Egyptian Journal of Chemistry

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Study and Synthesis of Polymer-Blend PVA-PEG Doped with 5wt% Mgo and Different wt% of Co_3O_4 Thin Film

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Abstract

In this study, Poly (vinyl alcohol) - Poly (ethylene glycol) (PVA-PEG) poly-blend and its composite with 5wt.% and different wt.% (2, 4, and 6) of Co_3O_4 films were synthesized using blend casting method. The characterization was considered such as; Fourier transforms infrared (FT-IR), electrical properties, and its application for gamma ray shielding. The electrical properties showed that the dielectric constant and dielectric loss for all different rates of Co_3O_4 particles decreases with the increase of the electric field frequency, and that its values increase with the increasing of the wt.% of Co_3O_4 particles. The (PVA-PEG) poly-blend and its composite with and different wt.% of Co_3O_4 films have good linear attenuation coefficients for gamma ray radiation.

Keywords: Poly (vinyl alcohol); Poly (ethylene glycol); PVA-PEG; gamma ray shielding; Co_3O_4 particles

1. Introduction

The innovation and the investigation of different polymer blends have been a significant subject of attention in recent years. Mixing two or more polymers strengthens polymer materials operation characteristics [1-3]. Polymers or mixtures with nano-sized fillers show significantly enhancement compared to thermal, mechanical, and optical properties of pure polymers or their traditional composites [4-7]. The production of antimicrobial activity polymer-based nanocomposites provides interesting possibilities because the polymer matrix. It can be differed in order to satisfy not only basic technical specifications, but also nanostructures that can be exploited with size and shape-dependent properties [8]. The oxides of metals like the TiO_2, MgO, and CaO are special concern, because they are not only stable under harsh conditions of the process. The potential for obtaining materials improved in different applications has been investigated in studies. The effect of the PEG content on PVA was studied by Abdel Tawab et al. [9] who found that the content of PEG can be up to 60% compatible with PVA/PEG blends. Other researchers have mentioned that a PVA/PEG combination with a good film does not form a cast because of phase separation [9]. PEG content is above 40 %. O Mousa Al-Ogaili, Abdulazeez, and Y. Khudair Obeys [10] were used the solution of cast technology to prepare polyvine alcohol (PVA)-polyethylene glycol (PEG) solid polymer mixing electrolytes. In the wavelength range (280-800) nm, the absorption spectra have been reported. Determined absorption coefficient, refractive index and extinction coefficient. The results show that optical constants increase as weight percentages are increased. Mohamed Bakr Mohamed and M. H. Abdel-Kader [11] investigated various nano-oxides (Co_3O_4, NiO and Cr_2O_3) when added to PEG-PVA (70/30 wt%) blend. The structure and microstructure features of nano-oxide fillers were used as the Rietveld profile analysis tool. The effect on optical transparency of the blend samples of various nano-oxide fillers is verified. The Co_3O_4 nanoparticles, of average size <61 nm, were prepared by the sol-gel method by M. E Sayed

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Receive Date: 01 March 2021, Revise Date: 28 March 2021, Accept Date: 29 April 2021
DOI: 10.21608/EJCHEM.2021.65573.3407

and S. El-Gamal [12]. For Co_3O_4 nanoparticles, there are two approved direct optical band gaps 1.445 and 1.915 eV. Mixture of Na-CMC/(PVA) with Co_3O_4 at various concentrations < 1% wt was doped in order to study the electric and the nanocomposite films dielectric properties. The physical properties of the PEG polymer dissolved in distilled water for different concentrations have been analysed by H.S. Rasheed [١٣]. The studied properties were found to be linearly dependent with the increase of PEG concentrations.

This study aimed to investigate the effect of adding MgO and Co_3O_4 to the polymer blend (PVA-PEG) using the casting method and study their electrical properties as candidate for gamma rays shielding.

