# The Influence of Copper Acetate Concentration on the Optical Properties of PVA/PVP Polymer Blend Films.

**Ahmad J.H. Almaliky[1], Shatha S. Ebade[2], Khalid I. Ajeel[3], Hussein F. Hussein[4], Mohammed T. Obeed[5], Nadhim A. Abdullah[6]*.**

**[1,2,4]Department of Physics, College of Education for Pure Sciences, University of Basrah, Basrah, Iraq**

**[3]Department of Instrumentation Engineering techniques, Al-Kunooze University, Basrah, Iraq.**

**[5,6]Department of Material Science, Polymer Research Centre, University of Basrah, Basrah, Iraq.**

**[*]Corresponding Author**

**DOI: https://doi.org/10.51584/IJRIAS.2026.11090101**

**Received: 23 September 2026; Accepted: 28 September 2026; Published: 16 October 2026**

## ABSTRACT

In the present work, PVA/PVP blend films were prepared by the solution-casting technique and doped with different concentrations of copper acetate. The prepared samples were named as $P_0$, $P_1$, $P_2$, $P_3$, and $P_4$ according to increasing dopant concentration. The optical properties of the films were investigated using UV–Visible spectroscopy through measurements of absorbance, transmittance, absorption coefficient, extinction coefficient, refractive index, and optical band-gap energy. The results showed a progressive enhancement in optical absorption with increasing copper acetate concentration, accompanied by a reduction in the optical band-gap energy from 2.69 eV for the undoped film ($P_0$) to 2.20 eV for the highly doped film ($P_4$). This behavior indicates the formation of localized electronic states within the polymer matrix and demonstrates the effectiveness of copper acetate in tailoring the optical properties of PVA/PVP blend films for potential optoelectronic applications.

**Keywords**: PVA/PVP polymer blend, copper acetate doping, optical properties, bandgap, Energy gap.

## INTRODUCTION

Hybrid polymer blends are a distinctive type of material that exhibits unique physical and chemical properties. These compounds have recently attracted serious research interest due to their concrete potential for a wide assortment of applications in environmental solution and solving various environmental problems. In addition to the polymers blending introduce a lot of useful characteristics depend on their miscibility and degree of compatibility interaction between the various polymers to get simple and low-cost technique for materials to enhance structures and characteristics different from the pristine polymer [1-3]. The miscibility and degree of compatibility for PVA and PVP get via the hydrogen bond interactions between the -OH groups of PVA and -CO groups of PVP to get polymer blend of (PVA/PVP). Polymer compound since it has excellent properties such as water soluble, semi crystallinity, high quality film can be formed with various containing materials and non-toxicity [4-5]. There are many fabrications of various optoelectronic devices, preparing by composed from different blending polymers such as (PVA) [C2H4O], (PVP) [C6H9ON], doped with different inorganic materials have been fabricated by the researchers and technical workers [6-7]. PVA considered as one of synthetic polymers, which used to synthesis many PVP is also water-soluble amorphous polymer which has a high glass transition temperature Tg due to the presence of rigid pyrrolidone group, so it can be used as good additive in fiber glass, ceramics and batteries [8-9]. Polymer blends have become a focal point of research in material science due to their ability to integrate the advantageous properties of individual polymers into a single matrix, offering tailored mechanical, thermal, and optical characteristics. Among these blends, the combination of polyvinyl alcohol (PVA) and polyvinylpyrrolidone (PVP) has shown significant potential due to its remarkable mechanical strength, thermal stability, and excellent film-forming properties [10]. [Poly (vinyl)

alcohol (PVA)] / [pyrrolidone (PVP)] polymer blend thin films doped by copper acetate (Cu ($CH_3COO$) $_2$) have gained interest for many years in science as introduction of materials in transparent polymer matrix and have much attention of researches as advanced technological materials according to their optoelectronic properties. Mechanical and structural characteristics. These characteristics are obtained from the specific combination of the inherent novel properties of polymers and metals providing new ideas in physics to explain it There are many researchers have looked at the different polymeric composites based on PVA and PVP such as silver sulfide (Ag2S) [11], ZnO [12], CdS [13], MnO2 [14], CuO [15], MgO [16] and TiO2 [17], Fe2O3 and Fe3O4 nickel acetate as well as Potassium Chromate (K2CrO4) for various optoelectronics applications. The present research aims to investigate how doping with copper acetate with different volume ratio's affects the structural, optical, and electrical properties of the PVA/PVP polymer films with the goal of advancing their applicability in optoelectronic devices, functional coatings, and other technological applications. PVA/PVP blend polymer with copper acetate ($Cu(CH_3COO)_2$ used as a protective layer for different technological applications because of their high durability and according to its excellent properties such as having high dielectric constant, high flexibility as well as their ability to be fabricated at normal temperature and low cost. The optical characteristics of PVA/PVP compound with different volume ratio's (0%, 1.5% ,6.5% and 8.5%, copper acetate ($Cu(CH_3COO)_2$) were studied via the optical absorption spectrum which considered as important tools for understanding the bands structure. The electronic properties and optical constants (refractive and absorption indices) of pure and doped the composite films included absorption (A), transmission (T), absorption coefficient (α) and optical energy gap (Eg) are investigated. As well as the dielectric constants have been determined.

## Experimental works

### Materials

1. Polyvinyl alcohol [-CH2CH(OH)-], Mw:14,000, Thomas Baker, CAS-No.:9002-89-5, Degree Hydrolysis (98%), India.
2. Polyvinyl pyrrolidone (C6H9NO), K-30 (PVP): CAS No.: 9003-39-8, Mw:4000, India.
3. copper (II) acetate (Cu ($CH_3CO_2$)$_2$) monohydrate (CAS-No.: 6046-93-1; Assay ≥ 98%; HIMEDIA).

