International Journal of Psychosocial Rehabilitation, Vol. 24, Issue 04, 2020
ISSN: 1475-7192

Effect of Cobalt Chloride Additive on the Optical Properties of (PEO/PVA) Composites Thin Films

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Abstract--- *Transparent films of (PEO/PVA) polymers composites with different cobalt chloride CoCl2 concentrations were prepared using solution cast technique. Measurements of optical absorption were made for all samples at room temperature across the wavelength. (190 – 1100 nm), It was found to increase in absorption spectra with an increase in the CoCl2 concentration in (PEO/PVA) composites, which has been attributed to the increasing in localized states and the optical absorption was also found to be due to direct transitions. And the values of the optical energy differences changed to less energy on cobalt chloride concentration for direct allowed electronic energy transitions as a result it was decreased from 1.72 to 1.68eV. The optical constant (coefficient of absorption (α), coefficient of extinction (k), refractive index (n), dielectric constant of the real and the imaginary part (εr, εi) and conductance optical (σ)) (PEO/PVA) polymers different composites of cobalt chloride concentrations were calculated.*

Keywords--- *PEO, PVA, Casting Method, Optical Properties, Thin Films*.

I. INTRODUCTION

Over the last few years much interest has focused on investigation of polymer thin films due to their great use of technology [1]. The technological applications of the thin films of polymer have a wide scope such as sensors, adhesives, coatings and electrochemical cells as solid state, they can be deposited directly into chips of any form or size [2]. Given their possible optoelectronic uses, the optical properties of polymers attract considerable attention, such as in light-emitting polymer diodes and solar cells [3]. Polymers have physical properties may be affected by doping and thickness. A grafting copolymer is a kind of branching copolymer with a separate side chain from the main chain. Detailed studies of different doped polymers and doped concentrations allow for the choice of the properties desired. [4].The study of visual absorption and particularly of the absorbing edge are an excellent method for examining optically induced transitions and to inform both crystalline and amorphous material on the band structure and power gap [5]. Measurements of the optical coefficient of absorption, especially close to the fundamental absorption edge, provide a standard investigation method [6].

The casting processes were effectively employed in the manufacture of thin films and a variety of organic materials and systems [7]. The gap of energy is an important optical constant, and it is of great importance in determining Possibility to use thin films in the manufacture of solar cells, sound cells, displays and other uses [8, 9]. In this work optical characteristics of (PE/PVA) polymers composites filled with different cobalt chloride $CoCl_2$ concentrations were studied.

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DOI: 10.37200/IJPR/V24I4/PR2020503
Received: 14 Mar 2020 | Revised: 28 Mar 2020 | Accepted: 14 Apr 2020

II. EXPERIMENTAL

Films of (PEO/PVA) polymers composites filled with different cobalt concentrations chloride was prepared using casting solution. A 1 gm of pure Polyvinyl alcohol (PVA) mixed with pure polyethylene glycol (PEO) which already dissolved in 30 ml water of distilled via water bath with stirred on magnetic stirrer for two hours, then dissolving 1gm of cobalt chloride ($CoCl_2$) in 10ml of distilled water with stirred 30 minutes. Polymers PEO/PVA composites filled with cobalt chloride salt with the ratio (10, 20, 30, 40 and 50) %. Final solution cast on a glass substrate at room temperature.. The final films labeled as (M, N, O, P and Q) respectively at $CoCl_2$ concentrations

Film thickness was measured by optical interferometer method employing He-Ne laser (632.8 nm), and the thickness of the films found to (0.235, 0.236, 0.235, 0.235 and 0.237)µm

The optical measurements comprise measuring the absorbance and reflectance were investigated by UV-VIS spectrometer in the wavelength range (190 – 1100) nm.

III. RESULTS AND DISCUSSION

Figures (1) clarify the relation between the absorbance and the wavelength (nm).

