Preparation and Investigated Third Order Optical Nonlinearities of Schiff bases by Using the Z-Scan

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Abstract

Nonliner optical properties of organic compound derivative from closed rings compound had been studied melted in (DMSO) Dimethyl sulfoxide dissolved in (10^{-3} and 10^{-6}) at temperature of room.
Lambert law agreement, the results had been showed an expansion in the range spectral of absorption with fluorescence show a change in the direction of short wavelength with max energy, the efficiency quantum of the melt compound (s) in Dimethyl sulfoxide DMSO had been result by using pure thin film for dye and use (PMMA) polymer add to dye and max with (Titanium dioxide nanoparticle) add polymer and dye (100, 120 and 140) nm thickness respectively, lifetime radiative for thin film add to dye with polymer and thin film, with polymer add dye and add nanoparticle has been less when comparative pure dye also efficiency quantum become high when we use nanoparticle with polymer, we can conclusion, the use this dye as application of laser media active.

Key Words: Optical Nonlinearity, Z-Scan, Schiff Base.
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Introduction

The of light scattering of scatter one, is call as the single scattering. The relationship between the outcome direction and income of radiation had been find, thus the media like random to viewer (Bachor *et al* 2019).
The single of scattering, electromagnetic radiation of incident wave on single particle, firstly an electric polarization induces of inside particle. A waves of electromagnetic is generated in the scatter and around it tat why of the polarization. The total of wave electromagnetic show the polarization of scatter. This stage repeated when complicated the process (Wiersma, 1995).
The describes of very important parameter which show absorption flux from single scatter or the total scattering we can called "cross section" (Molen, 2007). The scattering flux (F_{sc}) had the following eqution (Wiersma, 1995):

$$F_{sc} = \sigma_{sc} I_o \qquad (1)$$

I_o: intensity of incident particle and σ_{sc} : is the cross scattering section (Molen, 2007).
The incidence of waves scattering for multi varies particles result an interference between them, thus the interference resulted pattern appear an obvious result for contents and the media structure (Bachor *et al* 2019).
The scattering free path (ℓ_{sc}) show in easy form , the distance separation between one scattering happened and other them (kao *et al* 2013; Jimenez *et al* 2013; Yin *et al* 2016) (ℓ_{sc}) h the generic form as follow (Yin *et al* 2016; Zhang *et al* 2017; Molen, 2007):

$$(\ell_{sc}) = \frac{1}{d_{particles}\,\sigma_{sc}} \qquad (2)$$

Where $d_{particles}$: scatters density σ_{sc}: cross scattering:

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The scattering free path $\ell_{sc} < \lambda$, then, the scattered photons recurrent increasing for feed back coherent. The scattering free path effect of ℓ_{sc} which scattering strength and k was showed in the following form (kao *et al* 2013):

$$K\,\ell_{sc} = \left(\frac{2\pi}{\lambda}\right)\ell_{sc} \qquad (3)$$

Which ($K\ell_{sc}$) becomes smaller or equals to no.1, $K\,\ell_{sc} \leq 1$ (criterion Ioffe–Regel) but $K\,\ell_{sc} \cong \lambda$, then, the transfers of light propagation to localization (Jimenez *et al* 2013).

Non-linear optical phenomena represents the nonlinear response of the random medium properties are related by the incident electromagnetic waves (Dubtsov *et al* 2009). The nonlinearity is the main reason for the following variations: changing both of frequency and size of the resulted modes from an excited disordered material, shift of laser frequency, modifying the output laser intensity and the duration of laser pulse. But the instability of random system is attributed to the strong nonlinearity (Wiersma, 1995).

The lasing in random medium depends on two parameters : nonlinear response time and the upper life time excited case. So, in the low influence, the lasing modes buildup, but when the nonlinear response is fast, then the modes cannot find enough time to buildup. This behavior may be interpreted by when the response is slow (nonlinear response time $\geq$ laser mode lifetime), the nonlinearity modifies the mode size of the generated laser frequency. While at the fast response (nonlinear response time $<$ laser mode lifetime), many extra laser modes had been generated due to nonlinearity (Wiersma, 1995: kao *et al* 2013).

