Journal of Materials Science: Materials in Electronics
https://doi.org/10.1007/s10854-018-9167-0

Synthesis, surface profile, nonlinear reflective index and photophysical properties of curcumin compound

Hussain Ali Badran[1] · Ahmed Al-Maliki[1] · R. K. Fakher Alfahed[2] · Bahjat Ali Saeed[3] · A. Y. Al-Ahmad[1,4] · F. A. Al-Saymari[1,5] · Rita S. Elias[6]

Received: 4 December 2017 / Accepted: 22 April 2018

Abstract
Curcumin and other three curcuminoids (bisdemethoxycurcumin, α-chlorocurcumin and α-methylcurcumin) were synthesized. Fourier transform infrared spectroscopy, Fluorescence quantum yields, AFM analysis and image surface profiles were characterized. All compounds possessed electron donor moieties at both ends of the conjugated π-system and an electron acceptor moiety in the middle of the molecules (D-A-D system) and should exhibit different optical properties depending on substituents on the benzene rings. The third order nonlinear optical properties of the curcuminoids have been investigated by z-scan technique. The optical response was characterized by measuring the refractive index (n_2) of the derivatives of curcumin using the Z-scan technique. The compounds showed negative and large nonlinear refractive index values of the order of 10^{-7} cm^2/W and reverse saturable absorption with high values of the nonlinear absorption coefficient of the order of 10^{-4} cm/W. The nonlinear refractive index was found to vary with the different compound. The optical constants of the different compound films were studied and the dispersion of the refractive index was discussed in terms of the Wemple-DiDomenico single oscillator model. The photo-physical properties of these compounds are compared to those of native curcumin, in order to provide a rationale to the design of samples with molecular structures optimized for a photosensitizer. These types of materials may be considering new photonic applications.

1 Introduction

In recent years, chemists have employed a number of dyes and their derivatives in colorimetric detection of toxic substances [1]. Curcumin, 1,7-bis(4-hydroxy-3-methoxyphenyl)-1,6-heptadiene-3,5-dione) is a yellow pigment found in the rhizomes of curcuma longa, popularly known as turmeric. It is an active ingredient in turmeric (*Curcuma longa* L.) which is widely used as a food colorant. It is called C.I. Natural Yellow 3; World Health Organization (WHO) and Food and Agriculture Organization (FAO) committees have approved it as a food additive [2, 3]. Its structure was elucidated in 1910 and it was in fact the first known diarylheptanoid, a class of compounds containing a 7-carbon chain flanked by an aromatic ring on either side (Fig. 1). The antibacterial activity of curcumin is greatly enhanced by light [4, 5]. Curcumin absorbs in the visible region and gives fluorescence with low quantum yield. Emission properties highly depend on the polarity of its environment [6–8]. Its photochemistry, including reactions with oxygen, depends on the specific microenvironment of the molecule, such as polar or non-polar and protic or aprotic solvents. Curcumin is highly soluble in polar organic compounds but is slightly soluble in aliphatic or alicyclic organic solvents like hexane and cyclohexane. The photoproducts of curcumin are not toxic; therefore the toxicity is due to the excited state of curcumin [9]. The photo-physics of curcumin is very much dependent on solvent polarity [10, 11] predominantly due to the existence of the keto-enol tautomerism, which

✉ Hussain Ali Badran
badran_hussein@yahoo.com

[1] Physics Department, College of Education for Pure Sciences, University of Basrah, Basrah, Iraq

[2] Al-Nahrain Nano-renewable Energy Research Center, Al-Nahrain University, Baghdad, Iraq

[3] Chemistry Department, College of Education for Pure Sciences, University of Basrah, Basrah, Iraq

[4] School of Mathematical and Physical Sciences, University of Newcastle, Newcastle, Australia

[5] Department of Physics, Lancaster University, Lancaster, Lancaster, UK

[6] Department of Pharmaceutical Chemistry, College Pharmacy, University of Basrah, Basrah, Iraq