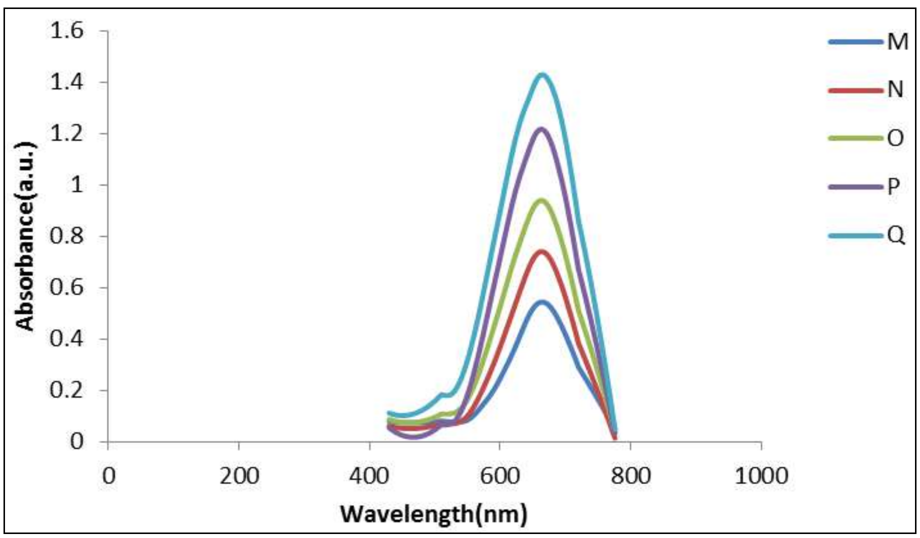

Figure 1: Absorbance for (PEO/PVA) composites thin films of different concentrations of $CoCl_2$.

The absorption spectrum for films of (PEO/PVA) polymers composites increases with an increase different filled with cobalt chloride concentrations. This result agrees with that shown by Jbaier [10]. This is because the increasing of the surface roughness promoting the decreasing of the surface scattering of the light.

The coefficient of absorption (α) for films of (PEO/PVA) polymers composites filled with cobalt chloride concentrations are calculated by equation (1) [11] and shown on the figure (2)

$$\alpha = \frac{2.303A}{t} \quad (1)$$

Where A is the absorbance and t is the material thickness.

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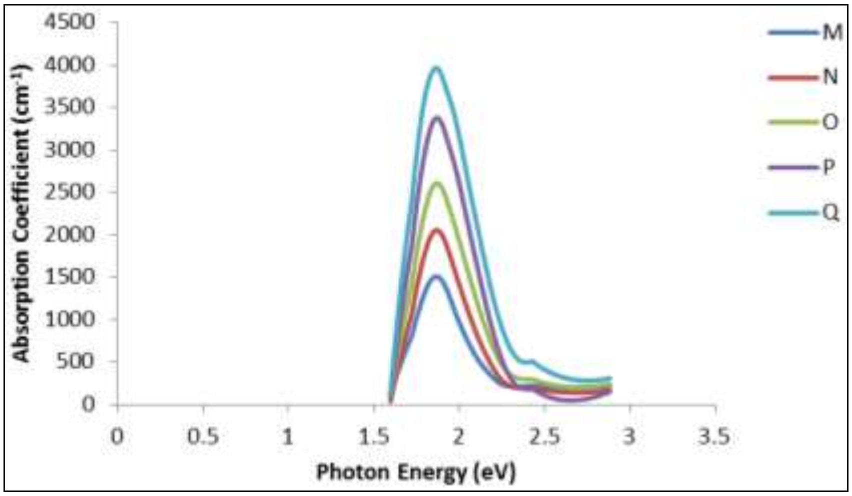

Figure 2: Absorption Coefficient for (PEO/PVA) Composites Thin Films of different Concentrations of $CoCl_2$.

The coefficient of absorption coefficient exhibits high values ($\alpha > 10^4$) that means the probability of a direct transition is high [12], it is observed that the coefficient of absorption α increases with the increasing concentration of the $CoCl_2$. This result agrees with the result shown by Kumaravel et al. [13]. This is becouse the decreasing gap of energy with a concentration of $CoCl_2$.

