



## Effect of Gamma irradiation on The Optical properties of (PVA: CuCl<sub>2</sub>) films

Seham Hassan Salman<sup>1</sup>, Esraa Akram Abbas<sup>2\*</sup>, Enas Yasseen abd<sup>1</sup>, Shaimaa Akram Abbas<sup>1</sup>

<sup>1</sup>Department of Physics, College of Education Ibn AlHaitham, University of Baghdad, Baghdad, Iraq

<sup>2</sup>Department of Physics, College of Education, University of Al-Mostansiriyah, Baghdad, Iraq

### Abstract

The study effect irradiation on optical properties of film (PVA: CuCl<sub>2</sub>) prepared by casting method, with thickness of (30±1) μm. And used Cs<sup>137</sup> to obtained Gamma ray with energy (662)keV and time irradiation(5,6 and 7) weeks and affectivity (4.3) ci. The spectra absorbance and transmittance register in range (300-1100) nm . Results show that the optical band gap for (PVA: CuCl<sub>2</sub>) decreasing after irradiation with gamma ray from (3.2,3.1,3 and 2.7)eV, urbach energy values increase with the increasing time radiation. And the absorption constants (α,k,n) and the optical conductivity are changing after irradiated with gamma ray .

**Keywords:** PVA: CuCl<sub>2</sub> , irradiation, band gap, urbach energy.

## تأثير التشعيع بأشعة كاما على الخواص البصرية لآغشية بوليمر فينال الكحول المشوبة بوكلوريد النحاس

سهام حسن سلمان<sup>1</sup>، اسراء اكرم عباس<sup>2\*</sup>، ايناس ياسين عبد<sup>1</sup>، شيماء اكرم عباس<sup>1</sup>

<sup>1</sup>قسم الفيزياء، كلية التربية للعلوم الصرفة (ابن الهيثم)، جامعة بغداد، بغداد، العراق

<sup>2</sup>قسم الفيزياء، كلية التربية، الجامعة المستنصرية، بغداد، العراق

### الخلاصة:

دراسة تأثير التشعيع على الخواص البصرية لغمشاء (PVA: CuCl<sub>2</sub>) والمحضرة بطريقة الصب وبسمك (30±1) μm، وقد استخدم المصدر المشع Cs<sup>137</sup> ذو طاقة 663keV للحصول على اشعة كاما وكان زمن التشعيع (5,6,7) اسابيع وفعاليتها (4.3)ci.

سجل طيف الامتصاصية والنفاذية ضمن المدى (300-1100) nm. اظهرت النتائج ان فجوة الطاقة ل(PVA: CuCl<sub>2</sub>) تقل بعد التشعيع بأشعة كاما من (3.2,3.1,3 and 2.7)eV ، وطاقة اورباخ تزداد بزيادة زمن التشعيع والثوابت البصرية (معامل الامتصاص ،معامل الخمود ،معامل الانكسار)، والتوصيلية البصرية تتغير بعد التشعيع بأشعة كاما.

### Introduction

Polymers usually have low thermal conductivity, ~ (0.1–0.3)Wm<sup>-1</sup> K<sup>-1</sup>[1–3]. Usually to modify and improve properties of polymer added different additives such as transition metal salts are changing the physical properties of PVA polymer [4,5].

Depending on the method in which they interact with the matrix and" chemical nature of the doping, the dopant change the physical properties" [6,7]. Generally have modern characteristics, unlike from matrix and filler ones, could be Inexpensive[3].

Also to modify and improve properties of polymer used Irradiation with X-rays, alpha, beta and gamma radiation also have important effect on polymer properties [8,9].

\*Email: riyadhys@yahoo.com

Khaled et al [8] show change the refractive indices and optical absorption with gamma irradiation to Poly(Vinyl Alcohol) doped with NiCl<sub>2</sub> and CrCl<sub>3</sub>.

Eid et al [10] bring to light impress of gamma irradiation on the optical Energy gap of PVA based ferrotitanium alloy film. The energy band gap was decreases after irradiation.

Basfar et al [11] investigated effectiveness of gamma irradiation on the optical properties of PS(C<sub>8</sub>H<sub>8</sub>)<sub>n</sub> doped by methylene blue dye. The Eg was determined it decrease after irradiation.

