Structural and Optical Properties of (PVA/PVP:Sr_2NO_3) Nanocomposites

Doaa E. Al-Kateb[1*], Ali R. Abdulridha[2]

Abstract

In this study preparing and investigating of the (PVA/PVP:Sr_2NO_3) nanocomposites films by using casting method with different concentration of Sr_2NO_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_2NO_3 nanoparticles concentrations, the energy-gap (allowed and forbidden) transitions decreased by increasing of the nanoparticles concentration.

Key Words: SR_2NO_3 Nanoparticle, Polyvinyl Alcohol, Polyethylene Glycol.

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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_2NO_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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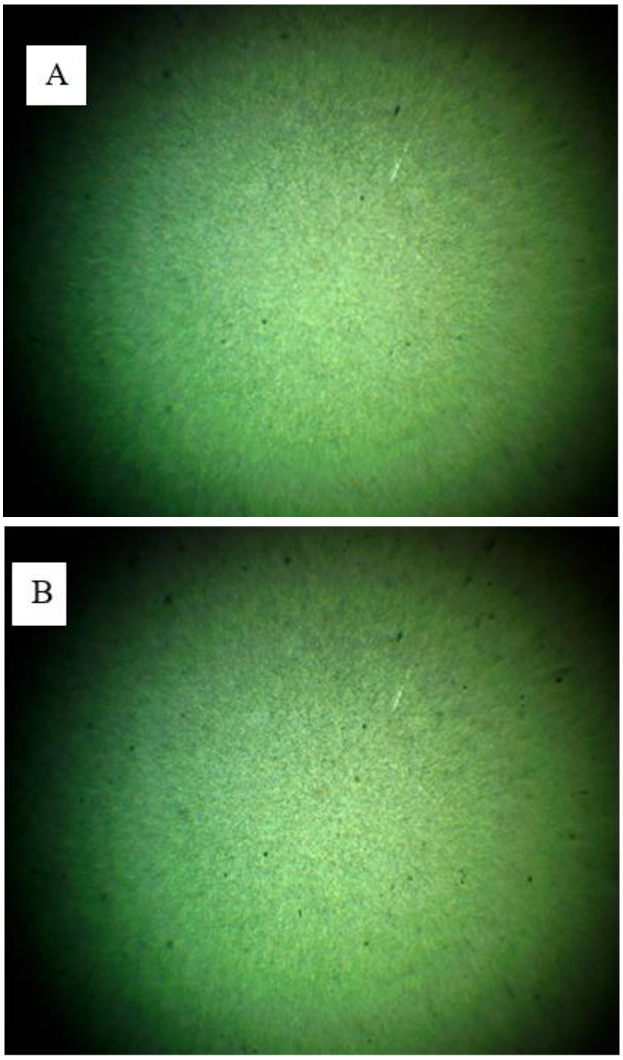
The solution was then tip into a plastic petri dish to dry completely at RT.

Results and Discussion

Optical Microscope

Figure. 1. show the images of (PVA/PVP:Sr_2NO_3) nanocomposites with different concentrations of Sr_2NO_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_2NO_3 into the polymer blends. The images of OM exhibited a successful preparation of the (PVA/PVP:Sr_2NO_3) nanocomposites using this method(Sapalidis et al, 2011).



