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The Study of Non-Linear Properties for Fluorescein Sodium Dye in Water

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Abstract: ***In this paper, the nonlinear properties of Fluorescein Sodium C20H10Na2O5 have been studied. This compound was solved in water with variable concentrations of (1 ×10^{-5}, 2 ×10^{-5}, 5 ×10^{-5}, 7 ×10^{-5}, 1 ×10^{-4}), and in a fixed thickness of 1 mm. The Method of (Z-Scan) was used to evaluate the samples. The results represent that the nonlinear refractive index n_2 and the absorption nonlinear coefficient β. It is found that the nonlinear coefficient changes with increasing the concentrations Where the nonlinear coefficient increasing with increasing the concentrations.***

Keywords: Optical limiting, nonlinear refraction index, Z-scan, Organic day

1. Introduction

Nonlinear optics has garnered special attention in the recent times owing to the wide array of practical uses in the fields of optoelectronic photonic devices. The demand for nonlinear optical materials having the distinct property of strong two-photon absorption (TPA) has risen exponentially as they have a multitude of uses in three-dimensional fluorescence imaging as well as multi- photon microscopy, protection of eye and sensor, frequency up conversion lasing, reshaping of optical signals and stabilizing fast fluctuations of laser power [1-5]. Numerous materials have been tested for the use in third –order nonlinear optics, organic materials have become the material of choice owing to their unique properties of optics and electronics which can be modified and altered as per the specification of the structure. The ability of organics to produce large as well as ultra-fast nonlinear optical response makes it a very appropriate choice for applications involving high band width. Three is a journey to create and build a truly unique nonlinear material having a considerable molecular two-photon absorption cross-section to cater to the present day needs. Optical limiting can be defined as a nonlinear optical process where in the transmittance of the material shows a reduction with the concurrent rise in the incident intensity of light [6]. In the following case study, optical nonlinearity induced by the use of dye Flourcence Sodium by CW diode laser having a 120mW power output at 532nm was studied by taking assistance of Z-scan technique, using the sample- induced changes in beam profile at the far field. The above study was designed for the concentration of dye in water solvent. Measuring of the nonlinear refractive indices n_2, and nonlinear absorption coefficients β.

2. Materials and methods

1-FlourcenceSoudium dye:dye has a chemical formula ofC20H10Na2O5 Molecular weight=376, ayellow color powder was dissolved in water. The method was incorporated to prepare our samples, were explained previously in [7, 8].

2-Developed a liquid dye in a glass cell thickness 1mm.

3. Z-Scan system

Under the standards z-scan using a CW Nd: YAGLaser at 1046 nm with multiplier frequency of 532nm at120mw output power. Lens of a focal length with 20cmwas used to focus the laser beam on our samples. To detect the output power after and before our prepared samples, a power meter of Canadian origin type(Solo2 R2) rang
(1µW-30KW).

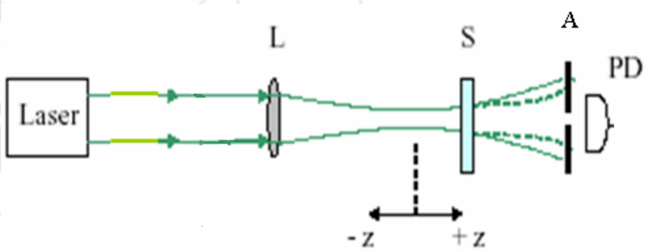


Figure 1: z-scan experimental setup

4. Results and Discussion

To study the nonlinear properties of the dye dissolved Fluorescein Sodium in water, a constant thickness of 1mmwith different concentrations of

(1 ×10^{-5}, 2×10^{-5}, 5×10^{-5}, 7×10^{-5}, 1 ×10^{-4}) mol/ liter.

Figure (2) showed the curves of the closed-z-scan aperture. The non-linear refractive index n_2 was calculated as followed [9, 10, 11]:

$$n_2 = \Delta\Phi_o / I_o L_{eff}\, k \qquad (1)$$

Where :$\Delta\Phi_o$: nonlinear phase shift . L_{eff}: the effective sample thickness, was calculated as followed

$$L_{eff} = (1 - exp^{-\alpha 0 L}) / \alpha_o \qquad (2)$$

α_O: linear absorption coefficient
I_o : represnmnts the laser beam intensity at focus z=0

k: is the wave number which gives by

$k = 2\pi / \lambda$.