Optical energy gap values for films of (PEO/PVA) polymers composites filled with cobalt chloride at different concentrations which were calculated with Tauc equation (2) [14], Which is calculated by portion extrapolation at $(\alpha h\upsilon)^2$ the relationships between $(\alpha h\upsilon)^2$ compared with (hυ), as indicated in figure (3).

$$\alpha = B\,\frac{(h\upsilon - E_g)^{\frac{1}{2}}}{h\upsilon} \qquad (2)$$

where: Eg: energy gap

B: constant

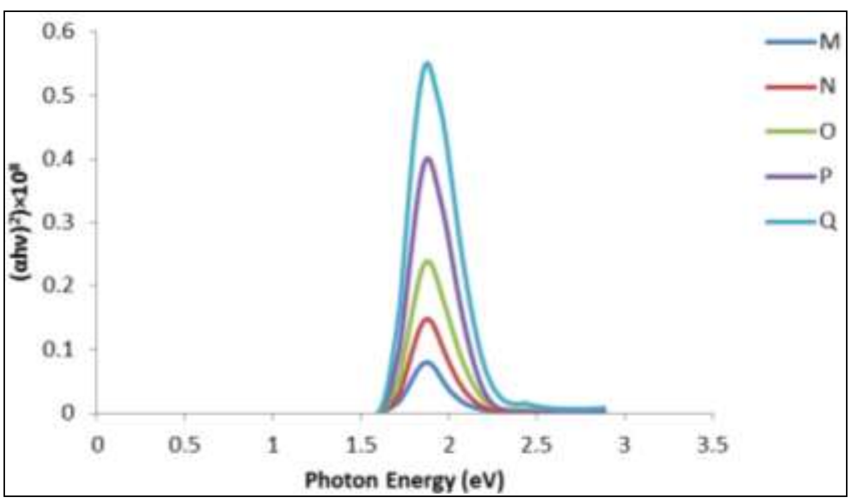

Figure 3: Relationship between (αhν) 2 and Photon Energy (eV) for (PEO/PVA) Composites Thin Films of different Concentrations of $CoCl_2$.

The addition of $CoCl_2$ salt to (PEO/PVA) composites enhanced optical characteristics of the films prepared

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therefore, the concentration increasing leads to decreasing of the gap of energy, as shown in table (1). The decreasing gap of energy is becouse increasing of photon collisions with matter, which increases the concentration. Therefore, the matter will be highly absorbed and the gap of energy will decreased from (1.72 eV) to (1.68 eV).The results agree with Ilican et al. [15].

Table 1: The values gap of energy for (PEO/PVA) composites thin films of different concentrations of $CoCl_2$.

Sample	Concentrations	Allowed direct band gap (e.V)
M	10%	1.72
N	20%	1.71
O	30%	1.70
P	40%	1.69
Q	50%	1.68

The behavior of the coefficient of extinction (k) of deposited films with a different $CoCl_2$ concentration at room temperature calculated by equation (3) [16] as indicated in figure (4).

$$K = \frac{\alpha\lambda}{4\pi} \qquad (3)$$

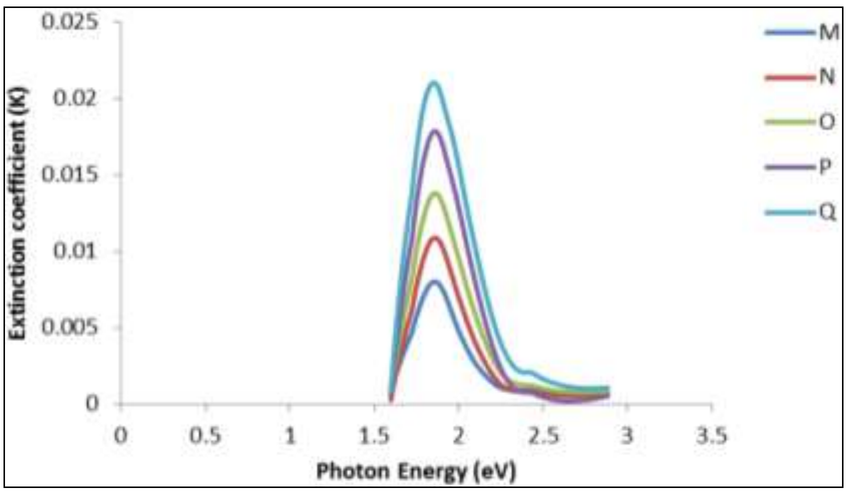

Figure 4: The variation of extinction coefficient with the Photon energy (eV) for (PEO/PVA) composites thin films of different concentrations of CoCl2.

One can clearly be seen that (k) increases as the cobalt chloride $CoCl_2$ concentrations increased, That may be because of the high coefficient of absorption and increase of absorb part of the incident light, this is agreement with [17].

