Particle Size effect of Sn on Structure and Optical Properties of PVA-PEG Blend

Ahmed N. Al-jamal
Department of Radiology Techniques
Al- Esraa University College
Baghdad, Iraq
Ahmedaljamel9@yahoo.com

Qunoot M. Hadi
Department of Radiology Techniques
Almustaqbal University College
Babylon, Iraq

Farah J. Hamood
Department of Physics, College of Education for Pure Sciences
University of Babylon
Babylon, Iraq

Khalid Haneen Abass
Department of Physics, College of Education for Pure Sciences
University of Babylon
Babylon, Iraq
kalidhanin@yahoo.com

Abstract - The Films of PVA-PEG-Sn were prepared with various particle size of Sn element (0, 10, 75 and 150 μm) by casting method technique with thickness of 800 nm. The effect of Sn additive on structural (FT-IR, optical microscope) and optical properties of polymeric blend has been studied. Optical microscope images indicated the uniform distribution of the Sn particles in the structure of PVA-PEG-Sn films. The optical properties of PVA-PEG-Sn films were calculated from recording the absorbance spectra by using spectrophotometer (UV/1800/ Shimadzu) in the wavelength range (190-1100) nm. The optical constants that calculated in this study were found out that all these constants increases with the increase of the particle size of (Sn). The optical band gap (E_g) decreased from 4.5 eV for PVA-PEG film to 4.25 eV as the 150 μm Sn particle size in the PVA-PEG-Sn film.

Key words - PVA-PEG, Structural and optical, FT-IR, optical microscope.

1. INTRODUCTION

Polyvinyl alcohol (PVA) that essentially made from polyvinyl acetate through hydrolysis, is easily degradable by biological organisms, this soluble in water [1]. The biopolymer is also a suitable material for biomedical applications, such as drug delivery make this polymer very important in the bio applications [2]. Polyvinyl alcohol (PVA) is a non-toxic, water-soluble, highly crystalline, light weight, transmittance, and biocompatible polymer. It has interesting physical and chemical properties and it can prepare it as film ability due to the abundance of hydroxyl groups [3,4].

The properties of the coated product are based on different parameters which are divided into four groups, namely: support properties, coating agent properties, coating technology of machine and process parameters. The interactions between these different groups of parameters generate the complexity of the process [5]. Polyethylene glycols (PEG), is liquid or solid polymers of the general formula $H(OCH_2CH_2)n{\cdot}OH$ [6]. For not having enough elasticity, it can added many polymers for this purpose. When plasticizer is added, the molecular rigidity is relieved by reducing the intermolecular forces along the polymer chain. [7]. For this purpose, it can not use the PEG to prepare films without plasticizer or added other polymer. Single advantage of nanoparticles, as polymer fillers appear to have is that compared to conventional fillers, loading necessities are rather low. Micro-sized particles or/and nano-sized particles used as reinforcing agents dispersion light, thus decreasing optical clarity and light transmittance. Efficient nanoparticle scattering combined with excellent polymer material particle interfacial adhesion eliminates dispersion and allows the exciting possibility of rising strong yet transparent films, coatings and films [8].

Optical properties of polymers are important aspects in the study of electronic conversion and the possibility of their application such as a cover in solar collection, optical filters, and antireflection coatings [9]. Many researchers are studied PVA-PEG blend [10-13], and no researcher studied the PVA-PEG-Sn system. It is found that the PEG content up to 60% can provide the best compatibility of the PVA/PEG blend [14]. The present work deals with preparation of (PVA-PEG-Sn) films with good plasticity and good morphology of surface, and study their structural and optical properties for piezoelectric and sensors applications.

