Spectroscopy - Study of spectra

(Spectra means radiations and scopy means measurement)

Spectroscopy deals with the study of electromagnetic radiations emitted or absorbed by a substance. The pattern of emitted or absorbed radiations recorded by spectrometer as a curve or a graph is called spectrum.

Classification of spectra

1) Emission spectra - A spectrum which is obtained by recording radiations emitted by a substance.

2) Absorption spectra - A spectrum obtained by recording radiations absorbed by a substance.

Absorption spectrum consists of dark lines while emission spectrum consists of bright lines.

If a number of groups of closely spaced lines are observed, these closely spaced lines in the spectrum is called band. Therefore atoms give line spectra while molecules give band spectra

In case of atom ~~spe~~ line spectra is the result of transition of electrons from one energy level to another energy level.

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However, in case of molecules, when the energy is absorbed, it may result into rotation, and vibration of constituent atoms and their bonds in the molecule along with electronic transitions, depending upon the amount of energy absorbed. The rotational, vibrational and electronic energy levels of a molecules are collectively called molecular energy levels. Due to a large number of energy level involved in transition, the molecular spectra are much more complex than atomic spectra.

The study of molecular spectra gives the information about the structure and properties of molecules such as bond lengths, bond angles, bond strength, shape, dipole moment etc.

Spectrometer

Absorption spectrum of a given sample is obtained experimentally with the help of an apparatus known as spectrophotometer or spectrometer.

Light of a suitable range of wavelengths from the source is passed through the sample. The wavelengths corresponds to allowed molecular transitions are absorbed. The transmited light passes through prism which resolves it into various wavelengths. It is reflected from a mirror into a detector. The pen recorder records the intensity of radiation as a function of frequency and gives the absorption spectrum of the sample.

Remarks

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The signals produced in the analysis of a sample consist of two types.

1) signals produced due to sample
2) Signals produced due to solvents and instrument used. These signals are known as 'noise'.

These 'noise' signals are unwanted and some times hinder the interpretation.

The ability of an instrument to distinguish between noise and the signal of sample is expressed as signal to noise ratio.

$$\frac{S}{N} = \frac{\text{Average signal amplitude}}{\text{Average noise amplitude}}.$$

Higher value of S/N indicates greater noise reduction i.e. more precision in measurement.

Resolving power - The resolving power of a spectrometer is its ability to distinguish between adjacent absorption band or two very close spectral lines as separate entities.

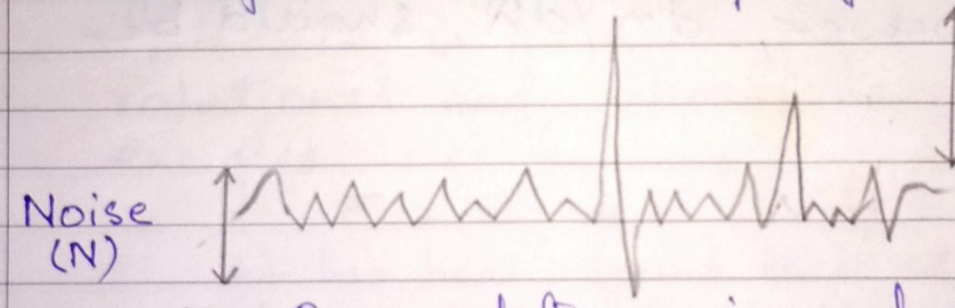

Fig: Representation noise and signal in a recorded spectrum by spectrometer.

Remarks

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amplification, because

⇒ S/N Ratio can't be increased by amplification, because the magnitude of both noise and signal increases.

Some hardware ~~and software~~ techniques like using filters and lock-in amplifiers and software techniques such as algorithm of ensemble averaging and ~~Fouri~~ Fourier transformations have been used with success to increase S/N ratio.

⇒ If 'n' is the refractive index and 'b' is the base length of the prism, then resolving power of the prism is give by

$$R = b \frac{dn}{d\lambda}$$

$dn/d\lambda$ represents the change in refractive index of the material of the prism with change in wavelength of the incident radiation. Therefore, for high resolving power, $dn/d\lambda$, should be high.