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Synchronous Luminescence Spectroscopy: A Powerful Tool for Investigation of Plant Physiology

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Abstract: ***The study of the effect of various stresses like light stress, temperature stress, pollutant stress etc. may be performed using various spectroscopic techniques like absorption spectroscopy, fluorescence spectroscopy, fluorescence kinetics, Fourier Transform Infrared spectroscopy etc. In addition to these techniques the synchronous luminescence technique may be successfully employed to study the effect of stresses on the plant health. In the present attempt we are going to use the synchronous luminescence spectroscopy for the study of plant health and classification. As per our information the type of measurements made by us is the first report of this kind. It is seen that more information can be obtained from the analysis of synchronous luminescence spectra of the plant leaves.***
Keywords: Photosynthesis, Deuterium/Halogen source, SL spectra.

I. INTRODUCTION

The study of the effect of various stresses on plants may be performed using various spectroscopic techniques. The synchronous luminescence technique may be successfully employed to study the effect of stresses on the plant health. In this technique the fluorescence signal is recorded by simultaneously scanning both the excitation and emission wavelengths at same speed with a fixed wavelength interval between the excitation and emission wavelengths. [1-3]

II. SAMPLE PREPARATION:

The plants that are selected for the experiment have been grown in the campus of the nursery at Amravati. The plants are developed in the natural condition of light and temperature. Plants are well watered and regularly nourished and developed in the good environmental conditions. Typical and healthy leaf from a plant has been chosen for the study of the synchronous luminescence spectra.

III. EXPERIMENTAL METHOD

A block diagram for recording synchronous luminescence spectrum is shown in fig 1.

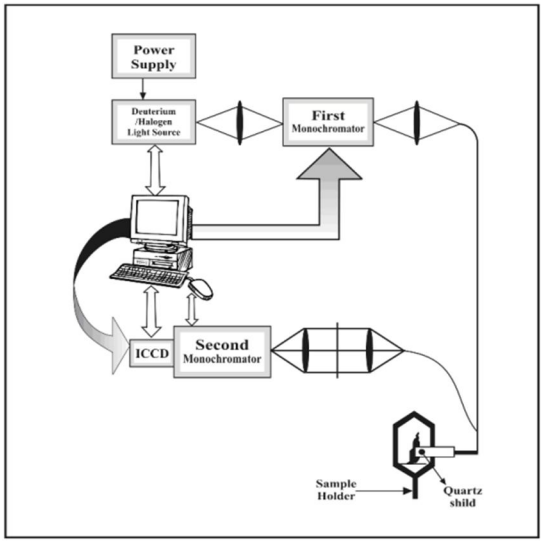

Figure 1 Experimental arrangement for recording synchronous luminescence spectra of plants leaves.

Commercial spectra physics fluorometer (SPEX, USA, Fluorolog –II) was used to record the synchronous luminescence spectra. The spectra were recorded by scanning both the excitation and emission monochromator simultaneously at the same speed of 5 nm/s with a fixed wavelength separation between them. For these studies wavelength difference between excitation and fluorescence emission was chosen to be 20 nm since it lead to the most resolved spectra. The band pass of both the excitation and emission monochromator was kept 2 nm wide. A xenon lamp of 45 W is used as the excitation source. The light from xenon lamp was incident perpendicular to the sample surface to a spot of size approximately 2 mm X 4 mm and the emitted light was collected at approximately 20^0 angle with respect to the direction of the excitation light. Excitation intensity varied with wavelength but was always less than 40 W/mm^2. A bundle of seven optical fibers is used as light transporting system. A single central fiber carries light from the source to the sample and six fibers surrounding the centro fiber collect the fluorescence signal given by sample.

IV. RESULTS AND DISCUSSION

The synchronous luminescence spectra of many plants belonging to different family have been recorded using SPEX USA fluorolog–II spectrophotometer and results are displayed in figure 2 (a-c).

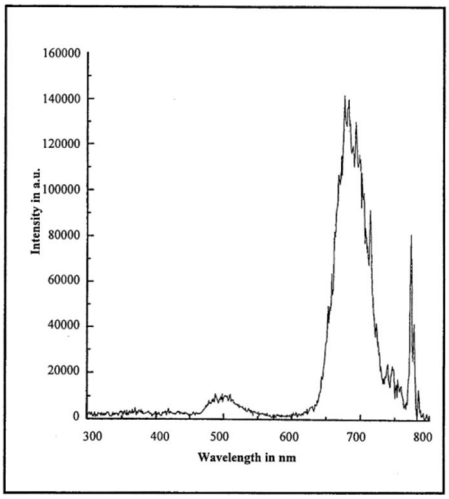

Figure 2 (a) Synchronous luminescence spectra of plants of Fiscus religiosa [Family-Moraceae].

