Structural and Optical Properties of (PVA/PVP: Sr$_2$NO$_3$) Nanocomposites

Doaa E. Al-Kateb$^1$, Ali R. Abdulridha$^2$

Abstract
In this study preparing and investigating of the (PVA/PVP: Sr$_2$NO$_3$) nanocomposites films by using casting method with different concentration of Sr$_2$NO$_3$ as (0, 1, 3, 5, and 7 wt. %). Optical properties obtained by UV-Vis spectrometer, OM and FTIR spectra have been revealed in this study, the absorbance increased by increasing of Sr$_2$NO$_3$ nanoparticles concentrations, the energy-gap (allowed and forbidden) transitions decreased by increasing of the nanoparticles concentration.

Key Words: Sr$_2$NO$_3$ Nanoparticle, Polyvinyl Alcohol, Polyethylene Glycol.

Introduction
As we cannot imagine our planet without the atmosphere layer, we also cannot ideate our daily life without polymers, specially the synthetic ones. Polymers are all around us and could be responsible for the life itself, we may find them in food, water, clothes, buildings, cars and even in our bodies (Carraher, 2017). The term nano is came from the Greek word for dwarf or an abnormally short person, usually used as a prefix for any unit like a second or a meter. It is mean a billionth of that unit, so nano materials are the materials whose the individual particles of sizes in the range of 1-100 nm, in one dimension or more. 1-nanometer is similar to 10 hydrogen or 5 silicon atoms aligned in a line (Hu, 2013). PVA is semi crystalline polymer composed of mainly amorphous phases with little pet of crystallinity (Chiellini et al, 2002). The molecular weight and degree of hydrolysis with the molecular weight is generally responsible for most PVA properties, PVA molecular weight is spanning between (20,000-400,000) g/mol which based on the length of vinyl acetate that used to produce PVA.

In world war II, the Germans introduced Polyvinyl Pyrrolidone (PVP) as a blood plasma substitute (Singha et al, 2015). A water-soluble polymer which its most important value is due to its ability to form loose addition compounds with many substances. PVP is a biocompatible and hydrophilic material that has take advantage of the pharma industries (Tanase et al, 2015).

Experimental Work
Materials and Method
(80%) of the PVA of molecular weight (67000 wt.%) was dissolved in (50 ml) of distilled water by using a magnetic stirrer with rising in temperature gradually until reaching 75 °C for (1.5 hour), then the solution was cooled to (45 °C), after that a 20% PVP with molecular weight (30k) was added to form the polymeric blend with keeping the mixture temperature for 40 minutes, to attain the polymeric nanocomposites, Sr$_2$NO$_3$ nanoparticles was added with different concentrations (0, 1, 3, 5, and 7 wt.%) gradually to the polymeric blend for half an hour.

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The solution was then tipped into a plastic petri dish to dry completely at RT.

**Results and Discussion**

*Optical Microscope*

**Figure 1.** show the images of (PVA/PVP:Sr$_2$NO$_3$) nanocomposites with different concentrations of Sr$_2$NO$_3$ at magnification power (10x). The change of surface morphology of the nanocomposites films is shown by the optical microscope images. These images illustrated fine homogeneity of the matrix with a good distribution of Sr$_2$NO$_3$ into the polymer blends. The images of OM exhibited a successful preparation of the (PVA/PVP:Sr$_2$NO$_3$) nanocomposites using this method(Sapalidis et al, 2011).

**Figure 1.** The OM images of the nanocomposites films with different concentrations of Sr$_2$NO$_3$ nanoparticles as (A) Pure Blend, (B) 1% wt Sr$_2$NO$_3$ Nanoparticles, (C) 3% wt Sr$_2$NO$_3$ Nanoparticles, (D) 5% wt Sr$_2$NO$_3$ Nanoparticles, (E) 7% wt Sr$_2$NO$_3$ Nanoparticles

*Fourier Transform Infrared Radiation*

**Figure 2.** show the FTIR spectrum and the functional groups that we got from the nanocomposites films were listed in the table below (Sinha Ray et al, 2005).
Figure 2. FTIR spectrum of (PVA/PVP: Sr\textsubscript{2}NO\textsubscript{3}) nanocomposites films with different concentrations of Sr\textsubscript{2}NO\textsubscript{3} nanoparticles as a function of wavenumber (A) Pure Blend, (B) 1% wt.Sr\textsubscript{2}NO\textsubscript{3} Nanoparticles, (C) 3% wt.Sr\textsubscript{2}NO\textsubscript{3} Nanoparticles, (D) 5% wt.Sr\textsubscript{2}NO\textsubscript{3} Nanoparticles, (E) 7% wt.Sr\textsubscript{2}NO\textsubscript{3} Nanoparticles

Table 1. The functional groups of the (PVA/PVP:Sr\textsubscript{2}NO\textsubscript{3}) nanocomposites films as appeared in FTIR spectra

<table>
<thead>
<tr>
<th>Functional Groups</th>
<th>Type of Bonds</th>
<th>Stretching cm\textsuperscript{-1}</th>
<th>Bending cm\textsuperscript{-1}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkanes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methylene group (CH\textsubscript{2})</td>
<td>C-H</td>
<td>2912.87</td>
<td>1400</td>
</tr>
<tr>
<td>Alcohol group</td>
<td>O-H</td>
<td>3355.84</td>
<td>----</td>
</tr>
<tr>
<td></td>
<td>C-O</td>
<td>1240</td>
<td>----</td>
</tr>
<tr>
<td></td>
<td>C-O-H</td>
<td></td>
<td>1350</td>
</tr>
<tr>
<td>Amines</td>
<td>C-N</td>
<td>1323.93</td>
<td>----</td>
</tr>
<tr>
<td>Ketone</td>
<td>C=O</td>
<td>1710.55</td>
<td>----</td>
</tr>
<tr>
<td>Nitro</td>
<td>N=O</td>
<td>1300</td>
<td>----</td>
</tr>
</tbody>
</table>

**UV-Vis Spectroscopy**

The absorbance of the (PVA/PVP: Sr\textsubscript{2}NO\textsubscript{3}) nanocomposites films with nanoparticles concentration as (0,1,3,5 and 7 wt.%) is showed in figure 3. A large absorption at ultraviolet region and a low absorption values at visible and infrared regions (Guimaraes, et al, 2015).