2. Materials and Methods

The polymer blend (PVA-PEG) is prepared by solution casting method. PVA with 0.9 g was dissolved with 50 ml of deionized water. The solution was stirred with a magnetic stirrer for 1 hour at room temperature, then for another hour at 75-80 ºC until the PVA was fully dissolved, then apply 0.1 g of PEG (after allowing the aqueous solution to cool to 40 ºC for 12 hours) for a clear solution. The resulting solution is poured into 8 cm diameter cups of Petri dishes of equivalent volume and dried at room temperature for 240 hours before the solvent has completely evaporated from the substance. The dried film was then peeled from the Petri dish and stored in a vacuum dryer until required.

To achieve full dissolution from a (PVA–PEG) composite film containing 5wt% MgO, dissolve 5wt% MgCl2.2H2O in a formulated solution of (PVA –PEG) containing 0.855g of PVA and 0.095g of PEG in 50 ml of deionized water for 12 hours at 40 ºC. The composite films (PVA – PEG -5wt percent MgO) with different wt% (2, 4, and 6) of Co_3O_4 were prepared.

A homogeneous solution was found after mixing the mixture with another blend for 1/2 hour. The casting method is used to make 8 cm diameter compounds of equal dimensions on Petri dishes, which are then dried at room temperature for 240 hours. A digital micrometre was used to determine the thickness of a film that ranged from 120 to 130 m.

The linear attenuation coefficients were determined by comparing N and N0, which are the measured count rates in the detector with and without the absorber.

$$N = N_0\, e^{-\mu x} \qquad (1)$$

where N is the number of counts reported in the attenuation of the detector; N_0 is the count before the attenuation of the detector; mu is the linear coefficient of attenuation; x is the marble thickness.

3. Results and Discussion

3.1. Characterization of Polymer Blend and its Composite Films

3.1.1. Fourier transform infrared radiation (FT-IR) of the casting samples

Figure 1 portrays the FT-IR transmission profile spectra of the pure PVA, (PVA-PEG) polymer blend and its composite films with 5wt.% MgO and different wt.% (2, 4, and 6) of Co_3O_4 under the investigated at RT in wavenumber (500-4000 cm^{-1}) ranges. the FT-IR spectra confirmed of the produce the functional groups present in polymer composite systems. The only possible reason for intensity changes and broadening of the functional groups in the backbone of the polymeric matrix is the strong incorporations with Co^{4+} and O^{3+} ions.

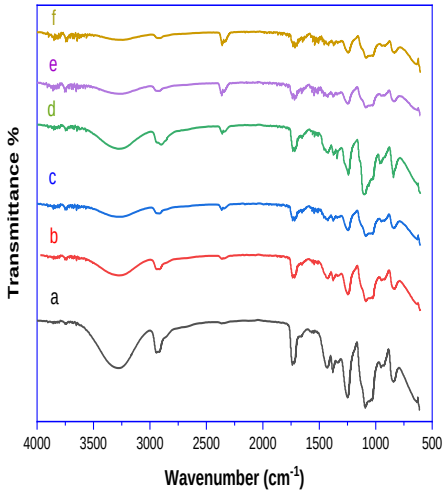

Fig.1. FTIR spectra of: a. PVA, b. (PVA-PEG) blend, c. (PVA-PEG-5wt.% MgO), d. (PVA-PEG-MgO-2wt.% Co_3O_4), e. (PVA-PEG-MgO-4wt.% Co_3O_4), and f. (PVA-PEG-MgO-6wt.% Co_3O_4) composite films.

3.1.2. Optical microscope (OM) of the casting samples

The OM images of the surface of pure PVA, (PVA-PEG) polymer blend and its composite films with 5wt.% MgO and different wt.% (2, 4, and 6) of Co_3O_4 at magnification power (40X) were shown in Fig.2. It demented good homogeneity and fine incorporation of MgO and Co_3O_4 particles in the polymer matrix, which leads to charge transfer complex formation inside the polymer films which was improved with the increasing the proportions level. This presented a successful preparation method that forms suitable conditions and used to prepare these composite films.