The variation of the index of refraction (n) versus photon energy for deposited (PEO/PVA) composites films with a different $CoCl_2$ concentrations at room temperature is calculated by equation (4) [18] and in the figure (5) shown.

$$\mathrm{n} = \left[\left(\frac{1+\mathrm{R}}{1-\mathrm{R}}\right)^2 - (\mathrm{k}^2+1)\right]^{1/2} - \frac{\mathrm{R}+1}{\mathrm{R}-1} \qquad (4)$$

where R is the reflectivity.

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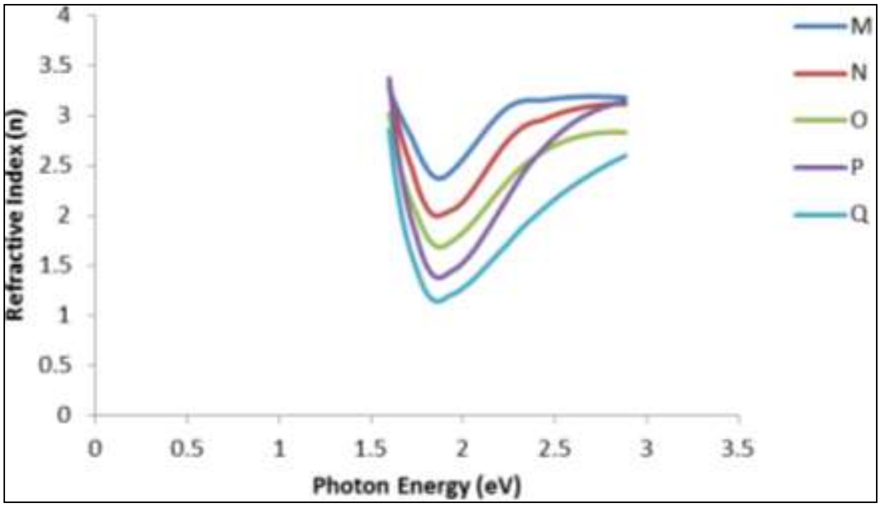

Figure 5: Refractive Index against the Photon energy (eV) for (PEO/PVA) composites thin films of different concentrations of $CoCl_2$.

It can be noticed from figure (5) that the index refraction increases when concentration of the $CoCl_2$ increases. That conduct could be described on the basis of the increase $CoCl_2$ concentration which leads to make prepared samples more dense (increasing the packing density) and the change in crystalline structure, which in turn decreases propagation speed of light through the sample which results in the increasing of the index refraction (n) values [19].

The variation of the real (ε_r) and imaginary (ε_i) parts of the dielectric constant values versus photon energy is calculated by equations (5, 6) [20] for (PEO/PVA) composites films with a different $CoCl_2$ concentration at room temperature and drown in figures (6, 7).

$$\varepsilon_r = n^2 - k^2 \quad (5)$$

$$\varepsilon_i = 2nk \quad (6)$$

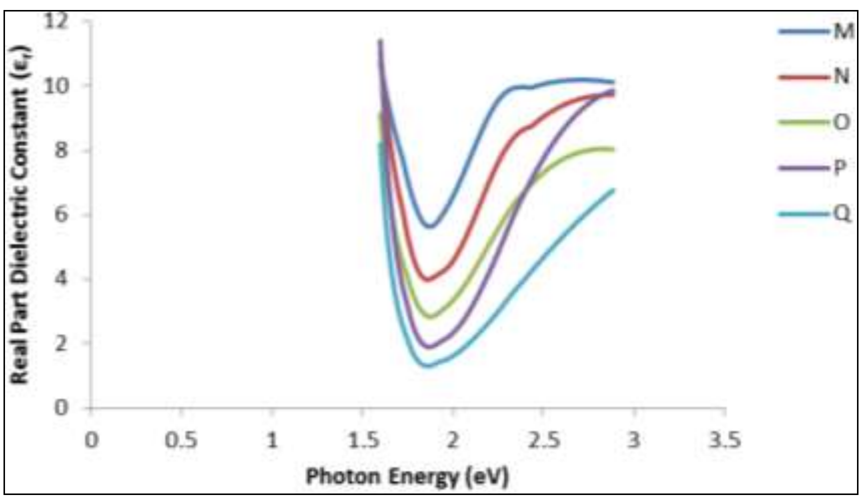

Figure 6: Real part dielectric constant against the Photon energy (eV) for (PEO/PVA) composites thin films of different concentrations of CoCl2.

