The effect of Adding (ZrC) Nanoparticles to (PVP-PVA) Blend on their Optical properties for Humidity Sensor Application

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Abstract. The optical properties for adding (ZrC) nanoparticles to (PVP-PVA) were studied. The Poly(vinyl alcohol) and poly(vinyl pyrrolidone) were blended and films were obtained by the casting method. Zirconium carbide nanoparticles (ZrC) were added with different weight percentages (4 wt.%, 8 wt.%, 12 wt.% and 16 wt.%) to the (PVP-PVA) blend. The wavelength range used to measure the optical properties is (220-820) nm. Analyzing the results it is found that the absorbance (A) decrease by increasing the (ZrC) nanoparticles concentrations, while the coefficient of absorption (α), coefficient of extinction (k), index of refraction and the constants of real and imaginary (ε1, and ε2) increased by increasing the concentration of (ZrC) nanoparticles. The gap of energy (Eg) of (PVP-PVA) blend increases with the increasing of (ZrC) nanoparticles weight percentages.

Keywords. Polyvinyl pyrrolidone, Poly (vinyl alcohol), Zirconium carbide nanoparticles

1. Introduction
The effect of adding nanoparticles to polymer blends is subject of interests for authors in recent years. The applications like, sensors, the conversion of solar energy, light-emitting diodes, coating and many other applications have great importance and attract the attention of scientists to study their properties [1,2]. The major benefits of electrolytes for the polymer are their mechanical properties, the facility of manufacturing desirable sizes for thin films and their capacity to make legitimate electrode/electrolyte contact in electrochemical gadgets [3]. The low cost of Poly vinyl alcohol (PVA) processing makes it very significant as polymeric materials in addition to its wide range of industrial applications. The PVA-doped phosphoric acid is condensed as sloid in solid photocells and in solid-state digital chromic displays as an electrolyte. PVA also exhibits certain physical properties as semi-crystalline content because of the precious interfacial effects without the shape of stone [4]. PVP is a conjugating polymer Polyvinyl pyrrolidone with electric conductivity is medium. Its significance stems from its simple procedural capacity and its high ecological reliability [5]. Physical blending (Mixing) of polymers makes another material with a portion of the ideal properties of every individual polymer [6]. Mixing is considered as an option in contrast to the mind-boggling expense of growing new materials. It is realized that the directing polymers have been of constrained helpfulness in applications as a result of its shakiness and in process capacity. It has been conceivable to acquire a procedure capable conductive mix by scattering leading polymer in a non–directing polymer. PVP/PVA mix have a decent charge stockpiling limit and its electrical and optical properties firmly rely upon the dopant. The point of the
The present work is to examine the optical properties for including (ZrC) nanoparticles to (PVP-PVA). The Poly (vinyl liquor) and poly (vinyl pyrrolidone) were mixed and films were acquired by the throwing technique.

2. Experimental

2.1. Materials and preparation of samples

VP-PVA Arrangement was made by dissolving it in water by utilizing attractive stirrer in blending procedure to get homogeneous. The Poly (vinyl liquor) and poly (vinyl pyrrolidone) were mixed and films were gotten by the throwing strategy. Zirconium carbide nanoparticles (ZrC) were included with various weight rates (4 wt.% , 8 wt.% , 12 wt.% and 16 wt.% ) to the (PVP-PVA) mix. what's more, blended for 20 minutes to get increasingly homogenous arrangement. The optical properties were estimated in the wavelength see the (220-820) nm. The optical constants are vital in light of the fact that they portray the optical conduct of the materials. The retention coefficient of the material is exceptionally solid capacity of photon vitality and band hole vitality.

Assimilation (An) is characterized as the proportion between consumed light power (IA) by material and the occurrence force of light (Ic).

\[ A = \frac{I_A}{I_0} \]

Transmittance (T) is given by reference to the radiation intensity transmitted from the movie (I) to the incident radiation intensity (Io) (T = I / Io) and can be determined by:

\[ T = \exp(-2.303A) \]

And reflectance (R) can also be achieved from spectra of absorption and transmission according to the energy conservation law by the relationship:

\[ R + T + A = 1 \]

The following formula determines the absorption coefficient \( \alpha \) of the addition of (ZrC) nanoparticles into (PVP-PVA) blend:

\[ \alpha = 2.303 \frac{A}{t} \]

Here the absorbance is A and specimen thickness is t.

