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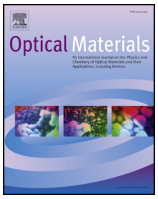

Far-field diffraction patterns and optical limiting properties of bisdemethoxycurcumin solution under CW laser illumination

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ABSTRACT

In this work, nonlinear optical properties of bisdemethoxycurcumin solution were studied using diffraction ring patterns method. Multiple diffraction rings observed as a continuous wave (CW) laser beam passes through a bisdemethoxycurcumin solution. The nonlinear refractive index, n_2, and change in refractive index, Δn, for sample were determined from the number of observed rings, and are found to be $0.8327 \times 10^{-6}\,\mathrm{cm^2/W}$ and 0.00946 respectively. The evolution of the diffraction ring patterns are numerically studied using the Fresnel–Kirchhoff diffraction integral theory. The experimental findings are in good agreement with theoretical analysis. Also the optical limiting properties of the sample were measured at 473 nm. The obtained results proved that the sample bear good optical limiting property.

1. Introduction

Due to the continuous considerable interest the search for materials exhibiting fast responses and large nonlinear refractive indexes have led to the discovery of large number of materials. These materials might have many applications in the future in the field of electronic and photonic devices [1–14]. In general, the variation of optical properties of materials induced by high intensity light is divided into light induced absorption changes and light induced refractive index changes. The second one i.e. light induced refractive index changes are usually described by

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

n is the total refractive index of the material in the presence of high intensity laser beams, n_o is the back ground refractive index, n_2 is the nonlinear refractive index and I is the incident light intensity.

Curcumin is the main curcuminoid of the Indian spice and food coloring agent turmeric, which is a member of the ginger family [15]. It can exists in at least two tautomeric forms in the electronic ground state; keto and enol. Curcumin exhibits interesting photo physical and photo chemical properties [16–18].

Curcumin is a natural yellow pigment isolated from rhizome of curcuma Longa L.(turmeric) [19]. It possesses a wide range of pharmacological properties including anti-inflammatory, hypocholesterolemic and anti-infections activities. According to Henari et al. [20], the powdered rhizome is used in curries for flavoring and coloring of the diet. Curcumin has been used as a medicine for the treatments of inflammation, skin wound and cough. Its anticancer properties have generated interest resulting in many applications. Chemical analysis of the extraction products of this powder by a variety of solvent mixtures has shown that one of the principle components is bisdemethoxy [1,7-bis (4-hydroxyphenyl)-1, 6-heptadiene-3, 5-dione], curcumin. Demethoxycurcumin and bisdemethoxycurcumin have received little attention to study their nonlinear properties [20–22].

The current study focuses on improving the nonlinear optical properties and synthesizing new material. A result of studying the nonlinear response of bisdemethoxycurcumin solution via diffraction patterns is presented. The value of nonlinear refractive index, n_2, of this material has been evaluated using diffraction ring patterns technique. The optical limiting properties of bisdemethoxycurcumin solution are also investigated.

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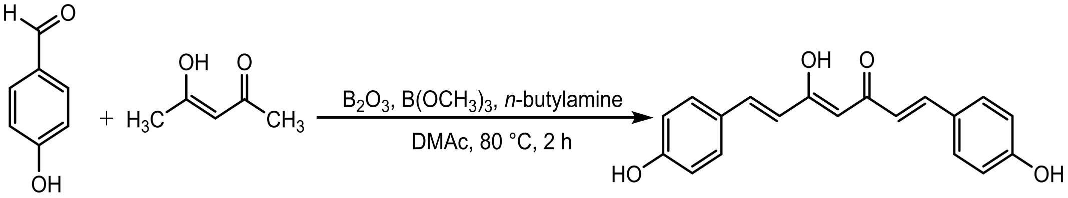

Fig. 1. The preparation of bisdemethoxycurcumin.

2. Experimental

2.1. The synthesis of the bisdemethoxycurcumin

Bisdemethoxycurcumin prepared according to the method described by Pabon [23], (Fig. 1). In a 100-mL round bottomed flask fitted with a condenser and supplied with a magnetic stirrer 0.43 g (0.14 mol) of the *p*-hydroxyaldehyde was mixed with boron oxide (0.675 g, 0.067 mol). To this mixture 5 mL of N,N-dimethylacetamide, 1.03 g mol (0.07) of freshly distilled acetylacetone and 2.23 g (0.14 mol) of trimethylborate were added. The mixture was heated to 80 °C on a water bath and 0.41 g (0.011 mol) of freshly distilled *n*-butylamine was added to it in portion within 2 h. The mixture was then heated for further 1 h, then poured while hot to 300 mL of 5% aqueous acetic acid and agitated for 1 h. The precipitate that formed was filtered and washed with water (3 × 5 mL) and dried. For further purification the product was recrystallized from methanol. The validity of the prepared compound was checked using Electrospray Ionization Mass spectra (ESI), ^{1}H NMR spectra (400 MHz, DMSO-d_6 as a solvent) and IR spectra as KBr disks.

