Optics

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OUTLINES

- Optical activity
- Optical rotation
- Specific Rotation

Optical activity

The property of rotating the plane of vibration of plane polarized light about its direction of propagation possessed by certain crystals or substances is known as Optical activity.

Apart from quartz, many other crystals like sodium chlorate, sodium bromate and cinnabar exhibit the phenomenon of optical activity and such substances are said to be optically active. In addition to these solids, there are certain liquids, *e.g.*, turpentine, sugar solution, alcoholic solution of camphor, etc, are also *optically active*. The optical rotations produced by liquids is, however, very small as compared to that produced by solids.

Optically active substances are of two types. Some of them rotate the plane of vibration to the right and are called right-handed or *dextro-rotatory*. The substances that rotate the plane of vibration to the left are called *left-handed* or *laevorotatory*. From the observer's point of view, a right-handed rotation means that when

the observer is looking towards light travelling towards him, the plane of vibration is rotated in a *clock-wise* direction. Similarly a left-handed rotation means an *anti-clockwise* rotation from the point of view of the observer. Cane sugar is dextro-rotatory whereas fruit sugar is laevorotatory. It has been found that some quartz crystals are dextro-rotatory while others are leavo-ratatory. One is the mirror image of the other in their orientation.

Optical rotation

When plane polarized light is passed through certain crystals, they rotate the plane of polarization. This phenomenon is called optical rotation. The crystals which show this phenomenon are called optically active crystals. Quartz and sodium chloride are the example of optically active crystals.

Certain solutions of organic substance, such as sugar and tartaric acid, show optical rotation. This property of optically active substances can be used to determine their concentration in the solutions.

Specific rotation

The term specific rotation or specific rotatory power, usually denoted by the letter s, is used to compare the optical activity of different substances. It is defined differently for solids, liquids and solutions.

In case of solids it is defined by the relation

$$\theta = s \times l$$

where 0 is the rotation produced (in degrees) by l millimetre length of the solid. Thus for solids the specific rotation is the angle of rotation produced by 1mm thickness of the solid in the direction of optic axis.

In case of liquids, it has been found that the plane of the linearly polarized light is rotated by liquids containing an optically active substance.

The optical activity of an optically active substance such as sugar is not affected if it is dissolved in an inactive liquid such as water. *For light of given wavelength and at a given temperature, the angle through which the plane polarized light is rotated, depends upon*

(i) the thickness of the medium (solution)

(ii) the concentration of the solution or the density of the active substance in the solvent

and (iii) the nature of the substance

Then

$$\theta \propto l.c$$

or, $\theta = s\, l\, c$

where l = length of the substance in decimetres

c = concentration in gm/cm^3 of the solution

s = a constant called *specific rotation* which depends upon the nature of the substance.

$$\text{or,} \quad s = \frac{0}{l.c}$$

If l = 1 decimetre and c = 1 gm/cm^3, then s = 0. *Specific rotation may, therefore, be defined as the rotation produced by one decimetre (10 cm) length of the solution of unit concentration i.e., containing 1 gm of the optically active substance per cm^3 of the solution.* Thus

Specific rotation

$$= \frac{\text{rotation produced by 1 decimetre length of the solution}}{\text{density of the solution in gms per c.c}}$$

$$= \frac{0}{l/10} \div c = \frac{100}{l\,c}$$

l in the above expression is measured in cms

The specific rotation of dextro-rotatory substance is considered *positive* while that of a laevo-rotatory substance is regarded as *negative.*