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Third-Order Nonlinear Optical Properties of Orange G Dye in Solution and Polymer Film Using Z-scan Technique

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Abstract: The nonlinear optical properties of Orange G dye in water at different concentrations and in a solid polymer film have been investigated using a single-beam z-scan technique. Experiments were performed using continuous wave (CW) laser operating at 532 nm wavelength as a source of excitation. Effect of different incident intensities on the nonlinear optical properties of Orange G dye was studied. The open aperture z-scan curves revealed that both the dye solution in water and dye doped polymer film exhibited reverse saturable absorption. While the closed aperture z-scan curves of the dye displayed negative nonlinear refraction (self-defocusing effect). The results showed that the Orange G dye exhibited large values of the nonlinear optical coefficients β, n_2, and $\chi^{(3)}$ of the order of 10^{-3} cm / W, 10^{-7} cm^2 / W, and 10^{-5} (esu), respectively. Our results suggest that the Orange G dye is a good candidate material for applications in nonlinear optical devices.

Keywords: Third-Order Nonlinearities, Optical Properties, Orange G Dye, Dye Doped Polymer Films, Z-scan Technique

1. Introduction

Nonlinear optical properties of materials have been the subject of numerous investigations ranging from theoretical and experimental points of views during recent years due to possible potential applications in optical signal processing, computing, and photonic devices [1, 2].

Azo dyes exhibiting nonlinear absorption and refraction are currently of interest because of their large third-order nonlinearities, good photo-thermal stability, dissolvability and easy preparation virtue, so they can be used as a kind of novel storage media [3-5]. The nonlinear optical materials exhibiting a large third-order optical nonlinearity are in great demand because of their functional applications in optical power limiting, optical switching, optical data storage, micro-fabrication, and optical phase conjugate [6-17].

There are several techniques have been used to measure the third-order nonlinearity of the material, such as z-scan [18-21], nonlinear interferometry [22], degenerate four-wave mixing [23], nearly degenerate three-wave mixing [24], optical third harmonic generation [25], ellipse rotation [26], and beam distortion measurements [27]. Z-scan technique is a simple, sensitive, and accurate method introduced in 1989 by Sheik-Bahae et al. to measure the nonlinear absorption coefficient (β) and refractive index (n_2) of optical material [18]. It is used widely in material characterization because; it provides the sign and magnitude of both the nonlinear absorption coefficient (β) and refractive index (n_2).

In this paper, the nonlinear optical properties of Orange G dye in water solution at different concentrations and dye-doped PVA polymer film were investigated using the z-scan technique with CW laser. Effect of different laser incident intensity values on the third-order nonlinear optical properties of Orange G dye was also studied.