The nonlinear β was calculated as in:

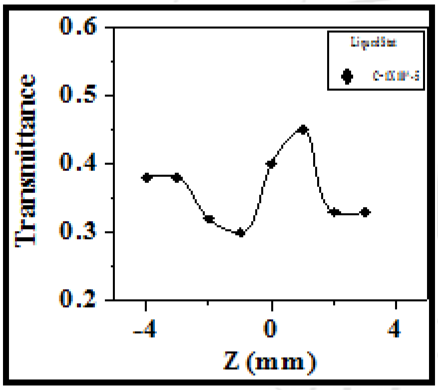
$$q_{\circ} = I_{\circ} L_{eff}\, \beta\, [1 + z] \qquad (3)$$

Then It was significant that β which was the nonlinear absorption coefficient changes randomly with increase the concentration of our samples. This means that the behavior of our prepared samples is variable depending on the intensity of the laser source into our samples. Also, our samples were inhomogeneous with the concentration that maybe causes such results in our measurements.

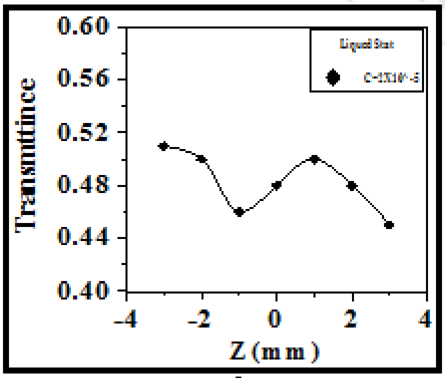
Table (1): The nonlinear Fluorescein Sodium dye at different concentrations, with a fixed thickness of 1 mm

Table 1: The nonlinear Fluorescein Sodium dye at different concentrations, with a fixed thickness of 1 mm

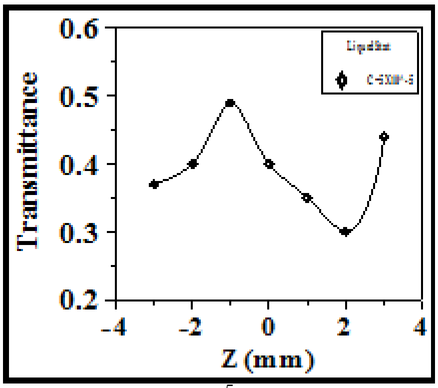
Concentration	Type	$n_2 \times 10^{-8}$ cm^2/mw	β cm/mw	ΔΦ0	Leff (mm)
1×10^{-5}	-ve	2.81	0.01202	0.09	0.676
2×10^{-5}	ve-	0.947	0.018	0.098	0.614
5×10^{-5}	ve+	8.91	0.027	0.46	0.311
7×10^{-5}	ve+	6.62	0.276	0.246	0.22
1×10^{-4}	-ve	0.12	0.054	0.394	0.188



