Lecture 25

Optical Activity

Optical activity is the ability of a chiral molecule to rotate the plane of plane-polarized light, measured using a Polari meter. An object or a system is chiral if it is distinguishable from its mirror image means that it cannot be superposed onto it hands are the best example of chiral system.. Conversely, a mirror image of an achiral object, such as a sphere, cannot be distinguished from the object. A chiral object and its mirror image are called enantiomorphs or when referring to molecules, enantiomers.

Measuring of Optical Activity:

Optical activity is measured using a light of wavelength 589nm. This is wavelength of yellow light from sodium lamp and is called D-line of sodium.

Polarized Light:

Ordinary or non-polarized light:

The light wave which is vibrating in more than plane is called non polarized light. Light emitted by sun, by a lamp and by candle flame are the examples of non-polarized light.

Polarized Light:

It is possible to transform unpolarized light into polarized light. Polarized light waves are light waves in which the vibrations occur in a single plane. The process of transforming unpolarized light into polarized light is known as polarization.

Measuring the Rotation:

The Polarimeter is a device used to measure the effect of plane-polarized light on optically active compounds. A simple polarimeter consist of following parts a light source which is usually a sodium lamp, a polarizer, a tube for holding sample in light beam, an analyzer and a scale to measure the rotation of plane polarized light.
**Working Principal of Polarimeter:**

Unpolarized light from the light source is first polarized. This polarized light passes through a sample cell. If an optical active substance is in a sample tube, the plane of the polarized light waves is rotated. The rotation is noticed by looking through the analyzer as a change in intensity of illumination. To reach the same illumination as was without an optical active sample the analyzer must be turned around for an angle.

![Diagram of light propagation and polarizer](image)

**Specific Rotation:**

The angle of rotation of plane polarized light by a 1.00 gram per cm$^3$ sample in a 1 dm tube is called specific rotation. Observed rotation depends upon number of molecules and is proportional to path length and concentration.

\[
[\alpha]_\lambda^T = \alpha/lc
\]

Where \([\alpha]_\lambda^T\) = specific rotation in degree. \(l\) is the wavelength of light used for the observation (usually 589 nm, the D line of a sodium lamp otherwise it is specified). \(T\) is the temperature in °C. This value is characteristic for a given compound, just like the melting point. \(\alpha\) = observed rotation in degrees. \(l\) = cell path length in decimeters. \(c\) = concentration in g ml$^{-1}$ for a pure liquid. Specific rotation of a compound is a characteristic property of the compound as long as the temperature, the wave length of the light, and, if a solution is used for the experiment, the solvent are specified. The units of specific rotation are degrees mLg$^{-1}$dm$^{-1}$. However, since the units of specific rotation are always the above, traditionally, specific rotation is reported without units.

These quantities are also incorporated while reporting \([\alpha]\)

\([\alpha]_D^{25} = +3.12^\circ\)
Means D line of a sodium lamp \((\lambda=589.6\text{nm})\) is used for light. Temperature is 25°C and Sample contains 1.00g/ml of the optically active substance in 1 dm tube then the rotation of 3.12 degree is observed in clockwise direction.

**Analyzer Result:**

The maximum brightness is achieved by rotating the analyzer in clockwise direction. The \(\alpha\) is said to be positive if substance is dextrorotatory. Dextrorotatory is a substance that rotates the ray of plane polarized light to the right.

If axis of analyzer rotates in counter clockwise direction then the \(\alpha\) is negative and substance is called levorotatory. If ray of light moves toward left then the substance is called levorotatory.

**Racemic Mixture:**

In chemistry, a racemic mixture is that which has equal amounts of left- and right-handed enantiomers of a chiral molecule. The first known racemic mixture was racemic acid, which Louis Pasteur found to be a mixture of the two enantiomeric isomers of tartaric acid. A racemic mixture is optically inactive. A substance which is optically inactive can be either achiral or racemic mixture.

**Importance of Chirality:**

**Enantiomers of Epinephrine:**

Epinephrine (adrenaline) acts as a neurotransmitter or hormone which binds to several different kinds of adrenergic receptors in the body and cause a large variety of physiological effects. The best known effect is the “fight or flight” phenomenon or “adrenaline rush” which increases heart rate and blood pressure.

Epinephrine is used as a drug for the treatment of anaphylactic shock where it increases heart rate and blood pressure. It is commonly added to local anesthetic injections to promote vasoconstriction at the injection site, thereby reducing the amount of local anesthetic that gets into the blood stream.

Epinephrine has a chiral center. The (+) S enantiomer does not typically bind as well to adrenergic receptors nor produce as much activity but its presence in the racemic mixture does not appear to be a clinical problem either. But (-) S enantiomer is more active and bind to the adrenergic receptors.
**General Applications:**

Polarimetric method is a simple and accurate means for determination of structure in microanalysis. It is employed in quality control (QC), Process control and Research in the pharmaceutical such as Chemical, Essential oil, Flavor, Food industries.

**References:**

http://www.physicsclassroom.com/class/light/Lesson-1/Polarization
www.chemconnections.org/organic/chem226/.../Ch05-optical%20activity
http://www.ochempal.org/index.php/alphabetical/s-t-/rotaspecificit
www.slideshare.net/MoshiurRahman21/polarimetry-1