### Preparation of (PVA)[Poly(vinyl)/ (PVP) composite.

In the present study, the polymeric materials were used to prepare (50:25 wt%) (PVA: PVP) polymer blend films. The amount copper (II) acetate (Cu ($CH_3CO_2$)$_2$) monohydrate ≥ 98%) was employed without more purification. The polymeric composite films were synthesized employing the simple casting method. The polymeric solutions were synthesized initially by dissolving a quantity of PVA (0.5gm.) and PVP (0.25gm.) composites in 10ml of distilled water (stirred in 80ºC for 2 hours). All solutions were filtered by using a 0.45 micrometer syringe filter. Then amount (0.5 gm.) of copper acetate (Cu ($CH_3CO_2$) $_2$) was dissolved in 10 mL of distilled water at 40°C for 15 minutes. A constant volume amount (3ml) of PVA/PVP blend was doped with different volume addition (0.0, 0.05ml, 0.1ml, 0.15ml, 0.2 ml, and 0.25 ml), of copper acetate solution as shown in table (1), and it was illustrated the figure (1).

Finally, the solutions were mixed and stirred continuously to get a homogeneous viscous liquid. The prepared solutions were cast onto clean glass substrates and left to dry at room temperature for 48 hours. After complete drying, the resulting films were visually inspected to ensure uniformity and absence of cracks as well as a bubble free of [(PVA: PVP)- copper acetate composite films. After 24 hours, the films annealed in temperature of 50ºC for 2 hours. The structural, optical, and electrical properties of the prepared films were characterized using several techniques. UV-V is spectroscopy (1800, SHIMADZU CO., Japan) with the wavelength range of (200–1000 nm) was employed to investigate the optical absorption and transmittance of the prepared films.

Table (1): Neat & doped PVP\PVA with copper acetate solutions and samples thickness.

| Sample name | PVA+PVP (ml) | Copper acetate (ml) | Thickness (µm) |
|---|---|---|---|
| P0 | 3 | 0 | 103 |
| P1 | 3 | 0.1 | 53 |

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume XI Issue IX September 2026

| | | | |
|---|---|---|---|
| P2 | 3 | 0.2 | 78 |
| P3 | 3 | 0.3 | 40 |
| P4 | 3 | 0.4 | 34 |

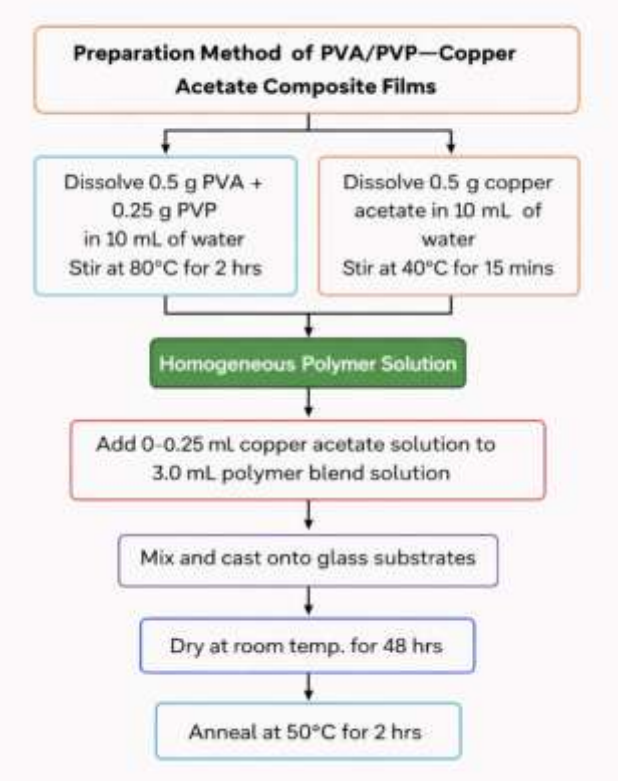



Figure (1): Preparation scheme of PVA/PVP composite films.

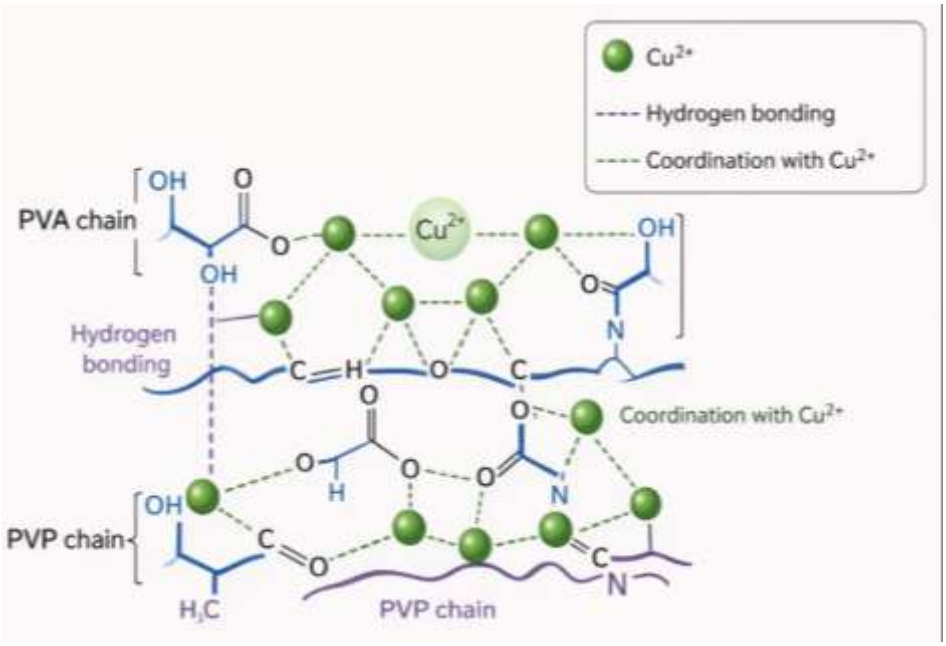



Figure (2): Schematic representation of $Cu^{2+}$– PVA/PVP films interactions.

Figure (2) illustrates the interaction mechanism between PVA and PVP polymer chains upon doping with copper acetate, where the green spheres represent $Cu^{2+}$ ions dispersed within the polymer matrix. The dashed purple lines indicate hydrogen bonding interactions formed between the hydroxyl (–OH) groups of PVA and the polar functional groups of PVP, which contribute to improved compatibility between the two polymers. The diagram

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume XI Issue IX September 2026

also shows the formation of coordination bonds between $Cu^{2+}$ ions and oxygen- and nitrogen-containing functional groups, particularly the carbonyl (C=O) groups in PVP and the hydroxyl groups in PVA. These coordination interactions promote partial crosslinking between the polymer chains, leading to modifications in the electronic structure of the composite. Such interactions account for the observed reduction in optical bandgap, enhancement of optical absorption, and improvement in the electrical properties of the copper acetate–doped PVA/PVP composite films.

