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Study the Effect of Irradiation by Gamma Rays on the Optical Properties of (Fe_2O_3) Thin Film Prepared by Chemical Spray Pyrolysis Method

[1]Mohammed Sami Abdali, [2]Ahmed Shaker Hussein and [3]Mohammed Hadi Shinen
[1]Department of Environmental, College of Science, University of Al-Qadisyah, Al Diwaniyah, Iraq
[2]Department of Basic Science, College of Dentistry,
[3]Department of Science, College of Basic Education, University of Babylon, Hillah, Iraq

Abstract: In this research, study the effect of gamma radiation on the some of optical properties of (Fe_2O_3) thin film prepared by chemical spray pyrolysis method in this study, structural properties including (X-ray diffraction, FTIR) tests were studied, the results were (X-ray) tests showed the membranes are multi crystallization and showed tests (FTIR) demonstrate the active groups of the prepared membrane. As for optical measurements, there was a change in optical properties after exposure of the membrane to irradiation as it has decreased energy gap as well absorbance spectrum, reflectance, refractive index, extinction coefficient, absorption coefficient, real and imaginary dielectric constant while the transmittance spectrum it has increased after exposure of the membrane to irradiation.

Key words: Fe_2O_3, thin films, optical and structural properties, gamma radiation, X-ray, FTIR

INTRODUCTION

Ferrous and ferric iron oxides present seven crystalline phase, the more common are α-Fe_2O_3 (hematite), γ-Fe_2O_3 (maghemite), Fe_2O_4 (magnetite) and $Fe_{1-x}O$ (wustite); the less commonly found the β and ε-Fe_2O_3 phase (Goyal *et al*., 2015). Ferric oxide is found in nature in the form of hematite, iron compounds exhibit high paramagnetic properties, also, ferric oxide is one of a ferric compound, basically basic as it dissolves in the bas that is the electrons keep it not double it can be obtained heating of ferrous sulphate it can also be obtained from iron oxide oxidation when adding alkali to iron solution from the where crystalline structure, the ferric oxide material has a hexagonal crystalline structure as a semi-ferric oxide conductor of negative type (Sanderson, 1960). In moreover to this lately iron oxide has become a new material for its potential applications in some medical science, for example, cancer therapy, magnetic resonance imaging and drug delivery system due to its biocompatibility, low toxicity and catalytic activity (Belkhedkar and Ubale, 2014).

MATERIALS AND METHODS

Practical part

Preparation of membrane: To prepare Ferric Oxide membranes (Fe_2O_3) thin-film by thermo-chemical analyzers. Nitrate ($Fe(NO_3)_3.9H_2O$) was used. Is a solid material of white color if it is completely dry and color light orange when melting with water it is a water-soluble substance faster, molecular weight (404.02 g/mol) it's done prepare their solutions with a molar concentration (0.1 mol/L) by adding (4.0402 g) including in (100 mL) of the distilled water gradually using a magnetic mixer. After the completion of the process of dissolving and obtain the appropriate solution, filter well using filter paper to get a smooth homogeneous solution free of plankton. This solution is finally placed in the spray tank, the following relationship was used to get on the weight to be dissolved within the standard in the above:

$$M = (W_t/M_{wt}) \times (1000/V) \quad (1)$$

Where:
M = Molaric concentration
W_t = Volume of distilled water
V = Molecular weight of material $Fe(NO_3)_3.9H_2O$)

After completing the process of dissolving and obtaining the solution, leaves for an appropriate time to ensure it is cooled before spraying and then placed in the spray machine after spraying and deposition on the glass bases prepared in advance after they have been cleaned bases well with alcohol and water we get the ferrous oxide membranes according to the following chemical Eq. 2:

Corresponding Author: Mohammed Sami Abdali, Department of Environmental, College of Science, University of Al-Qadisyah, Al Diwaniyah, Iraq