All the spectra recorded by us exhibit novel structure difference. The number of peaks observed in the spectra and the intensity of peaks differ from plant to plant. All the synchronous luminescence spectra of plant leaves were characterized by 2 to 5 narrow spectral bands with peak around 366, 416, 500, 677 and 772 nm. A prominent peak around 677 nm exhibits some extra structure of few plants. The synchronous luminescence spectra contains main peak and few side peaks. The main peak in the emission spectrum is wide and appears around 680 nm. However, there is a slight difference in the position of the other peaks depending upon the species selected for the studies. [4-6]

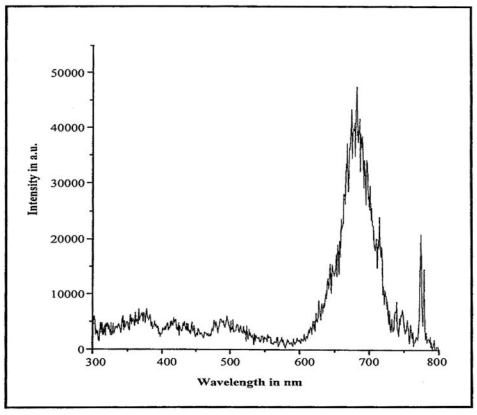

Figure 2 (b) Synchronous luminescence spectrum of leaf of Fiscus benghalensis [family-Moraceae].

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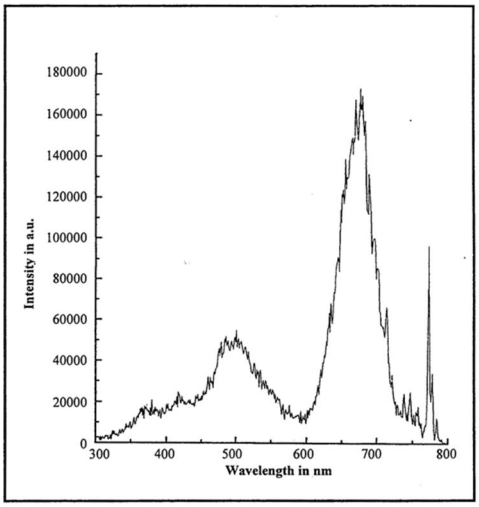

Figure 2 © Synchronous luminescence spectrum of leaf of Hibiscus rosasinensis [Family-Malvaceae].

It is seen that position of the main peak lies between 650 to 683 nm and the width of the main peak is between 40 to 70 nm FWHM (full width at half maximum) for all samples under investigation. It is noticed from the analysis of the spectra that all plants on the longer wavelength slope of the main peak exhibit peaklets. It is also clear that lot of information about the plant health may be extracted from the position and properties of peaklets with respect to main peak.

The synchronous luminescence spectra of all the plants exhibit a narrow peak near 680 nm. The relative height of this peak shows the considerable difference depending upon the families of the plant. The structure of peak carry a lot of physiological information about the plants as the related height of the peak changes from 0.2 to 0.3 with respect to the height of main peak.

Depending upon the plant type we get the different structure such as prominent peak of maximum height, double peak structure near the main peak or extra structure at main peak, widths of the different peaks, exact position of the peak, number of peaks in the spectrum, position of peaklets near the main peak.

Thus several excitation and emission spectra are required to obtain the information on fluorophores concentration, the same information can be obtained more conveniently in the single step by recording synchronous luminescence spectra. Since synchronous luminescence spectrum provides more information compared to emission spectrum at single excitation wavelength. The study of synchronous luminescence spectra may lead to better discrimination in the plant physiology. The study of the synchronous luminescence spectra is helpful in the investigation of band structure of the pigments present in the plant leaves. [7-10]

V. CONCLUSION

It is noticed that each sample of plant leaves from various families and plant types gives the different feature. An attempt can be made to record the synchronous luminescence spectra of all possible samples having some medicinal value or special characteristics such as oil producing plant, poisoning plant etc. and then by differentiating and classifying according to various parameters such as peaklets position, total number of peaks, position and intensity of various peaks in the spectra, full width at half maximum of each peak, the ratio of different peak heights. Some conclusion may be drawn about the position of the plant. An unknown sample may be identified as a medicinal and non medicinal plant. The synchronous luminescence spectroscopy is very much useful in the identification of various plants, which belong to different families, species etc. It is obvious that from the study of synchronous luminescence spectra large amount of information may be provided to the branch of bio-informatics.