A purpose of the search is study the optical characteristics of the polyvinyle alcohol(PVA): CuCl<sub>2</sub> (7%) films and irradiation effect, were exposed to Cs<sup>137</sup> γ-radiation source.

### Experimental

Were used as requisite polymeric material, polyvinyle alcohol (PVA), distilled water and magnetic stirred used to solubility PVA at 50 °C for two hours, and used it to solubility CuCl<sub>2</sub>.H<sub>2</sub>O at 30 °C for one hour. Congenial mixtures of PVA and (7%) from CuCl<sub>2</sub>.H<sub>2</sub>O solution were appears Homogenous. The solution was but into level glass plate, After run dry in the kiln for (one hour) at 50 °C were obtained on films. The thickness gauge (indicating micrometer) used to found sample thickness.

(Ultraviolet -visible 1800 spectra photometer) in the wavelength range (300 – 1100) \*10<sup>-9</sup>m. Used to Absorbance measurement.

Cs<sup>137</sup> was used to obtained Gamma ray with energy(662)keV and time irradiation(4,5,6 and 7) weeks and effective( 4.3)ci.

### Results and Debate

The most ways in expansion and comprehension the energy gap and structure materials by optical absorption spectra. Figure-1 The absorption spectrum of before and after radiation Poly(Vinyl Alcohol) doped with CuCl<sub>2</sub>. It is shows that the absorption decreases with time radiation increases at low wavelength (350)nm and increased the absorption with time radiation increases wavelength, the absorbance change after irradiation that it is related to changes in film structure.

Figure-2 shows the transmittance spectrum in the rang (300 – 1100)nm, It is figure the transmittance increase after irradiation, may be due to the some physical effects such as, surface nature.

Figure-3 shows the optical absorption coefficient (α) with photon energy. It is very important to determined kind of electronic transition if (α>10<sup>4</sup>) the transition is direct and if (α≤10<sup>4</sup>) the transition is indirect [12].

We used the following equation to determine the absorption coefficient [12]:

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

A = the absorbance, d is the sample thickness.

The following equation [13]:

$$\alpha = \alpha_0 \exp(h\nu / E_e) \quad (2)$$

(α<sub>0</sub>) is a constant and E<sub>e</sub> is the urbach energy. Used to determine the urbach energy. Urbach tail is the the distance between the localized states ready in the optical band gap. Figure-4 shows the change of Lnα with photo energy for (PVA: CuCl<sub>2</sub>) films before and after radiation with different time radiation, the E<sub>e</sub> were studied from the slope and the obtained E<sub>e</sub> in Table-1, which indicates that E<sub>e</sub> increase after radiation [14].

The following equation to found E<sub>g</sub> [10,15]:

$$\alpha \propto h\nu = B(h\nu - E_g)^m \quad (3)$$

B is a constant, m=2, 3, 1/2 and 3/2 (experimental index), depending on kind of transition accountable m = 2 which specific indirect, allowed transitions [16] [17]. Figure-5 shows that and the obtained value of energy gap in Table-1." the energy gab dependence in general on the crystal structure of the composites" [16], also the decrease of energy band gap due to decrease the distance between the valance band and conduction band with the increase the time radiation

Figure-6 shows the dependence of the extinction coefficient on the photon energy the extinction coefficient can be related by the equation [18].

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

The extinction coefficient ( $k$ ) behaves just like the absorption coefficient ( $\alpha$ ) because they are joined by previous relation (4). This is due to increase in absorption coefficient the extinction coefficient values increased.

The refractive index  $n$  value provides the optical properties of the film and it is related by the following equation [19].

$$n = \frac{(1 + \sqrt{R})}{(1 - \sqrt{R})} \quad (5)$$

Where  $R$  is the reflectance was calculated depended energy save law using the relation: [19,20]

$$R + T + A = 1 \quad (6)$$

The real part ( $\epsilon_r$ ) and imaginary part ( $\epsilon_i$ ) of dielectric constants were determined from the following equations [21]

$$\epsilon_r = n^2 - k^2 \quad (7)$$

$$\epsilon_i = 2nk \quad (8)$$

It can be observed from Figure-7 and Figure-8, the values of  $n$ ,  $\epsilon_r$  and  $\epsilon_i$  dependence on the photo energy. The refractive index, real part ( $\epsilon_r$ ) and imaginary part ( $\epsilon_i$ ) of dielectric constant values of irradiated is less than that un-irradiated film, this may be due to the change in stoichiometry and internal strain of films. The behavior of  $\epsilon_r$  similar to the behavior of  $n$ , because of  $k^2$  very small comparison with  $n^2$ , but the behavior of  $\epsilon_i$  mainly depends on the variation of  $k$ . Therefore concluded that  $\epsilon_r$  is larger than  $\epsilon_i$

