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Synthesis of liquid crystalline Azo dye: study its structural, thermodynamical, and nonlinear optical properties

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ABSTRACT

Liquid crystal (LC) azo dye compound (*E*-CH_3O) of chemical formula $C_{22}H_{17}N_3O_3S$ is synthesized. Compound *E*-CH_3O is characterized via mass, FT-IR, and NMR spectra. Compound thermodynamic properties revealed a nematic phase on cooling and heating, and the textural appearance of a nematic phase on heating is a marble tetaral. Under irradiation with a laser beam 473 nm continuous wave (CW), nonlinear optical (NLO) properties of azo dye are investigated through calculation of its nonlinear refraction index (NLRI) based on diffraction patterns (DPs) and Z-scan. Two NLRI values of 5.49×10^{-11} and 0.16×10^{-11} m^2/W are obtained, respectively. The change of the LC azo dye compound refraction index (Δn) equals to 5.2×10^{-3}, which is calculated by DPs method. By employing two visible laser beams viz., 473 nm and 532 nm, all-optical switching (AOS) in sample is tested. Static AOS switching occurs when the two beams have CW character, and dynamic AOS results when the controlling (473 nm) beam has pulse character while the controlled beam (532 nm) has CW character.

1. Introduction

Refraction index (RI) variation of media occurs due to the third optical response and the propagation of an intense light beam through media. Nonlinear optical (NLO) properties of organic materials have drawn continuous research in experimental studies during the last four decades. Various studies have been carried out by research groups for their applications in nanostructured NLO effects for various devices viz., optical switching, optical limiting, etc. [1–3]. As applied field intensity increased, the NLO properties are manifested by a change of medium RI. The continuous wave (CW) laser beams with power in mW to kW range are employed extensively in many applications [4–6].

The interaction between laser beam propagating divergence and NLO sample response can elicit a number of self-action behaviors, viz., spontaneous pattern and soliton formation etc. Due to modulation instability, spatial self-modulation (SSM), formation of rings [7–9] in the far field is a related phenomenon. Diffraction patterns (DPs) can be adopted to estimate medium RI change and nonlinear refraction index (NLRI) [10]. Distortion of the beam wave front as it pass nonlinear medium can lead to open aperture (OA) and closed aperture (CA) Z-scans [11,12]. Such an effect can be used to measure a medium NLRI and related parameters.

Heterocyclic compounds are cyclic compounds that contain at least one or more carbon atoms linked to a different atoms, such as oxygen, nitrogen, sulfur, etc. [13]. It is a possible hole-transporting materials, viz., photovoltaic cells, OLEDs, and memory devices [14–16]. They exhibit interesting photophysical properties [17]. FET performance of liquid crystal (LC) compounds has future potential applications in organic devices [18]. In recent years it has been studied extensively because of its mesogenic properties [19].

Azo dye and it's derivatives have received extensive studies concerning it's spectral properties, it's optical parameters and absorption, it's optical characterization and all-optical switching, it's nonlinear optical response and optical limiting [20–23] etc. The main objective of the current study is to find a material with high nonlinear optical (NLO) properties that can be used in photonic applications. Previous studies have shown that azo dye possesses high NLO properties; therefore, we synthesized a liquid crystal (LC) azo dye compound and selected it as the sample in this study. A LC azo dye compound was characterized via mass, FTIR, and NMR spectra. The NLO properties of LC azo dye were examined with a CW 473 and 532 nm laser beams, where it's NLRI and change of it's refractive index are determined using DPs and the Z-scan

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