2.2. Physical and spectral properties

Bisdemethoxycurcumin was obtained as yellow crystals, mp 223–224 °C; IR 1618 cm^{-1} (C=O str.), 1600 cm^{-1} (C=C str.); ^{1}H NMR δ 10.02 (2H, s, OH), 7.56 (2H, d, J = 8 Hz), 7.55 (2H, d, J = 15.8 Hz), 6.86 (2H, d, J = 15.8 Hz), 6.80 (2H, d, J = 8 Hz), 6.02 (1H, S); MS-ESI *m/z* 309.

2.3. The FTIR spectrum of bisdemethoxycurcumin

The infrared spectrum of bisdemethoxycurcumin was scaned as KBr disc and is shown in Fig. 2. The main features in this spectrum is the strong C=O stretching vibrational band of the carbonyl group which appears at 1618 cm^{-1}. The frequencies of the bands are highly shifted to lower wave numbers as compared to aliphatic ketones (near 1715 cm^{-1}) and α,β-unsaturated ketones [24] (1715-1690 cm^{-1}) due to the highly conjugated electronic structures of the compound and the participation of the carbonyl group in the strong intrahydrogen bonded chelated ring that is characteristic for the enolic form of the curcuminoids. These factors result in delocalization of the carbonyl group, which shift the absorption band to lower frequency. The bands that appear within the range 1600-1512 cm^{-1} could be attributed to the stretching vibrations of the C=C groups of both the methylene and the aromatic moieties. The strong and broad band that appears at 3213 cm^{-1} is due to the stretching vibration of the terminal OH groups. On the low frequency side of the spectrum exists the out-of-plane bending band at 831 cm^{-1} indicating a *para* substitution at the phenyl ring. This is in accordance with the fact that the terminal hydroxyl groups are substituted at the *para* position of the peripheral phenyl rings in the molecule. The intrahydrogen bonded OH group ordinary shows very broad and weak band within the range 3400-2500 cm^{-1}.

2.4. The electronic spectrum of bisdemethoxycurcumin

The electronic spectrum of bisdemethoxycurcumin is measured in

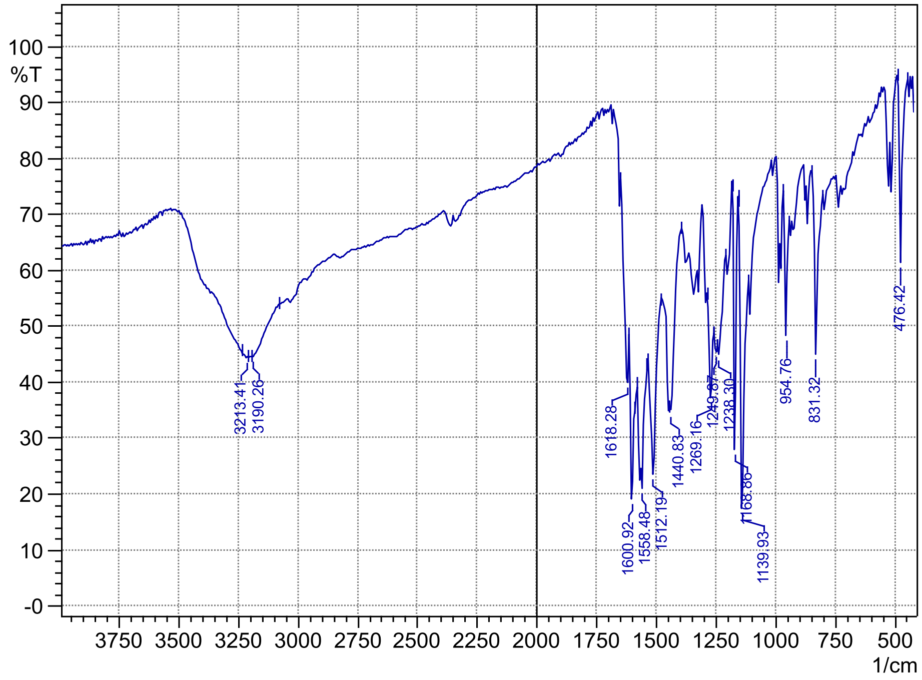

Fig. 2. FTIR spectrum of bisdemethoxycurcumin.