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Gamma radiation effect on physical properties of 2,9-Bis [2-(4-chlorophenyl)ethyl] anthrax [2,1,9-def:6,5,10-d′e′f′] diisoquinoline-1,3,8,10 (2H,9H) tetrone films

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ABSTRACT

Thermal evaporating technique was used to prepare 2,9-Bis [2-(4-chlorophenyl)ethyl] anthrax [2,1,9-def:6,5,10-d′e′f′] diisoquinoline-1,3,8,10 (2H,9H) tetrone (Ch-diisoQ) thin films. The studied films were irradiated with gamma rays in the air at room temperature with different absorbed doses (50–200 kGy). X-Ray diffraction was used to comprehend the structure of Ch-diisoQ thin films. The outcomes affirmed that Ch-diisoQ films have nanostructure nature. The optical parameters were obtained by using spectrophotometric measurements. It was found that the dispersion of the refractive index follows the trend of single oscillator model. The optical dispersion parameters of Ch-diisoQ thin films such as dispersion energy, oscillator energy were investigated. The nonlinear susceptibility values of Ch-diisoQ films at different gamma radiation dose were calculated. Furthermore, the investigation of the optical absorption mechanism verified that the value of fundamental band gap energy, E_{g2}, increased when Ch-diisoQ films were exposed to gamma radiation. However, the conductivity was observed to be increased as the gamma radiation dose increased, while the activation energy of Ch-diisoQ films decreased with the increasing of gamma radiation dose.

1. Introduction

The investigation of organic semiconductor materials in the recent years participates dramatically in the improvement of the performance of the optical and electronic device such as photovoltaic devices, light emitting diodes, field effect transistors, nonlinear optical material and gas sensing devices [1–6]. These materials which are realized with their ease treatment, and the ability to progress their structure with required electrical and optical properties, introduce widespread adoption in the application when compared with conventional inorganic semiconductors [7,8].

Among this group of materials, organic molecules with π-conjugated electron such as quinoline derivatives have created a new class of dyes materials that offer intensive particular applications in the field of organic light emitting diodes [9,10], information storage [11], and non-linear optical material [12], and optoelectronic devices [13]. Quinoline and its derivatives are characterized by

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their thermal stability, easy processing, and high photoluminescence quantum yield [14], which makes these dyes possible candidates for application in optical sensors or as optical probes.

Actually many, of literature were involved in studying the effect of gamma radiation on the quinoline and its derivatives in several fields of pollution, pharmaceutical chemistry, and biological effects. For example, the quinoline "which possess a higher solubility in water and thus resulting in the pollution of the groundwater" was realized by extreme degradation rate under the effect of gamma radiation [15]. On the other hand, quinoline and its derivatives were evaluated for their ability to enhance the cell killing effect of γ radiation [16]. In the biological field of studies, the complexes of 8-hydroxyquinoline with several gamma-emitting nuclides, have been used to label red blood cells, platelets, and leukocytes [17]. But according to our best knowledge, the investigation of γ-radiation effect on the optical properties of quinoline and its derivatives had not been reported yet.

Understanding of the optical properties of organic semiconductor thin films is essential in many scientific, technological and industrial applications of organic semiconductor thin films such as photo-conductivity, solar energy, photography, and other several applications. It is well known that the exposure of organic semiconductor materials to gamma rays induce structural defects [12], which lead to changes in its optical properties. These changes are relevant to the internal structure of the material, the radiation energy, and the irradiation dose. For instance, optical properties of nanocrystalline tin phthalocyanine (SnPc) thin films were studied under the effect of γ-radiation. It was found that the transmission edge of SnPc was shifted towards lower wavelength, and increase optical band gap as gamma radiation dose increases [18].

To discover a lot of information about the influence of gamma radiation on the optical properties of quinoline and its derivatives, 2,9-Bis [2-(4-chlorophenyl)ethyl] anthrax [2,1,9-def:6,5,10-d′e′f′] diisoquinoline-1,3,8,10 (2H,9H) tetrone (Ch-diisoQ) compound has been chosen in our scope of the study. In fact, the optical properties of Ch-diisoQ under the effect of different annealing temperatures, and the dependence of ac conductivity of Ch-diisoQ on temperature and frequency were surveyed in our previous works [19,20]. The appropriate activation energy and the convenient optical band gap confer this material the opportunity to be one of the potential candidate materials in the fabrication of photo-electronic materials and solar cells.

The comprehensive study of the optical properties of Ch-diisoQ can be completed by elucidating the effect of different doses of γ-radiation on the optical properties of such material, so the purpose of this work is to unveil the influence of gamma radiation on some of the optical parameters of Ch-diisoQ films.

2. Experiment technique

The n-type organic compound Ch-diisoQ was purchased by Sigma-Aldrich Company. The schematic diagram of the molecular structure is shown in Fig. 1. At a pressure of 1.86×10^{-4}Pa, the films of Ch-diisoQ on cleaned glass substrates with a thickness of 140 nm, were prepared by thermal evaporation technique using an HHV Auto 306 high vacuum coating unit which was described previously in our previous work [19,20]. Irradiation was performed by using a gamma cell type ^{60}Co located at Jordan Atomic Energy Commission (JAEC). In order to attain a sequence of different absorbed doses, four samples of Ch-diisoQ thin films were exposed to gamma radiation for different periods of time. The absorbed dose rate was 330 Gy/h and the total doses varied from 50 to 200 k Gy. The structural characterization was investigated by using X-ray diffraction patterns (XRD) (Philips Diffractometer1710) with CuKα radiation operated at 40 kV and 25 mA. For electrical estimation, Ohmic contacts were made by evaporating Au on the Ch-diisoQ irradiated films. The electrometer was utilized to gauge the electrical resistance by two probe test. The transmittance, T, and reflectance, R, were measured at normal incidence in the wavelength range of 300–1100 nm employing a double beam spectrophotometer. The absorption coefficient, α, the absorption index, k, and refractive index, n, were calculated by using a private PC program [20,21].

3. Result and discussion

3.1. Structural characterization

Fig. 2 illustrated XRD of as-deposited and gamma irradiated Ch-diisoQ thin films. As shown from this figure, XRD intensity of Ch-diisoQ thin films exhibits single peak located at $2\theta = 13.30^{o}$ with a hump of amorphity exists in the scale of 20°–40°, which means that Ch-diisoQ thin films belong to the crystalline structure. According to Scherrer's equation, the grain size, D, was calculated by substituting XRD half-width in the following expression [22]

$$D = \frac{K\lambda}{\beta\cos\theta} \tag{1}$$

where K is Scherrer's constant, λ is the X-ray wavelength, θ is the Bragg's angle and β is the full width at half maximum. The calculated average crystallite sizes were found to be 9, 14, 17, 21 nm for as-deposited Ch-diisoQ thin films, which are corresponding

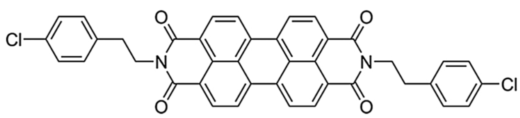

Fig. 1. The molecular structure of Ch-diisoQ material.