2. THEORETICAL PART

The absorption coefficient (α) that depends on the energy of the incident photon and the type of the carrier (p or n) of a semiconductor. It can be calculate from the following equation [14]:

$$\alpha = 2.303\ (A/t) \quad \ldots\ldots\ldots\ldots\ (1)$$

where A: is the absorbance and t: is thickness.
For amorphous semiconductors, the transitions model is [15]:

$$\alpha h\upsilon = B\ (h\upsilon - E_g)^m \quad \ldots\ldots\ldots\ldots\ (2)$$

where B is a constant, hυ is the photon energy, h is Planck's constant, E_g is the optical energy band gap (calculated from the extrapolation line acting the x-axis). The values of m = 2 for allowed indirect transition and m = 3 for forbidden indirect transition.

978-1-7281-3021-7/19/$31.00 ©2019 IEEE
DOI 10.1109/DeSE.2019.00137

The refractive index (n) of (PVA-PEG-Sn) composites calculated by using following equation [16] :

$$n = (1+R1/2) / (1-R1/2) \quad \ldots\ldots\ldots\ldots (3)$$

The extinction coefficient (k_o) is given by using the equation [16]:

$$k_o = \alpha\lambda /4\pi \quad \ldots\ldots\ldots\ldots (4)$$

The real and imaginary parts of dielectric constant (real part ε_1 and imaginary part ε_2) for (PVA-PEG-Sn) composites can be calculated by using equations [17]:

$$\varepsilon_1 = n^2 - k^2 \quad \ldots\ldots\ldots\ldots (5)$$

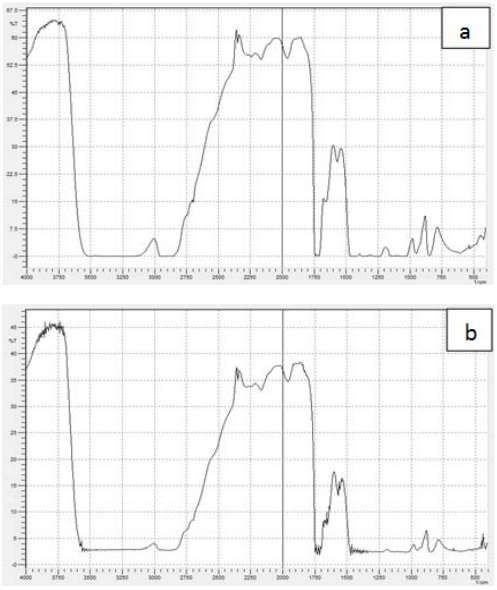
$$\varepsilon_2 = 2nk \quad \ldots\ldots\ldots\ldots (6)$$

3. EXPERIMENTAL PART

The (PVA-PEG-Sn) films were prepared with various particle size of Sn via casting solution method. The films were prepared from dissolving 1 g of polymers (80 wt.% PVA, 20 wt.% PEG) in 50 ml of distilled water. Magnetic stirrer was used to solve the PVA in the distilled with temperature 50℃, and then the PEG was added. The Sn particles (0.02 wt.%) was added to the PVA-PEG polymeric blend with various particle size (0, 10, 75 and 150 μm). The homogeneity will achieved because the magnetic stirrer that examined from the optical microscope. FT-IR device was used to determine the nature of the structure and the function group of PVA-PEG blend. The optical properties of PVA-PEG-Sn films were measured by using UV/1800/ Shimadzu in the wavelength range of 190-1100 nm.

4. RESULTS AND DISCUSSION

Fig.1 represents the FT-IR examination of PVA-PEG-Sn films with various particle size of Sn. The activation groups can determine using FT-IR. From the figure, some changes in the transmittance spectra especially in the region of finger print (wave number = 1500-500 cm^{-1}), refer to the affect of the PVA-PEG blend in the additive of Sn, as seen in the Fig.1 (parts a, b, c, d).



