Non-linear properties for Membranes of Rhodamine tincture by using Z-Scan Technique

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ABSTRACT

This research study the spectral properties for Rhodamine (R6G) dissolved in chloroform and blended with epoxy resin with a ($3*10^{-5}$ mol /L) concentration at different thickness (4.6,22.6,23.3,29.6,32.3 mm). The membrane was prepared by spin coating method. The Z- scan technique was used to the study of nonlinear absorption coefficient(β) and nonlinear refractive coefficient (n_2) using a (100 mW) Neodymium- doped Yttrium Garnet(Nd: YAG) continuous laser (CW) with second harmonic generate at wavelength (532 mW). In general the results showed that the non-linear properties appears clear when the thickness of the sample decreased.

Key word:- Z-Scan , Rhodamine (6G), Non-linear optical properties .

1. INTRODUCTION

The solute of many of organic matters forms active medium laser, one of them is the dye matter. The molecule of the organic dye is a big and complex , and solute in some solvents and it can be absorbed in wide range of spectrum that take place in visible or the ultra violet light. The emitted light from these solvents give a wide range relatively. This range depends on the type of solute and the concentration of organic dyes, the emission spectrum would be shifted to the longer wavelength[1-3].

Nonlinear optical phenomena can be due to electronic and non electronic processes. The former refers to those radiative interactions between the active electron and the optical electric field[4] . The z-scan method has gained rapid acceptance by nonlinear optics community as a standard technique because it has several advantages. It has simple alignment set up. Under certain conditions, it is possible to isolate the nonlinear refractive index and nonlinear absorption. Both the magnitude and the sign of nonlinear refractive index can be determined [5-7].

Many studies interested on Xanthenes family which Rhodamine dye belong to them because of thier aloft gain and their properties differ with many parameters (like different solvents, different concentrations, different ratio of mixing many type of dyes, ..etc.)[8-11].

2. PRACTICAL PART

2.1. Materials & Instrument

Organic dye, Rhodamine 6G (Rhodamine590) from Himedia Laboratories Pvt.Ltd , India., was used , dye solutions at different concentration was prepared by weighting accurately amount of dye using analytical balances from Denver instrument, TP-214, Germany, and dissolved it in Chloroform from Gainland Chemical Company(GCC), UK ., according to following relationship[8,11]:

$$W = \frac{M_W \times V \times C}{1000} --- (1)$$

Where: W weight of the dye (gm), M_W molecular weight of the dye (gm/mol), V the volume of the solvent (ml), C dye concentration (mol/l).

And the solution that has been prepared was diluted with epoxy resin according to the following relationship:

$$C_1 V_1 = C_2 V_2 \quad (2)$$

Where: C_1 concentration of the initial solution, C_2 concentration of the final solution, V_1 initial volume, V_2 final volume.

The membranes have been prepared by a spin coating method using Spin Coater from Holmarc Opto-Mechatronics PVT-Ltd , India ,with speed (2000rpm) and time (30sec). The film was dried for (24hr) in desiccator's at room temperature.

Samples thickness was measured by using Sonacoat III from Sonatest Ltd , England.

Transmittance spectrum of samples were measured by using spectrophotometer (Metertech, SP8001,UV/VIS spectrophotometer) .

Z-Scan measurements were taken by using the system consists of laser Neodymium- doped Yttrium Aluminium Garnet(Nd: YAG) continuous (CW) with wavelength (1046µm) with generate harmonic second at wavelength (532nm) and the ability of the amount (100mw), lens of (15)cm focal length, and detector ,THORLABS, (400-1100nm) (500mW)which use to determine input and output laser ability.

3. RESULTS AND DISCUSSION

The transmittance for membranes of Rhodamine 6G mixed with epoxy resin are illustrated in figure (1).It can be notice that the value of (T%),(98.1%, 97.9%, 97.8%, 97.3%,96.9%) decreased with increasing the sample thicknesses (4.6µm,22.6µm,23.3µm,29.3 ,and 32.3µm) respectively. This is due to that when thickness is increased the numbers of molecules increased so transmittance decreases.

Thickness effect of Rhodamine 6G mixed with epoxy resin have been studied at concentration ($3* 10^{-5}$ mol/l), and different thickness (4.6, 22.6, 23.3, 29.3, 32.3µm) at wavelength (532nm) and ability(100mw).