Synchronous luminescence spectral study also gives good information about leaf structure, degree of stresses and leaf contents. Thus the synchronous luminescence spectroscopy is very powerful tool for investigation of plant physiology.

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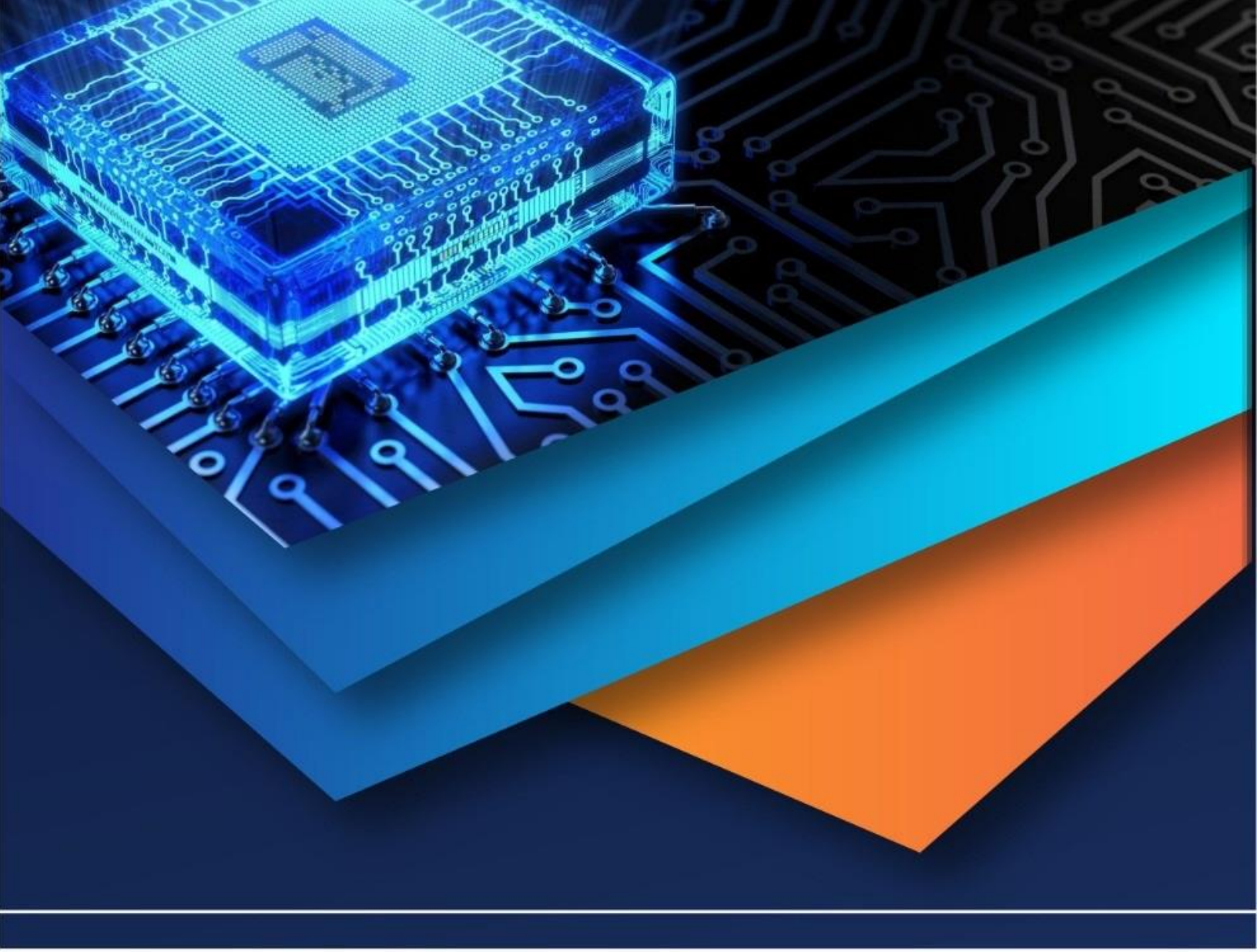

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