There are many nonlinear effects had been appeared in random laser systems because of the complexity and the openness shape of such systems (Wiersma, 1995). We will discuss three of these effects which are proved experimentally in random laser systems: represents the nonlinear response of the random medium properties are related by the incident electromagnetic waves (Zhang *et al* 2017). The nonlinearity is the main reason for the following variations: changing both of frequency and size of the resulted modes from an excited disordered material, shift of laser frequency, modifying the output laser intensity and the duration of laser pulse. But the instability of random system is attributed to the strong nonlinearity (Bachor *et al* 2019).

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Preparation Compounds and Sample

Compound Aurintrithiadiazol (0.1g, 0.0009) mol have been mixed (0.03) formaldehyde with and (8 mL) of benzene solvent, when solvent begin boiling than melt for 3hours with increase temperate from 50-300°C fifty degree every half hour with continuous stirring. The precipitate has been filtered.

Liquid of molarity had concentrations (10^{-4} and 10^{-5}) mol. for Aurintricarboxylic acid compound in Dimethy sulfoxide (DMSO) solvents were prepared.

The weighted of powder is using an balance electronic type Germany (BL 210 S), Varies concentrations are made relatively to the down formal (Wiersma *et al* 1995; Skipetrov *et al* 1996; Graydon *et al* 20130):

$$W = \frac{M_w \times v \times c}{1000} \qquad (4)$$

Where, W: the dissolved Weight of material (g), (M_w): weight of Molecular of the material (g /mol), V: the solvent volume (mL) and C: The concentration molar (M) (Nastishin *et al* 2013)

The solutions was prepared for diluted relatively to the down equation (Yan *et al* 2003: Fang *et al* 2006; Quochi *et al* 2006; Wiersma *et al* 1996):

$$c_1V_1 = c_2V_2 \qquad (5)$$

Thus: c_1: first concentration, c_2: second concentration, v_2: The volume after dilution v_1: The volume before dilution and.

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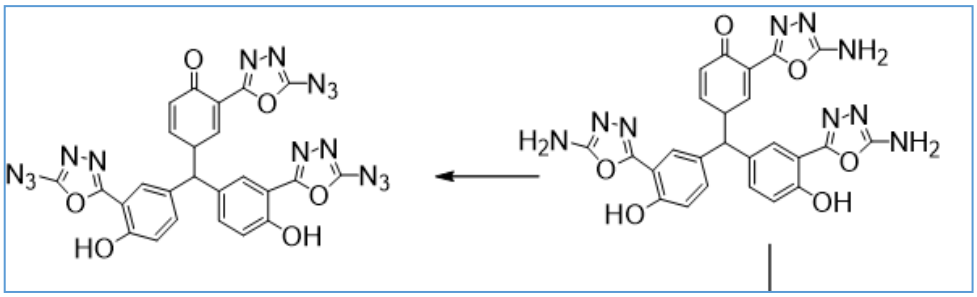

Figure 1. Diagram Scheme of processing for the compounds (h) preparation from Aurintricarboxylic acid

Result and Dissection

HNMR Spectra

The spectrum HNMR of compound (h) had appeared the show of a top singlet peak at 3.9 ppm result from the quinone group, and 4.4 appearance OH group, six aromatic protons from 6.5-7.7, at 8.8 appearance CH=N ppm, but, disappearance of top singlet peak at 6.66 ppm also show the six protons of groups of three amines as appear.