The optical conductivity was calculated using the relation [21]

$$\sigma = \frac{an c}{4\pi} \quad (8)$$

$$c = 3 \times 10^8 \text{ m/s}$$

Figure-9 shows the relation between optical conductivity and photon energy. The optical conductivity increased after irradiation in low photon energy and decreased in the visible range. The optical conductance and band gap indicated that the films are transmittance within the visible range" [21].

### Conclusions:

1. The band gap decreases after irradiation.
2. Urbach energy values increase with the increasing time radiation.
3. The ( $\alpha, n, k, \epsilon_r$  and  $\epsilon_i$ ) of (PVA: CuCl<sub>2</sub>) are changing after irradiation.

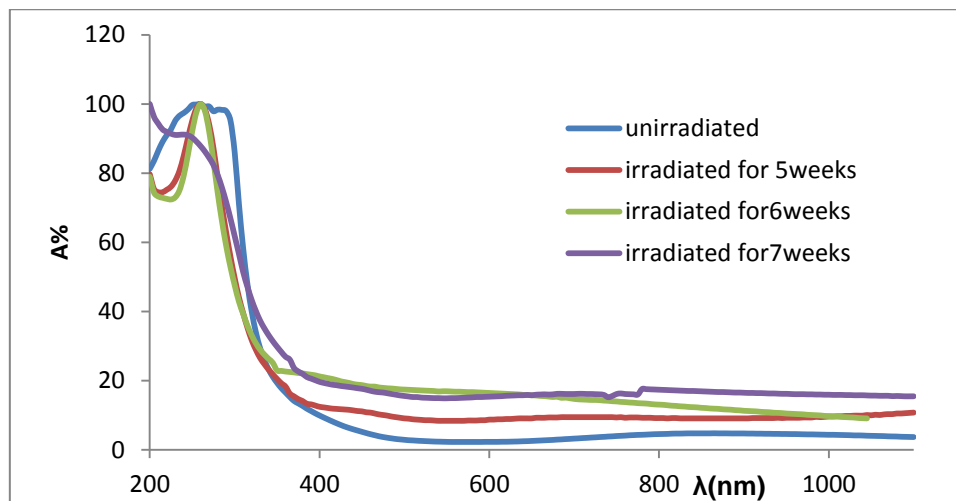


Figure 1-The variation of the absorbance(A) with wavelength( $\lambda$ )

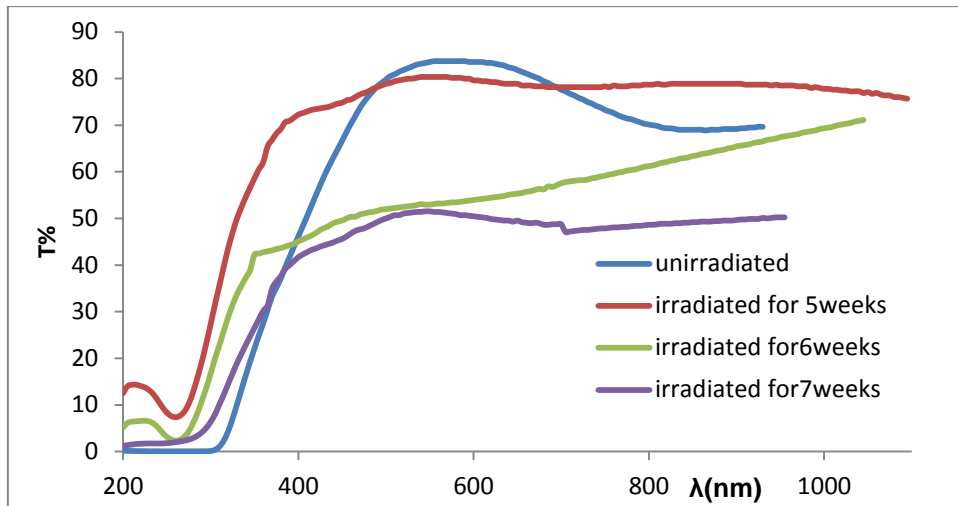


Figure 2- The variation of the transmittance(T)with wavelength( $\lambda$ )