The figure (3) illustrates the structure of copper acetate–doped PVA/PVP blend films, where copper acetate species are distributed within and on the surface of the polymer layer. The films are prepared by the solution casting method on a glass substrate, resulting in a uniform composite layer with enhanced optical and electrical properties.

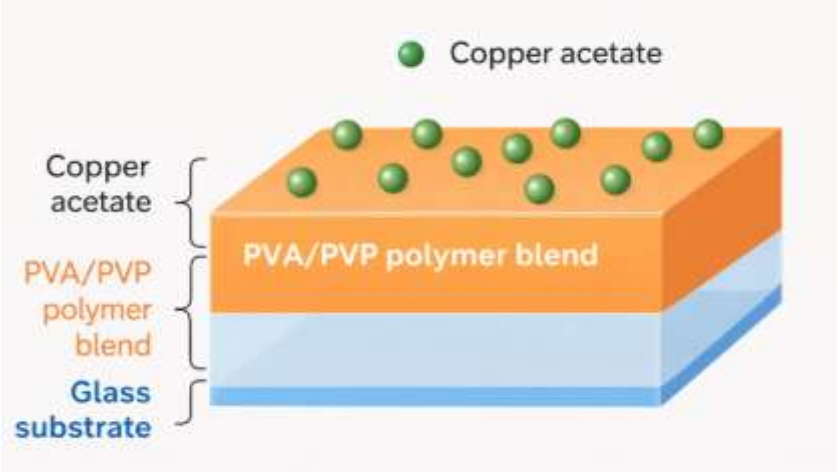



Figure (3). Schematic illustration of the structure of copper acetate–doped PVA/PVP polymer blend films deposited on a glass substrate.

The diagram illustrates the overall effect of increasing copper acetate concentration on the properties of PVA/PVP blend films, where higher concentrations lead to increased optical absorbance, refractive index, and electrical conductivity, accompanied by a reduction in the optical bandgap. This behavior reflects the role of copper acetate in modifying the electronic structure and enhancing light–matter interaction within the polymer composite.

## RESULTS AND DISCUSSION.

**Optical absorption and transmittance spectra**.

In order to gather information on the nature of the pure and copper acetate-doped PVA/PVP blend films charge transfer, we performed UV-Vis-NIR absorption spectroscopy on films. The absorbance and the transmittance spectra of pure and copper acetate-doped PVA/PVP blend films were measured across the wavelength range of 300–800 nm. as shown in Fig. 4(a) and (b) respectively. The absorbance spectra reveal that the peak intensity increases with the copper acetate doping ratio. The undoped film exhibits relatively low absorption in the visible region, whereas the doped films show increasing in absorption intensity with increasing copper acetate content. The high absorption observed in the ultraviolet region can be attributed to electronic transitions associated with the polymer backbone and the functional groups present in both PVA and PVP chains. Upon incorporation of copper acetate, a significant enhancement in absorption intensity is observed, indicating the formation of additional electronic states within the forbidden energy gap. These localized states originate from the interaction of $Cu^{2+}$ ions with the hydroxyl groups of PVA and the carbonyl groups of PVP, leading to charge-transfer complexes and structural modifications within the polymer matrix.

A noticeable shift of the absorption edge toward longer wavelengths is observed with increasing copper acetate concentration. This shift suggests a reduction in the optical band gap energy, which is commonly associated with

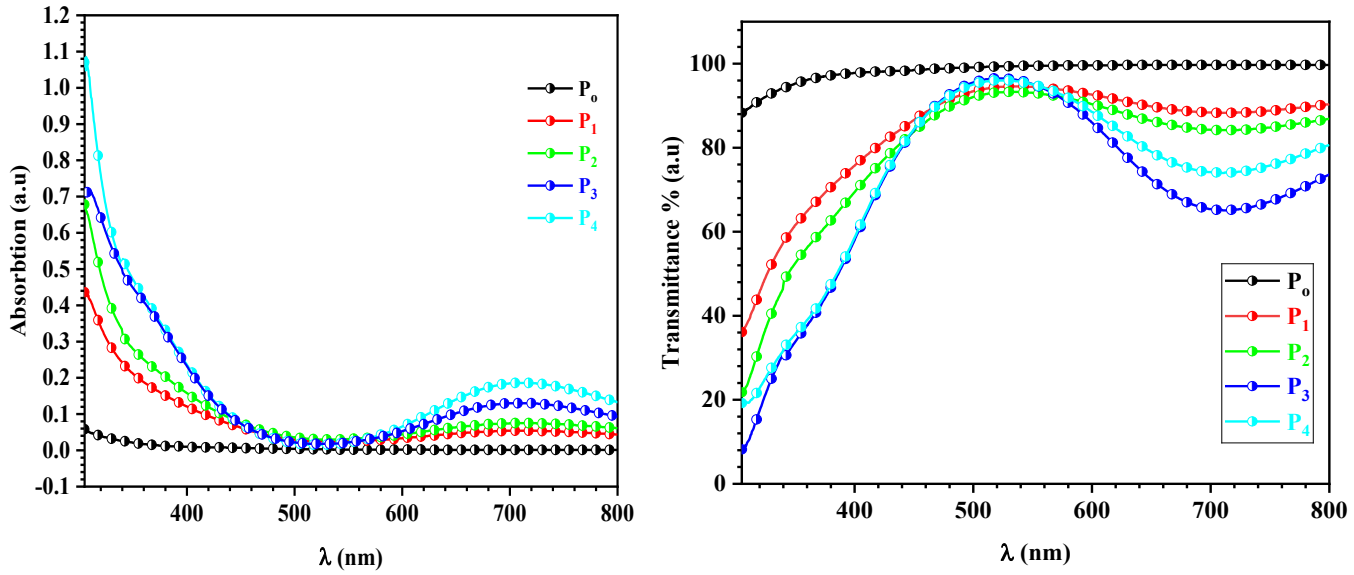
ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume XI Issue IX September 2026

the introduction of defect levels and increased disorder within the polymeric network. The presence of these localized states facilitates electronic transitions at lower photon energies, thereby enhancing optical absorption.

