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RESEARCH

Nonlinear optical properties of Azo compound synthesized via diazonation reaction using continuous wave laser beams

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Abstract

In the presence of nitrite and an aqueous hydrochloric acid medium, sulfadiazine is diazonated to create an azo compound. With the chemical formula (E)-4-((3- (tert-butyl)-2-hydroxy-5-methoxyphenyl) diazenyl)-N-(pyrimidin-2-yl), the compound is a synthetic benzenesulfonamide. Characterization of the azo molecule is done using mass, FTIR, and ^{1}H and ^{13}C NMR spectra. Azo compound structure is optimized using Density Functional Theory (DFT). This study examines the nonlinear optical (NLO) characteristics of the azo compound via the utilization of two visible, continuous wave (CW) laser beams. The nonlinear refractive index (NLRI) and the nonlinear absorption coefficient (NLAC) of the azo compound are estimated using diffraction patterns (DPs) and Z-scan and found equal to 5.38×10^{-7} cm^2/W and 2.03×10^{-3} cm/W, respectively. The DPs are numerically simulated using the Fraunhofer approximation of the Fresnel-Kirchhoff integral with good accord compared to the experiment's findings. The all-optical switching (AOS) behavior of the azo compound is examined under irradiation with 473 and 532 nm CW laser beams.

1 Introduction

Over the last four decades, there has been a continuing increasing interest in the development of new materials that can be used with low-intensity, continuous wave (CW) laser beams for possible use in optical switching [1], optical limiting [2], optical information processing [3], harmonic generation [4], and optical computing [5]. Many classes of materials, such as organic materials [6], organometallics [7], inorganic materials [8], and fullerenes [9] are extensively explored. In the last four years, we have investigated the linear and nonlinear properties of a large number of materials [10–22]. Azo compounds are another group of materials whose nonlinear optical (NLO) properties have been investigated thoroughly [23–31]. During the period 1965–1990, three techniques viz., thermal lens (TL) [32], diffraction patterns (DPs) [33, 34], and Z-scan [35, 36], have been developed to measure the nonlinear refractive index (NLRI), n_2, and the change of refractive index, Δn. The Z-scan (closed and open) developed by Sheik Bahae et al. [35, 36] is a simple and effective tool used to measure NLRI of so many materials, together with magnitudes of the real and imaginary parts of the nonlinear susceptibility and the sign of the real part. These two parameters are obtained via the closed aperture (CA) Z-scan, while the nonlinear absorption coefficient (NLAC), β, obtained using the open aperture (OA) Z-scan.

The presence of azo (–N=N–), which conjugates the two aromatic rings, gives azo compounds their vibrant color [37, 38]. These compounds have gained massive attraction owing to their versatile biological such as, antimicrobial [39, 40], and anticancer [41], as well as industrial applications, electronic devices [42], sensors [43], and fluorescent probes [44]. The azo aromatic compounds are used in the field of nonlinear optics, optical data storage and their optical and spectroscopic properties [45–48]. The electronic and structural properties of materials can be identified by using quantum chemical calculation techniques [49, 50]. Density functional theory (DFT) study was used to analyze the localization of the highest occupied molecular orbital (HOMO) – and the lowest unoccupied molecular orbital (LUMO).

The aim of the current study is to find a new material that possesses high nonlinear optical (NLO) properties.

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