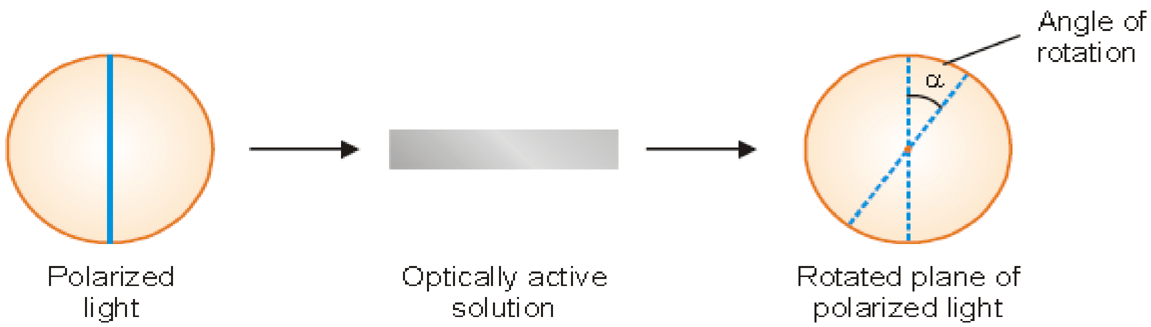
https://www.youtube.com/watch?v=RdN15OTAIV0

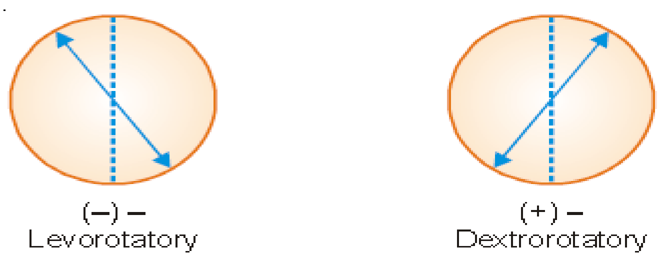
2) OPTICAL ACTIVITY

A beam of ordinary light consists of electromagnetic waves oscillating in many planes. When passed through a polarizer (*e.g.*, a Polaroid lens), only waves oscillating in a single plane pass through. **The emerging beam of light having oscillations in a single plane is said to be plane polarized.**



When plane-polarized light is passed through certain organic compounds, the plane of polarized light is rotated. **A compound that can rotate the plane of polarized light is called optically active.** This property of a compound is called **optical activity.** A compound which rotates the plane-polarized light to the left (anticlockwise), is said to be **levorotatory.** A compound that rotates the plane-polarized light to the right (clockwise), is said to be **dextrorotatory**. By convention, rotation to the left is given a minus sign (–) and rotation to the right is given a plus sign (+). For example, (–)-lactic acid is levorotatory and (+)-lactic acid is dextrorotatory.





Specific Rotation

The rotation of plane-polarized light is an intrinsic property of optically active molecules. When a polarized beam of light is passed through the solution of an optically active compound, its plane is rotated through an angle α (**angle of rotation**). This rotation depends on the number of optically active molecules encountered. Therefore, α is proportional to both the concentration and the length of the sample solution.

The **specific rotation** which is characteristic of an optically active substance, is expressed as

$$[\alpha] = \frac{\alpha}{l \times c}$$

Where, $[\alpha]$ = specific rotation in degrees

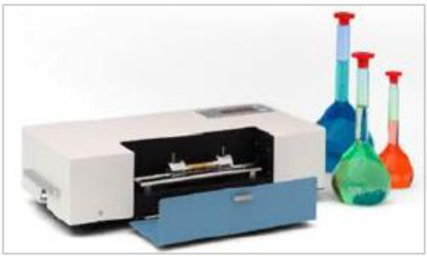
α = observed angle of rotation in degrees

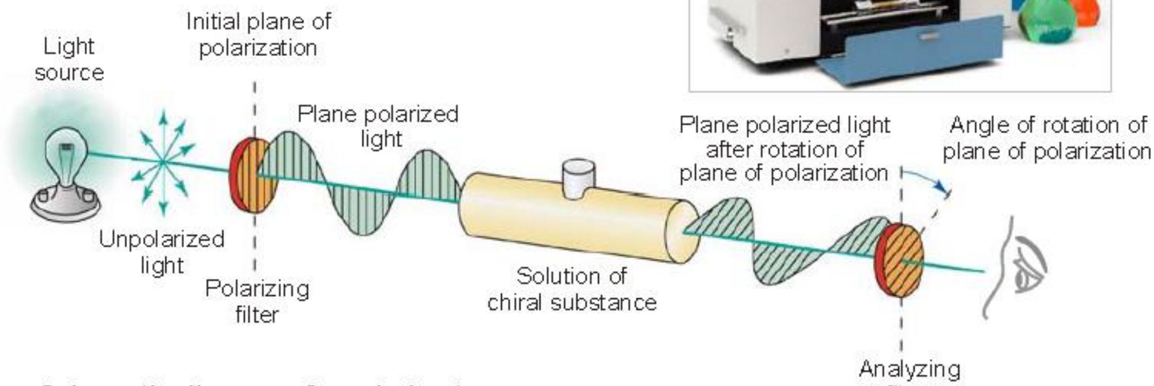
l = length of the sample solution in decimeters (dm; 10 cm)