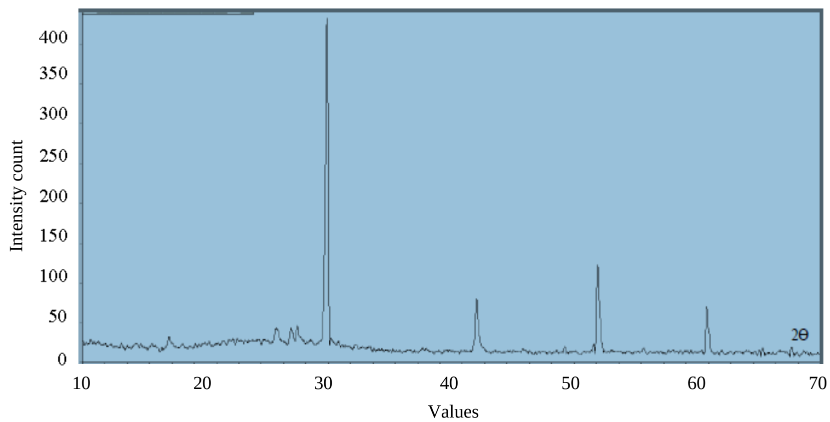

Fig. 1: XRD pattern of sample

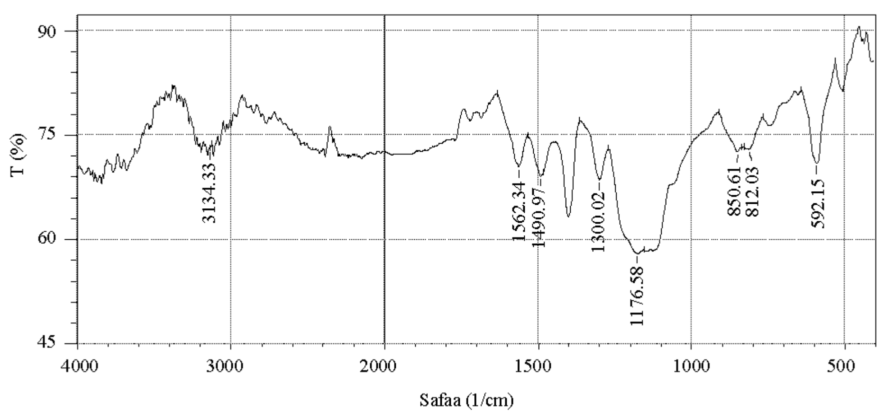

Fig. 2: FTIR spectra of Fe_2O_3 sample

$$4Fe(NO_3)_3 \rightarrow 2Fe_2O_3+3O_2+12NO_2 \quad (2)$$

The temperature of the glass bases suitable for the formation of ferric oxide membranes (Fe_2O_3), she was (500°C), the sedimentation rate from which we obtained homogeneous membranes is (10 cm^3/min) and high spray device about 30 cm about glass bases and at the time of deposition of (15 sec) to avoid sudden cooling of the bases which leads to leading to membrane failure, the sedimentation process is followed for a duration of 3 min to ensure the heat back to the original value and to complete the process of crystalline development and that the membranes obtained were reddish-brown.

Measuring thickness of prepared membranes: The weight method was used to measure the thickens of prepared membrane, a sensitive balance was used for this purpose, sensitive (10 to 4 g) by weighing the bases before and after the sedimentation process, the membrane that was prepared was thick (2500 A), after examination using a microscope light (Optical microscope) it was found to be homogeneous and highly glued with glass, free from fine cracks and holes.

Structural measurements: By using X-ray diffraction, the crystallization of the membrane was specified at room temperature. After procedure the structural tests of the membrane it was shown that the membrane had a crystallized structure as shown in Fig. 1. This agrees with (Sathiyanarayanan *et al*., 2007; Zhang *et al*., 2013; Farahmandjou and Soflaee, 2014).

According to Fig. 2, the Infrared spectrum (FTIR) of the synthesized Fe_2O_3 was in the range of 500-4000 cm^{-1} wave number which similar the chemical bonds as well as functional groups in the compound. Figure 2 shows the FTIR spectra of Fe_2O_3 sample. In Fig. 2 a broad band appears at 3134.33 cm^{-1} due to the stretching vibration of O-H. A weak broad band is shown around 1562.34 cm^{-1} due to bending vibration of H-O-H. A broad band appears at 1176.58 cm^{-1} due to bending vibration of C-O and a weak broad band is shown around 592.15 cm^{-1} due to Fe-O vibration. The result is in agreement well with early report on Fe_2O_3 by Mohanraj and Sivakumar (2017).