Figure (2) illustrates close aperture Z-scan curves to calculate non linear refractive coefficient (n_2) by using following relationship [12,13] :

$$\Delta T_{p-v} = 0.406 \left| \Delta\Phi_0 \right| -----(3)$$

Where $\Delta\Phi_o$: nonlinear phase shift , ΔT_{p-v} the difference between the normalized peak and valley transmittances,

$$n_2 = \frac{\Delta\Phi_0}{I_0 L_{eff} K} -----(4)$$

Where k is the wave number which gives by:

$$K = \frac{2\pi}{\lambda} -----(5)$$

Where λ: is the wavelength of the beam. , L_{eff}: the effective thickness of the sample which calculated by using following relationship:

$$L_{eff} = \frac{(1-\exp^{-\alpha_0 L})}{\alpha_0} -----(6)$$

Where L : thickness length of sample, α_o : linear absorption coefficient which is given as :

$$\alpha_0 = \frac{1}{t \ln \frac{1}{T}} -----(7)$$

Where t : sample thickness, T : transmittance .
I_0 is the intensity of the laser beam at focus z =0, which is given as :

$$I_0 = \frac{2P}{\pi W_{or}^2} -----(8)$$

Where P : laser ability , W_{or} : beam spot radius at focus.
It is clear from figure (2), the dye films at different thicknesses(22.6, 23.3, , 32.3µm) have negative refractive index while the film of thickness (4.6,29.3 µm) have positive refractive index.

Figure (3) illustrates open aperture Z-scan curves to calculate non linear absorption coefficient (β) by using following relationship[14]**:**

$$T_{(Z)} = \frac{1-q_0}{2\sqrt{2}} -----(9)$$

Where $T_{(z)}$: sample transmittance ,

$$q_0 = I_0 L_{eff} \beta[1+z] -----(10),$$

and z :sample position.

Figures (3) indicates that the absorption coefficient at films of thicknesses (22.6, 29.3 μm) are saturable absorption (SA),while (4.6,23.3,32.3μm) are two-photon absorption.

All results obtained have been clarified in table (1), which shows non linear absorption coefficient (β) value decreases with increasing sample thickness because of the decrease in transmittance T(z) which was taken from open aperture Z-scan curves. Also the value of non linear refractive coefficient (n_2)decreases with increasing the thickness of sample and this is due to the change of the effective length (L_{eff}) of the sample

4. CONCLUSION

From obtained results , the nonlinear absorption(β) and nonlinear refraction index (n2) changes with change of the thickness at constant concentration. Also the behavior of nonlinear refraction coefficient change from negative to positive type, and nonlinear absorption coefficient changes from two photon absorption to saturable absorption.

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Table(1): The linear and nonlinear variables of Rhodamine 6G mixed with epoxy resin at concentration ($3*10^{-5}$ mol/l) and different thickness.

Thickness μm	T%	$\alpha_{0\times10^{-7}}$ cm^{-1}	L_{eff} cm X10^{-4}	ΔT_{pv}	$\Delta\Phi_0$	$n_{2\times10^{-7}}$ cm^2/mW	n_2 type	T(z)	β cm/mW
4.6	98.1	4.1	4.56	0.006	0.0147	2.67	+ve	0.75	1.521
22.6	97.9	0.938	22.3	0.233	0.573	0.2135	-ve	0.87	0.161
23.3	97.8	1.171	23.04	0.058	0.142	5.15	-ve	0.63	0.445
29.3	97.3	0.092	29.17	0.059	0.145	4.132	+ve	0.97	0.0282
32.3	96.9	9.72	31.78	0.011	0.027	70.6	-ve	0.89	0.096