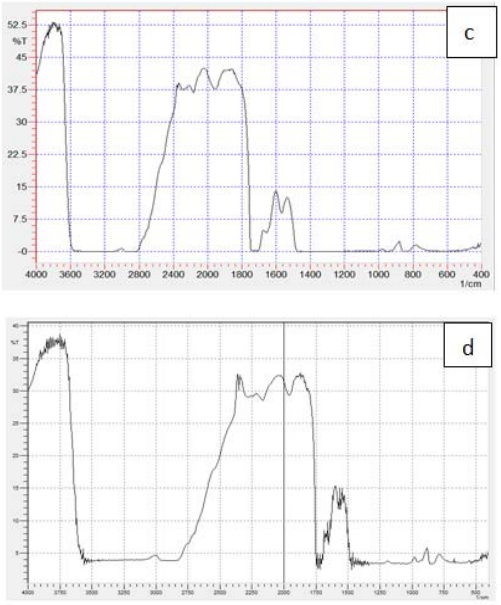
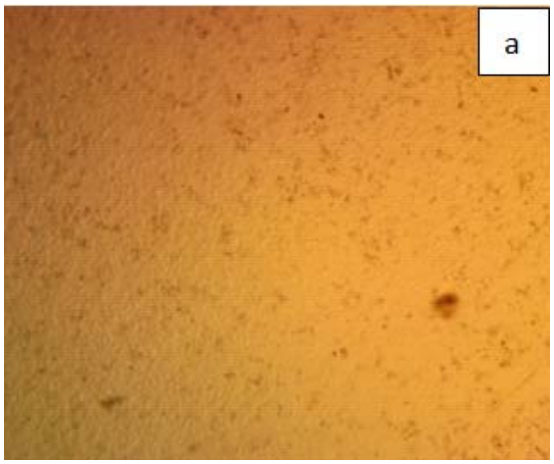


Fig.1: The FT-IR spectra of PVA-PEG blend with various particle size content of a. bare, b. 10 μm, c. 75 μm, and d. 150 μm Sn.

Optical microscope images of PVA-PEG-Sn films with different particle size of Sn are shown in Fig.2. From optical microscope can study the surface morphology and the arrangement and distribution of Sn particles inside the PVA-PEG blend. Optical microscope image for (PVA-PEG-Sn) films show that the Sn particles are aggregated with good distribution as a clusters at smaller particle size (10 μm and 75 μm, Fig.1 parts b and c). At bigger particle size of Sn (150 μm, Fig.1 part d) the Sn particles form a paths network inside the prepared films.