Moreover, the absorption intensity of sample $P_4$ at approximately 300 nm is significantly higher than that of the lower-doped samples, and the increase is clearly non-linear with copper acetate concentration. This behavior indicates that, the role of copper acetate is unlimited to increase the number of absorbing centers. it suggests that, the formation of coordination complexes between $Cu^{2+}$ ions and the functional groups of the PVA/PVP matrix. Such complex formation can alter the local electronic environment and generate additional energy states that contribute to the observed enhancement in optical absorption.

Furthermore, the broad absorption feature observed in the wavelength region between approximately 650 and 750 nm becomes more pronounced as the copper acetate concentration increases. This behavior may be attributed to electronic transitions involving impurity-induced states, charge-transfer mechanisms, or copper-related localized states within the polymer matrix. The increase in absorption in this spectral region reflects an increase in the density of localized electronic states near the band edges.

These observations strongly suggest that copper acetate acts as an active electronic modifier rather than a passive filler within the polymer blend. The interaction between $Cu^{2+}$ ions and the polymer chains lead to the formation of coordination complexes, enhanced charge-transfer interactions, and the generation of localized states inside the band gap. Consequently, the optical absorption is enhanced, the optical band gap is reduced, and the electronic transport properties of the composite films are expected to improve.




(a) (b)

Figure (4): a- The relationships between absorption and the wavelength. b- The relationships between transition and wavelength.

Figure (4-b) shows the optical transmittance spectra of pure and copper acetate-doped PVA/PVP blend films in the wavelength range of 300–800 nm. The pure PVA/PVP film exhibits very high optical transmittance throughout the visible region, reaching values close to 100%, indicating the high transparency of the polymer blend and the absence of significant absorption centers within the matrix.

Upon the addition of copper acetate, a substantial reduction in transmittance is observed, particularly in the ultraviolet and short-wavelength visible regions. The decrease in transmittance becomes more pronounced with increasing copper acetate concentration, indicating enhanced interaction between the incident photons and the electronic states introduced by the dopant within the polymer matrix.

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume XI Issue IX September 2026

The transmittance spectra of the doped samples exhibit a gradual increase with wavelength up to approximately (500–550) nm, where maximum transmittance values are achieved. Beyond this region, a noticeable decrease in transmittance occurs, especially for the highly doped samples. This behavior is consistent with the absorption spectra and reflects the formation of additional localized electronic states associated with $Cu^{2+}$ incorporation into the PVA/PVP network.

The significant reduction in transmittance at higher copper acetate concentrations can be attributed to increase optical absorption arising from charge-transfer interactions between $Cu^{2+}$ ions and the functional groups of the polymer chains. Such interactions are expected to introduce defect-related energy levels within the forbidden band gap, facilitating photon absorption and reducing the amount of transmitted light.

Furthermore, the decreasing in transmittance with increasing dopant concentration suggests an increase in structural disorder and electronic state density within the polymer matrix. These modifications enhancing light–matter interaction and contribute to the observed reduction in optical band gap energy.

It can be demonstrated from the results that, the highly transparent PVA/PVP blend into a material with enhanced optical absorption and reduced transparency, which is desirable for various optoelectronic and photonic applications requiring efficient light harvesting and charge-carrier generation.

**The absorption coefficient**

The absorption coefficient is a fundamental optical parameter that describes the ability of a material to absorb incident electromagnetic radiation at different wavelengths The absorption coefficient can be estimated from Figure (5) which illustrates the variation of the optical absorption coefficient (α) as a function of wavelength (λ) for the samples $P_0$–$P_4$.

A sharp decline in α is observed in the wavelength range of approximately 320–450 nm. This decrease can be attributed to the reduction in photon energy with increasing wavelength, according to the relation: [18]

$E=hc/\lambda$ ……(1)

Where E is the photon energy, his Planck's constant, and cis the speed of light. As the photon energy decreases, the probability of electronic transitions across the band gap becomes lower, leading to reduced optical absorption.

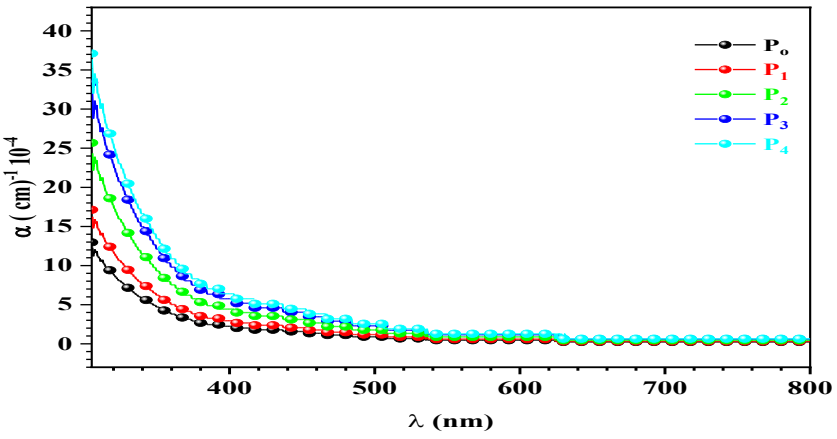



Figure (5) The relationship between absorption coefficient and wavelength.

The magnitude of varies significantly with concentration, highlighting the role of dopants in modifying the sample's optical properties [19].

The reference sample ($P_0$) demonstrates the lowest values throughout the energy range, signifying minimal absorption. With increasing dopant concentrations ($P_{0.05}$, $P_{0.2}$, $P_{0.25}$), the extinction coefficient rises, with exhibiting the highest values. This behavior suggests that higher dopant concentrations introduce additional

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume XI Issue IX September 2026

localized states or defect sites within the bandgap, which enhance light-matter interactions and increase the absorption.

Furthermore, the absorption coefficient values follow the order ($P_4>P_3>P_2>P_1>P_0$) throughout most of the investigated spectral range. This trend indicates that the modification introduced from $P_0$ to $P_4$ significantly enhances the optical absorption capability of the material. The enhancement may be associated with an increase in charge carrier concentration, the formation of additional localized energy states, improved crystallinity, or a higher density of allowed electronic transitions.