Optical measurements: The optical properties of thin films depend on membrane thickness, homogeneity, structure, membrane material and preparation conditions These factors are responsible for demonstrating the properties of semiconductor membranes use a spectrometer (UV-visible recording spectrophotometer) to procedure optical measurements optical measurements included measurement (absorbance, transmittance) membrane pure iron oxide thick is 2500 A°. These readings were taken before and after irradiation with gamma rays.

RESULTS AND DISCUSSION

Absorbance spectrum: From the Fig. 3 shown that the absorbance measurements of Fe_2O_3 were plotted against wavelength in the range of 300-1000 nm. From this figure it is noticed that decreased absorbance whenever the higher the wavelength this agrees with Ekwealor and Ezema (2013).

We note from the comparison between Fig. 3 and 4 that the absorbance spectrum of Fe_2O_3 as a function of wavelength decreases after the membrane is expose into the beam of gamma rays this is consistent with the researcher's findings (Hussein *et al*., 2010).

Transmittance spectrum: From the Fig. 5 shown that the transmittance measurements of (Fe_2O_3) were plotted against wavelength in the range of 300-1000 nm. From this figure it is noticed that increased transmittance whenever the higher the wavelength because there are logarithmic relation between absorbance and transmittance and this agrees with Ekwealor and Ezema (2013), Farhmandjou and Soflaee (2014).

We note from the comparison between Fig. 5 and 6 that the transmittance spectrum of Fe_2O_3 as a function of wavelength increases after the membrane is expose into the beam of gamma rays this is consistent with the researcher's findings (Hussein *et al*., 2010).

Optical energy gap: The optical energy gap for Fe_2O_3 thin films is calculated by using the equation $\alpha h\nu = B(h\nu - E_g^{opt})^r$. The scheme of $(\alpha h\nu)^2$ with energy ($h\nu$) shows that Fe_2O_3 films are direct transition type semiconductors for the thin films. The value of photon energy at the point where $(\alpha h\nu)^2$ is zero is 2.4 eV.

Also from the comparison between Fig. 7 and 8 that the energy gap of (Fe_2O_3) decreases after the membrane is expose into the beam of gamma rays where the value of the energy gap before irradiation equal nearly (2.4 eV), either after irradiation the value of the energy gap became nearly (1.6 eV), this is consistent with the researcher's findings (Hussein *et al*., 2010).

In some research, shown that Fe_2O_3 is an indirect band gap material (Mallick and Dash, 2013) and some other research the existence of direct band gap in Fe_2O_3.

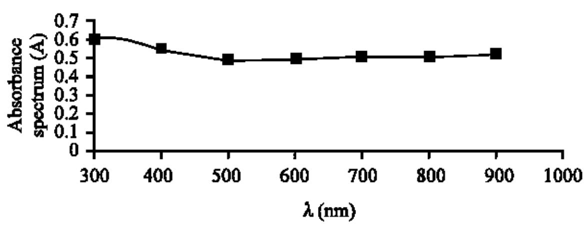

Fig. 3: Variation of absorption spectrum of Fe_2O_3 with wavelength before irradiation

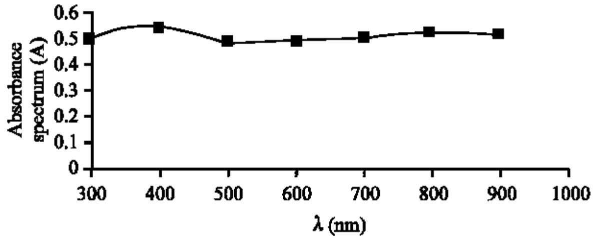

Fig. 4: Variation of absorption spectrum of Fe_2O_3 with wavelength after irradiation

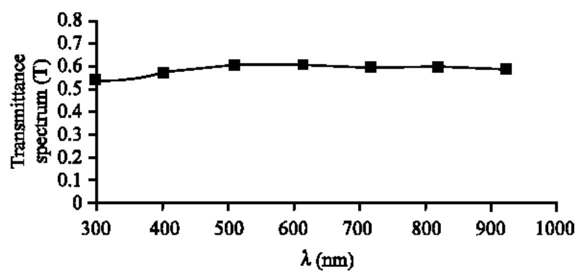

Fig. 5: Variation of transmittance spectrum of Fe_2O_3 with wavelength before irradiation