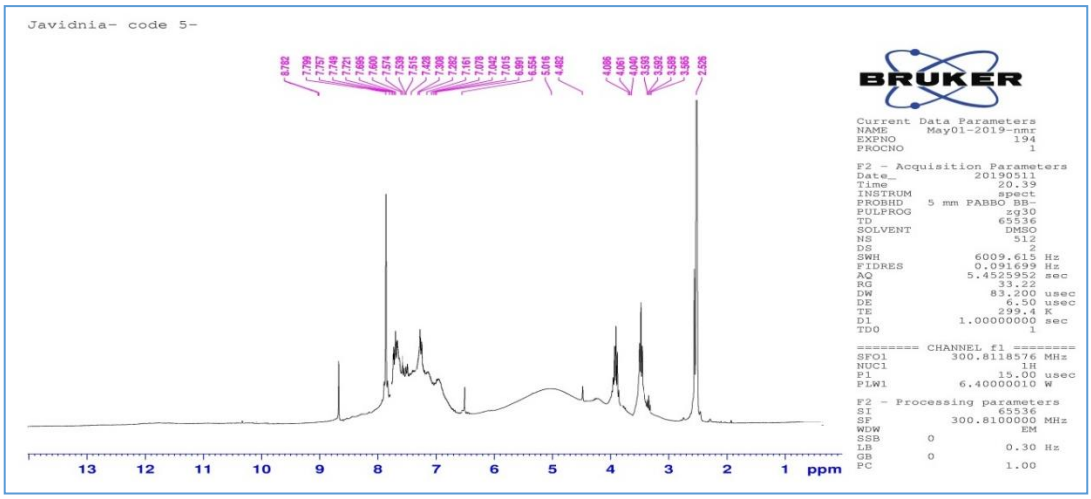

Figure 2. HNMR spectra of Aurintricarboxylic and compounds (h) respectively

Raman Scattering Spectroscopy

Raman shift of Aurintricarboxylic acid and compound B_4 where shows in figure 4 The exact peak positions frequency of each band were determined by Raman spectrometer. To achieve the most accurate to spectra of Raman every spectrum is split in three peaks.

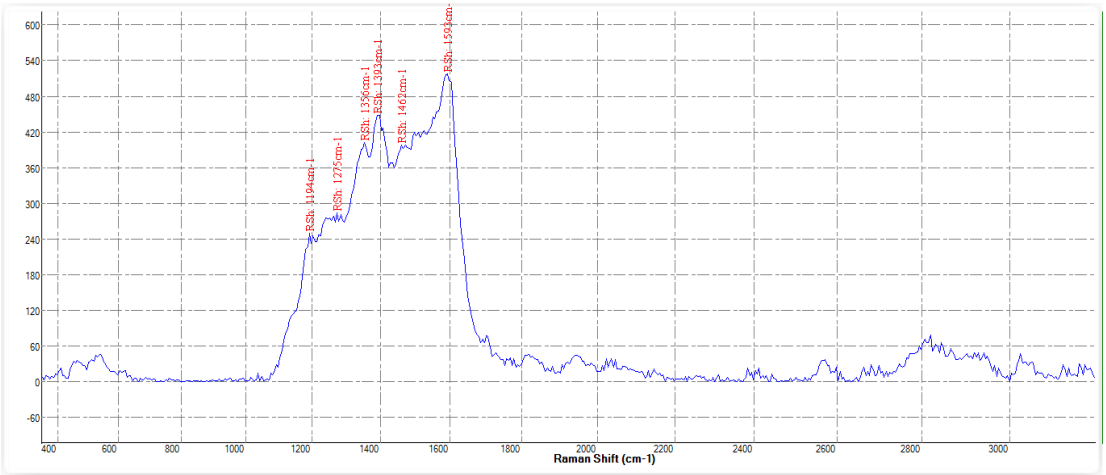

Figure 3. Raman spectral for Aurintricarboxylic acid dye and compound (h) respectively

Figure (3) for compound (h) shows the number of high frequency region formed by acoustic overtones for (1194, 1275, 1356, 1462 and 1593) cm^{-1} there is a difference in the intensity of the peaks, Raman mode–associated with the vibration of (N-N, C-N, N=C=O, N=N, C=N, O-H) respectively with increasing the intensity of the peak count/s due to change the structure of compound (h) which have large number of molecular vibration which cause high frequency region.