The absorption coefficient reaches values on the order of $10^5$ $cm^{-1}$ in the UV region, which is indicative of strong optical absorption and efficient photon–matter interaction. Such high values are commonly associated with direct electronic transitions in semiconductor materials and suggest that the samples possess excellent light-harvesting properties. At wavelengths above approximately 600 nm, the absorption coefficient approaches very low values for all samples, indicating reduced photon absorption due to insufficient photon energy to induce significant interbond transitions. The results demonstrate that the optical absorption coefficient decreases with increasing wavelength for all samples, reflecting the dependence of absorption on photon energy. The increase in absorption coefficient ( α ) from $P_0$ to $P_4$ confirms that the applied modification effectively improves the optical response of the material. The high absorption coefficients observed in the UV region suggest strong electronic transitions and highlight the potential suitability of these materials for optoelectronic applications such as photodetectors, solar cells, and UV-shielding devices.

The relationship between photon energy and the squared product of the absorption coefficient and photon energy, Equation (1) represent the reflectance coefficient which is: [20-21]

$R=1-(Texp(A))^{1/2}$……. (2)

**The energy gap**

Figure (6) presents the variation of $((\alpha h\nu)^2)$ as a function of photon energy ($h\nu$) for samples $P_0$–$P_4$. This plot, commonly known as the Tauc plot, is employed to determine the direct optical band gap energy ($(E_g)$) of semiconductor materials according to the Tauc relation:[22]

$(\alpha h\nu)^2=A(h\nu-Eg)$ ……(3)

where (A) is a constant, ($h\nu$) is the photon energy, and (Eg) is the optical band gap energy. The linear portion of each curve is extrapolated to intersect the energy axis, yielding the corresponding band gap value. The estimated band gap energies obtained from the plot are in Table (2) which its shows variation of optical Band Gap Energy (Eg) with dopant concentration for $P_0$–$P_4$ samples.

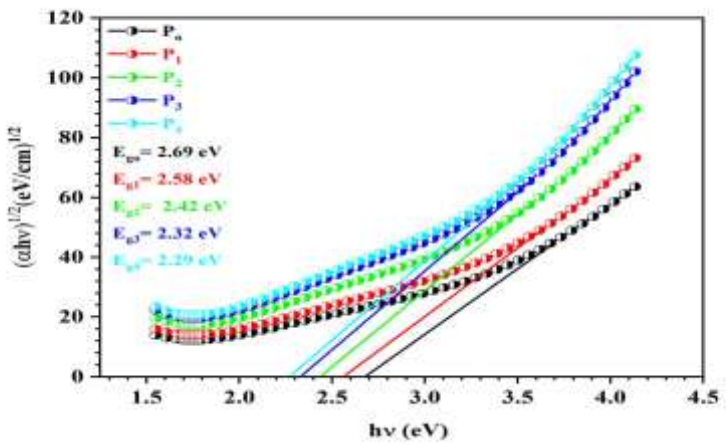



Figure (6): The $(\alpha h\nu)^2$ versus the photon energy to finding $E_g$ with doping concentrations.

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume XI Issue IX September 2026

Table (2): The energy gap ($E_g$) for each doping concentration.

| Sample | $P_0$ | $P_1$ | $P_2$ | $P_3$ | $P_4$ |
|---|---|---|---|---|---|
| $E_g$ (eV) | 2.69 | 2.58 | 2.45 | 2.32 | 2.28 |

These results reveal a systematic reduction in the optical band gap with the progression from $P_0$ to $P_4$. The observed band-gap narrowing suggests that the modification introduced into the material significantly alters its electronic structure. This behavior can be attributed to the formation of localized energy levels within the forbidden band, an increase in structural disorder, enhanced defect density, or electronic interactions associated with dopant incorporation. Such effects facilitate electronic transitions at lower photon energies, thereby reducing the energy required for excitation from the valence band to the conduction band.

Moreover, the gradual decrease in ($E_g$) is consistent with the increase in the absorption coefficient observed in the UV–visible absorption spectra. As the band gap narrows, the absorption edge shifts toward lower energies (longer wavelengths), enabling the material to absorb a broader portion of the electromagnetic spectrum. This red shift enhances the optical response and light-harvesting capability of the samples.

The highest band-gap value is observed for $P_0$ (2.69 eV), indicating the widest separation between the valence and conduction bands, whereas $P_4$ exhibits the lowest band-gap value (2.20 eV), reflecting the strongest modification of the electronic structure and the greatest enhancement in optical absorption.

The Tauc analysis confirms that all samples exhibit a direct allowed optical transition. The optical band gap decreases progressively from 2.69 eV to 2.28 eV as the composition changes from $P_0$ to $P_4$, indicating a significant modification of the electronic band structure. The reduction in (Eg) correlates well with the increase in the absorption coefficient, demonstrating that the treated samples possess improved visible-light absorption characteristics. These findings suggest that the modified materials are promising candidates for optoelectronic and photovoltaic applications, where enhanced light absorption and reduced band-gap energies are desirable.

Figure (7) shows the extracted bandgap energies for the samples at various dopant concentrations, demonstrate a systematic reduction as the dopant concentration increases, highlighting significant alterations in the sample's electronic structure

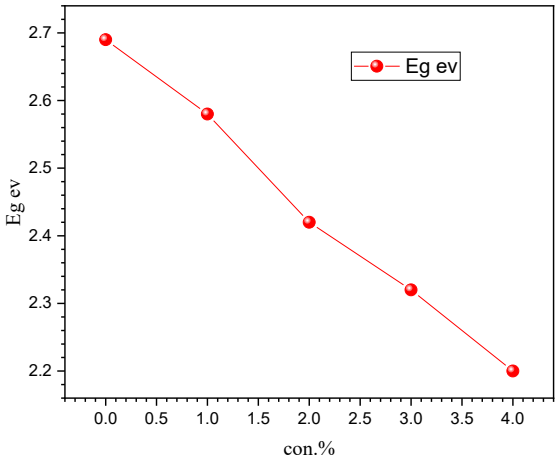



Figure (7): The energy gap (Eg) verses doping concentrations.