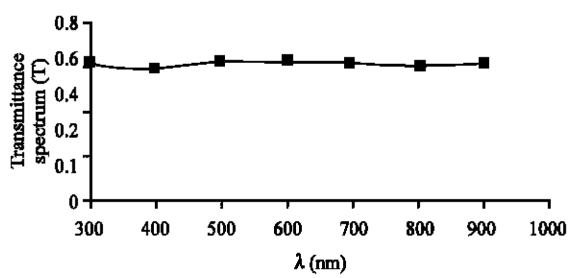

Fig. 6: Variation of transmittance spectrum of Fe_2O_3 with wavelength after irradiation

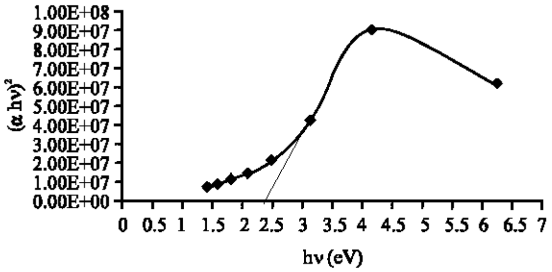

Fig. 7: Variation of $(\alpha h\nu)^2$ vs. photon energy (hν), for Fe_2O_3 before irradiation

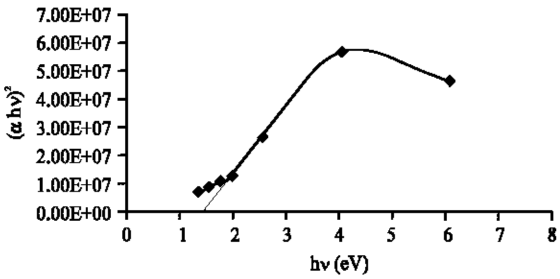

Fig. 8: Variation of $(\alpha h\nu)^2$ vs. photon energy (hν) for -Fe_2O_3 after irradiation

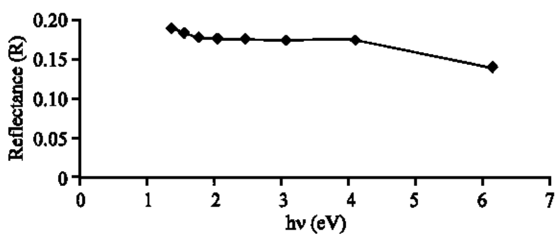

Fig. 9: Variation of reflectance vs. with photon energy (hν), for Fe_2O_3 before irradiation

It has also been reported that Fe_2O_3 exhibits both direct band gap and indirect band gaps. The value of direct band gap for the sample is nearly 2.35 eV (Mallick and Dash, 2013).

Reflectance spectrum: Figure 9 show that the values of reflectivity varies with increasing of photon energy and it can be attributed to the basis of reflectance that depend on the refractive index as the relationship $R = (n-1)^2+k^2/(n+1)^2+k^2$, therefore, the reflectance behave is similar to the refractive index.

From the comparison between Fig. 9 and 10, note that the reflectance of Fe_2O_3 as a function of photon energy (hν), decreases after the membrane is expose into the beam of gamma rays this is consistent with the researcher's findings.

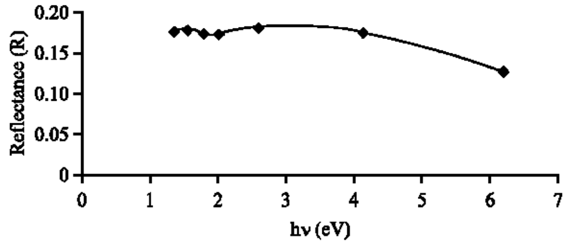

Fig. 10: Variation of reflectance vs. with photon energy (hν), for Fe_2O_3 after irradiation