For amorphous materials, the indirect transition is:

\[ \alpha h \nu = B(h \nu - E_g)^r \]

Here the constant is B and the energy of the photon is \( h \nu \), \( E_g \) is the gap of optical band of energy, \( r=2 \) is the indirect transition permitted and \( r=3 \) is the indirect transition forbidden. The refractive index (n) is defined by the following equation for adding (ZrC) nanoparticles to (PVP-PVA) blend:

\[ n = \left(1 + R^{1/2}\right)\left(1 - R^{1/2}\right) \]

The dielectric constants (\( \varepsilon \)) is divided into two real parts (\( \varepsilon_1 \)) and the imaginary parts (\( \varepsilon_2 \)) are calculated using the following equations:

\[ \varepsilon_1 = n^2 - k^2 \]
\[ \varepsilon_2 = 2nk \]

Optical conductivity (\( \sigma_{op} \)) can be determined as:

\[ \sigma_{op} = \frac{\alpha_{pc}}{4\pi} \]

Manufacturing of humidity sensors: the humidity sensors were used to apply (ZrC) nanoparticles to (PVP-PVA) blend, using a (2x2) cm2 spin-coating process after cleaning by ethanol and distilled water and was left for two days to be dried mixture by the precipitated solution of these bio-multi-composites. A vacuum evaporation method (Edwards Coating Method C) type used aluminum electrode deposition on the sample surface of nanoparticles attached (ZrC) to (PVP-PVA). The water vapor as a moisture source was used to test the specimen in the box. The sensor network monitors and controls humidity changes. The power was assessed by using the local LCR meter (Hioki 3532-50 LCR HiTester) type system for different moisture ranges (40-90 %).
3. Result discussions
The main purpose of this studying the optical properties for adding (ZrC) nanoparticles to (PVP-PVA) Blend. The study covers the recording of the spectrum of absorbance for the (PVA-PVP-ZrC) films and the calculation of the absorption coefficient at room temperature, extinction coefficient and other optical constants, and identify the types of electronic transitions and calculate the energy gaps.

3.1. The Absorbance (A)
Figure 1 demonstrates the ingestion range of including (ZrC) nanoparticles to (PVP-PVA) Blend as a component of the wavelength of the occurrence light. It very well may be seen from the assumption that the absorbance for all movies has a high incentive at the wavelength

![Absorbance as a function of wavelength for adding (ZrC) nanoparticles to (PVP-PVA) Blend.](image1)

In the area of the principal ingestion edge (240 nm), at that point the absorbance diminishes with the expansion of wavelength. By and large, the absorbance of movies has low qualities in the obvious and close infrared locale. This conduct can be clarified as pursues: at high wavelength the episode photon doesn't have enough vitality to collaborate with molecules, So, as wavelength decreases, the photon is transmitted (at the area of the major assimilation edge), the communication between occurrence photon and material will happen, and afterwards absorbance will increment [8]. As it were, the episode light retains by the free electrons. Subsequently, by the expansion of the load rates of yttrium oxide nanoparticles, absorbance is expanded.

![Transmittance as a function of wavelength for adding (ZrC) nanoparticles to (PVP-PVA) Blend.](image2)
3.2. Transmittance Spectrum
Figure 2 indicates the optical transmission spectrum in comparison to the incident light wavelength in (PVP-PVA) blend of nanoparticles (ZrC). The figure shows that transmittance decreases with the increase concentration (ZrC) nanoparticles. It is due to the addition (ZrC) of nanoparticles in which outer orbits can absorb energy from the incident light to lower levels of energy, which is not followed by radiation emission because of the vacant position of the electron in high levels of the energy bands. Therefore, absorption of the light incident in some parts by and does not penetrate the material; pure electron on the other hand (PVA and PVP) is of considerable because no free electrons are there transmission (i.e. electrons bound to atoms by the covalent ties) [9].

3.3. Absorption Coefficient ($\alpha$)
Equation 4 is used to calculate the $\alpha(cm)^{-1}$ absorption coefficient; Fig. 3 shows the $\alpha(cm)^{-1}$ absorption coefficient as a feature of the nanoparticle-adding photon energy (ZrC) for PVP-PVA Blend. The absorption coefficient can be seen as being the lowest at Long wavelength and low energy, meaning that the transfer of the electron is small because of the photon incident energy is not enough to shift the electron from the valence range to the conducting range ($h\nu < E_g^{opt}$) [10].