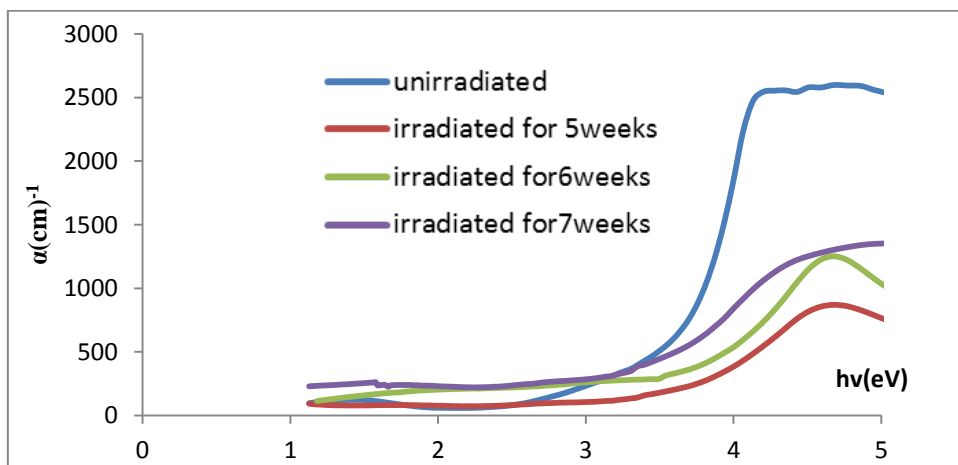


Figure 3- The variation of the absorption coefficient( $\alpha$ ) on the photon energy.