The difference for (εr, εi) with (λ) of the radiation of incident is because the shift of reflectance and absorption spectra. Real part dielectric constant is determined with formula (5). It is evident that the difference of εr depends Mainly on reactive index values (n2) resulting from low extinction coefficient values (k^2) compared with (n^2) and

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because effective coefficient of extinction is very small may be canceling, whilst the imaginary part of dielectric εi is determined with relation (6), because the index refraction is very small. This depends mainly on the variation of (k) values that contribute to the coefficient of absorption variance (PEO/PVA) composites films with a different $CoCl_2$ concentration sample values of εr decreases with the increasing $CoCl_2$ concentration The imaginary part of the constant dielectric (εi) increases with the increasing $CoCl_2$ concentration for all prepared samples. That result was agreement with [21].

Optical conductivity (σ) is calculated by the formela (7). An increase in optical conductivity was observed as the level of doping increased of $CoCl_2$ as described in figure (8). Might this be because of Increase the electron transitions contribution between the bands of conduction and valence conduction, That leads to reduction gap Of energy resulting from the generation of sit level. Results similar to those published in literature [22].

$$\sigma = \frac{\alpha n c}{4\pi} \qquad (7)$$

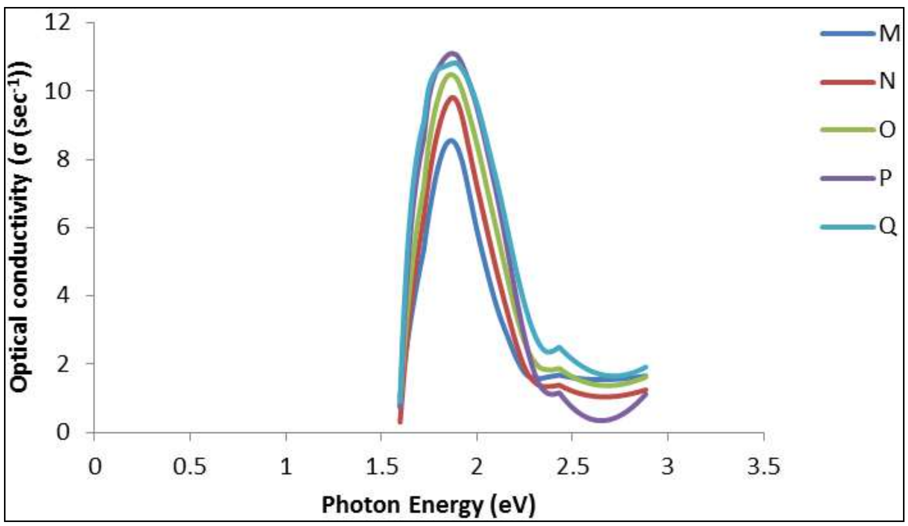

Figure 8: Optical conductivity as a feature of photon energy (eV) for (PEO/PVA) composites thin films of different concentrations of $CoCl_2$.

IV. Conclusion

In this work, Through the study, this polymer appears to be a continuous improvement in their optical characterizations as a result of doping $CoCl_2$ to (PEO/PVA) composites polymer. The addition of $CoCl_2$ salt to the (PEO/PVA) polymer enhanced the optical characteristics of the prepared films therefore, the increasing in concentrations leads to decreasing gap of energy. The electronic transition in (PEO/PVA) polymers composites filled with different types of cobalt chloride concentrations indicated to direct transition. The higher energy gap value is about 1.72 eV for sample M and decreasing within range (1.72 – 1.68) eV when $CoCl_2$ concentration increased in (PEO/PVA) composites samples. Optical constants like coefficient of absorption, extinction coefficient, imaginary parts of constant dielectric and optical conductivity increased after an increased concentration of impurity, but refractive index, real parts of the constant of dielectric decreased after filling with increasing concentration of impurity

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DOI: 10.37200/IJPR/V24I4/PR2020503
Received: 14 Mar 2020 | Revised: 28 Mar 2020 | Accepted: 14 Apr 2020