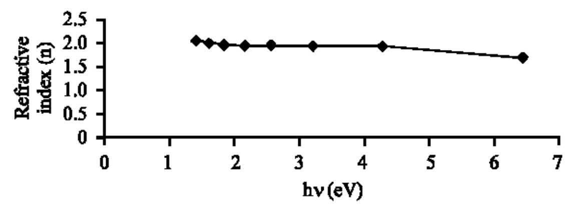

Fig. 11: The variation of refractive index, of -Fe_2O_3 as a function of photon energy (hν) before irradiation

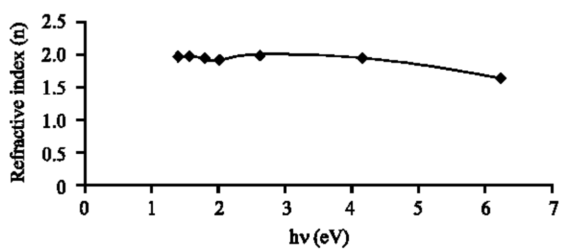

Fig. 12: The variation of refractive index of Fe_2O_3 as a function of photon energy (hν) after irradiation

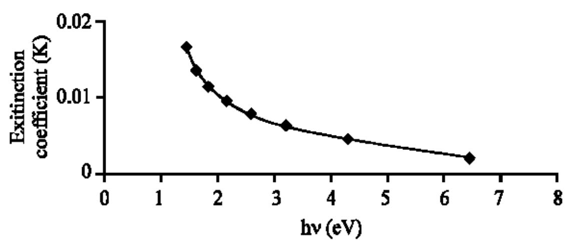

Fig. 13: The variation of extinction coefficient, of Fe_2O_3 as a function of photon energy (hν) before irradiation

Refractive index: Also from the comparison between Fig. 11 and 12, found that the refractive index of Fe_2O_3 as a function of photon energy (hν), decreases relatively little after the membrane is expose into the beam of gamma rays this is consistent with the researcher's findings.

Extinction coefficient: Figure 13 shows the variation of extinction coefficient, of Fe_2O_3 as a function of photon

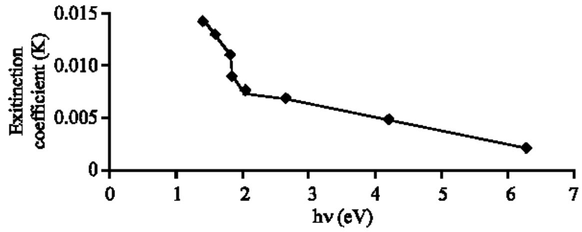

Fig. 14: The variation of extinction coefficient, of -Fe_2O_3 as a function of photon energy (hν) after irradiation

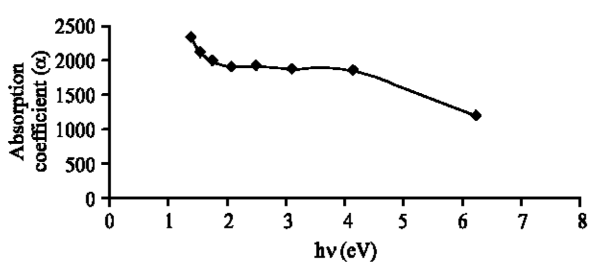

Fig. 15: The variation of absorption coefficient of -Fe_2O_3 as a function of photon energy (hν) before irradiation

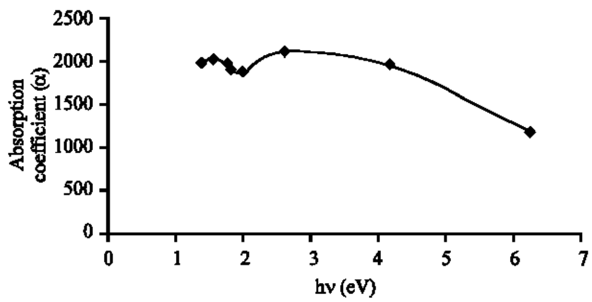

Fig. 16: The variation of absorption coefficient, of -Fe_2O_3 as a function of photon energy (hν) after irradiation

energy (hν) before irradiation. Found from the comparison between Fig. 13 and 14 that the extinction coefficient of Fe_2O_3 as a function of photon energy (hν), decreases after the membrane is expose into the beam of gamma rays this is consistent with the researcher's findings.