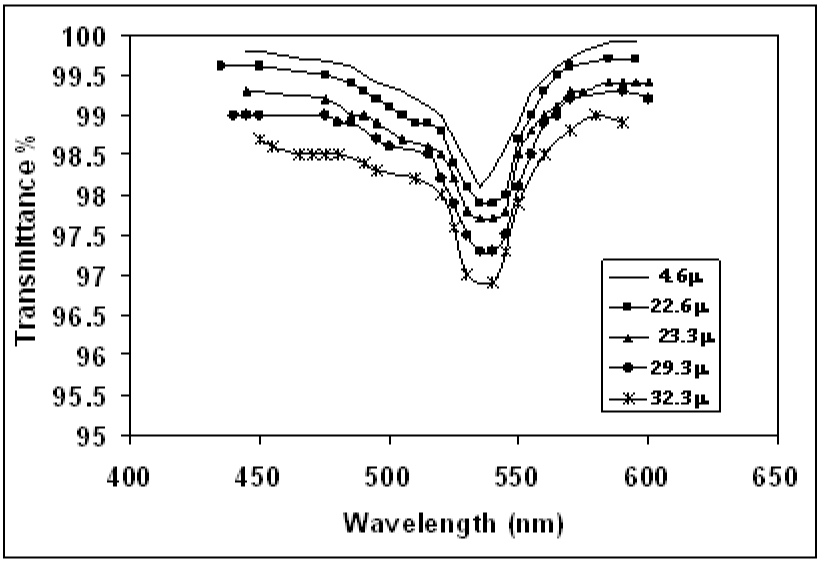
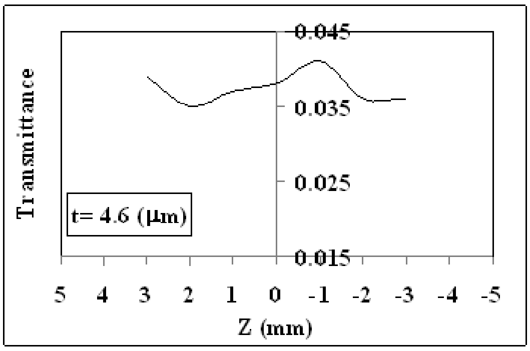


Figure (1): Transmittance spectrum for membranes of Rhodamine 6G mixed with epoxy resin at concentration (3*10-5 mol/l) and different thickness.



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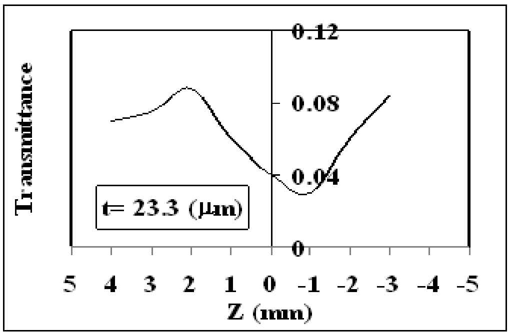

Figure (2c)

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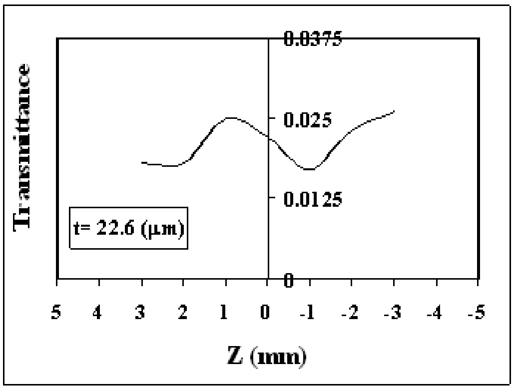

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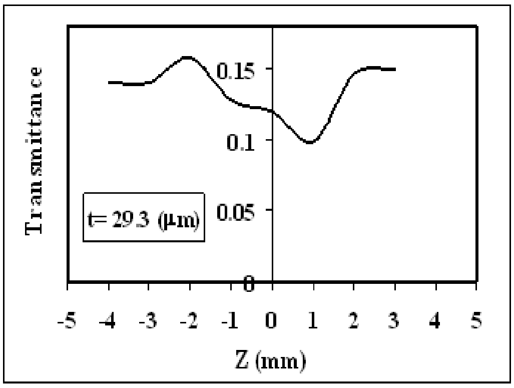

