Optics & Laser Technology 82 (2016) 34–37

Contents lists available at ScienceDirect

Optics & Laser Technology

journal homepage: www.elsevier.com/locate/optlastec

The optical length effect, diffraction pattern and thermal lensing of Disperse Orange 25

S. Salmani*, M.H. Majles Ara

Photonics Lab, Department of Physics, Kharazmi University, Tehran, Iran

ARTICLE INFO

Article history:
Received 28 July 2015
Received in revised form
18 December 2015
Accepted 20 February 2016
Available online 26 February 2016

Keywords:
Optical length effect
Z-scan
Nonlinear refraction index
Nonlinear diffraction rings

ABSTRACT

The nonlinear responses of an azo dye, Disperse Orange 25 (DO25), are investigated under two irradiation of continuous Lasers at 532 and 632 nm wavelengths and the third order refractive index is measured by use of Z-scan technique. At 632 nm wavelength (far from the absorption peak), the close z-scan plots show that this material has a very good nonlinear response with negative sign indicating self-defocusing. The effect of optical length and concentration of samples in nonlinear responses have been investigated experimentally. Also, the radius variation at far field observed due to thermal lens effect. Finally, at other wavelength, 532 nm (near from the absorption peak), the nonlinear optical responses increase sharply so the diffraction rings appear and the numbers of rings increase with the incident laser power.

© 2016 Elsevier Ltd. All rights reserved.

1. Introduction

As depicted in many papers, the nonlinear optical properties of different type of materials such as semiconductors, discrete organic molecules, organic solvents, nano particles, have been widely investigated [1–4]. Among all kind of materials, organic compounds have attracted much attention due to the possibility of endowing with other organic molecules, easy fabrication, mechanical flexibility, and low cost [5]. Also, the organic materials with high nonlinear optical properties are good candidates for photonic applications such as optical switches and optical modulators [6,7]. Two mechanisms, self-focusing and self-defocusing occur in these materials due to nonlinear refractive index which is a very important parameter to design such devices [8]. Recently, azo-dyes which are categorized as colorants are well known for their opto-optical behavior; furthermore due to the simplicity of synthesis, high molar extinction coefficients, and wet fastness, have been employed in a wide range of applications [9]. Large optical nonlinearity in the Azo-dye materials is induced by trans-to-cis isomerization in the dye molecules which might be observed due to refractive index variations. Isomerization modifies the azo-dye molecules structure and allows the linear and nonlinear macroscopic susceptibilities to easily change [10]. One of the azo-dyes, Disperse Orange 25 (DO25), has stable chemical structure and large dipole moment; thus, large nonlinear responses take place in this material [11].

Lots of techniques have been employed for measuring nonlinear refractive index of materials such as nonlinear interferometry, ellipse rotation, four wave mixing and so on, each technique has own advantages and disadvantages. In this paper, we have used well known single beam z-scan technique, a very popular tool for measurements of nonlinear index, sign and magnitude [12]. The effect of incident wavelength of the laser, optical length and concentration investigated on the DO25 soluble in dichloromethane which will describe in detail in next section.

2. Experimental

2.1. Materials

The Disperse Orange 25 (DO25), azo-dye, and solvent used in the current work were of highest purity from Merck. We have solved the azo dye in a polar solvent, Dichloromethane, and prepared the samples in three concentrations, 0.1, 0.5 and1 mM. For better solvability, the samples placed in the Ultrasonic and passed through a filter.

2.2. Absorption spectroscopy

The absorption spectra of sample recorded by double beam Shimadzu UV-2450 Scan UV–visible spectrophotometer over a wavelength range between 200 and 800 nm which were combined with a cell temperature controller. The molecular structure of DO25 and UV–vis spectrum of the sample is shown in Fig. 1.

* Corresponding author.
E-mail addresses: salmani@khu.ac.ir, salmani.somaieh@gmail.com (S. Salmani).

http://dx.doi.org/10.1016/j.optlastec.2016.02.016
0030-3992/© 2016 Elsevier Ltd. All rights reserved.

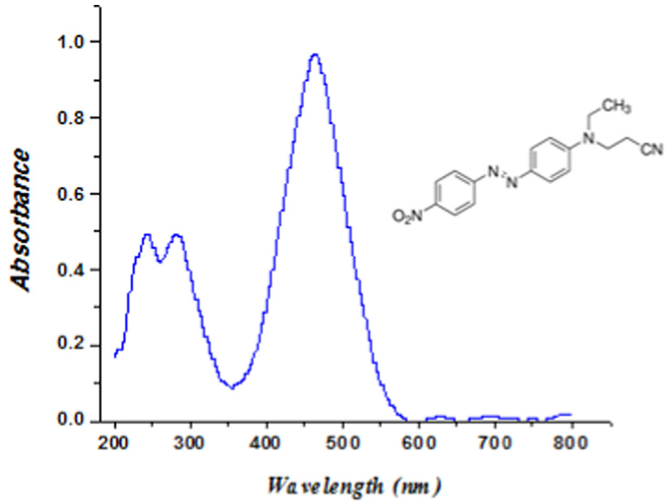

Fig. 1. UV-Visible and molecular structure of Disperse Orange 25. The absorption peak (λ=458 nm) is near the laser wavelength.

