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RESEARCH

Curcumin Analogue Spectral, Nonlinear Optical Properties and All-optical Switching Using Visible, Low Power Cw Laser Beams

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Abstract
In this study, we conducted the synthesis and diagnosis of compound denoted as 1A3, specifically, (2E,4E,9E,11E)-7-chloro-2,12-diphenyltrideca-2,4,9,11-tetraene-6,8-dione. The photoluminescent and UV-vis spectral properties of this compound are investigated. The compound is dissolved in both chloroform and DMF for analysis purposes. Compound 1A3's nonlinear optical (NLO) characteristics when dissolved in DMF, are extensively studied through a series of experiments including diffraction patterns (DPs) and Z-scan. The optical limiting (OL) property of the 1A3 compound is tested and a threshold value of 12.4 mW at the wavelength 473 nm is obtained. Additionally, we explored its potential for all-optical switching utilizing two low-power visible laser beams. Notably, we achieved a significant nonlinear refractive index (NLRI) reaching up to 5.921 x 10^{-11} m^2/W. To analyze the obtained diffraction patterns, we employed the Fresnel-Kirchhoff integral equation and conducted meticulous simulations. The numerical outcomes showed satisfactory agreement with the experimental observations.

Keywords Curcumin analogue · Photoluminescence · Nonlinear optics · Diffraction patterns · Z-scan

Introduction

Nonlinear optical (NLO) materials are gaining popularity due to their potential use in a variety of photonic applications, such as optical computing, and optical switching., harmonic generation, optical information processing, optical limiting, frequency conversion, data storage , image manipulation, and optical communication [1–11]. These materials need to possess notable nonlinear refractive indices (NLRI), swift response times, and minimal nonlinear absorption coefficients (NLAC). NLRI can be effectively determined by analyzing the diffraction patterns (DPs) generated if laser beam passes through a nonlinear medium. Additionally, both NLRI and NLAC can be derived from close and open-aperture (CA, OA) Z-scan experiments, wherein the same laser beam utilized in the previously mentioned technique is employed once again. Furthermore, these methods not only provide access to these fundamental constants but also allow for the identification of the sign of NLRI and NLAC, which are connected to the real ($Re\chi^{(3)}$) and imaginary ($Im\chi^{(3)}$) components of third-order nonlinear susceptibilities. In recent years, these approaches have been extensively used to investigate the NLO properties of a diverse array of newly synthesized materials [12–23].

Discovered in 1815 and successfully crystallized in 1870, It was discovered that curcumin is also known as diferuloylmethane or 1,6-heptadiene-3,5-dione-1.7-bis(4-hydroxy-3-methoxyphenyl)-(1E,6E) [24–26]. Over the past four decades, curcumin and its derivatives have found wide-ranging applications, including enhancing the antimicrobial properties of wool fabric through curcumin treatment [27], exploring the impact of deuterated solvents on curcumin's excited-state photophysical characteristics [28], examining the NLO characteristics of curcumin's metal derivatives [29], developing ZnO nanoparticle-based photoactive curcumin-derived dyes for sensitized solar cells [30, 31], looking into how curcumin interacts with Zn(II) and Cu(II) ions [32], analyzing the linear and nonlinear plasmon-enhanced characteristics of natural dye systems [33], assessing the NLO properties

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