Properties of Nonlinear Optical

The properties of nonlinear optical are investigated for compounds (h) Aurintricarboxylic and B_4as liquid and thin film and use the method of drop at temperature room, using diode pump at 457 nm wavelength and 84 mW power with continuous wave (CW) of blue laser solid state.To measure the nonlinear properties of the material two parts were process by use technique of Z-Scan the first part is the open-aperture of Z-Scan and the second part is closed-aperture of Z-Scan.

Nonlinear refractive index of the Aurintricarboxylic compounds (h) in two different concentrations 10^{-3} and 10^{-6} M in DMSO solvents, and their thin films, are use by closed-aperture Z-Scan technique.

The transmittances normalized by Z-Scan measurements as a properties of space shown in figures (5) as solution.

Peak and valley location, of the z-axis, base on the nonlinear phase shift. Thus the the normalized transmittance change from peak of the curve to the valley (ΔT_{p-v}) was directly relatively to the shift of nonlinear phase which is imparted in the beam.

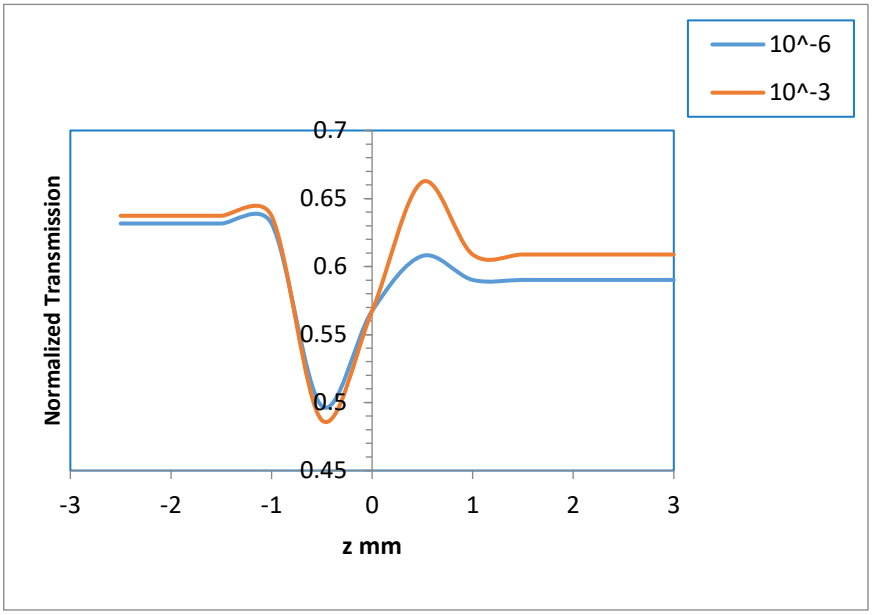

Figure 5. Z-Scan close-aperture data in two different concentrations of compounds (h) as liquid

Transmitted light is pass through medium in nonlinear form the shift in phase can too be either negative or positive in self–focusing or self, defocusing. The phase shift magnitude can be measurement from transmittance change between peak and valley, also we can note the amount (ΔT) increase with increase concentration because at the beginning the transition decrease with high concentration but when the phase inverse the sample work to combine all the radiation and the translation become high.

The nonlinear absorption coefficient of investigated compounds B_1, B_2, B_3 and B_4 for two different concentrations 10^{-4} and 10^{-5} M in DMSO liquid are measured by use Z-Scan technique open-aperture.

The operator of Z-Scan open aperture exhibits become more in the transmission for the lens focus. Z-Scan of Open–aperture of sample for (457nm), (84mW) are shown in figure (6) for compounds as liquid. It noticed two photon absorption phenomenon, This behavior reported in the literatures.

