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Thermal nonlinearities for three curcuminoids measured by diffraction ring patterns and Z-scan under visible CW laser illumination

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ABSTRACT

The Gaussian visible Continuous-wave (CW) laser beam propagation in three curcuminoids compounds has led to diffraction ring patterns. These patterns believed to be originated due to self-phase modulation. The study focuses on the effect of input power on the diffraction ring patterns. As a result of increasing input power each circular ring pattern flattened in the upper part due to the convection. These results are reproduced numerically using the Fresnel-Kirchhoff integral. It appears that each ring pattern evolve with time from circular to flattened ones. The thermal nonlinear refractive indexes of the curcuminoids are calculated based on diffraction ring patterns and the Z-scan technique.

1. Introduction

The search for new suitable materials, which can be possibly used in various applications related to electronic and photonic devices, has not stopped yet. Therefore, so many materials that exhibit nonlinear properties have been discovered including liquid crystals, organic materials, phthalocyanines, vegetable oils, etc. [1–8]. The induced refractive index changes due to laser light intensities is the most important nonlinear property that has attracted much attention in general [9].

Generally, the variation of the optical properties of materials induced by laser light intensity could be divided into; (1) light induced absorption changes and (2) light induced refractive index changes. The refractive index changes due to light intensity can be generally described by relation (1)

$$n = n_0 + n_2 I \tag{1}$$

where n is the material refractive index in the presence of laser light, n_o is the linear refractive index of the material, n_2 denotes the nonlinear refractive index which is due to number of effects depending on the relation between laser light frequency, ω, and any resonance absorption line of the medium, and I represents the laser light intensity. When light angular frequency is far removed from any resonance absorption line, n_2 can arise from 1 – molecular redistribution [10], 2 – third-order nonlinear electronic polarizibility [11], 3 – electrostriction [12], 4 – molecular- orientation [13] and 5 – thermal changes [14].

The turmeric (curcuma longa) plant, a perennial herb which belongs to the ginger family, is bioactive component of turmeric [15]. It induces mitochondrial permeability transition mediated by membrane protein thiol oxidation [16]. Fluoride curcumin derivatives are new mitochondrial uncoupling agents [17], it induces inhibition of cellular reactive oxygen species in novel therapeutic implications [18], etc. The rhizome of this plant is also referred to as the "root" and is the most useful part of the plant for culinary and medicinal purposes. The most active component of turmeric is curcumin, which makes up to 2 to 5% of the spice. The characteristic yellow color of turmeric is due to the curcuminoids.

Turmeric is used as a dietary spice, coloring agent in foods and textiles, and a treatment for wide variety of ailments. It is widely used in traditional Indian medicine to cure biliary disorders, anorexin, cough, diabetic wound, hepatic disorder, rheumatism, and sinusitis [19].

During the last seven years, numerous studies on curcumin were carried out. Nardo et al. [20] studied the photophysical properties of curcumin and curcuminoids. Priyadarsini [21] studied the photophysics, photochemistry and photobiology of curcumin. Kim et al. [22] studied the photo and electrophysical properties of cur-

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