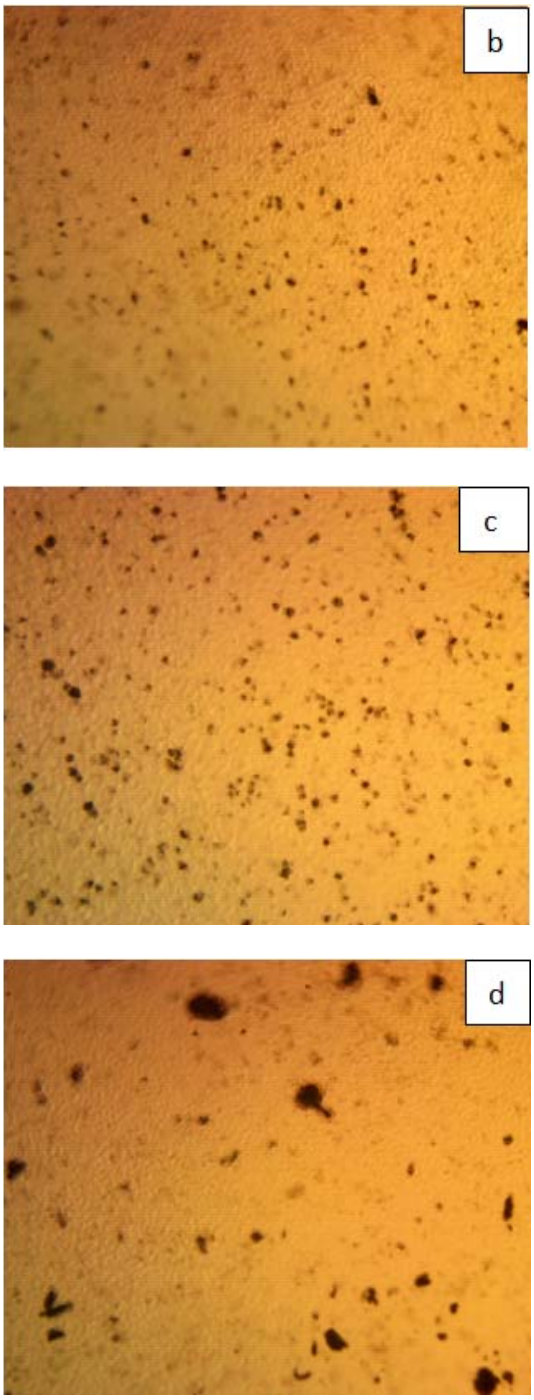


Fig.2: The optical microscope images of PVA-PEG blend at 100X with various particle size content of a. bare, b. 10 µm, c. 75 µm, and d. 150 µm Sn.

In Fig.3 the relation between the absorbance and the wavelength is presented. It is well known that PVA-PEG blend absorbs the radiation strongly in the wavelength region 200–400 nm. Fig.3 signifies the shift in the absorption bands and the band edges towards the lower energies with different absorption interfaces for different particle size of Sn in the PVA-PEG blend. This can be more explained by using Beer's law. The shift that appear in the absorption edge of the PVA-PEG-Sn films are essentially due to the variation in crystalline parameters and the variations in the particle size of Sn, leads to changes the energy band gap.

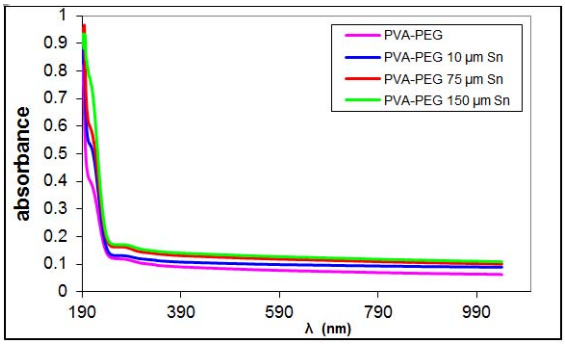


Fig.3: The absorbance spectra of PVA-PEG-Sn films.

Fig.4 signifies the shift in both transmittance bands and the band edges towards the higher wavelengths with different absorption intentsites for different concentrations of doped PVA-PEG blend samples. The transmittance decreasing with the increasing of Sn particle size, leads to a decrease in light scattering losses.

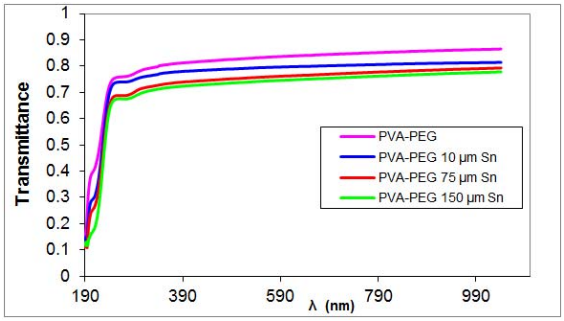


Fig.4: The transmittance spectra of PVA-PEG-Sn films.

The values of energy band gap for indirect transition calculated for different Sn particle size of the composites samples are presented in Fig.5. It is clear from Fig.5 that as the Sn particle size increases the band gap value decreases. The energy gap decreased from 4.5 eV for the PVA-PEG film to 4.25 for the film PVA-PEG-Sn with 150 µm particle size of Sn. The decrease in the optical energy gap (E_g) values are due to the forming the network inside the polymeric blend (PVA-PEG) make the prepared films less resistance to the electrical and optical conductivity.