The transmittance behavior of linearly starts at varity distance for far field of the sample position (-z). The curve transmittance start to decrease until to the top of the min. value (T_{min}) in focal point, where (Z =0mm). The begins transmittance of increase in the direction of behavior of linear for sample at the far field in the direction (+Z). The intensity change, in this state, is result from two

photon absorption when the travels sample pass through beam waist. The Z-Scan for open-aperture defines for different transmittance values, which is used to measure absorption coefficient.

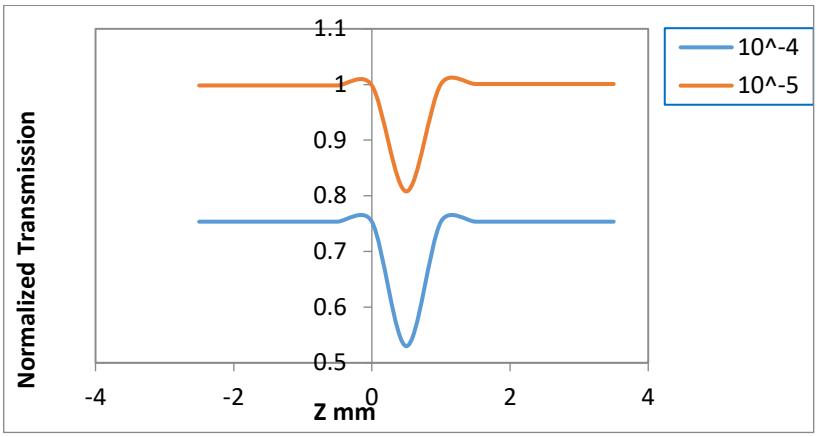

Figure 6. The Z-Scan data open-aperture of two verities concentration of compounds (h) as solution

Table 1. The optical parameters for linear and nonlinear for two concentrations of compounds solution for λ=457nm

Compound	C (M)	α_0 (cm)$^{-1}$	n_0	ΔT_{P-V}	$n_{2\times10^{-11}}$ cm^2/mW	T_{min}	$\beta\times10^{-3}$ cm/mW
(h)	**10^-3**	**0.0542**	**1.5312**	**0.0231**	**0.4511**	**0.7290**	**0.0144**
	10^-6	**0.0234**	**1.44620**	**0.0452**	**0.4271**	**0.6580**	**0.0106**

The best result can get from above table the nonlinear parameters (n_2 and β) for pure dye as liquid.

Behavior of Optical Limiting

The behavior of optical limiting for liquid samples B_1, B_2, B_3 and B_4, are made by Z-Scan for close - aperture. Power output increase initially with the rise in the power input, thus,after a threshold certain value, the sample began defocusing the resulting beam in a greater part of the cross-section beam and being cut off by the aperture.

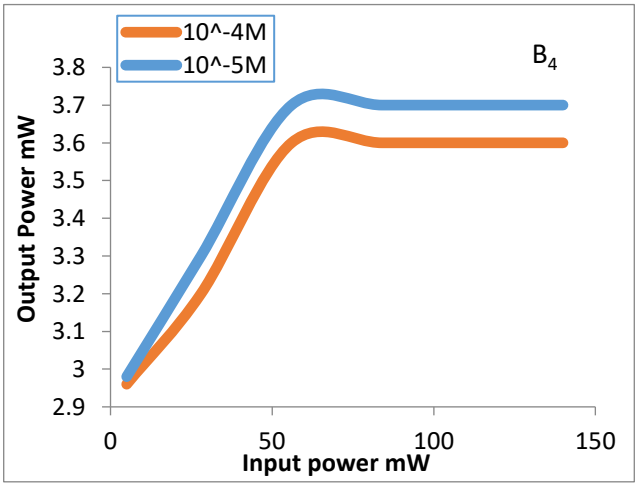

Figure 7. The response of optical limiting of two concentrations of (h)

Conclusions

The linear absorption coefficient and linear refractive index (n_o), for all samples are rise when increase the concentrations, the results, can be measure of lasers resonator cavity add to other photonic and optical devices, and The parameter nonlinear refractive index for all samples rise when concentrations increasing, and the absorption nonlinear coefficient for samples of solution increases when decrease the concentrations, results of the Z-Scan for closed-aperture for all samples of compounds as solution and thin films give self-focusing phenomena, the results of the open-aperture Z-Scan of organic dyes as solutions give two photon absorbtion, while for solution of compound give saturation of absorbtion, the ability of use the dyes like important optical limiting, the application technological like, optical- switching devices, and can be used to control noise in laser beams.