Absorption coefficient: Figure 15 illustrates the change in the values of the variation of absorption coefficient of Fe_2O_3 as a function of photon energy (hν) before irradiation.

Also from the comparison between Fig. 15 and 16 that the absorption coefficient of Fe_2O_3 as a function of photon energy (hν), decreases after the membrane is expose into the beam of gamma rays this is consistent with the researcher's findings.

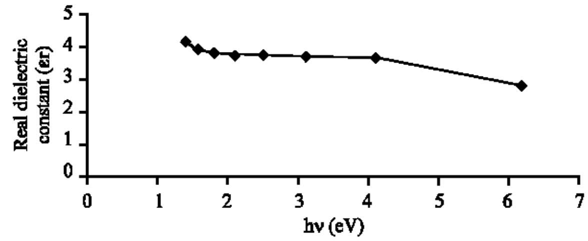

Fig. 17: The variation of the real dielectric constant, of Fe_2O_3 as a function of photon energy (hν) before irradiation

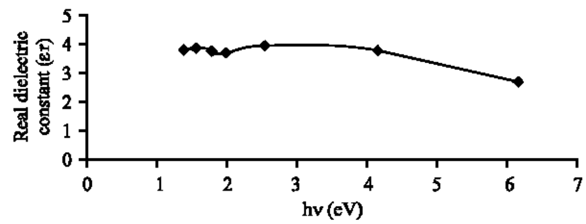

Fig. 18: The variation of the real dielectric constant, of Fe_2O_3 as a function of photon energy (hν) after irradiation

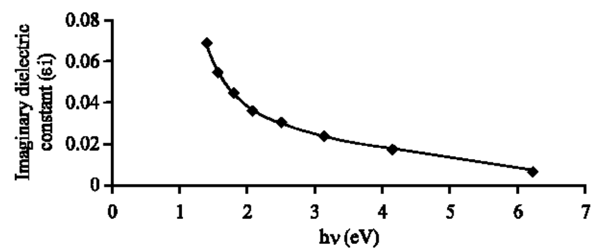

Fig. 19: The variation of the imaginary dielectric constant, of -Fe_2O_3 as a function of photon energy (hν) before irradiation

Real and imaginary dielectric constant: Figure 17 illustrates the change in the values of the variation of real dielectric constant of Fe_2O_3 as a function of photon energy (hν) before irradiation.

From the comparison between Fig. 17 and 18 that the real dielectric constant of Fe_2O_3 as a function of photon energy (hν), decreases after the membrane is expose into the beam of gamma rays this is consistent with the researcher's findings.

Figure 19 illustrates the change in the values of the variation of imaginary dielectric constant of Fe_2O_3 as a function of photon energy (hν) before irradiation.

Also from the comparison between Fig. 19 and 20 that the imaginary dielectric constant of Fe_2O_3 as a function of photon energy (hν), decreases after the membrane is expose into the beam of gamma rays this is consistent with the researcher's findings.

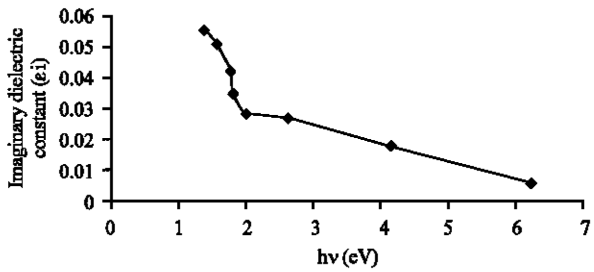

Fig. 20: The variation of the imaginary dielectric constant, of Fe_2O_3 as a function of photon energy (hν) after irradiation

CONCLUSION

The X-ray scan shows that crystalline membrane. Absorption as a function of wavelength decrease after exposure of the membrane to radiation.

Transmittance as a function of wavelength increased after exposure of the membrane to radiation. The exposure of the membrane to the radiation of gamma for Ferric Oxide membrane (Fe_2O_3) to decrease in reflectivity, extinction coefficient refractive index, absorption coefficient energy gap and values of real and imaginary insulation constant.

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