At low concentrations the bandgap remains relatively high and, respectively, indicating minimal perturbation to the lattice. However, as the dopant concentration increases, the bandgap narrows significantly, suggesting the introduction of localized states within the bandgap due to structural distortions or defect generation [23,24]. These localized states increase the material's absorption at lower photon energies and broaden its optical response; a behavior linked to Urbach tail effects. Such bandgap narrowing enhances light absorption in optoelectronic applications but may introduce trade-offs, such as higher recombination rates due to defect states,

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume XI Issue IX September 2026

requiring optimization in device design. This trend underscores the tunability of optical and electronic properties through dopant engineering, with applications ranging from transparent coatings at low dopant levels to high-absorption devices at higher concentrations. Further studies, such as density functional theory (DFT) simulations, could provide deeper insight into the mechanisms influencing this behavior [25].

**4-The refractive index (n)**

Figure (8) shows the variation of the refractive index (n) with wavelength (λ) for the pure and copper acetate-doped PVA/PVP blend films. The refractive index exhibits a strong wavelength dependence throughout the investigated spectral range. All samples display a sharp increase in refractive index (n) at the ultraviolet region near 300 nm, followed by a rapid decreasing. The appearance of a broad peak in the visible region at (approximately 500–600 nm). The maximum refractive index is observed for sample $P_1$, reaching a value of about 14.5 at around 540 nm, whereas the other samples exhibit lower peak intensities. Beyond 600 nm, the refractive index gradually decreases with increasing wavelength and tends to stabilize in the near-infrared region. The observed dispersion behavior can be attributed to electronic polarization and inter-band optical transitions, indicating that the modification introduced in the samples significantly influences their optical constants and light–matter interaction properties.[26]

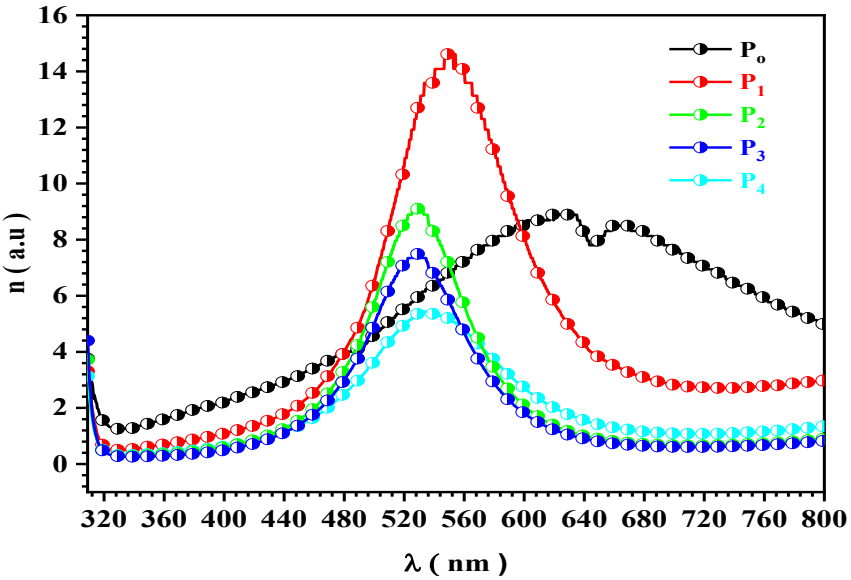



Figure (8): The relationship between the optical refractive index (n) and wave length for samples with varying concentrations.

**The Extinction coefficient (K)**

The plotted data in figure (9) illustrates the extinction coefficient (K) for four different concentrations of a material, denoted as $p_0$, $p_{0.05}$, $p_{0.2}$ and $p_{0.25}$, measured as a function of photon energy. This analysis provides valuable insights into the optical absorption behavior of the material under varying dopant concentrations [27].

At lower photon energies (eV), all concentrations exhibit negligible extinction coefficients (K), indicating high optical transparency in this region. This transparency is attributed to the photon energies being insufficient to overcome the sample's bandgap energy, which prevents electronic transitions from the valence band to the conduction band[28-29]. As the photon energy increases (eV), a significant rise in is observed, signaling enhanced optical absorption due to interbond electronic transitions. The onset of this increase in provides an estimate of the material's bandgap energy, which appears consistent across all concentrations.

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume XI Issue IX September 2026

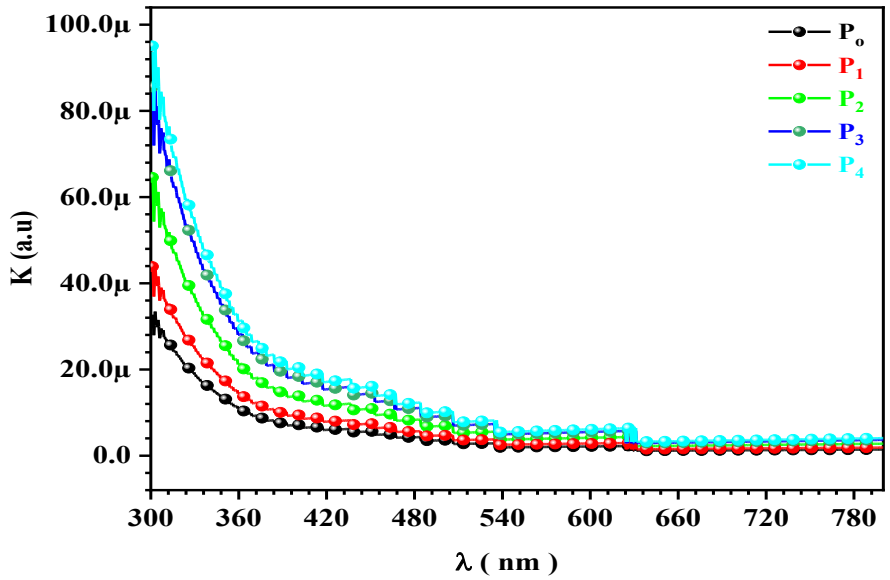



Figure (9): The extinction coefficient (K) verses wave length for manufacturing samples.