The absorbance is given by the equation:

\[ A = \frac{I_A}{I_0} \quad (1) \]
Figure 3. The Absorbance of the (PVA/PVP:Sr$_2$NO$_3$) nanocomposites films with different concentrations of Sr$_2$NO$_3$ nanoparticles as a function of wavelength

A decrease in transmittance of the (PVA/PVP:Sr$_2$NO$_3$) nanocomposites films as the concentrations of Sr$_2$NO$_3$ nanoparticles increase as a function of wavelength region that calculated by the equation (2) (Tang et al, 2008).

\[ T = \exp (-2.303A) \]  \hspace{1cm} (2)

Where T is the transmission, A is the absorption.

Figure 4. The Transmittance of the (PVA/PVP:Sr$_2$NO$_3$) nanocomposites films with different concentrations of Sr$_2$NO$_3$ nanoparticles as a function of wavelength

A decrease in the energy gap of (PVA/PVP:Sr$_2$NO$_3$) nanocomposites films as shown in figure. 5. The absorbance coefficient takes a small value at small photon energy and rises gradually as the photon energy rising, the absorbance coefficient is given by: (Tang et al, 2016).

\[ \alpha = 2.303A/t \]  \hspace{1cm} (3)

where t is the thickness of sample, A the absorption.
A decrease in the energy gap for (allowed and forbidden) indirect transitions as a result of adding the nanoparticles of Sr2NO3 with different concentrations for the (PVA/PVP:Sr2NO3) nanocomposites films according to equation (4). As shown in figures (6) and (7) (Mousa et al, 2016).

$$\alpha h\nu = B(h\nu - E_g)^r$$  (4)

Where B is a constant, $h\nu$ is the photon energy, $E_g$ is the energy-gap and $r = 2$ for allowed-indirect transitions, $r = 3$ for forbidden indirect transitions.
**Table 2.** The values of energy band gap for the allowed and forbidden indirect transition for (PVA/PVP: Sr$_2$NO$_3$) nanocomposites

<table>
<thead>
<tr>
<th>Sr$_2$NO$_3$ Nanoparticles Concentrations</th>
<th>Eg (eV) Allowed</th>
<th>Forbidden</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5.2</td>
<td>5</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
<td>4.8</td>
</tr>
<tr>
<td>3</td>
<td>4.8</td>
<td>4.7</td>
</tr>
<tr>
<td>5</td>
<td>4.7</td>
<td>4.63</td>
</tr>
<tr>
<td>7</td>
<td>4.6</td>
<td>4.5</td>
</tr>
</tbody>
</table>

The extinction coefficient ($k$) and refractive index ($n$) of the (PVA/PVP: Sr$_2$NO$_3$) nanocomposites are shown in figures (8) and (9) respectively. Extinction coefficient ($k$) and refractive index ($n$) will increase with the increasing of Sr$_2$NO$_3$ nanoparticles, this means that the adding of Sr$_2$NO$_3$ nanoparticles enhanced the absorbance, because of the high transmittance values at the visible region, the refractive index will takes a small values whereas, in ultraviolet region, refractive index takes a large values because of low transmittance values at this region (Gaas et al, 2015).

$$k = \frac{\alpha \lambda}{4\pi} \quad (5)$$

Where ($\lambda$) is the wavelength of incident light.

$$n = (1 + R^2)(1 - R^2) \quad (6)$$

Where $R$ is the nanocomposites reflectance, given by:

$$R = 1 - \frac{\lambda}{4} - T \quad (7)$$
The real and imaginary dielectric constant of the (PVA/PEG: Sr$_2$NO$_3$) nanocomposites films as a function of wavelength are shown in figures (10) and (11) respectively. A similar behavior of the real dielectric constant $\varepsilon_1$ as the refractive index and its depends on $n^2$, there is a direct relationship between $\alpha$ and $k$, so the imaginary part depend on $k$. $\varepsilon_1$ and $\varepsilon_2$ are both increasing by increasing the nanoparticles amount (Zhou et al, 2009), which represented by equations (8,9):

$$\varepsilon_1 = n^2 - k^2$$  \hspace{1cm} (8)
$$\varepsilon_2 = 2nk$$  \hspace{1cm} (9)
Figure 11. The imaginary dielectric constant of the (PVA/PVP:Sr$_2$NO$_3$) nanocomposites films with different concentrations of Sr$_2$NO$_3$ nanoparticles as a function of wavelength

Conclusions
Optical microscopy images showed a fine homogeneity of the matrix with a good distribution of Sr$_2$NO$_3$ into the polymer blends. FTIR spectra showed a shifted peak for stretching and bending of the bonds comparing with standard spectra. The absorbance increased by increasing the nanoparticles concentrations, all samples showed a decrease in the energy gap for allowed and forbidden transitions, real and imaginary dielectric constant showed increasing as the nanoparticles of Sr$_2$NO$_3$ amount increased.

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References


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