Journal of Fluorescence
https://doi.org/10.1007/s10895-023-03257-5

RESEARCH

Nonlinear Optical Properties and All Optical Switching of Curcumin Derivatives

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Received: 29 March 2023 / Accepted: 2 May 2023

Abstract
In this work OR1(E1,6E) -1,7-bis (4-propyloxy phenyl) hepta-1,6-diene-3,5 dione compound is synthesized. The compound has been characterized *via* computational technique by studying the molecule's electronic structures through calculating its HOMO and LUMO energies, and its band gap energy (E_{HOMO}-E_{LUMO}). The nonlinear refractive index (NLRI) of the solution of OR1 compound in DMF solvent is determined using diffraction patterns (DPs) which resulted when a continuous wave laser beam of wavelength 473 nm traversed the compound solution in a glass cell of 1 mm thickness. By counting the number of rings under maximum beam input power, the NLRI of value 10^{-6} cm^2/W resulted. The NLRI is calculated once more *via* the Z-scan technique and a value of 0.25×10^{-7} cm^2/W is obtained. The vertical convection current in the OR1 compound solution appears to be responsible for the asymmetries noticed in the DPs. The temporal variation of each DP is noticed together with the evolution of DPs against beam input power. DPs are numerically simulated based on the Fresnel-Kirchhoff integral with good accord compared to the experimental findings. Dynamic and static all-optical switching in the OR1 compound using two laser beams (473 and 532 *nm*) is tested successfully.

Keywords Curcumin derivative · Diffraction patterns · Z-scan · All-optical switching · Numerical simulation

PACS Number(s) 42.70.-a · 42.65-k · 42.65.An

Introduction

The needs for new materials with large nonlinear refractive indexes (NLRIs) and fast response times have triggered the race among vast number of researchers around the globe for the last four decades [1–21]. These materials can be used in variety of applications such as image processing, optical limiting, phase modulation, and all-optical switching (AOS) using low intensity laser beams [22–34]. As a beam propagates through a nonlinear medium, it modulates its spatial profile *via* the inducing of a gradient of its refractive index (RI), that induces a related phase shift on the optical field. The modulation can lead to generation of circular diffraction rings that can be used in the determination of the medium NLRI. Another new method, named Z-scan, can be used in the determination of NLRI and nonlinear absorption coefficient (NLAC) [35]. The laser beam interaction with different materials changes their RIs, are commonly described by (i) induced changes of its absorption coefficient, α, which can be written as follows [36]:

$$\alpha = \alpha_o + \beta \mathrm{I} \tag{1}$$

α_o, β and I are the medium linear absorption coefficient, nonlinear absorption coefficient and light beam intensity respectively. (ii) light induced changes of its RI, n, can be written as follows [36]:

$$\mathrm{n} = \mathrm{n_o} + \mathrm{n_2 I} \tag{2}$$

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Published online: 20 May 2023