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Evaluation of surface roughness, linear and nonlinear optical parameters of a mixture of sudan black b and polymer films for optical limiting application

Watan H. Jabber, Qusay M.A. Hassan *, F.A. Al-Saymari

Department of Physics, College of Education for Pure Sciences, University of Basrah, Basrah 61001, Iraq

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ABSTRACT

A film of a mixture of sudan black b (SBB) dye and a poly methyl methacrylate (PMMA) is fabricated by casting. X-ray diffraction measurement proves the SBB/PMMA film's structure is amorphous. The scanning probe microscope confirmed that the SBB/PMMA film has a good quality and homogeneous surface. The SBB/PMMA film's optical constants are estimated via the transmittance, absorbance, and reflectance spectra. The indirect optical band gap is calculated and found to be 1.49 eV. The single oscillator energy, E_o, the dispersion energy, E_d, and the static refractive index, n_o, are computed by using Wemple and DiDomenico model. Semi-empirical relation, Z-scan, and diffraction ring patterns are three methods used to determine the film's nonlinear refractive index value. The SBB/PMMA film exhibited a high nonlinear refractive index ($n_2 = 7.83 \times 10^{-7}$ cm^2/W) and nonlinear absorption coefficient ($\beta = 9.3 \times 10^{-3}$ cm/W), calculated by the Z-scan method. Under a continuous wave laser beam, the property of the optical limiting of the film is examined. The film exhibited optical limiting properties with a limiting threshold value of 5 mW.

1. Introduction

The study of linear optical (LO) and nonlinear optical (NLO) properties has become attractive to many researchers during the past four decades, because of their usefulness in determining the appropriate photonic applications for the materials they prepare [1–11]. The refractive index (RI), nonlinear refractive index (NRI), absorption coefficient (AC), and nonlinear absorption coefficient (NAC) are the crucial parameters that need to be computed for each material. Calculating these parameters is important, because their values determine the appropriate photonic application for that material. Solar cells [12], photonic crystals [13], optical limiting (OLg) [14], optical switching [15], data storage [16], and optical phase conjugation [17] are all possible photonic applications in which prepared materials can be used. All of these applications depend on the values of the parameters mentioned above.

One of the common ways to evaluate the RI and AC for any material is the use of spectra measurements. During this method, the reflectance, transmittance, and absorbance are measured as a function of the wavelength, and by using some well-known mathematical formulas; RI and AC can be calculated. While NRI and NAC can be determined using the Z-scan method. Through this method, the transmitted intensity passing through the material is measured as a function of distance around the focus point. In addition to the Z-scan, the diffraction ring patterns (DRPs) method can be used to determine the NRI. This method depends on the number of diffracted

* Corresponding author.
E-mail address: qusayali64@yahoo.co.in (Q.M.A. Hassan).

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