**The Dielectric constants**

The dielectric constant describes the response of electrons to the electromagnetic field and the dielectric constant is represented by its real and imaginary parts. The dielectric constant which is consists real part (εr) and the imaginary part (εi) can be determined by using are the following relations: - [30-31]

$\varepsilon r = n2+k2$ (8)

$\varepsilon i = 2nk$ (9)

Figures (10) and (11) represent the relationship between the real and imaginary dielectric constant with the energy of the incident photon energy for PVA/PVP at various copper acetate concentrations as a function of photon energy respectively. It can be observed that, the real dielectric constant behaves like a refractive index, while the imaginary dielectric constant behaves like Extinction coefficient.

It can be seen that the behavior of real part (εr) similar to the behavior of the refractive index (n), because the effect of extinction coefficient is very small which implies to smaller values of ($K_2$) in comparison with ($n_2$) but the behavior of imaginary part (εi) mainly depends on the variation of extinction coefficient (K). Also, it can be noticed that, the values of the real dielectric constant (εr) are greater than the imaginary part of dielectric constant (εi).

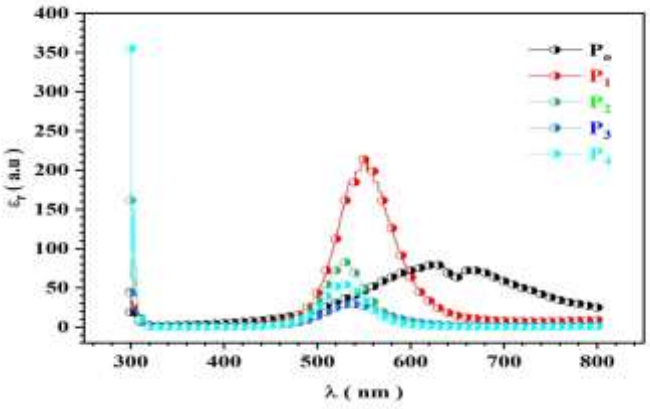



Figure (10): The relationship between the real dielectric constant and wavelength.

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume XI Issue IX September 2026

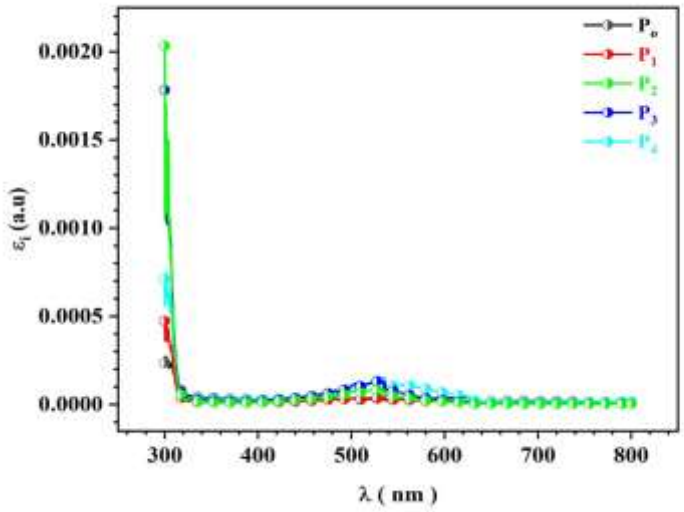



Figure (11): The relationship between the imaginary dielectric constant and wavelength.

## CONCLUSION:

The present study investigates the influence of copper acetate doping on the structural, optical, and dielectrical properties of polyvinyl alcohol (PVA) and polyvinylpyrrolidone (PVP) polymer blend films, prepared using the solution casting method.

The absorption coefficient increased with doping, particularly in the UV-Visible region (300–800 nm). the extinction coefficient (K) and refractive index (n) increased with doping, reflecting enhanced light-matter interaction. Bandgap narrowing and the presence of defect states due to doping were observed, improving the material's absorption at lower photon energies. Copper acetate doping significantly modifies the optical, structural, and electrical properties of PVA/PVP films.

UV-Vis spectroscopy revealed that increasing copper acetate concentration decreased the optical bandgap from 2.69 eV (pure sample) to 2.28 eV indicating enhanced light absorption. These changes make the materials suitable for optoelectronic applications, such as photodetectors and photovoltaic devices.

## REFERENCES:

1. Almaliky, A.J.H., Abdullah, N.A., Hussein, H.F., Ajeel, K.I., Ibrahim, I.K. (2023). The influence of nickel acetate $Ni(CH_3CO_2)_2$ concentrations on the optical properties of epoxy resin-based $ZnO/Al_2O_3$ composites. Web of Scientific Research Journal, 4(5), May 2023. ISSN: 2776-0979.
2. Al-Maliky, A.J., Grebennikov, A.A., Semenenko, K.I., Smirnov, A.N., Stogner, O.V. (2015). Effect of the matrix material on the magneto transport properties of Fe–Al–O and Fe–Nb–O. Bulletin of the Voronezh State Technical University, 5, 123–128.
3. Almaliky, A.J.H., Hussein, H.A., Mohsin, Y.R., Stognei, O.V. (2024). Thermo-emf granular metal–dielectric composites: $Fe(Al_2O_3)$, $Fe(Nb_2O_3)$, $Ni(Al_2O_3)$, and $Ni(Nb_2O_3)$. Letters in High Energy Physics, 2024. ISSN: 2632-2714.
4. Abdullah, N.A., Mohammed, A.J., Falik, Z.T., Almaliky, A.J.H., Ibrahim, I.K. (2023). The influence of palm fronds ash on some physical properties of polypropylene. Journal of Polymer Research, 18, May 2023. ISSN: 2795-7667.
5. Jeong, S.H., Park, B.N., Lee, S.B., Bos, J.H. (2005). Surface modification and coating characteristics. Surface and Coatings Technology, 193, 340–346.
6. Kim, H., Gilmore, C.M. (2000). Electrical and optical behavior of polymer films. Applied Physics Letters, 76, 259–261.

