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Sonochemical-Promoted Multicomponent Synthesis of a New Amidoalkyl Naphthol Derivative Catalyzed by [(Msim)Cl] Ionic Liquid and Assessment of Its Nonlinear Optical Properties

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The sonochemical-assisted multicomponent reaction catalyzed by ionic liquid, solvent-free synthesis, improving chemical structure, computational calculations, and nonlinear optical properties (NLO) assessment of a new amidoalkyl naphthol derivative **4**, that is, [*N*-((2-hydroxynaphthalen-1-yl)(4-nitrophenyl)methyl)-2-phenylhydrazinecarbothioamide ($C_{24}H_{20}N_4O_3S$), are introduced. The corrected structure of the synthesized derivative **4** is confirmed by different spectroscopic techniques viz., (^{1}H and ^{13}C) NMR, Infrared radiation (IR), Mass spectra, and UV-vis. spectra. To obtain geometrical structure and confirm the experimental findings, DFT-assisted B3LYP/6-31G* method is used. The NLO properties of the synthesized derivative are studied using two visible laser beams where its nonlinear refraction index (NLRI) at 473 nm cw laser beam is obtained using diffraction patterns (DPs) and the Z-scan techniques. As high as 5.312×10^{-11} m^2/W of NLRI is obtained. The all-optical switching (AOS) which is usually carried out utilizing two laser beams, the controlling and controlled, is generalized by the use of three laser beams, controlling, 473 nm beam and two controlled 532 nm and 635 nm beams.

Introduction

During the last thirty years, there has been continuous large demand for materials having NLO properties at low intensity laser beams in the visible region. Several classes of materials, ranging from polymers, organometallic materials, inorganic and organic materials, etc.,[1] have been widely explored. When laser light passes through a nonlinear medium, a number of NLO phenomena occur based on the intensity dependent nonlinear refractive index (NLRI). Based on those phenomena, researchers have developed many novel applications, such as all optical switching, optical storage, and optical signal processing, etc.[2] In the realm of spatial dynamics, the interplay between the medium NLO properties and the divergence of a propagating beam can give rise to many self-action phenomena, including spontaneous, optical self-trapping, soliton formation, and pattern generation.[3] These behaviors are a result of modulation instability. The process involves a Gaussian beam inducing a refractive index (RI) gradient within the medium, leading to a phase shift in the optical field. The phase-modulated beam then produces circular diffraction patterns (DPs) in the far field. These DPs offer insights into changes in the total RI and the NLRI, referred to as n_2, of the nonlinear medium.

To ascertain the NLRI, one commonly employed technique is the single–beam Z-scan method, which capitalizes on spatial beam distortion and high sensitivity and simplicity. This approach involves translating the sample being investigated through the focus of a positive lens along a tightly focused Gaussian beam. As the sample's position (z) varies concerning the focal lens ($z=0$), the interaction of the laser light and medium undergoes changes, experiencing different intensities depending on its location. By measuring the power transmitted (transmittance) from the sample at different z-positions, valuable information about the light-matter interaction can be extracted. In samples possessing of a negative NLRI with a thickness (d) less than the Rayleigh length of the focused beam, the transmittance versus the position ($\pm z$) exhibits a peak succeeded with a valley. Two variants of the Z-scan technique are introduced: the closed (CA) and open (OA) aperture Z-scans. In the first one, a power meter is utilized to measure the transmitted power from the sample, which is covered with a narrow circular iris. Conversely, in the second one, a positive lens replaces the iris, enabling measurement of the entire transmitted beam power.[4]

In chemistry, multi-component reactions (MCRs) are identified as a one-pot reaction that includes the rapid assembly of at least three or more simple starting substances to create diverse molecules via new bond formation (carbon-carbon and carbon-heteroatom).[5] The newly created molecules usually involve the essential moieties of the starting components. MCRs have been demonstrated to be a powerful and highly efficient way for the construction of highly diverse molecules in a one-pot operation.[6] Also, MCRs provide an important route for synthesis

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