References

Bachor HA, Ralph TC. (2019). *A guide to experiments in quantum optics.* John Wiley & Sons.

Wiersma DS. Light in strongly scattering and amplifying random media. *FOM-Institute for Atomic and Molecular Physics* 1995.

Van Der Molen KL. *Experiments on scattering lasers: from Mie to random* 2007; 68(02).

Kao MH. Multiple Light Scattering from Isotropic and Anosotropic Turbid Media. *Engineering Documents* 1995: 7.

*e*ISSN 1303-5150

Jimenez-Villar E, Mestre V, De Oliveira PC, De Sa GF. Novel core–shell (TiO_2@Silica) nanoparticles for scattering medium in a random laser: higher efficiency, lower laser threshold and lower photodegradation. *Nanoscale* 2013; 5(24): 12512-12517.

Yin J, Feng G, Zhou S, Zhang H, Wang S, Zhang H. The shape effect of Au particles on random laser action in disordered media of Rh6G dye doped with PMMA polymer. *Journal of Modern Optics* 2016; 63(19): 1998-2002.

Zhang H, Feng G, Zhang H, Yang C, Yin J, Zhou S. Random laser based on Rhodamine 6G (Rh6G) doped poly (methyl methacrylate) (PMMA) films coating on ZnO nanorods synthesized by hydrothermal oxidation. *Results in physics* 2017; 7: 2968-2972.

Andreasen J, Sebbah P, Vanneste C. Nonlinear effects in random lasers. *Journal of the Optical Society of America B* 2011; 28(12): 2947-2955.

Dubtsov AV, Pasechnik SV, Shmeliova DV, Tsvetkov VA, Chigrinov, VG. Special optical geometry for measuring twist elastic module K 22 and rotational viscosity γ 1 of nematic liquid crystals. *Applied physics letters* 2009: 94(18).

Wiersma DS, Van Albada MP, Lagendijk A. Coherent backscattering of light from amplifying random media. *Physical review letters* 1995; 75(9): 1739-1742.

Skipetrov SE, Maynard R. (1996). Dynamic multiple scattering of light in multilayer turbid media. *Physics Letters A* 1996; 217(2-3): 181-185.

Graydon O. Subwavelength localization. *Nature Photonics* 2013; 7(12): 939-939.

Nastishin YA, Dudok TH. Optically pumped mirrorless lasing. A review. Part I. Random lasing. *Ukrainian journal of physical optics* 2013; 14(3): 146-170.

Johnson JC, Yan H, Yang P, Saykally RJ. Optical cavity effects in ZnO nanowire lasers and waveguides. *The journal of physical chemistry B* 2003; 107(34): 8816-8828.

Wu X, Fang W, Yamilov A, Chabanov AA, Asatryan AA, Botten LC, Cao H. Random lasing in weakly scattering systems. *Physical Review A* 2006; 74(5).

Quochi F, Cordella F, Mura A, Bongiovanni G, Balzer F, Rubahn HG. Gain amplification and lasing properties of individual organic nanofibers. *Applied Physics Letters* 2006; 88(4).

Wiersma DS, Lagendijk A. Light diffusion with gain and random lasers. *Physical Review E* 1996; 54(4): 4256-4265.

Hasan KH, Mhawes AJ. Use diode laser to estimate foot diabetes disease. *NeuroQuantology* 2020; 18(4): 27-30.