With a higher energy absorption, the strength of the photon incident is, therefore, enough to transfer an electron between the valence conduction bands, so the energy of the photon incident is greater than that of the forbidden energy gap. It shows that the absorption coefficient helps to sense the essence of the electron transfer when the absorption coefficient values are large ($\alpha > 10^4$) cm$^{-1}$ It is assumed that the energy and moment of electrons and photons will be preserved in the case of high energies, because the coefficient of absorption is small ($\alpha < 10^4$) cm$^{-1}$ at low energies, Indirect transfer of electron is predicted, and with phonon on support the electronic momentum remains[10], The other results include that absorption coefficient for adding (ZrC) nanoparticles into (PVP-PVA) blends is less than $(10^4$ cm$^{-1}$).

3.4. The (Allowed and Forbidden) Indirect Transition Optical Energy Gaps
The allowed and prohibited energy gap indirect band transition was determined from eq. 5. The relationship between the absorbent edge is shown in Fig.4 ($\alpha h \mu$)$^{1/2}$ (ZrC) to (PVP-PVA) mixture and photon energy (PVP-PVA) blend, when drawing directly from the top of the curve into the (x) value axis ($\alpha h \nu$)$^{1/2}$, we get energy gap for the indirect transfer allowed the energy gap is. The energy gap values decrease with increased ZrC nanoparticles. This was because localized rates were generated in the forbidden energy gap [11]. This behavior is explained by the fact that nanocomposite is of a heterogeneity type (i.e. the electron conduction depends on the extra concentration) during a two-phase transition of electron from the valence to the local level into the leading band as a result of the increase of the weight portion of the ZrC nano-pieces. Localized state density has been increased by increasing ZrC nanoparticles concentration. In the same way, the prohibited conversion of the indirect energy gap is measured, so the permitted transfer of the indirect energy gap to (PVP-PVA) blend (ZrC) is obtained. Figure 5 indicates the prohibited transition from (PVP-PVA) to (PVP-PVA) blend for the indirect energy gap for adding (ZrC).
3.5. **Real and Imaginary Parts of Dielectric Constant ($\varepsilon_1$, $\varepsilon_2$)**

The dielectric constant for two parts (real and imaginary) for adding (ZrC) nanoparticles to (PVP-PVA) blend were calculated from eqs. 7 and 8, respectively. The transition from ($\varepsilon_1$) to wavelength shows in figure 6. Figure 3. The figure shows that ($\varepsilon_1$) is also considerably dependent on ($n^2$) due to the low level of ($k^2$), with the increase in ZrC-nanoparticles concentration the actual dielectric constant is also increased. The change of ($\varepsilon_2$) as a wavelength function is shown in Figure 7. The figure shows that ($\varepsilon_2$) dependent on ($k$) values that, as a consequence of the relationship between ($\alpha$) and ($k$), change the absorption coefficient.
Figure 6. Real dielectric constant as a function of wavelength to add (ZrC) nanoparticles to (PVP-PVA) blend.

3.6. Coefficient of extinction ($k$)
Coefficient of extinction ($k$) is determined by equation 6, extinction coefficient for Blend as a function of the wavelength is shown in Figure 8. The low concentration of ($k$) can be seen to be lower and to grow with the increase in ZrC nanoparticles. This is because the absorption is enhanced with an increase in ZrC nanoparticles. This result indicates that the atoms of ZrC nanoparticles will modify the structure of the host polymer [12].

Figure 7. Imaginary dielectric constant as a function of wavelength for adding (ZrC) nanoparticles to (PVP-PVA) Blend.
3.7. Index of refraction (n)
The index of refraction (n) is determined from eq. 6. Figure 9 shows the refractive index for adding (ZrC) nanoparticles to (PVP-PVA) Blend as a function of wavelength. It is clear from the figure that the refractive index increases with increasing weight percentages of the concentration of ZrC nanoparticles to the (PVA and PVP) because of increasing in density nanocomposites. In the ultraviolet region, it can be noticed that therefore high values of the refractive index due to low transmittance in this region, whereas in the visible region, low values were observed due to high transmittance in this region. [13].

4. Conclusions
The (PVP-PVA) blend absorbance increase with the increase in nanoparticle ZrC concentrations and a decrease in transmission with the increase in ZrC nanoparticle concentrations. Optical constants for (ZrC) addition of nanoparticles to (PVP-PVA) blend (absorption, extinction coefficient, refractive index and real and imaginary dielectric constants). Increasing concentrations of nanoparticles with increasing concentrations (ZrC).

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