Incident laser power and concentration effects on the fluorescence of R101 dye in PMMA polymer.

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Abstract

Incident laser power and concentration effects on fluorescence emission from R101 dye in PMMA polymer have been investigated. Different concentrations of the dye were used. It was found that the fluorescence intensity decreased with increasing of the concentration of the dye as a solution and in PMMA polymer, with a red shift. In addition it was found that the fluorescence intensity increased with increasing of the incident laser power I_0.

1- INTRODUCTION

Dye lasers are the most versatile and one of the most successful laser sources known today due to their significant contribution to basic physics, chemistry, biology and additional fields. Such versatility emerges from the large choice of molecular dye species available coupled with the wide variety of excitation sources. The need to use large volumes of organic solvents has limited the use of these lasers in some technical applications. As a result, solid matrices containing laser dyes have been developed in the recent years with the aim of developing practical solid state dye lasers. The high gain and broad visible tunability of liquid-dye lasers are retained in solid host media with the advantage of clean and inexpensive active elements that are readily exchanged to access different spectral regions with different dyes [1]. The first solid state dye lasers where reported in the late 1960 by Soffer and Macfarland, and Peterson and snavely [2]. Concentrationeffect on fluorescence of Rhodamine B (RB) and Rhodamine 6G (R6G) have been studied by Binddhu and Harilal [3] and Kurian et.al. [4] respectively. Effect of concentration on the lifetime and emission spectra of some dyes like R6G and RB and Com 102 have been studied by Al-Khafahji [5]. In the present work, the effects of concentration and incident laser power on fluorescence emission of R101 dye have been investigated.

2- MATERIALS AND METHOD

The materials used were: Rhodamine 101 dye (R101), (LC 6400), spectroscopic standard, supplied from Lambda physiks, MMA (methyl methacrylate), (Fluka & Buchs, Switzerland), and methyl chloroform (Philip Harris, England).

Two kinds of solutions were prepared: The first using methanol as solvent with primary concentrations of R101 dye between 10^{-3}-10^{-5} M. The second using a mixture of MMA and methyl chloroform in ratio (1:1) (to form PMMA polymer later), and then adding the first solution to this mixture with different percentages (20% and 40% by volume). The final concentrations of the mixtures were determined by multiplying the corresponding primary concentrations by the mixing ratios (e.g. 0.20 and 0.40). The solutions were pour in identical cylindrical cells, 22mm in diameter and kept under normal laboratory condition in dark room to avoid photo degradation of the dye.

During fluorescence measurements the cells were put in identical positions in front the entrance slit of the analyzing monochrometer (Fig.1). Fluorescence spectra of the R101 dye in PMMA polymer have been recorded through a designed spectrofluormeter using a diode pumped solid state CW green laser of 531nm and 10mW power as a light source. The samples' emission spectra were detected through a Jarrell Ash monochrometer model 82-000, which operates in wavelength range from 190 nm to 910 nm with resolution 0.2Å in the first order. The instrument has 0.5 meter focal length, with eight speed electric drive, plane reflection grating of 1180 groove/mm. The detection unite was a photomultiplier PMT (type S666 Hamamatsa) which was connected to an X-Y recorder (Siemens)to detect the output signal .The power of the exciting laser light was reduced from 10mW to 8.7 mW and 3.2 mW using natural density filters. Figure (1) shows the layout of the experimental setup.

