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ORIGINAL PAPER

Synthesis and study the optical nonlinear properties of polypyrrole and poly(vinyl acetate) copolymer

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Abstract: Poly [pyrrole-co-(vinyl acetate)] is prepared via chemical polymerization method. Obtained copolymer is characterized by Fourier transform infrared (FTIR) and thermal gravimetric analysis (TGA). The nonlinear optical properties of this copolymer are studied using the diffraction ring patterns and the Z-scan techniques using 473 nm wavelength laser beam. The total change in the copolymer index of refraction and nonlinear index of refraction are determined via the first technique while the nonlinear refractive index is determined via the second technique. The property of optical limiting of the copolymer is investigated where it is found that this medium possess optical limiting with limiting threshold of 14 mW is obtained. The diffraction rings patterns are simulated numerically via the diffraction integral of Fresnel-Kirchhoff with reasonable agreement compare to the experimental findings.

Keywords: Poly pyrrole; Polyvinyl acetate; Diffraction ring patterns; Z-scan; Optical limiting

1. Introduction

Materials having large nonlinear refractive indexes have attracted vast interest, since the word's first ruby laser developed in 1960 by T.H. Maiman, for their potential uses in variety of applications such as optical switching, optical data storage, beam flattening, self-focusing, self-defocusing, optical bi-stability, optical limiting, etc., [1–25]. Any material thought to be used in one of these applications must possess high nonlinear refractive index, third order nonlinear optical susceptibility, nonlinear absorption coefficient, etc.

To determine each one of those properties three techniques have been established viz., thermal lens, diffraction ring patterns, and the Z-scan [26–28]. The diffraction ring patterns technique can be used to calculate the total change of the medium refractive index and nonlinear refractive index while in the Z-scan the nonlinear refractive index and its sign, third order nonlinear optical susceptibility (real and imaginary parts), nonlinear absorption coefficient, etc., can be obtained.

Among the wide range of materials used in these applications are organic and inorganic materials, nematic liquid crystals, atomic vapors, chromophore substituted silica, metal nanoparticles polymers etc. The negative sign of the nonlinear refractive index indicates self- defocusing while the positive sign indicates self-focusing.

The organic materials have received the main interest of the optical society in the study of the nonlinear properties by one of these methods. We during the last three years have studied many materials that behave nonlinearly against visible continuous wave (CW), single fundamental transverse, $TM_{00,}$ mode, low power, laser beams based on the diffraction rings and Z-scan (open and closed) techniques.

The polypyrrole (PPy) is one of conducting polymers, widely studied in various applications viz., in composites of different materials, with Zeolite [29], as composites films with poly(vinylidene) fluoride, with multi-walled carbon nanotube composites layers for detection of mercury, lead and iron ions, in nanowire/graphene composite, in multi-walled carbon nanotube nanocomposites, in metacomposites, with yttrium oxide composites, in cobalt aluminum oxide nanocomposites, in one-dimensional nanostructures for shielding of electromagnetic interference, in fly ash composites, in tin oxide nanocomposites,

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