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Low power continues wave nonlinear optics in red BS dye doped PVA thin film

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ABSTRACT

Effect of laser beam intensity and red BS dye on the nonlinear optical properties of red BS dye doped commercial Polyvinil Alcohol (PVA) film is studied employing different techniques. Nonlinearity measurement was performed using the second harmonic of a continuous Nd-YAG laser beam at 532 nm wavelength and 50 mW power. The nonlinear refractive index and nonlinear absorption coefficient of samples were measured using Z-scan method. Second order nonlinear refractive index of samples was measured to be in the range of 10^{-5} cm^2/W which was increased with increasing the amount of dye in the films structure. Both nonlinear refractive index and absorption coefficient of samples increased with increasing the amount of dye in the structure of the films and laser intensity.

1. Introduction

Since nonlinear properties of organic material have widely studied under the search for nonlinear optical material with large nonlinearities, they are imperative for potential application in optical limiting, optical devices, optical switching, electro-optic (EO) modulation, information storage, or optical signal processing. Third order polarization allows for self-focusing, third harmonic generation, and two-photon absorption. All polymers exhibited good film-forming ability, thermal stability, and large optical nonlinearities. Nonlinear optical polymer have been put forth as promising candidates for the future second-order nonlinear optical applications, such as optical information processing, data storage, and telecommunications, due to their high bandwidth, large optical nonlinearity, ease of fabrication, and low cost in comparison with inorganic compounds. In this hi-tech applications of optoelectronic using the functional dyes such as azo compounds, were carefully studied for their third-order nonlinear optic properties. Third-order nonlinear optical materials have attracted considerable interest because of their potential applications in the development of high-speed and low electric photonic devices [1]. Generally, polymeric materials can be endowed with nonlinear functionality easily by attaching various non-

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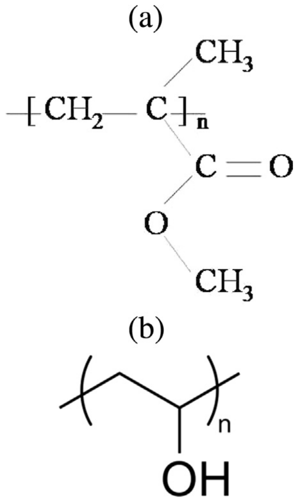

Fig. 1. Chemical structure of red BS dye (a) and PVA (b).

linear optic chromophores to the backbone or side chains of the polymer system. Compared to nonlinear optic inorganic crystal, organic nonlinear materials display have faster response times, larger bandwidths, higher electro-optic coefficients and better processability. Organic nonlinear optic materials are generally composed of push-pull organic chromospheres. For the practical processing of the chromospheres into thick and good optical quality films, their incorporation in polymer matrix is most often a prerequisite. The polymeric electro-optic material must also fulfill other requirements such as a high chemical, thermal and photochemical stability and a high transparency at the laser wavelength.

Dye chromophores are a class of organic molecules with multiple π-conjugated bonds which can exhibit large optical nonlinearities. Polymer films doped with dyes are absorptive materials for application in optical devices. Dye chromophores doped in liquid hosts can be used for many applications involving low intensity light source. Several studies on organic dyes have been reported, most of which were carried out using dye solutions. Due to advantages of device fabrication of nonlinear optical material for various applications, the solid film configuration of the dye molecules doped in Polyvinyl Alcohol (PVA) was chosen to work [2]. This study involves investigation of the nonlinear optical (NLO) behavior of solid films of a low cost organic dye, which was prepared by doping it in PVA at two concentrations, employing the single–beam Z-scan technique, with the 532 nm, laser light generated from a low power continues wave (CW) Nd-YAG laser source, serving as the excitation beam.

Z-scan technique has been used in material characterization, is efficient way to measure nonlinear refractive index, which utilizes the principal of spatial beam distortion to measure both imaginary and real parts of complex nonlinear refractive indices and their signs [3–6]. Although it is an old technique but still, it is the easiest and cheapest technique to determine the nonlinear optical parameters of materials.

In this article, we report the results of experiments performed by using the Z-scan technique to measure the sign and magnitude of the optical nonlinearity of solid film of a dye doped in PVA. The experiment was performed for several concentrations.

2. Experimental

PVA film were prepared by solving 2 gr commercial PVA powder in 20 ml distilled water and stirred for 2 h at 50° C temperature. To prepare two samples, 1 gr and 1.5 gr red BS dye was solved in 15 ml distilled water and was added drop wise to the PVA solvent and again stirred for 1 h at room temperature. Two samples of dye doped PVA films were dried on a glass substrate using spin coater at 1000 rpm for 1 min to obtain 1 μm thickness film. 1 gr and 1.5 gr red BS dye doped PVA films are labeled as sample 1 and 2 respectively. A schematic of PVA molecular structure and red BS dye are presented in Fig. 1(a) and (b).

The transmission and reflection spectrum of samples were measured using a Varian carry 500 spectrophotometer.

The experimental setup of Z-scan experiment is shown in Fig. 2. The excitation source in our experiment was the second harmonic beam of a continuous wave (CW) Nd-YAG laser at 532 nm wavelength. In the experimental setup of Fig. 2, the laser beam of 2 mm diameter after propagating through a beam splitter was focused by a 6.5 cm focal length lens on the polymer target, leads to Rayleigh length of Z_0 = 1.7 mm. Different beam splitters were used to control the beam intensity on the surface of the target at 10 and 25 mW. Two power meters were used to measure the incident and transmitted power of laser beam. Movement of sample or detector in the experiment was done using a micrometer translating stage. The distance between the lens focal point and power meter 1 was changed 6 cm during the experiment. The pinhole was 0.8 mm in diameter.