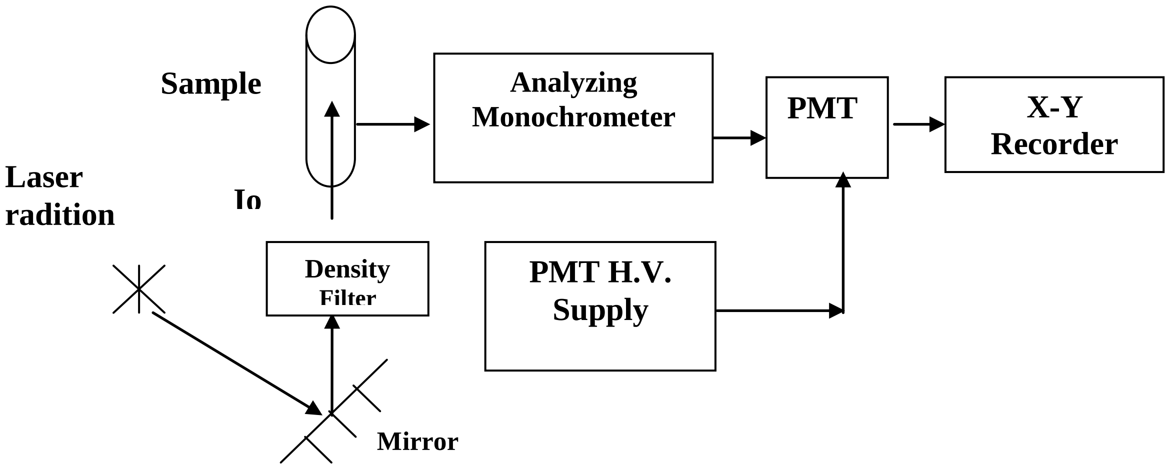

Fig.(1) :Schematic diagram of fluorescence spectra system.

3-RESULTE AND DISCUSSION

The measured fluorescence spectra of the first solution samples of R101 dye in methanol with different primary concentrations and incident laser power 10 mW is shown in Fig. 1.

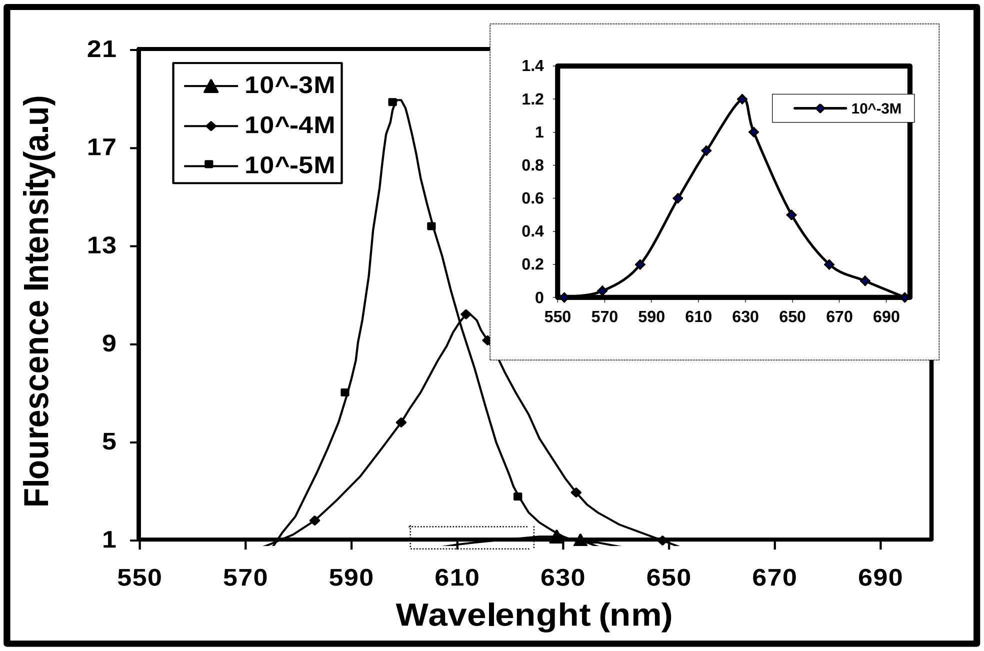

Fig.(1): Fluorescence intensity vs. wavelength of R101 dye as solutions, using different primary concentrations and incident laser power 10mW.

It has been found the fluorescence intensity of R101 dye decreases with increase of the dye concentration. The dependence of the fluorescence intensity, I_F , on the concentration, c, may by explained as follows: at higher concentration, the bimolecular competing processes to the molecular fluorescence, such as self-absorption (re-absorption and re- emission of emitted fluorescent photons), and dimmer (and possibly higher aggregates) formation of the dye molecules, play more important rule. This will ultimately reduce the fluorescence emission. Hence the formation of dimmers and higher aggregates, and resulting decrease of fluorescence intensity, put an upper limit to the concentration used. Therefore, 10^{-4} M and 10^{-5}M used for the solid samples.