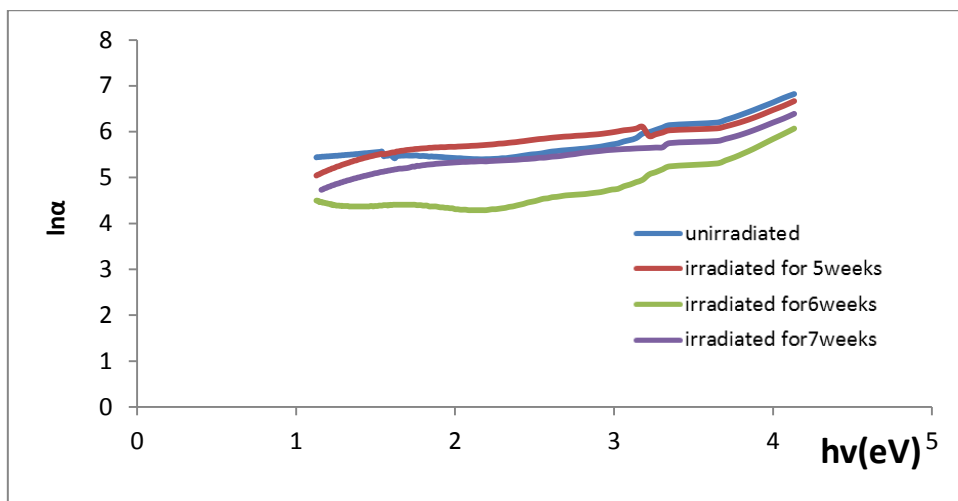


Figure 4- Variation of  $\ln(\alpha)$  with photon energy

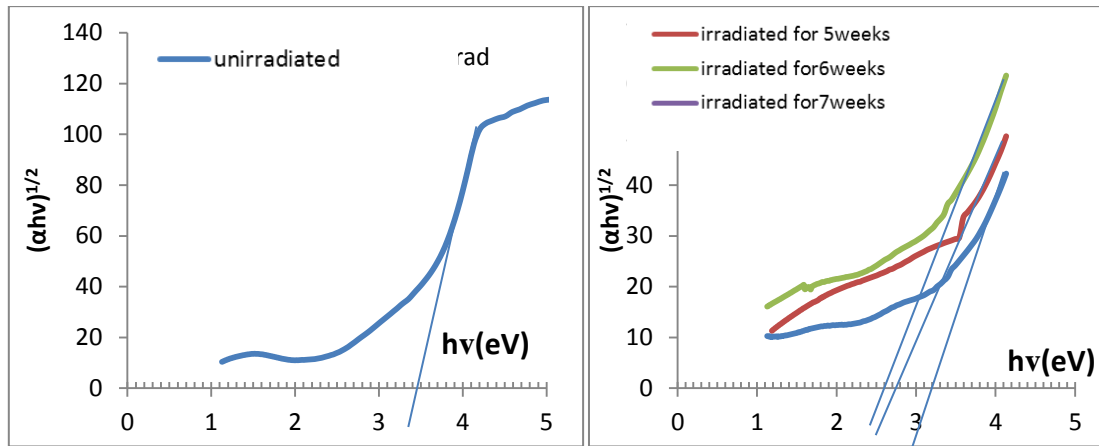


Figure 5- Variation of  $(\alpha hv)^{1/2}$  with photon energy

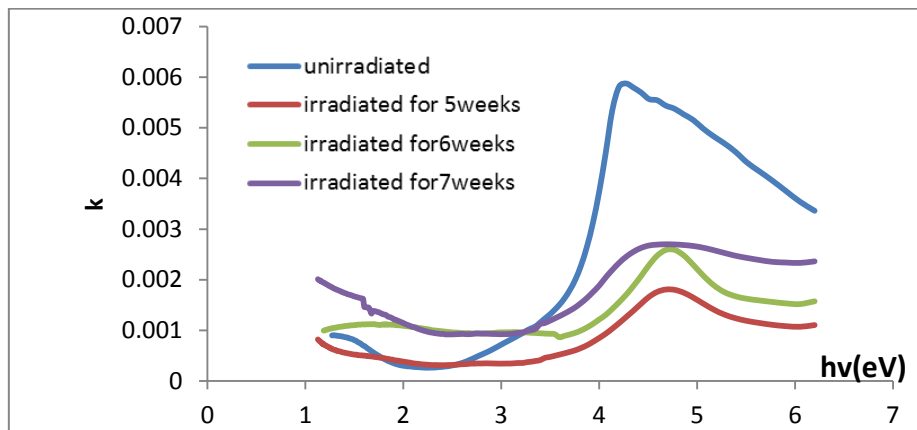


Figure 6- Variation of extinction coefficient(k) with photon energy.