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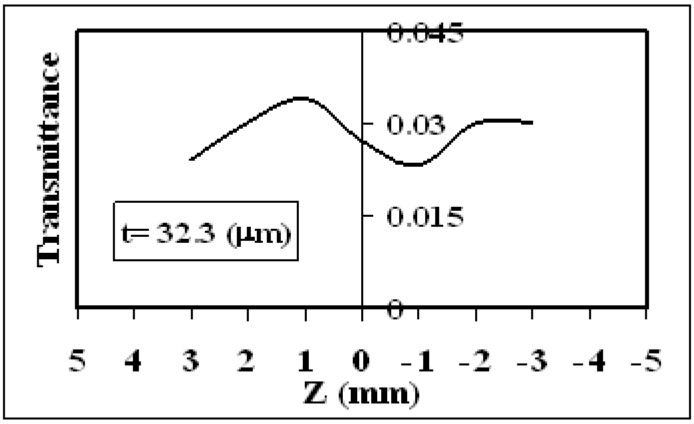
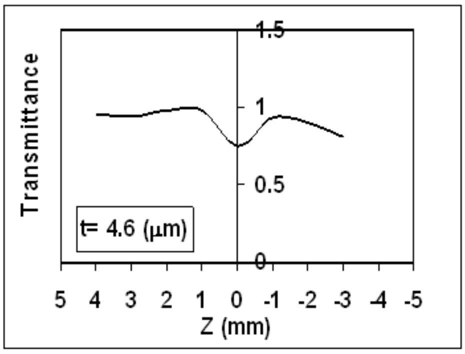


Figure (2e)

Figure (2): Close aperture Z-scan of Rhodamine 6G mixed with epoxy resin epoxy resin at concentration (3*10-5 mol/l) and different thickness.



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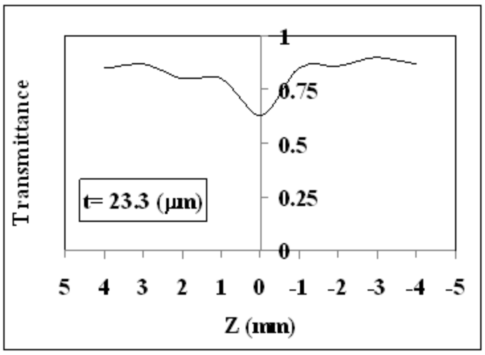

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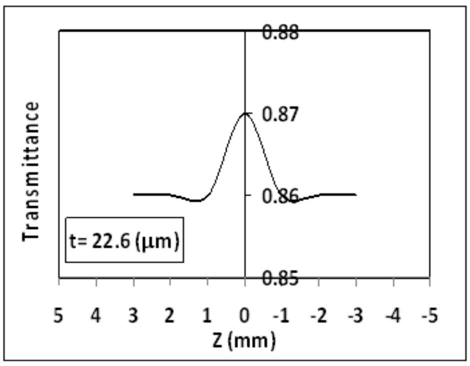

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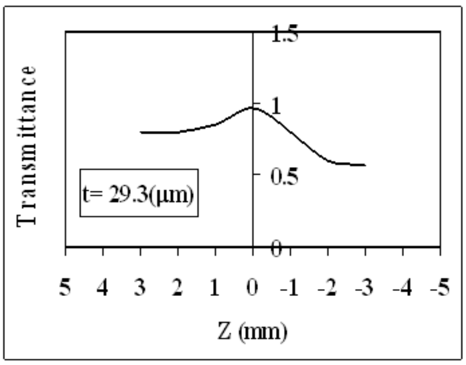

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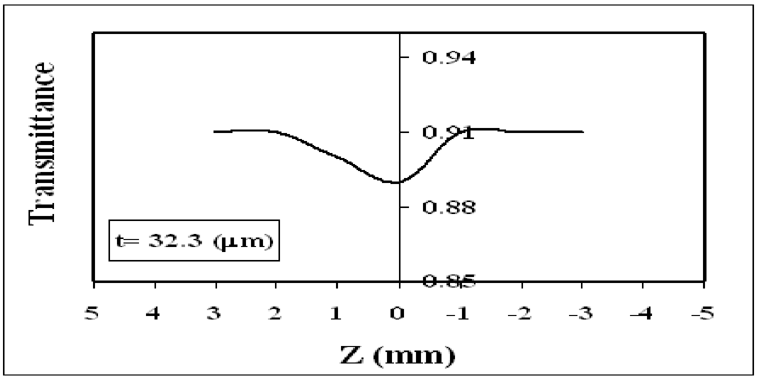

Figure (3e)

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