We noticed also that there is a red shift of the fluorescence spectra, which increases as the concentration of R101 dye increase. This red shift can be attributed to the self-absorption which modifies the observed (technical) fluorescence spectrum by reducing the intensity of the short wavelength region of the spectrum(due to overlap with the absorption spectrum) and enhancing the intensity of the long wavelength region [6,7].

The measured peak fluorescence spectra of the solid samples of R101 dye in PMMA polymer with different concentrations and incident laser powers, mixing ratio 20% is shown in Fig. 2. and the peak fluorescence spectra of the solid samples

of R101 dye in PMMA polymer with different incident laser power and mixing ratios for the same concentration are shown in Figs. 3- 4.

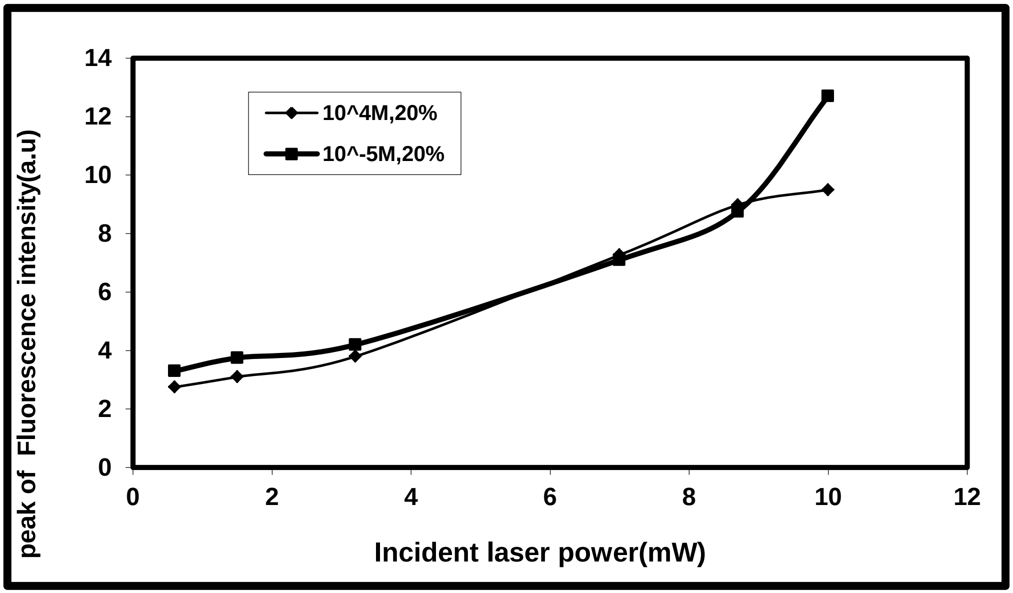

Fig.(2): Peak fluorescence intensity vs. incident laser power (I_0) of R101 dye in PMMA polymer with different concentrations and incident laser powers, mixing ratios 20%.

