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Linear and Nonlinear Optical Properties of Natural Dyes Freestanding Films and Application in Optical Limiting

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***Abstract*-Natural dyes were followed and prepared from a pomegranate, purple carrot, and eggplant peel. The absorbance spectra was measured in the wavelength range 300-800 nm. The linear properties measurements of the prepared natural dye freestanding films were determined include absorption coefficient (α_0), extinction coefficient (κ), and linear refraction index (n). The nonlinear refractive index n_2 and nonlinear absorption coefficient β_2 of the natural dyes in the water solution were measured by the optical z-scan technique under a pumped solid state laser at a laser wavelength of 532 nm. The results indicated that the pomegranate dye can be promising candidates for optical limiting applications with significantly low optical limiting of 3.5 mW.**

Keywords: Optical limiting, Natural dyes, z-scan measurements.

I. Introduction

Organic dyes are investigated to have large nonlinear optical (NLO) properties in different applications (Jazbinsek *et al.*, 2008; Marder *et al.*, 2006). This type of dyes is extended to natural dyes which is demonstrated a great interesting in the field of nonlinear optical effect. Such of these materials are used in photonic applications including optical communications, optical limiting, optical-switching, and photonic devices (Unnikrishnan *et al.*, 2001; Zongo *et al.*, 2015). Natural dyes are derived from natural sources such as plants, animals, and minerals (Chengaiah *et al.*, 2010). Most of synthesized materials/dyes require difficult preparation method and expensive materials. Therefore, the suggestion of natural dyes due to its friendly environment, low cost, simple extracts method. Number of natural dyes which exhibit good nonlinear optical properties such as curcuma, henna, and beet root have been investigated (Henari *et al.*, 2013; Thankappan *et al.*, 2012). Anthocyanin dye is responsible for the red/purple color of many fruits and vegetables for example cherry, strawberry, purple carrot, and eggplant peel (Todaro *et al.*, 2009).

In this work, we investigate the linear and NLO properties as well as the optical limiting behavior of pomegranate, purple carrot, and eggplant peel. The technique which is used in this investigation is called the z-scan technique (Sheik-Bahae *et al.*, 1990). The nonlinear absorption coefficient β and nonlinear refractive index n_2 were measured at a laser wavelength of 532 nm.

II. Materials and Methods

Polyvinyl alcohol (PVA) (Central Drug House (P) Ltd. CDH, M.W=125000), pomegranate, purple carrot, and eggplant peel were used to prepare the natural dye freestanding films. In freestanding films, polyvinyl alcohol is used as a matrix owing to its good mechanical, thermal, and adhesive properties and water solubility, which it a suitable choice for the fabrication of optical devices (Pandey *et al.*, 2015).

However, the method which used to extract natural dye from three fresh fruits is called the simple aqueous extraction method (Kumar and Konar, 2011). Pomegranate, carrot, and eggplant were cleaned several times with distilled water to remove the adhering particles and dust from their surfaces, and then dried. Purple carrot and eggplant peel were cut into small pieces and soaked in distilled water one at time, then boiled for half an hour, while the pomegranate seeds was squeezed and placed in a clean container. All dyes were filtered by a 0.45 μm filter. For measurements reported here, the samples prepared by using PVA solution, and adding 2gm of PVA powder in 100 ml deionized (DI) water under vigorous stirring for 1 h at 90 ^{o}C. After the polymer solution is cool down to room temperature, 3 ml of each dye added to 3ml of polymer solution and the solution was stirred for 30 min. Finally, the prepared solutions were casted into a glass Petri dish and left to dry naturally at room temperature for 2 days. After the drying process was completed, a high quality film with uniform surface were peeled off from the Petri dish and the thickness of the samples was approximately 100±10 μm. The optical absorption was investigated by Shimadzu UV-vis 1800 spectrophotometer within wavelength range of 300-800 nm.

III.Experimental results and Discussion

1. Experimental Technique

The nonlinear optical properties of the samples were investigated by z-scan technique (Sheik-Bahae *et al.*, 1990) that is shown in Figure 1.

The nonlinear absorption coefficient β and nonlinear refractive index n_2 are obtained by monitoring the transmitted intensity variation via a focusing of a laser beam passing through an aperture in the far field on a NLO sample. Initially, a CW 532 nm Nd:YAG Gaussian laser