CHRISTIAN EMINENT COLLEGE, INDORE

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E-Content

On

"Optical Rotation"

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OPTICAL ROTATION

When a plane polarised light is passed through some specific substances (such as quartz, sugar solution, oil of turpentine, tartaric acid etc.), the plane of polarisation of the light emerging out of them is not that of the incident plane polarised light i.e. the plane of polarisation or the plane of vibration of light gets rotated through some angle about the direction of propagation of light. This phenomenon is called the optical rotation or the rotatory polarisation. The substances which rotate the plane of polarisation are called the optically active substances.

Types of Optically Active Substances

(1)Dextrorotatory and (2) Leavo rotatory

- Dextrorotatory: Those substances which rotate the plane of polarisation of the incident plane polarised light in a clockwise direction when seen in the direction of light, are called the dextrorotatory substances e.g., sugar solution, quartz, glucose etc.
- Leavo rotatory: Those substances which rotate the plane of polarisation of the incident plane polarised light in the anticlockwise direction when seen in the direction of light, are called the leavo rotatory substances e.g., quartz, fructose solution, nicotine etc.

Laws of rotation of the plane of polarisation

- *Biot, from his experiments, propounded the following laws regarding the rotation of the plane of polarization by optically active substances*

(i) For a given wavelength of light, the angle of rotation of the plane of polarisation by an optically active substance(solid, liquid or solution)is directly proportional to that length of the substance through which the incident plane polarised light passes. i.e., $\theta \propto \ell$

(ii) The angle of rotation produced by a solution or vapour for a given optical length is directly proportional to the concentration of that solution or vapour. i.e.,

$$\theta \propto c$$

Laws of rotation of the plane of polarisation

(iii) In a mixture of several optically active substances, the resultant angle of rotation is equal to the algebraic sum of the individual angle of rotation produced by each component of that mixture. The clockwise rotation is taken positive and the anticlockwise rotation is taken negative. i.e.,

$$\theta = \theta_1 + \theta_2 + \theta_3 + \ldots\ldots\ldots = \Sigma\,\theta_\iota$$

(iv) For a given optical length of an optically active substance, the angle of rotation produced is inversely proportional to the square of wavelength of light used i.e.,

$$\theta \propto 1/\lambda^2 \textit{(nearly)}$$

Rotatory Dispersion

If a plane polarised white light is made incident normally on a quartz plate, the plane of polarisation of light of different colours present in the white light rotates through different angles.

The angle of rotation of light of violet colour is more than the angle of rotation of light of red colour. Hence light emerging out of the quartz plate, when is seen through the nicol used as anlyser, the field of view appears coloured. This phenomena is called the rotatory dispersion. The angle of rotation also depends on the nature of the substance and its temperature.

Specific Rotation

we define the specific rotation for a solid , liquid and solution in the following way

For a solid - $\theta = \alpha \ell$

Where α is the specific rotation of solid. Since angle of rotation θ is measured in degree and the length of solid measured in mm, hence the specific rotation is expressed in degree/mm. If $l=1$, then $\theta = \alpha$. hence at a particular temperature for the light of a given wavelength, the specific rotation of a solid is equal to that angle of rotation (in degree) which is produced by 1 mm length of that substance.

Specific Rotation

For a liquid - $\theta = \alpha \ell$

Here the angle of rotation is measured in degree and the length of liquid is measured in decimeter ,then the specific rotation is expressed in degree/decimetre. If l=1, then $\theta = \alpha$. hence at a particular temperature for the light of a given wavelength, the specific rotation of a liquid is equal to that angle of rotation (in degree) which is produced by 1 decimetre length of that substance.

Specific Rotation

For solution: $\theta = \alpha l c$

Here the angle of rotation is measured in degree, the length of solution l is measured in decimeter and the concentration of solution c is measured in g/cm^3, then the specific rotation of solution is expressed in (degree cm^3/g decimeter.) if l=1,c=1,then $\theta = \alpha$. hence at a particular temperature for the light of given wavelength, the specific rotation of a solution is equal to that angle of rotation (in degree) which is produced by 1 decimeter length of that solution of concentration $1 g/cm^3$.

FRESNEL'S THEORY OF OPTICAL ROTATION

To explain the rotation of plane of polarisation, Fresnel made the following assumptions.

1. A plane polarised light on entering into a double refracting crystal along the optic axis, splits into two circularly polarised waves, out of which the vibrations in one wave are clock wise(right- handed), while in the other wave are anti-clock wise (left- handed).
2. In an optically inactive substance, both the circularly polarised waves travel with the same speed. But in optically active substance , these waves travel with different speeds due to which when they pass through the substance, a phase difference is produced between them.

FRESNEL'S THEORY OF OPTICAL ROTATION

(3)In a dextrorotatory substance, the speed of right handed circularly polarised light is more than the speed of left handed polarised light (i.e.$v_R › v_L$),while in a leavorotatory substance, the speed of left handed circularly polarised light is more than the speed of right handed circularly polarised light(i.e. $v_L › v_R$).

(4)On emergence from the optically active substances, both the circularly polarised waves recombine to produce the plane polarised light with its plane of polarisation rotated relative to the plane of polarisation of the incident plane polarised light. The value of this angle depends on the phase difference produced between the two wave in passing through the substance.

Thank You