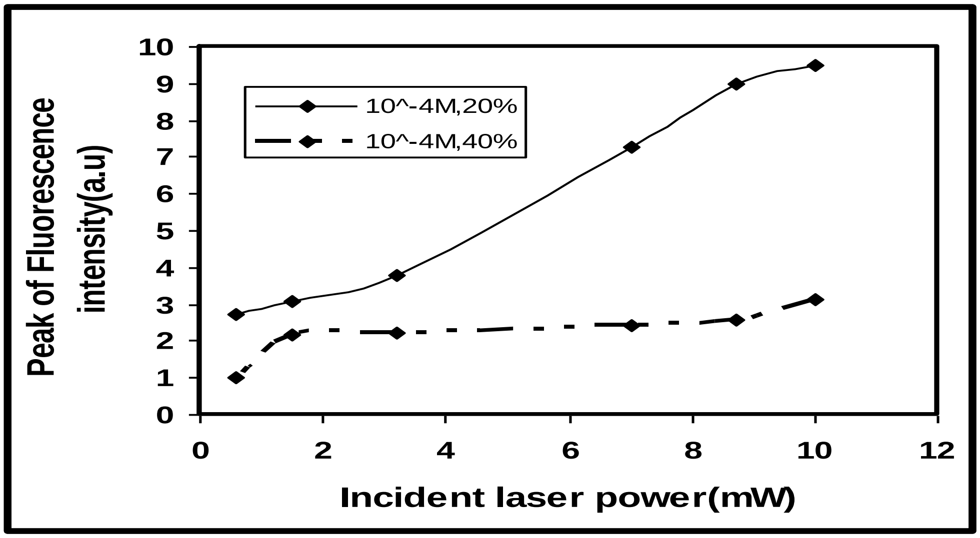

Fig.(3): Peak fluorescence intensity vs. incident laser power (I_0) of R101 dye in PMMA polymer with different incident laser powers and mixing ratios of primary concentration 10^{-4}M.

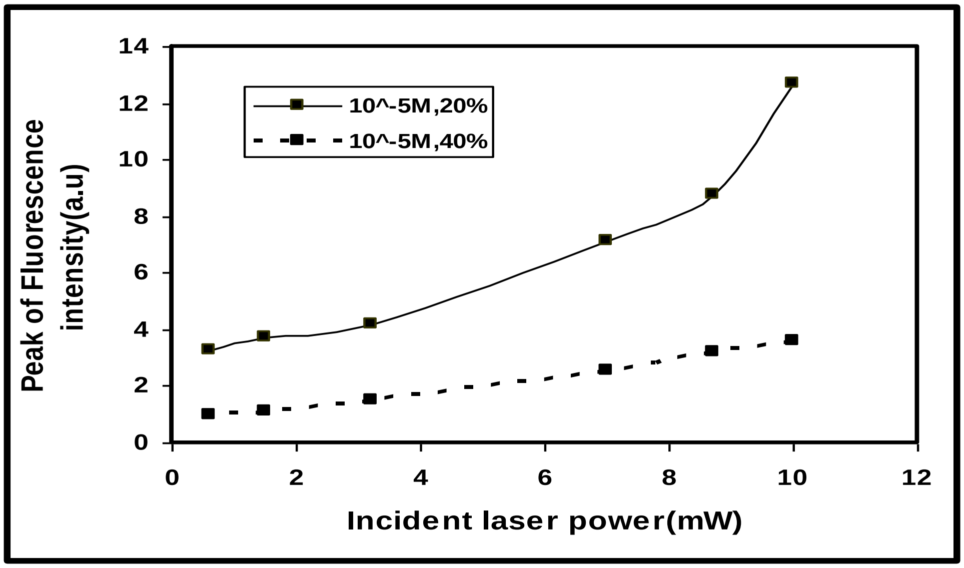

Fig.(4): Peak fluorescence intensity vs. incident laser power (I_0) of R101 dye in PMMA polymer with different incident laser powers and mixing ratios of primary concentration 10^{-5}M.

It has been found the fluorescence intensity of R101 dye increases with he increase of the incident laser power. This can be explained as follows:
The fluorescence intensity (I_F) is proportional to the fluorescence quantum efficiency (q_F) and the absorbed light intensity (I_A), namely[6]

$$I_F = q_F \ I_A \qquad \text{……………………….(1)}$$

From Beer-Lambert law, I_A is proportional to the incident light intensity (I_0), and given by

$$I_A = I_0 \left(1-10^{-\varepsilon c d}\right) \qquad \text{………………………..(2)}$$

Where ε is the extinction coefficient, c is the concentration, d is the sample thickness. Hence,

$$I_F = q_F \ I_0 \left(1-10^{-\varepsilon c d}\right) \qquad \text{……………………..…(3).}$$

As can be seen from Eq.(3), that I_F increases linearly with I_0 when other quantities are fixed, which is clear from Figs. 2-4.

الخلاصة

تناولت هذه الدراسة دراسة تأثير تغير التركيز وقدرة الليزر الساقطة على انبعاث طيف الفلورة لصبغة R101 بتراكيز مختلفة بوسط صلب من بوليمر PMMA.
بينت هذه الدراسة ان هناك زيادة بشدة الفلورة عند تغير تركيز الصبغة يرافقها زحزحة نحو الأحمر. أضافة الى ذلك تبين ان شدة الفلورة تزداد بزيادة قدرة الليزر الساقطة.

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