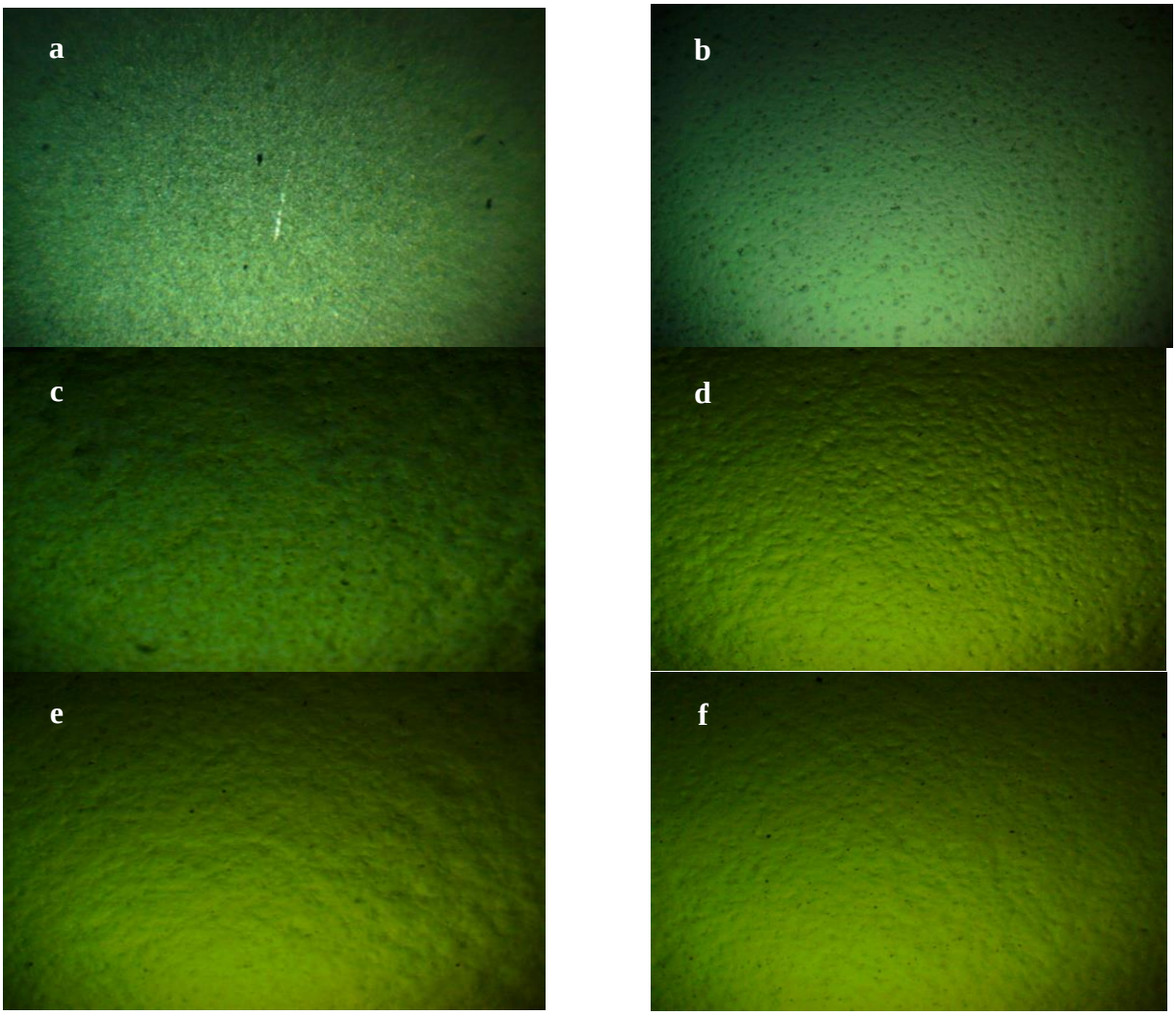

Fig. 2: Optical microscopy at (40X) of: a. (PVA), b. (PVA-PEG) blend, c. (PVA-PEG-5wt.% MgO), d. (PVA-PEG-MgO-2wt.% Co_3O_4), e. (PVA-PEG-MgO-4wt.% Co_3O_4), and f. (PVA-PEG-MgO-6wt.% Co_3O_4) composite films.