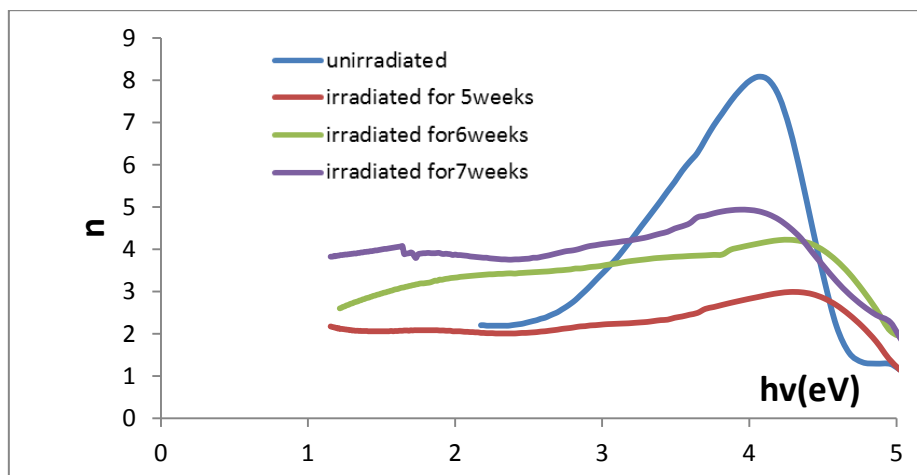


Figure 7- Variation of refractive index(n) with photon energy

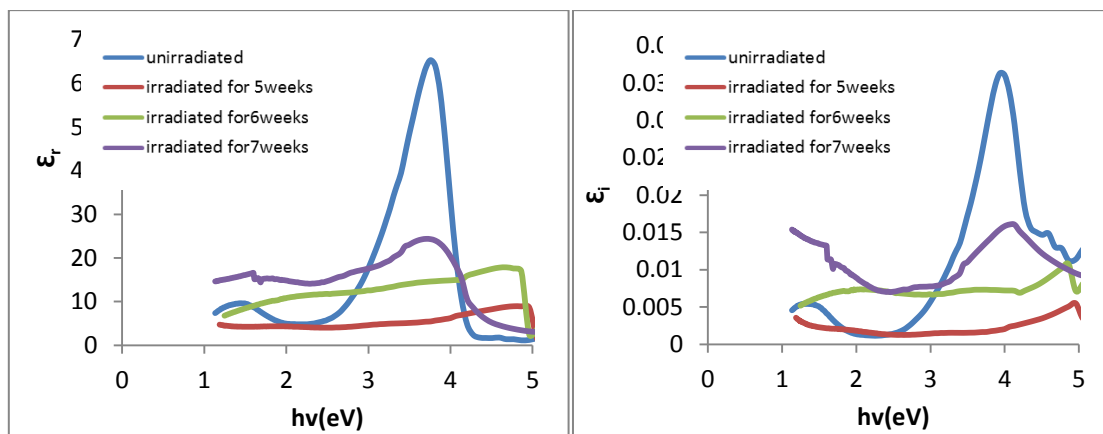


Figure 8- Variation of imaginary ( $\epsilon_i$ ) and real part ( $\epsilon_r$ ) of dielectric constant with photon energy

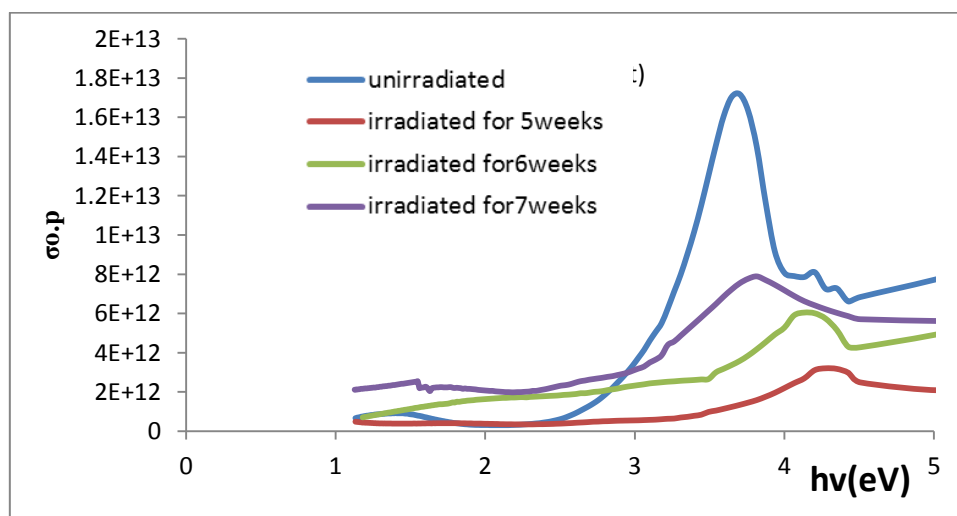


Figure 9- Variation of optical conductivity with photon energy

Table 1- properties of PVA:CuCl<sub>2</sub> films at different time radiation

Time of irradiation.	E <sub>g</sub> (eV)	E <sub>e</sub> (eV)
un irradiated.	3.5	0.276
5week	3.1	0.318
6week	2.8	0.376
7week	2.6	0.387

#### References:

- Henry A, Chen G, Plimpton S J and Thompson A. **2010**. 1D-to-3D transition of phonon heat conduction in polyethylene using molecular dynamics simulations, *J. Phys. Rev. B* 82, p:144308
- Shen S, Henry A, Tong J, Zheng R and Chen G. **2010**. Polyethylene nanofibres with very high thermal conductivities, *J. Nat. Nanotech.* 5, pp:251-255.
- G. Amin and M. Abd-El Salam. **2014**. Optical, dielectric and electrical properties of PVA doped with Sn nanoparticles, *J. Materials Research Express*, 1, pp:1591,025024
- M. El-Sherbiny, N.Saieh A. El-Rehim. **2001**. Spectroscopic and dielectric behavior of pure and nickel-doped polyvinyl butyral films. *J. Polymer Testing*, 20, pp:371-378.
- A. Baha, M. Amin, K. Darwish and H. Abdel-Samad. **1988**. *J. Polymer Mater.* 5, p:115.
- Bahri R. **1992**. *J. Phys. D: Appl. Phys.* 15, p:1036
- M. Ahmed, M. Abo-Ellil. **1998**. Effect of dopant concentration on the electrical properties of polyvinyl alcohol (PVA), *J. of Materials Science: Materials in Electronics*, 9, pp:391-395
- M. Khaled, F. Sharaf, M. Risk and M.M. El-Ocker, Polymer. **1993**. Effect of  $\gamma$ -irradiation on the refractive indices and optical absorption of Poly (Vinyl Alcohol) doped with NiCl<sub>2</sub> and CrCl<sub>3</sub>. *J. Degradation and stability*, 40, pp:385-388.