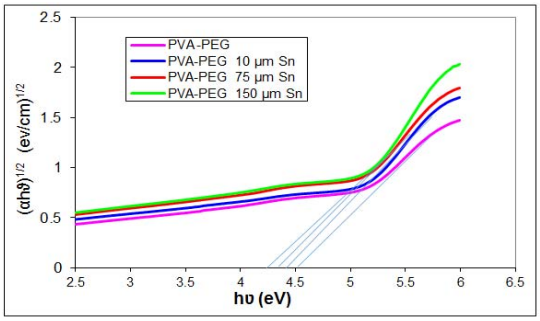


Fig.5: The values of energy band gap for allowed indirect transition calculated for different Sn particle size of the PVA-PEG-Sn.

Fig.6: shows the refractive index versus wavelength of the PVA-PEG-Sn films. The refractive index of PVA-PEG-Sn films increases with increasing of Sn particle size. It has been concluded that when the incident light interacts with a material has a large amount of particles, the refraction will be high and hence the refractivity of the films will be increased [18].

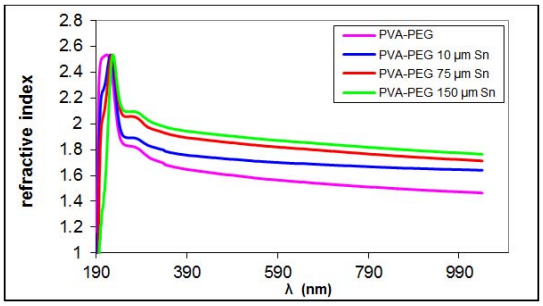


Fig. 6: the refractive index of (PVA-PEG-Sn) composites with wavelength.

The variation of extinction coefficient (k) with wavelength for PVA-PEG-Sn films are shown in Fig.7. The extinction coefficient increases with increasing of Sn particle size. This behavior of extinction coefficient can be explained as a high absorption coefficient. The extinction coefficient is high at the longest wavelength.

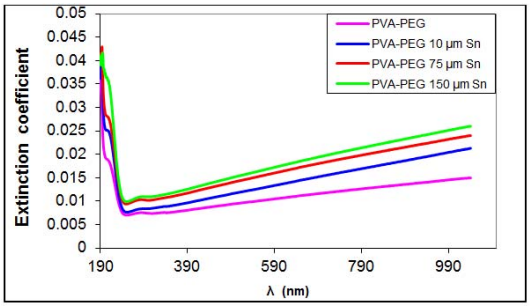


Fig.7: The variation of extinction coefficient with wavelength for (PVA-PEG-Sn) films.

The variation of real (ε_1) and imaginary (ε_2) parts of dielectric constant of (PVA-PEG-Sn) films with wavelengths are shown in Figs. (8 and 9). As shown in figures, the real and imaginary parts of dielectric constant are changed with Sn particle size and wavelength. The values of the real dielectric constant (PVA-PEG-Sn) composites are high with respect to the imaginary dielectric constant [19,20].

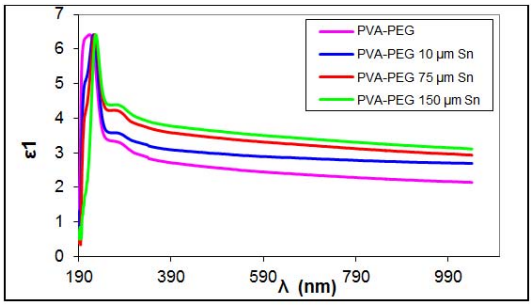


Fig.8: The variation of real part of dielectric constant of (PVA-PEG-Sn) films with wavelength.

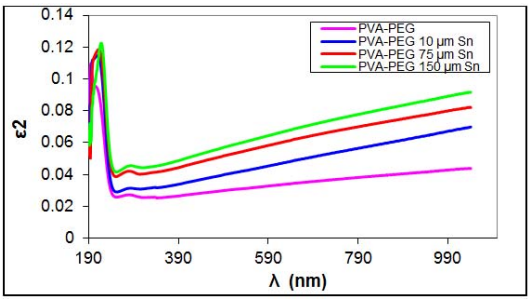


Fig. 9: The variation of imaginary part of dielectric constant (PVA-PEG-Sn) films with wavelength.

