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Optical nonlinear properties and all optical switching in a synthesized liquid crystal

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ABSTRACT

A liquid crystal (LC) type 4-((4-(benzothiazol-2-yl) phenyl) diazenyl) −3-hydroxyphenyl 4-methoxybenzoate (E-OCH_3) is synthesized and characterized using ^{1}H NMR, mass spectra and DSC thermo gram Marble and Schlieren textures. The DFT WB97XD/6–311+ g(d,p) is used to obtain the LC optimized geometry. The possibility for the optical nonlinear (ONL) properties of the LC are studied using some chemical quantum descriptors (CQDs). The ONL properties are characterized by the determination of the LC nonlinear index of refraction (NIR) through diffraction ring patterns (DRPs) and the Z-scan methods using a continuous wave (CW) low power laser beam. The all-optical switching (AOS) of the LC is characterized using two visible laser beams of wavelengths 473 nm and 532 nm.

1. Introduction

In the recent years, there have been continuous demands for materials that responds nonlinearly to the irradiation with continuous wave (CW), visible, laser beams in short times. These materials with high nonlinear index of refraction (NIR) and high coefficient of nonlinear absorption (CNA) are always of large interest based on their potential applications in optical computing [1], optical high density data storage [2-4], frequency mixing [5], dynamical holography [6], all optical switching [7-11], optical communication [12], optical limiting, etc., [13-19].

Among the experimental techniques used for the investigation of material nonlinear properties, the most simple and convenient techniques are the diffraction ring pattern (DRPs) and the Z-scan. Due to the first technique, medium refractive index change and the NIR, n_2, can be obtained while the second technique leads to obtain the sign and value of NIR,n_2.

As a laser beam with Gaussian intensity extent traverses a medium with NIR, number of effects occurs in the traverse directions (x,y) relative to the z-axis. Some of these effects are beam break-up, self-focusing (SF) / defocusing (SDF), spatial phase modulation (SPM) [20-28], etc. SPM is belong to the phenomena self-action due to the interplay between excitation laser beam divergence and medium nonlinear photo response. The generation of DRPs that can be used to determine the NIR, n_2, based on the total rings number at the high power input. The technique of Z-scan is the most used by the researchers since 1990 due to its simplicity and sensitivity for measuring the NIR and NAC, it has been used and applied to study large number of materials [29,30]. When SF occurs in the medium under laser beam irradiation, the relation of power transmitted of laser beam against the position of the medium is a valley succeeded by a peak and when SDF occurs the relation will be a peak succeeded by a valley. Z-scan, works on the laser beam amplitude spatial distortion during the beam propagation. There are two types of Z-scans, when the detector used to measure the beam power traverses the sample covered with a circular narrow aperture, this is the closed aperture (CA) Z-scan, while using a positive lens instead of the narrow iris measure the entire laser beam power traversing the sample, this is the open aperture (OA) Z-scan.

Liquid crystal (LC) or mesophase, imply a state intermediate between solid crystalline and the amorphous liquid. A material in this state is strongly anisotropic and shows a certain degree of fluidity which may be compared to ordinary liquid [31-33]. Since 1990, LC engaged in variety of applications viz., in display applications [34], in photonic applications [35], in pharmaceutical applications [36] in drug delivery [37], etc. The nonlinear electrical properties of LC in respond to electrical field through the

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