3.2. The D.C Electrical Properties of the Casted Samples

3.2.1. D.C electrical conductivity (PVA-PEG) poly-blend and its composite

The D.C electrical conductivity depends upon several factors such as the preparation technique, and the measurement conditions. Figure 3 shows the variation of D.C conductivity for polymer blend and its composite with MgO and different wt.% of Co_3O_4 films with temperature. The conductivity is increased with increasing temperature, which ensures the tolerance of these materials to negative thermal coefficient is debated on the basis that polymer chains and additives will serve as traps for the load carriers when the temperature is lifted by the hops, and that the movement of the polymer chains increases. As a result, the surrounding carriers free themselves and increase the leading potential as a result of increasing the charge carriers and their mobility.

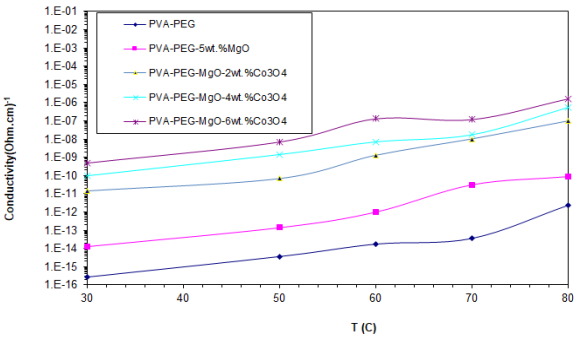

Fig. 3. The conductivity of D.C. for (PVA-PEG) blend and its composite with MgO and different wt.% of Co_3O_4 films with temperature.

3.2.2. Activation energy of (PVA-PEG) poly- blend and its composite with MgO and different wt.% of Co3O4

Figure 4 shows the variation of (lnσ) versus reciprocal of the absolute temperature (1000/T) measured at a temperature range (298–353K) for

polymer blend and its composite with MgO and different wt.% of Co_3O_4 films. The calculated results of the electrical activation energy values are display in Table 1. The high value of Pure Polymers (PVA-PEG) electrical activation energy is due to the fact that free ions occur in polymers. With the increase in particle concentrations for composites, activating energies reducing, this action is due to the formation of a local energy gap, which serves as trap for carriers.

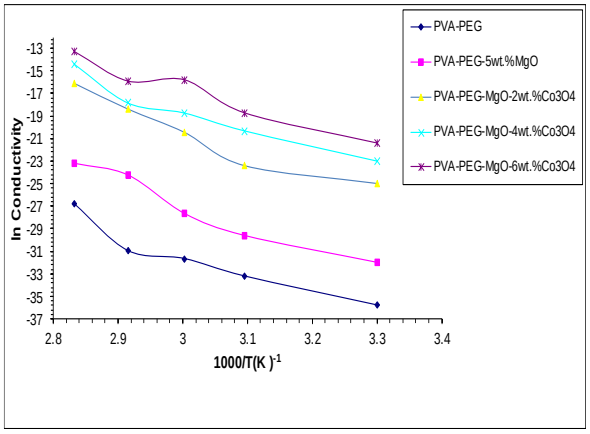

Fig. 4. ln conductivity versus (1000/T) of (PVA-PEG) blend and its composite with MgO and different wt.% of Co_3O_4 films.

Table 1: The experimental results of the electrical activation energy values.

Samples	Activation energy (eV)
Pure(PVA-PEG)	1.688803
5wt.%MgO	1.659623
2wt.% Co_3O_4	1.497818
4wt.% Co_3O_4	1.480826
6wt.% Co_3O_4	1.451501

3.3. The A.C Electrical Properties of the casting samples

The use of MgO and different wt.% of Co_3O_4 in this work in order to prepare and increase the transport carriers because the (PVA-PEG) polymer blend used is an electricity insulation material. The A.C electrical properties of polymer blend and its composite films include, the loss of dielectric, dielectric constant, and electrical conductivity of A.C., which were studied in the room temperature over the frequency range 10^2 - 5×10^6 Hz.