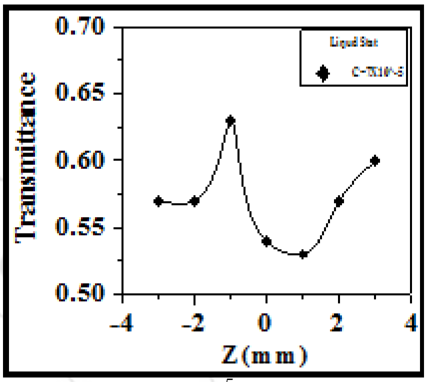
a\ c=1×10^-5 mol/ liter



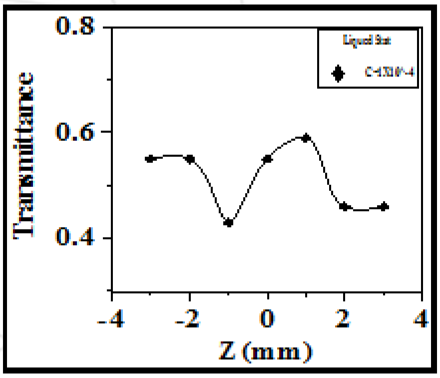
b\ c =2×10^-5 mol/ liter



c\ c=5x10^-5 mol/ liter

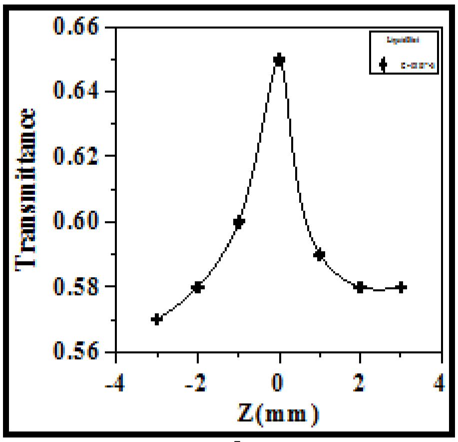


d\ c=7x10^-5 mol/ liter



e \ c=1x10^-4 mol/ liter

Figure 2: Closed – aperture z-scan of FS dye solved in water for different concentrations at a fixed thickness of 1 mm.



a\C=1×10^-5 mol/ liter

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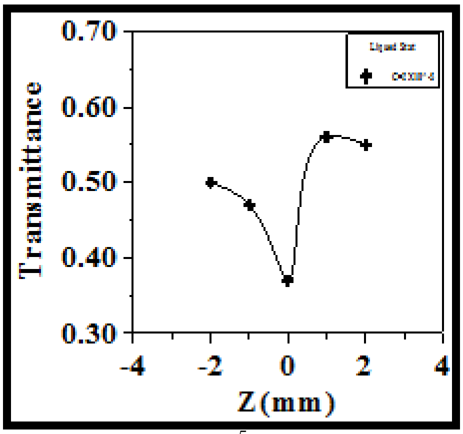
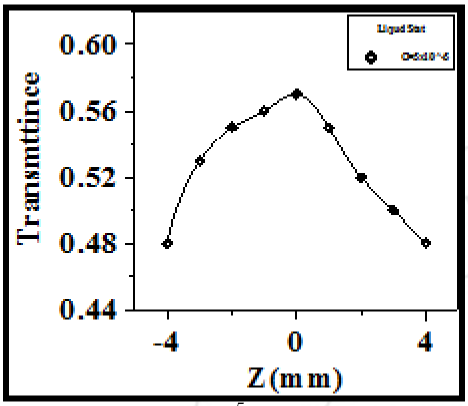
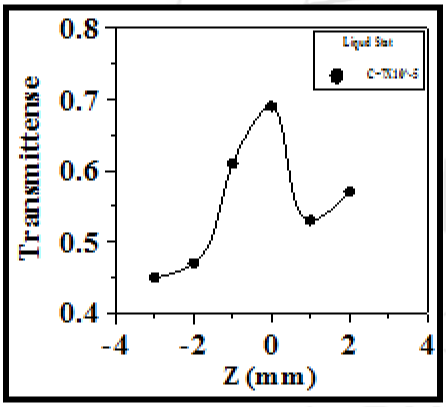


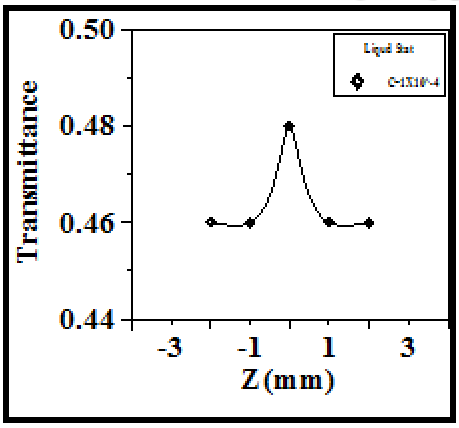
b \C=2×10^{-5} mol/ liter



c\C=5×10^{-5} mol/ liter



d\ C=7X10^{-5} mol/ liter



e\C=1×10^{-4} mol/ liter

Figure 3: Open – aperture z-scan of FS dye solved in water for different concentrations at a fixed thickness of 1 mm

5. Conclusion

The data presented here represent our study of the nonlinear coefficients of Fluorescein Sodium dye. The Fluorescein Sodium was solved in water with different concentrations, and a fixed thickness of 1 mm has nonlinear coefficients of nonlinear refractive index n2 and nonlinear absorption coefficient B. It is found that the nonlinear coefficients changes with increasing the concentrations of FS dye by

(1 ×10-5 - 1 ×10-4)mol/ liter

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