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Synthesis and optical nonlinear properties performance of azonaphthol dye

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Abstract

Azonapthol dye viz., (E)-4-(phenyldiazenyl)naphthalen-1-ol ($C_{16}H_{11}N_3O_3$) is synthesized via diazotization of *p*-nitro aniline and subsequent coupling with α-naphthol. 1H NMR spectrum is used to identify the position of protons in obtained compound. FTIR spectrum is used to assign the absorption bands of vibration bonds at the expected regions. Mass spectrum proved a good agreement with structure of the prepared azonaphthol dye. The third order optical nonlinear properties of the azonaphthol dye **4** dissolved in acetone viz., the nonlinear index of refraction and the nonlinear absorption are obtained using 473 nm laser beam via diffraction ring patterns at 42 mW and Z-scan at 5 mW techniques separately. High nonlinear refractive index, 10^{-6} cm^2 W^{-1}, is obtained via diffraction ring pattern. Optical limiting property of azonapthol dye **4** solution is tested and a limiting threshold value of 17 mW is obtained, and prove that the sample can be used as an optical limiter. The Fraunhofer approximations of the Fresnel-Kirchhoff theory have led to the diffraction ring patterns simulation where very good agreement have been obtained.

1. Introduction

During the last thirty years a continuing interest in development and exploring of new materials with nonlinear optical properties owe to the possible applications in optical modulation, all optical switching, telecommunication, optical memory devices, data storage, protection of optical sensors and human eyes, etc [1–15]. Organic materials being the prime materials that have been studied extensively for these purposes [16–20]. They show excellent optical nonlinear properties and large nonlinearities, easy molecular design, fast response time, and good ability to process to build optical devices [21].

When a laser beam traverses a nonlinear medium number of spatial effects occurs viz., spatial ring formation, beam break-up, self-focusing and self-defocusing and thermal lens formation. The spatial ring formation was discovered in 1967 by Callen *et al* [22], then it was demonstrated that such diffraction ring patterns can be used in the determination of the change of the medium index of refraction and the nonlinear index of refraction. During 1990 Shake bahae *et al* pioneered the Z-scan technique [23] which can be used in the calculation of the coefficient of nonlinear absorption, the nonlinear index of refraction, the optical nonlinear susceptibility of the nonlinear medium and the assignment of the sign of the nonlinear index of refraction and coefficient of nonlinear absorption. Based on the diffraction ring patterns, the Z-scan and the thermal lens so many materials have been proved to behave nonlinearly in response to the propagation of low power, sub-Watt, with Gaussian intensity distribution laser beams [24–28].

Azo compounds or the compounds that bear an azo group (-N = N- group) gain importance in organic and industrial chemistry. The azo materials optical nonlinear response might be attributed to either electronic process or to nonelectronic process or to both. The first one results from the bound electrons nonlinear response. The second one is due to nonradiation interaction for instance the change in density, cis-trans