The optical absorption coefficient α behavior for PVA-PEG blend is given in Fig.10, it resembles the absorption spectra. From the figure, the absorption coefficient increases by the increase of Sn particle size, this may be attributed to increase the absorbance [21].

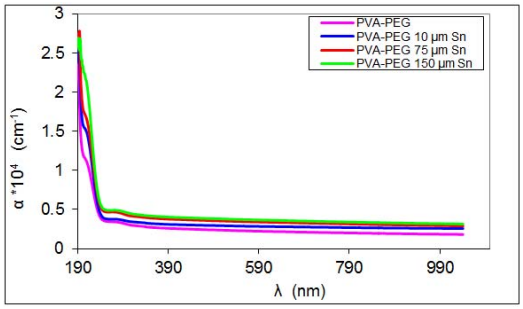


Fig.10:The variation of the absorption coefficient with wavelength for (PVA-PEG-Sn) films.

CONCLUSIONS

The PVA-PEG-Sn films were successfully prepared via solution casting method with various particle size of Sn. The additives of Sn affected on the structure from the changes the activation groups. The good distribution of Sn

in the PVA-PEG films can concluded from the optical microscope images. The optical properties are studied in the wavelength range 190-1100 nm. The absorbance was increased with the increasing of particle size of Sn, whereas the transmittance decreased. The optical constants that studied are increased with the increasing of Sn particle size. The optical energy gap was decreased from 4.5 eV for the PVA-PEG film to 4.25 for the film PVA-PEG-Sn with 150 μm particle size of Sn. The uniform distribution of Sn and good optical properties of the PVA-PEG-Sn system and suitable energy gap can candidate it in solar cell application.

REFERENCES

[1] Razzak, M.T.; Darwis, D.; Zainuddin; Sukirno. Irradiation of polyvinyl alcohol and polyvinyl pyrrolidone blended hydrogel for wound dressing. Radiat. Phys. Chem. 2001, 62, 107–113.

[2] Dash, M.; Chiellini, F.; Ottenbrite, R.M.; Chiellini, E. Chitosan—A versatile semi-synthetic polymer in biomedical applications. Prog. Polym. Sci. 2011, 36, 981–1014.

[3] Kaiwen C, Yern C C, Cheng H C, Sabariah J, and Nai-Shang L. Preparation and Characterization of Polyvinyl Alcohol-Chitosan Composite Films Reinforced with Cellulose Nanofiber", Materials, 2016; 9, 644.

[4] A. A. Khadayeir, Khalid Haneen Abass, S. S. Chiad, M. Kh. Mohammed, N. F. Habubi, T. Kh. Hameed, and I. A. Al-Baidhany, "Study the influence of Antimony Trioxide (Sb_2O_3) on optical properties of (PVA-PVP) composite", Journal of Engineering and Applied Sciences, Vol.13, No.22, pp.9689-9692, 2018.

[5] Fabien Laboulfie, Mehrdji Hémati, Alain Lamure, and Sylvain Diguet, "Effect of the plasticizer on permeability, mechanical resistance and thermal behaviour of composite coating films", Powder Technology, Vol. 238 . pp. 14-19 (2013).

[6] Buong Woei Chieng, Nor Azowa Ibrahim, Wan Md Zin Wan Yunus and Mohd Zobir Hussein, "Poly(lactic acid)/Poly(ethylene glycol) Polymer Nanocomposites: Effects of Graphene Nanoplatelets", Polymers 2014, 6, 93-104.

[7] Nadarajah, K., 2005, Dissertation, Louisiana State University Agricultural and Mechanical College, 18–22.

