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An all-optical switch and third-order optical nonlinearity of 3,4-pyridinediamine

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Abstract We investigated the third-order nonlinear optical properties of 3,4-pyridinediamine solution. The nonlinear measurements were taken by using single-beam Z-scan technique with cw laser at 473 nm. The effect of varying glucose concentration in a sample solution has been studied. The experimental results show that the nonlinear refractive index, n_2, and nonlinear absorption coefficient, β, are strongly dependent on the glucose concentration in a sample solution. The optical limiting properties are measured by a transmission technique. We find that the limiting threshold can be improved by a proper choice of glucose concentration in sample solution. A 3,4-pyridinediamine with 80 mmol glucose concentration showed a good switching property. This phenomenon was demonstrated by waveguiding a transistor–transistor logic modulated cw 473 nm laser beam as an excitation beam modulated at 10 Hz frequency collinearly with a continuous-wave SDL-635-100T laser beam of wavelength 653 nm through a quartz cuvette of thickness 1 mm. The results of pump–probe experiments show that the time of switch-on and switch-off of the 3,4-pyridinediamine was in μs for the pump intensity. The energy-dependent transmission studies also reveal better limiting property of the sample compound at nanosecond regime. Also, thermo-optic coefficients have been determined by thermal lens (TL) technique (-9.54×10^{-5} K^{-1}) and it was found to be temperature dependent. This value was compared with result obtained by Z-scan calculations (-7.46×10^{-5} K^{-1}). Thus, the nonlinear response of the material suggests that it has a potential application for high-sensitive photonic devices.

1 Introduction

The most promising application of organic materials is the fabrication of an optical limiting solid-state device, which can be used to protect optical sensors and human eyes from the damages caused by high-energy laser light [1]. An ideal limiter exhibits a linear transmission below threshold and a constant transmission above threshold [2]. The threshold value of an optical limiting is dependent on the parameters of the system configuration such as aperture size [3], position of the sample behind the focal point of the lens [4], concentration of the solution [5–8], nature of the solvent [9], pH of sample [10], salt concentration of the solution [11, 12] and the wavelength of the laser used [13, 14]. All these parameters have been studied elsewhere. For our knowledge, still now no one studied the influence of glucose concentration on the optical limiting properties. Therefore, in this work we have studied the influence of this parameter on threshold value of an optical limiting.

Organic and metal–organic materials which possess optical power limiting (OPL) property have attracted great interests owing to their potential applications in sensor and eye protection against intense light [15–17]. All-optical switching (AOS)-related devices have gained interest in optical communication and form building blocks of future information processing systems. All-optical devices have been proposed for large variety of materials based on nonlinear absorption using pump–probe technique [18–20], and their theoretical and experimental investigations are based on resonant nonlinearity using fiber Bragg grating technique [21–24]. Based on the above consideration and

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