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RESEARCH

The Preparation and Nonlinear Properties Study of a Mixture of Polyurethane and Neutral Red Dye Solution

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Abstract
A mixture of polyurethane (PU) and neutral red (NR) dye solution is prepared. The nonlinear optical properties of the mixture of PU with NR dye solution are studied using a 473 nm laser beam of continuous fashion. The nonlinear refraction index of prepared material is determined via diffraction patterns and Z-scan. The diffraction patterns are calculated based on the Fresnel-Kirchhoff integral. Optical limiting of the prepared material is tested. All-optical switching occur in the sample using two low power visible laser beams.

Keywords Polyurethane · Diffraction ring patterns · Z-scan · All-optical swiching · Fresnel-Kirchhoff integral

Introduction

The search for materials having large nonlinear optical properties and short response times have led during the last three decades to the extensine research activities of different nonlinear optical organic, inorganic, liquid crystals [1–9] etc. Materials with nonlinear optical properties are popular due to their potential applications in development of photonic devices viz., optical data storage, optical communication, optical limiting, optical switching [10–16] etc. To study nonlinear optical properties of various materials, three techniques have been discovered or created since 1967. The first technique is the diffraction patterns [17], the second one is the thermal lens [18] and third one is the Z-scan [19]. The first one depends on the generation of diffraction ring patterns discovered in 1967 by Callen et al. [20], while the third one was pioneered by Sheik-Bahae et al. [21, 22] based on the deformation of the beam wave front. These two techniques have been used in the calcution of change of the medium refractive index, calculation of the nonlinear refractive index, both by calculating the maximum number of diffraction rings patterns at the high input power, while in the second technique the nonlinear refractive index and the nonlinear absorption coefficient can be calculated based on the closed and open aperture Z-scans.

During the last six years we have been engaged in using both techinques in the studying and investigating the linear and nonlinear optical properties of available materials [23–28], other materials with improved properties [29, 30], and developed new materials [31–42].

In this work a mixture of polyurethane (PU) and neutral red (NR) dye solution was used as a sample. The nonlinear optical properties of the mixture of PU and NR dye solution was studied via calculations of nonlinear refractive index, the nonlinear absorption coefficient, the optical limiting property using continuous wave (cw) laser beam at 473 nm wavelength, with Gaussian intensity distribution and low power. The experimental results were numerically determined using the Fresnel-Kirchhoff diffraction integral. All-optical switching property of the mixture of PU and NR dye solution was investigated using a controlling 473 nm and controlled 532 nm laser beams.

Experimental Details

Sample Preparation

To prepare a polyurethane (PU) doped with neutral red (NR) dye solution, methyl isocyanate mixed with neutral

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