Third-order nonlinearities and optical limiting properties of rose Bengal at 532 nm wavelength

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Abstract

The nonlinear refractive index n_2 and nonlinear absorption coefficient β for aqueous solution of rose Bengal were obtained using closed aperture and open aperture Z-scan technique at the same wavelength. The nonlinear refractive index n_2 shows negative nonlinearity of the sample and it is measured to be $n_2 = -5.6 \times 10^{-8}$ cm^2 /W. Moreover, a variation of nonlinear refractive index with intensity is observed. The nonlinear absorption coefficient is measured to be $\beta = -8.3 \times 10^{-3}$ cm/W. Also the optical limiting property of the sample has been investigated using frequency doubled Nd:YAG laser.

Key words: Nonlinear optics, Nonlinear refractive index, Z-scan technique, Optical limiting, Dye.

1. Introduction

With the extensive use of continuous wave (cw) lasers at power levels ranging from μW to kW in various applications, the need for protecting the human eye and the sensors used in handling the cw output has become increasingly important. Under cw illumination, the form of optical nonlinearity exhibited by materials is predominantly refractive rather than absorptive [1,2] and suitable schemes based on nonlinear refraction have to be exploited for obtaining the limiting action. Certain materials such as liquid crystals, prophyrins, organics such as azobenzene, etc, are known to be optically nonlinear under cw laser illumination [3-5]. The refractive index of these materials depends on the input intensity, resulting in either focusing or defocusing effects on the incident laser beams. The defocusing effect under cw laser irradiation, usually associated with nonlinearity of thermo-optics origin, can be used for the design of an optical limiting devices. An aperture can be used to limit the cross section of a beam defocusing by the nonlinear medium, thereby controlling the output intensity. This type of optical limiting based on the nonlinear refraction has been demonstrated successfully with a few materials such as pthalocyanines and InO_2 [6-8].

Xanthene dyes were identified and characterized as materials suitable for optical phase conjugation (OPC) by degenerating four wave mixing in solid matrices of gelatin, poly vinyl alcohol (PVA) and boric acid glass [9,10], high density optical data storage [11] and nonlinear optics [12]. The present paper reports the study of nonlinear refractive index and nonlinear absorption coefficient of aqueous solution of an xanthene dye, namely rose Bengal by the Z-scan technique using cw diode pumped Nd:YAG laser (frequency doubled) of total power 50 mW at 532 nm. Also the optical limiting property of this sample has been studied. We found that the dye has large nonlinear refractive index and nonlinear absorption coefficient. The negative nonlinear refractive index and saturation absorption coefficient were measured for this dye.