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Concentration effect on optical properties and optical limiting of PVA doped with nigrosin films

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ABSTRACT

Polyvinyl alcohol doped nigrosin films are fabricated on glass substrates with four concentrations. The surface images and optical transmission and absorption spectra of the four films are investigated via microscope and softwares. The linear and nonlinear susceptibilities of the four films are determined. The open aperture and closed aperture Z-scan measurements are adopted to measure the optical nonlinearities viz., the nonlinear index of refraction (NIR) and the nonlinear coefficient of absorption (NCA), where as high as 10^{-8} cm^2/W and 10^{-3} cm/W of both are determined respectively with 532 nm continuous wave (CW) laser beam. The optical limiting property of the four films at 532 nm are tested where it is proved that nigrosin doped PVA films are potential candidates for the use as optical limiters.

1. Introduction

Materials having large third-order optical nonlinear (ONL) properties with fast response times stimulated considerable research activities during the last three decades, as a result of the special laser beams properties, in various applications viz., data storage, harmonic generators, optical computing, frequency mixing, optical communication, dynamical holography, optical switches, etc [1–4].

The ONL properties of various organic materials can be obtained via two routes, first linear measurements of the materials absorbances and transmittances using spectroscopical methods where different linear properties such as real and imaginary parts of the medium dielectric constant, index of refraction (IR), extinction coefficient, absorption coefficient, etc. Second is the use of the well-established Z-scan technique [5] where the value and sign of the nonlinear index of refraction (NIR) can be determined. This technique has been used extensively in different materials in continuous wave and pulse regimes [6–9]. The IR is related to the light beam field in the organic materials and to the electrons polarization. When IR of a medium is larger than 1.65, the material is suitable for the use as Bragg gratings [10,11] and solar cells [12], while it can be used in solid state lasers to calibrate the reflectors [13,14] and as a medium for storing data for holographic systems [15] when its values is low. Materials with high optical conductivity ($\sim 10^{10}$ sec^{-1}) are potential candidates for the study of their linear and nonlinear properties are of prime importance [16,17].

Optical limiting (OL materials) are devices usually used in the protection of the human eye and optical instruments against the power of laser beam so that it is important to study the OL properties where the limiting threshold that represent the input power at which the transmittance of the laser beam through the medium is reduced by half can be obtained.

During the last decade we have been engaged in the synthesization, development, and use of different materials to study their linear and nonlinear properties [18–28]. Nigrosin is a mixture of black synthetic dyes fabricated via the heating of a mixture of hydrochloric acid, nitrobenzene and aniline in the presence of either iron or copper. To prepare a film of nigrosin in the present study we have chosen polyvinyl alcohol (PVA) polymer as its host. PVA is asymmetric polymer soluble in water, it is important in film forming having adhesive quality and emulsifying, and it is grease resistance, and act as high oxygen and aroma barrier. PVA is a resin, made of noncrystalline or viscous substance so that it is often used for the preparing of other resins. PVA have been used with various materials for different reasons. It was used with methylene blue sensitized acrylamide to find the effect of chromium doping [29], with silver to study its effect on the optical properties [30], to find its effect on the structure and optical properties of Ag-nanoparticles [31], to find its effect on nonlinearities of DNA [32], to find its effect on the optical constants of violet 1 [33], to find its influence on crystal and optical properties of europium doped strontium aluminate nanoparticles [34], in the characterization and

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