7. Badran, H.A., Hussain, H.F., Ajeel, K.I. (2016). Nonlinear characterization of conducting polymers for solar cell and antibacterial applications. Optik, 127, 5301–5307.
8. Hasan, H.A., Ajeel, K.I. (2020). Effect of dopant concentration in sol–gel derived AZO layers on solar cell efficiency. International Journal of Physical and Applied Sciences, 7(1), 42–54.
9. Badran, H.A., Al-Hazam, H.A., Alfahed, R.K., Ajeel, K.I. (2021). Second-order hyperpolarizability and nonlinear optical properties of organic compound-doped polymers. Journal of Materials Science: Materials in Electronics,32,14623–14641. https://doi.org/10.1007/s10854-021-06021-2
10. Stognei, O.V., Al-Maliky, A.J., Sitnikov, A., Makagonov, V. (2015). Thermoelectric power of gradient Fex($Al_2O_3$)$_{100–x}$ composite films. Solid State Phenomena, 233–234, 694–698.
11. Stognei, O.V., Sitnikov, A.V., Al-Maliky, A.J. (2014). Preparation of Fex($Al_2On$)$_{100–x}$ concentration-gradient composite films. Bulletin of the Voronezh State Technical University, 10(1), 7–11.
12. Hasan, H.A., Ajeel, K.I. (2019). Bulk heterojunction solar cells based on poly(o-anisidine)/$TiO_2$ nanocomposites. Iraqi Journal of Polymers, 22(1), 75–87.
13. Almaliky, A.J.H., Hussein, H.F., Ajeel, K.I. (2020). Electrical properties of Fe$Al_2O_3$/paraffin wax composites. IOP Conference Series: Materials Science and Engineering.
14. Lazim, H.G., Ajeel, K.I., Badran, H.A. (2015). Photovoltaic efficiency of P3HT:PCBM devices fabricated on nano-anatase $TiO_2$. Spectrochimica Acta Part A, 145, 598–603.
15. Enriquez, J.P., Mathew, X. (2003). Optical properties of semiconductor thin films. Solar Energy Materials and Solar Cells, 76, 313–320.
16. Al-Hazam, H.A., Alfahed, R.K., Imran, A., et al. (2019). Optoelectronic properties of organic compound-doped PMMA. Journal of Materials Science: Materials in Electronics, 30, 10284–10292.
17. Fakher Alfahed, R.K., Al-Asadi, A.S., Badran, H.A., Ajeel, K.I. (2019). Structural and nonlinear optical properties of ZnS nanoparticles. Applied Physics B, 125, 48–58.
18. Ullrich, B.U., Bagnall, D.M., Sakai, H., Segawa, Y. (2000). Luminescence properties of semiconductor films. Journal of Luminescence, 87–89.
19. Ojha, K.S., Srivastava, R.L. (2013). Chalcogenide thin films: optical behavior. Chalcogenide Letters, 10, 1–10.
20. Abdullah, O.G., Sabar, D.R. (2012). Optical absorption of PVA films doped with nickel chloride. Applied Mechanics and Materials, 110, 177–182.
21. Gao, J., Xu, J., Chen, B., Zhang, Q. (2007). QSPR study of refractive indices of conjugated polymers. Journal of Molecular Modeling, 13(5), 573–578.
22. Ezema, E.I., et al. (2007). Growth and optical properties of $Ag_2S$ thin films. Journal of the University of Chemical Technology and Metallurgy, 42(2), 217–222.
23. R. K. F. ALfahad, Dheyaa Alameri, Khitam Alsaedi, Hanan A.Al-hazam, Hussain A Badran, Riyadh Ch.Abul-Hail, and Khalid I. Ajeel. "Investigation of the structural and optoelectronic properties and nonlinear characteristics of poly(O- toluidine )/ inorganic materials. " J Mater Sci: Mater Electron 36 : 569 (2025). Springer. https://doi.org/10.1007/s10895-025-140626-0
24. Nadhim A. Abdullah, Hussein F. Hussein, Khalid I. Ajeel, Shatha S. Ebade. "Investigation of Optical Properties of Polymeric Composite (PVA/PVP) Doped by Potassium Chromate. "Engineering and Technology Journal. Volume 09 P.No.-5131-5139 e-ISSN: 2456-3358, DOI: 10.47191/etj/v9i09.15, I.F. – 8.227 © 2024, ETJ
25. Qasim Sattar Kareem, Hussan K. Ibrahim, Abd-Alamer Imran, Hussain A. Badran, Riyadh Ch. Abul-Hail, and Khalid I. Ajeel. "Holographic and diffraction patterns of Schiff base liquid crystal-doped PMMA polymer". J Mater Sci: Mater Electron (2025) 36:2258. Springer. https://doi.org/10.1007/s10854-025-16329-y
26. Qasim S. Kareem 1, Nadhim A. Abdullah, Hassan K. Ibrahim, Khalid I. Ajeel, Hussein F. Hussein, Ibrahim K. Ibrahim." Structural and Optical Characteristics of ZnO Nanoparticles-Doped Epoxy Resin Thin Films" IRAQI JOURNAL OF APPLIED PHYSICS Vol. 22, No. 3, (2026), pp. 350-357 5
27. H.A. Badran, K.I. Ajeel, and H.G. Lazim, "Effect of nano particle sizes on the third-order optica nonlinearities and nanostructure of copolymer P3HT:BCPM thin film for organic photovoltaics", Mater. Res. Bulletin, 76, 422, (2016).

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume XI Issue IX September 2026

28. K. M. Ziadan, H.F. Hussein, and K.I Ajeel," Study of the electrical characteristics of poly(O-tolidine) and application in Solar cell", Energy Procedia, 18, 157, (2012).
29. H. A. Al-Hazam, R.K. Fakher Al-fahad, A. Imran, H.A. Badran, H.S. Shaker, A. Alsalihi, and K.I. Ajeel, "Preparation and optoelectronic studies of the organic compound [2-(2,3 dimethyl phenylamino)-N–Phenyl benzamide doped (PMMA)]", J. Mater. Sci.: Mater. Electron., 30, 10284, (2019).
30. Ajeel, K.I and Kareem, Q.S, "Optical Properties For Prepared POLYANILINE/GRAPHENE Nano Composites Films", Journal of Basrah Researches (Sciences), 45(2), (2019).
31. Ajeel, K.I and Kareem, Q.S, "Synthesis and characteristics of Polyaniline (PANI) Filled by Graphene (GR) Nano film", IOP. Conf., Journal of Physics Conf. Series, 1234, (2019).