3.3.1. *Dielectric constant*

Dielectric constant magnitude reveals the material's ability to store electricity from the electric field that applied. Figure 5 shows the variation of dielectric constant of (PVA-PEG) polymer blend and its composite with MgO and different wt.% of Co_3O_4 films in the RT over the electric field frequency range 10^2-5×10^6 Hz. Generally, the dielectric constant for all different rates of Co_3O_4 decreases with the increase of the electric field frequency, that could be due to samples' tendencies to dipole orientation against the electric fields applied, and to the decrease of the polarity of the space charge in relation to the overall polarization. Polarization of space charge increases the form of polarization at low frequencies and less the frequency increase.

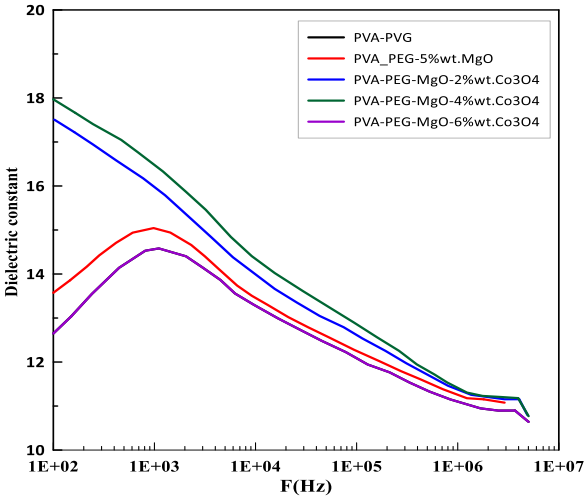

Fig.5. Variation of dielectric constant of (PVA-PEG) blend and its composite with MgO and different wt.% of Co_3O_4 films versus frequency at RT

The effect of Co_3O_4 concentrations on dielectric constant of (PVA-PEG) polymer blend in the case of constant MgO at 100Hz is shown in Fig.6. As the weight percent of Co_3O_4 increases, the dielectric constant increases in an irregular pattern. The increase in charge carriers and interfacial polarization within the polymer matrix in an applied alternating electric field will explain this action. Since the mass of an ion is larger than that of an electron, ionic polarization responds somewhat differently to variations in field frequencies than electrical polarization. Also, the highest frequencies of the field vibrations evoke a reaction from the electrons.

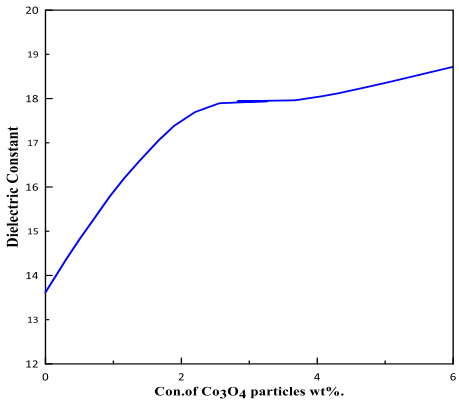

Fig.6. Effect of Co_3O_4 particles concentrations on dielectric constant of (PVA-PEG) –in the case of constant MgO at 100Hz

3.3.2. *Dielectric loss*

Dielectric loss measures the electrical energy lost in the application field sample and converted in the sample to thermal energy. Figure 7 shows the variation of the dielectric loss of (PVA-PEG) polymer blend and its composite with MgO and different wt.% of Co_3O_4 films in the RT over the electric field frequency range 10^2 - 5×10^6 Hz. The dielectric loss has a high level of polarization of space charges for all various rates of low frequency Co_3O_4 particles and decreases with an increased frequency of applied electrical field.

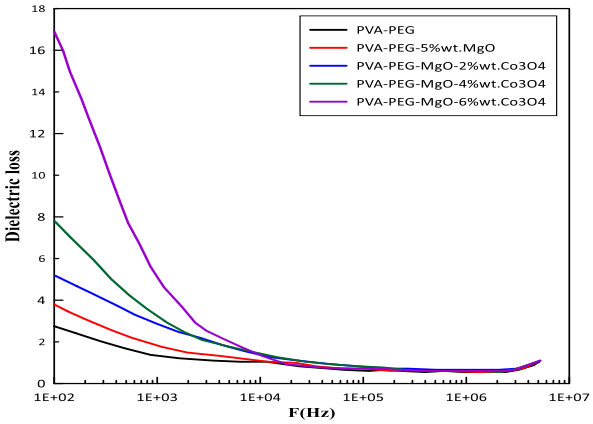

Fig. 7. Variation of dielectric loss of (PVA-PEG) blend and its composite with MgO and different wt.% of Co_3O_4 films versus frequency at RT