9. Mohamed, R. and Gadou, A. **2000**. AC-Conductivity and Dielectric Properties of gamma - Irradiated PVA Films Doped With Mn<sup>2+</sup> Ions, *Egypt. J. Sol.*, 23(1), pp:277-286.
10. R. Ahmed and S. El-Bashir, Sayeda Eid, Seif Ebraheem, and Nehad M. Abdel-Kader. **2014**. Study the Effect of Gamma Radiation on the Optical Energy Gap of Poly (Vinyl Alcohol) Based Ferrotitanium Alloy Film: Its Possible Use in Radiation osimetry. *J.of Polymer Chemistry*, 4, pp:21-30
11. A.Basfar, K. Rabaeh, A.Moussa, and R. Msalam. **2011**. Dosimetry Characterization of Nitro-Blue Tetrazolium Polyvinyl Buteral Films for Radiation Processing, *J. Radiation Physics and Chemistry*, 80, pp:763-766.
12. A. Dakhal. **2003**. Structural and optical properties of evaporated Zn Oxide, Ti oxide and Zn-Ti oxide films, *J. Appl. Phys. A*, 77, p:677.
13. Y. Caglar, S. Ilican, M. Caglar and F.Yakuphanoglu. **2007** .Effects of In, Al and Sn Dopants on The Structural and Optical Properties of ZnO Thin Films, *J. Spectrochimica Acta Part A.*,67, pp:1113-1119.
14. S.Oleary, S. Zukotynskiand and J.Perz. **1997**. Disorder and Optical Absorption in Amorphous Silicon and Amorphous Germanium, *J. Non-Cryst. Solids*, 210 (2-3), pp:249-253.
15. H. Ahmad, S. Sabeeh, S. Hussen. **2012**. Electrical and Optical Properties of PVA/LiI Polymer Electrolyte Films, *Asian Transactions on Science & Technology*,1(6), pp:16-20.
16. T.Alwan. **2012**.Gamma Irradiation Effect on the Optical Properties and Refractive Index Dispersion of Dye Doped Polystyrene Films. *Turkish Journal of Physics*, 36, pp:377-384.
17. A. Abdel-Fattah,H. Abdel-Hamid, and R.Radwan. **2002**. Changes in the Optical Energy Gap and ESR Spectra of Proton-Irradiated Unplasticized PVC Copolymer and Its Possible Use in Radiation Dosimetry, *Nuclear Instruments and Methods in Physics Research*, 196, pp:279-285.
18. H.Ibrahim and R. Salem. **2012**.Optical Properties of poly vinyl alcohol ( PVA) doped with Ali Zarin Orange Azo Dye thin films prepared by cast method, *J. of Kufa- Physics*.4(1),pp:11-21.
19. O. Abdullah, B. Aziz, and S. Hussen. **2013**.Optical Characterization of Polyvinyl alcohol – Ammonium Nitrate Polymer Electrolytes Films, *Chemistry and Materials Research*,3(9), pp:84-90.
20. O. Abdullah, and D. Saber. **2012**.Optical absorption of polyvinyle alcohol films doped with Nickel Chloride, *Applied Mechanics and Materials*. 110-116, pp:177-182.
21. A. Ganem, Hadi, N. Mohammed , S. kareem , A. Hashim. **2014**. Study of the Effect of Potassium Bromide on Optical Properties of PVA. *J. of Babylon University, Pure and Applied Sciences*, 22(2).
22. F.Buet.,J.Olivier-Fourcade,Y.Bensimon,P.Belougne. **1991**. *State Communications*,77(1), pp:29-32.