c = concentration of the sample solution in g/ml

Measurement of Optical Activity

Optical activity is measured with the help of an instrument known as **polarimeter**. This is basically a system of polarizers with a sample tube placed in between. First, an optically inactive medium (air or solvent) fills the sample tubes and polarized sodium light emerging from the polarizer passes through it. The analyzer is then turned to establish a dark field. This gives a zero reading on the circular scale around the analyzer. Then the solution of the given optically active compound is placed in the sample tube. The plane of polarized light passing through it is rotated. The analyzer is turned to re-establish the dark field. The angle of rotation (α) is then noted in degrees on the circular scale. The specific rotation is calculated using the expression (1) above.





Schematic diagram of a polarimeter.

3) DIPOLE MOMENT

In a molecule such as HCl, the bonding electron pair is not shared equally between the hydrogen atom and the chlorine atom. The chlorine atom with its greater electronegativity, pulls the electron pair closer to it. This gives a slight positive charge (+*q*) to the hydrogen atom and a slight negative charge (– *q*) to the chlorine atom.

$$H - : - Cl \quad \text{or} \quad \overset{+q}{H} \text{———} \overset{-q}{Cl}$$

Such a molecule with a positive charge at one end and a negative charge at the other end is referred to as an **electric dipole** or simply **dipole.** The degree of polarity of a polar molecule is measured by its dipole moment, μ.

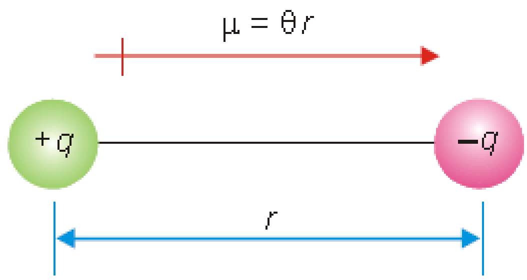
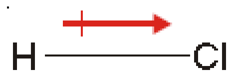


Figure
An electric dipole of the magnitude μ = θr.

The dipole moment of a polar molecule is given by the product of the charge at one end and the distance between the opposite charges. Thus,

$$\mu = q \times r$$

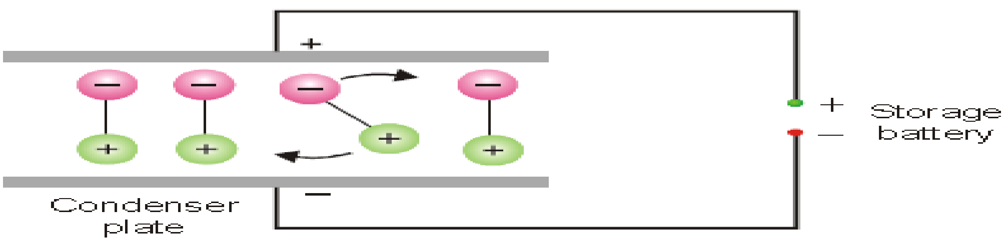
The dipole moment (μ) is a vector quantity. **It is represented by an arrow with a crossed tail.** The arrow points to the negative charge and its length indicates the magnitude of the dipole moment. Thus a molecule of HCl may be represented as



The CGS unit for dipole moment is the **debye,** symbolised by **D,** named after the physical chemist Peter Debye (1884-1966).

Determination of Dipole Moment

Electric condenser: The dipole moment of a substance can be experimentally determined with the help of an electric condenser. The parallel plates of the condenser can be charged by connecting them to a storage battery. When the condenser is charged, an electric field is set up with field strength equal to the applied voltage (*V*) divided by the distance (*d*) between the plates. Polar molecules are electric dipoles. The net charge of a dipole is zero. When placed between the charged plates, it will neither move toward the positive plate nor the negative plate. On the other hand, it will rotate and align with its negative end toward the positive plate and positive end toward the negative plate. Thus all the polar molecules align themselves in the electric field. This orientation of dipoles affects the electric field between the two plates as the field due to the dipoles is opposed to that due to the charge on the plates.



Polar molecules rotate and align in electric field.

The plates are charged to a voltage, say V, prior to the introduction of the polar substance. These are then disconnected from the battery. On introducing the polar substance between the plates, the voltage will change to a lower value, V'. Just how much the voltage changes depends on the nature of the substance. The ratio $\varepsilon = V/V'$ is a characteristic property of a substance called the **dielectric constant.** The experimentally determined value of dielectric constant is used to calculate the dipole moment.