The effect of Co_3O_4 particles concentrations on dielectric loss of (PVA-PEG) polymer blend in the case of constant MgO at 100Hz is shown in Fig. 8. The dielectric loss increases with the increasing of the wt.% of Co_3O_4 particles. This related to the increases of the charge carriers' number.

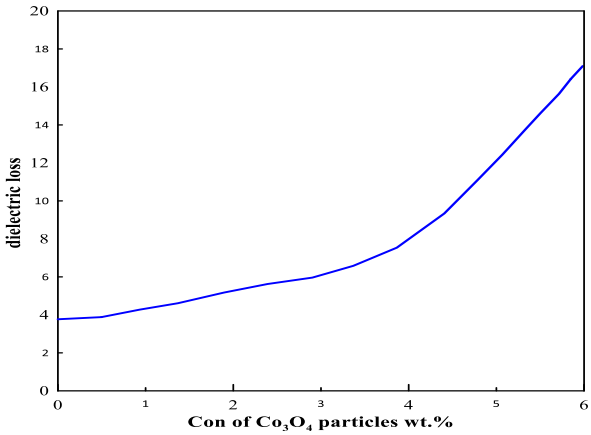

Fig.8. Effect of Co_3O_4 particles concentrations on dielectric loss of (PVA-PEG) in the case of constant MgO at 100Hz.

3.3.3. *A.C electrical conductivity*

Figure 9 display the electrical conductivity of A.C for (PVA-PEG) polymer blend and its composite with MgO and different wt.% of Co_3O_4 films in the RT over the electric field frequency range 10^2 -5×10^6 Hz. The conductivity of A.C increases considerably with the increase of electric field frequency for all different rates of Co_3O_4 particles.

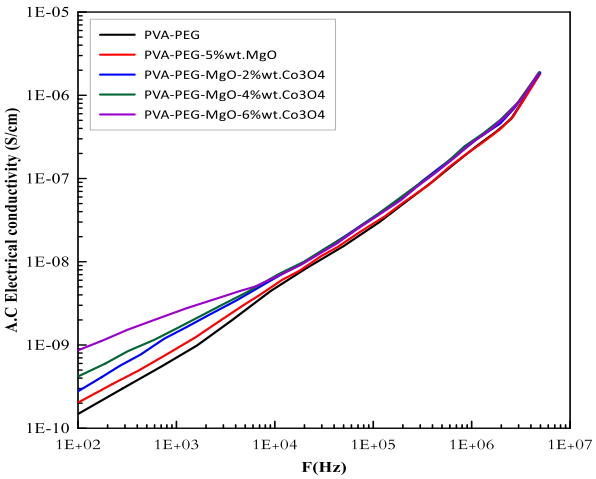

Fig.9. The electrical conductivity of A.C for (PVA-PEG) poly-blend and its composite with MgO and different wt.% of Co_3O_4 films versus frequency at RT

The effect of Co_3O_4 particles concentrations on A.C. electrical conductivity of (PVA-PEG) polymer blend in the case of constant MgO at 100Hz is shown in Fig.10.The conductivity increases with the increasing of the wt.% of Co_3O_4 particles. This behavior is due to the effect of the space charge as a result of the increase of the charge carriers, due to the regular distribution in the polymer matrix.