2.3. Experimental setup

As it has been mentioned, for determining the nonlinear refractive index, the closed-aperture z-scan setup shown in Fig. 2 was employed. A TEM_{00} Gaussian beam from a He–Ne laser (Coherent, 75 mW) propagating in the z-direction was focused by a lens having an 8-cm focal length. In the closed-aperture z-scan setup employed, the laser intensity (I_0) and the laser beam waist at the focus (ω_0) were measured as 1580 W/cm^2 and 50×10^{-4} cm, respectively. The saturated solution was poured at room temperature into a 1-mm quartz cell having only a negligible degree of absorbance in the visible range. The samples were translated across the focal region along the axial direction (direction of propagation of laser beam, the z-direction), the transmission intensity being measured through a one aperture at the far end as a function of the sample position z. As the sample moved through the beam focus, self-lensing modified the wavefront phase, thus modifying the beam intensity. The transmission intensity was measured by a digital powermeter (D1) (Lab master, Coherent) placed behind the aperture and got normalized by other powermeter (D2).

3. Results and discussion

We have done our experiments at two incident laser wavelength, 632 and 532 nm. Clearly, with attention to UV–vis spectrum (Fig. 1), there is no absorbance at 632 nm which may someone predict no nonlinear effect takes place due to saturation absorption. But in azo-dyes several mechanism happen such as Cis-Trans-Cis isomerization that the molecular configuration change in the isomerization causes a drastic reduction in the molecule's polarizability and then providing a large negative

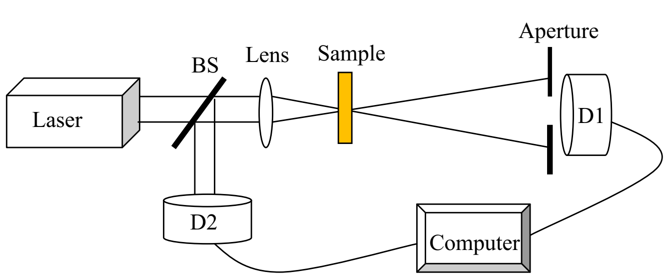

Fig. 2. The experimental set up of close Z-scan.

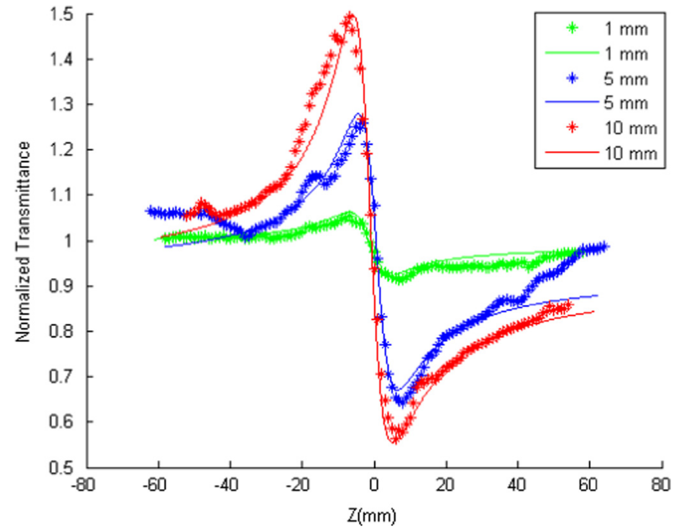

Fig. 3. The close Z-scan plots for 0.1 mM of DO25 in 1, 5 and 10 mm thickness. The dots and lines are experimental and theoretical data, respectively.

nonlinearity. Other mechanism is local thermal effect which explains in detail at 3.2 sub section. Therefore, it is not so far to observe nonlinear optical response even without any absorption at UV–vis spectrum and experiment results establish this fact. The next incident wavelength is 532 nm and there is an acceptable absorption at this wavelength. Interestingly, the nonlinear responses increase very fast insofar as the z-scan technique cannot be use for analyzing the results which we describe later.

3.1. Nonlinear responses at 632 nm wavelength

After preparing the samples, we have investigated the effect of concentration and optical length on the nonlinear responses. Therefore, the z-scan experiments have been done separately for 0.1, 0.5 and 1 mM of concentration and in every concentration, the length of quartz cell as sample cavity changes by 1, 5 and 10 mm respectively. First, the experimental results for 0.1 mM of DO25 shown in Fig. 3. The peak-valley transmissions for all thicknesses show that this material behaves as a divergent lens and the sign of nonlinear refraction is negative. Similarity it happens for other concentration 0.5 and 1 mM as presented in Figs. 4 and 5. In all

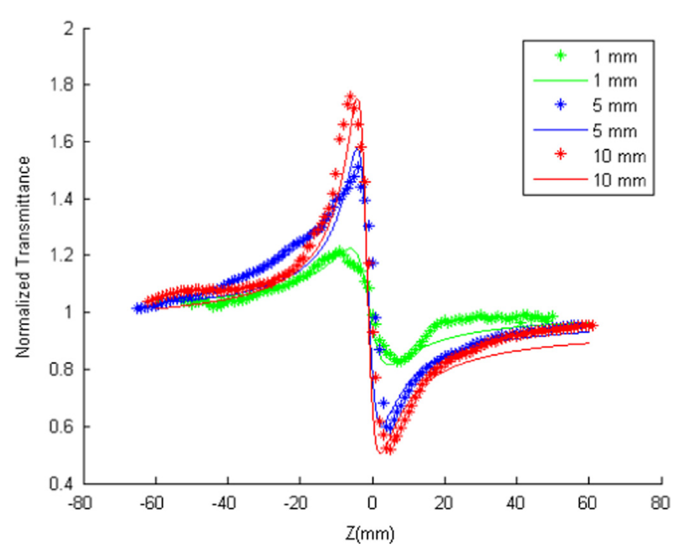

Fig. 4. The close Z-scan plots for 0.5 mM of DO25 in 1, 5 and 10 mm thickness. The dots and lines are experimental and theoretical data, respectively.

Download English Version:

https://daneshyari.com/en/article/733366

Download Persian Version:

https://daneshyari.com/article/733366

Daneshyari.com