

Physical Principles of Fluorescence

Abstract

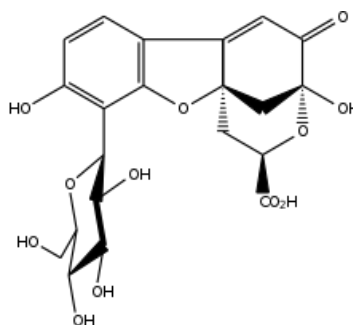
Fluorescence may be called as the emission of light by a substance resulting into the absorption of light or electromagnetic radiation. It is seen that the emission of light has a longer wavelength, so there is lower energy in it, than the absorbed radiation. For example fluorescence occurs in a process of absorbed radiation in the ultraviolet region of the spectrum. Which is invisible to the human eye. On the other hand the emitted light is visible, which gives the fluorescent substance a specific color. When it is exposed to UV light.

Fluorescence has many uses in areas of mineralogy, gemology, medicine, chemical sensors biological detectors, cosmic-ray detection, and, most commonly, fluorescent lamps.

Keywords: Electromagnetic Radiation, Light, Wavelength, Colour.

Introduction

In 1560 Bernardino de Sahagun and in 1565 Nicolas Monardes described fluoresces. It is a infusion known as lignum nephriticum (Latin for "kidney wood"). It is derived from the wood called species, Pterocarpus indicus and Eysenhardtia polystachya. In this the chemical compound responsible in fluorescence is mataline, called as it is the result of oxidation product of flavonoids which is found in this wood.



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In the history of researches Edward 1819, D. Clarke and in 1822 René Just Haüy narrated fluorescence in fluorites, Later Sir David Brewster termed the phenomenon for chlorophyll in 1833 and Sir John Herschel described it the same for quinine in 1845.

George Gabriel Stokes in 1952 described the ability of fluorspar and uranium glass to change invisible light beyond the violet end of the visible spectrum into blue light. He called this phenomenon as Fluorescence: "I am almost inclined to coin a word, and call the appearance Fluorescence, from fluorspar [i.e., fluorite], as the analogous term opalescence is derived from the name of a mineral." Actually the name is derived from the mineral fluorite (calcium difluoride). In his experiment Stokes used a prism to isolate ultraviolet radiation from sunlight and observed blue light emission by an ethanol solution of quinine exposed by it.

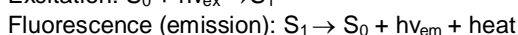
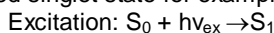
Objectives of the Study

To study various uses of Fluorescence such as mineralogy, medicine, gemology, chemical sensors (fluorescence spectroscopy), fluorescent labelling, dyes, biological detectors, cosmic-ray detection.

Fluorescence has following physical principles

Photochemistry

It is occurred when an orbital electron of a molecule, atom, or nanostructure, throws to its ground state by emitting a photon from an excited singlet state for example :-



Therefore $h\nu$ is a generic term for photon energy with h = Planck's constant and ν = frequency of light.

In this process S_0 is called the ground state of the fluorophore (fluorescent molecule), and S_1 is its first (electronically) excited singlet state.

In it A molecule in S_1 can relax by various competing pathways. The process undergoes *non-radiative* relaxation in which the excitation energy is dissipated as heat (vibrations) to the solvent. So, organic molecules can also relax via conversion to a triplet state. It may subsequently relax via phosphorescence.

Mostly, the emitted light has a longer wavelength, and therefore lower energy, than the absorbed radiation; this phenomenon is known as the Stokes shift. But when the absorbed electromagnetic radiation is intense, it is possible for one electron to absorb two photons, which two-photon can lead to emission of radiation. Which have a shorter wavelength than the absorbed radiation. The radiation may also be of the same wavelength as the absorbed radiation which is termed "resonance fluorescence".

Quantum yield

In the process fluorescence quantum yield gives the efficiency of the fluorescence. It is the ratio of the number of photons emitted to the number of photons absorbed.

Therefore maximum possible fluorescence quantum yield is 1.0 (100%). Compounds with quantum yields of 0.10 are still considered quite fluorescent.

So, the Fluorescence quantum yields are measured by a comparative parametre.

The actual lifetime fluorescence is termed as to the average time the molecule stays in its excited state. Fluorescence follows first-order kinetics:

$$[S_1] = [S_1]_0 e^{-\Gamma t}$$

S is the concentration of excited state molecules at time t , $[S_1]_0$. It is the initial concentration and Γ is the decay rate or the inverse of the fluorescence lifetime. Various radiative and non-

radiative processes are attached to it. Which depopulated the excited stage.

The process of Fluorophores are more likely to be excited by photons if the transition moment of the fluorophore is parallel to the electric vector of the photon. The actual transition moment is dependent on the physical orientation of the fluorophore molecule. It means that the intensity and polarization of the emitted light is dependent on rotational diffusion. So, anisotropy measurements is used to investigate how freely a fluorescent molecule moves in a particular environment.

There are other general rules which deal with fluorescence. Each one of the rules has exceptions. But they are useful guidelines for understanding fluorescence.

In this term Kasha's rule dictates that the quantum yield of luminescence is independent of the wavelength of exciting radiation. It is occurred because excited molecules usually decay to the lowest vibrational level of the excited state before fluorescence emission takes place. A more reliable statement, would be that the fluorescence spectrum shows very little dependence on the wavelength of exciting radiation.

Conclusion

In the mirror image rule fluorophores are the absorption spectrum in a mirror image of the emission spectrum. It is known as the mirror image rule which is related to the Franck–Condon principle. This states that electronic transitions are vertical. Energy is changed without distance change. Therefore, nucleus does not move and the vibration levels resemble with vibration levels.

References

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