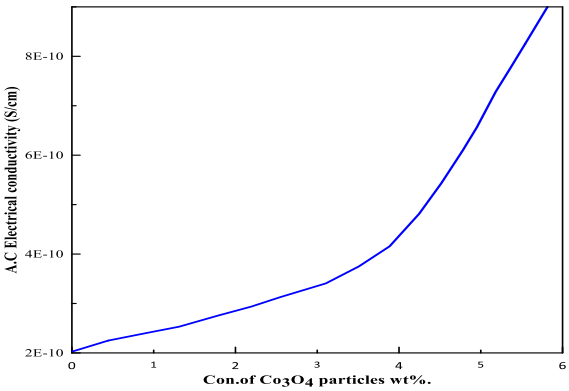

Fig.10. Effect of Co_3O_4 particles concentrations on the electrical conductivity of A.C. for (PVA-PEG) in the case of constant MgO at 100Hz.

3.3.4. Application of (PVA-PEG-5wt.%MgO and Co_3O_4) Composites for Gamma Ray Shielding

Figure 11 shows the variation of (N/N_0) for (PVA–PEG- 5wt.%MgO) polymeric composite films with different wt.% (2, 4, and 6) of Co_3O_4. The transmission radiation decreases with the increasing of the concentrations of Co_3O_4 particles which is attributed to the increase of the attenuation radiation.

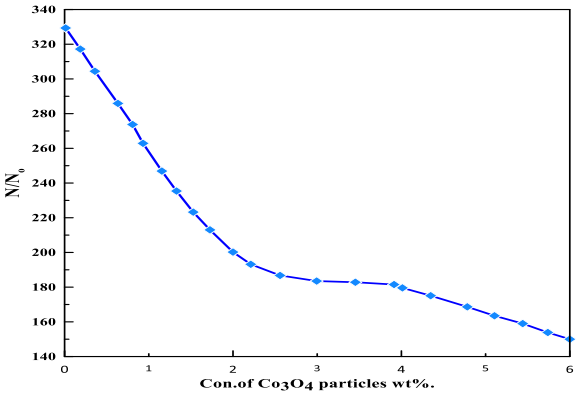

Fig.11. Variation of (N/N0) for (PVA–PEG-5wt.%MgO) composite with different concentrations of Co_3O_4 particles.

Figure 12 shows the coefficients of attenuation variation with gamma radiation for (PVA–PEG-5wt.%MgO) polymeric composite films with different wt.% of Co_3O_4. The attenuation coefficients increase with the increase of the proportion level of Co_3O_4, this is due to the absorption or reflection of gamma radiation by composites shielding materials. From the Figure, it showed good results compared to the results achieved by polymer composite with concretion, however, composite polymer has an advantage over concretion due to its mobility, low electrical properties, and the avoiding of neutron emission

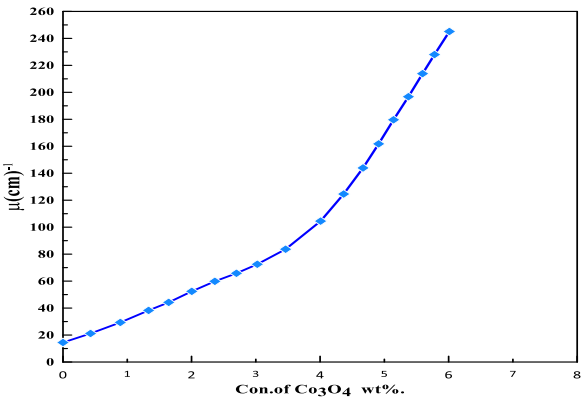

Fig. 12. The attenuation coefficients varied with gamma radiation for (PVA–PEG-5wt.%MgO) composite with different concentrations of Co_3O_4 particles.

4. Conclusions

The (PVA–PEG) polymer composite with MgO and different wt.% of Co_3O_4 films were deposited successfully by using the casting technique. FT-IR spectra show shift in some bands and change in the intensities of other bands comparing with pure poly-blend films. D.C conductivity of the polymeric system increases with MgO and various wt.% of Co_3O_4 for all temperatures under test. D.C measurements indicate that all films having one activation energy, and that its value increases with the increase in the percentage of addition. The AC electrical properties showed that the dielectric constant and dielectric loss for all different wt.% of Co_3O_4 particles decreases with the increase of the electric field frequency. The (PVA-PEG) poly-blend and its composite with MgO and different wt.% of Co_3O_4 films exhibit good gamma ray shielding properties.

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