[8] Nadir F Habubi, Khalid H Abass, Chiad S Sami, Duha M A Latif, Jandow N Nidhal, and A Ismaeel Al Baidhany, "Dispersion Parameters of Polyvinyl Alcohol Films doped with Fe", IOP Conf. Series: Journal of Physics: Conf. series, 1003, 2018.

[9] Duha M A Latif, Sami S Chiad, Muhssen S Erhayief, Khalid H Abass, Nadir F Habubi, and Hadi A Hussin, "Effects of $FeCl_3$ additives on optical parameters of PVA", IOP Conf. Series: Journal of Physics: Conf. series, 1003, 2018.

[10] S. A. Nouh, A. G. Nagla, M. H. Othman, S. A. Eman, and Z. I. Lotfi, " Thermal, structural, and optical properties of γ-irradiated poly(vinyl alcohol)/poly(ethylene glycol) thin film", Vol.124, Issue1, (2012) 654-660.

[11] H. Hristov, Penka Vasileva Tsanova, and M. Nedialkova, "Preparation and Characterization of PVA/PEG/Boron Hybrid Materials", Nanoscience & Nanotechnology, 12, 2012, 47-51.

[12] Fahad H. Falqi, Osamah A. Bin-Dahman, M. Hussain, and Mamdouh A. Al-Harthi, " Preparation of Miscible PVA/PEG Blends and Effect of Graphene Concentration on Thermal, Crystallization, Morphological, and Mechanical Properties of PVA/PEG (10 wt%) Blend", International Journal of Polymer Science, Volume 2018, Article ID 8527693,10 pages.

[13] Kapil Gulati, Sohan Lal, P.K. Diwan, and Sanjiv Arora, " Investigation of Thermal, Mechanical, Morphological and Optical Properties of Polyvinyl alcohol Films Reinforced with Buddha Coconut (Sterculia alata) Leaf Fiber", International Journal of Applied Engineering Research ISSN 0973-4562 Vol.14(1), (2019) pp. 170-179.

[14] K. Abdel Tawab, M. M. Magida, and S. M. Ibrahim, "Effect of ionizing radiation on the morphological, thermal and mechanical properties of polyvinyl alcohol/polyethylene glycol blends", Journal of Polymers and the Environment, vol. 19, no. 2, pp. 440–446, 2011.

[15] Khalid Haneen Abass, Anmar Adil, and Musaab Khudhur Mohammed, " Fabrication and Enhancement of SnS:Ag/Si Solar Cell Via Thermal Evaporation Technique", Journal of Engineering and Applied Sciences, Vol.13, No.4, pp.919-925, 2018.

[16] A. P. Indolia and M. S. Gaur, "Optical properties of solution grown PVDF-ZnO nanocomposite thin films", J. Polym. Res, Vol. 20, no. 43, 2013.

[17] A. Kurt, "Influence of $AlCl_3$ on the optical properties of new synthesized 3-armed poly(methyl methacry- late) films", Turk. J. Chem, Vol. 34, pp. 67 –79, 2010.

[18] A. M. E. Sayed and W. M. Morsi, "α -Fe_2O_3 /(PVA + PEG) nanocomposite films; synthesis, optical, and dielectric characterizations," Journal of Materials Science, Vol. 49, pp. 5378–5387, 2014.

[19] V. Sangawar, "Evolution of the optical properties of polystyrene thin films filled with zinc oxide nanoparticles," International Journal of Scientific & Engineering Research, vol. 4, no. 6, 2013.

[20] Khalid Haneen Abass and Duha M. A. Latif, "The Urbach Energy and Dispersion Parameters dependence of Substrate Temperature of CdO Thin Films Prepared by Chemical Spray Pyrolysis", International Journal of ChemTech Research, Vol.9, No.9 pp.332-338, 2016.

[21] A. H. Ahmad, A. M. Awatif and N. Zeid Abdul-Majied, J. of Eng. & Technology,25, 4, 2007, p.558.