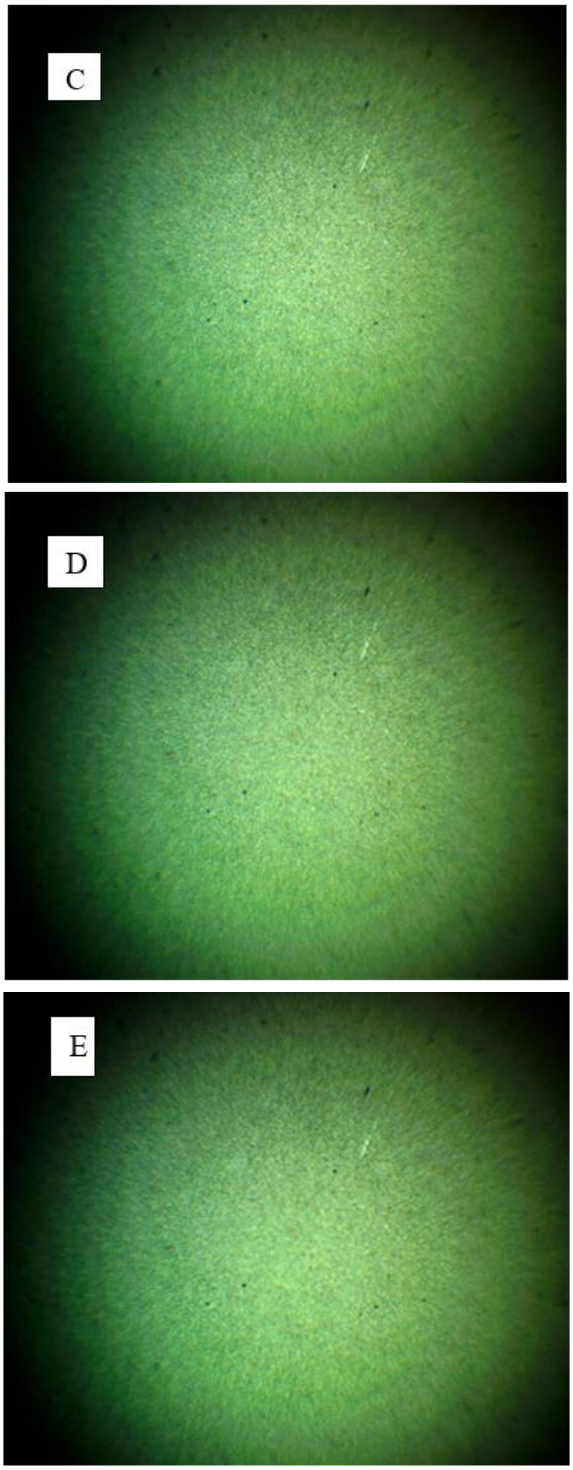
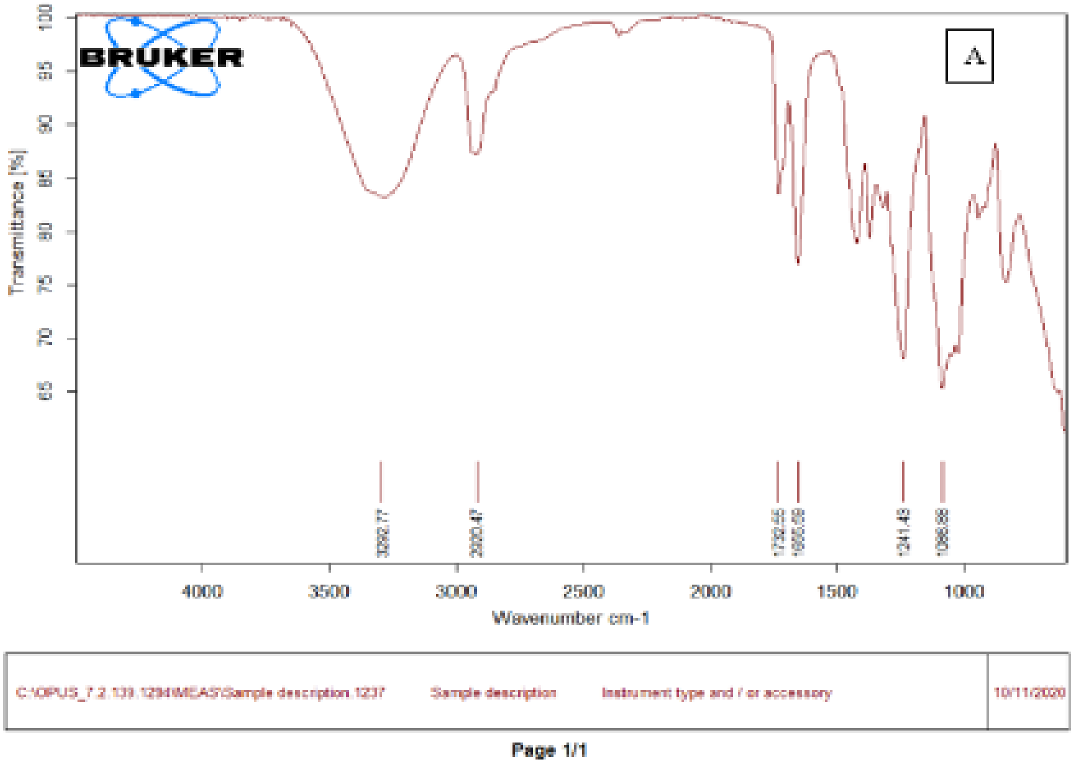


Figure 1. The OM images of the nanocomposites films with different concentrations of Sr_2NO_3 nanoparticles as A) Pure Blend, (B) 1% wt.Sr_2NO_3 Nanoparticles, (C) 3% wt.Sr_2NO_3 Nanoparticles, (D) 5% wt.Sr_2NO_3 Nanoparticles, (E) 7% wt.Sr_2NO_3 Nanoparticles

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 (Sinharay et al, 2005).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Transmittance [%]
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Sample description
Instrument type and / or accessory
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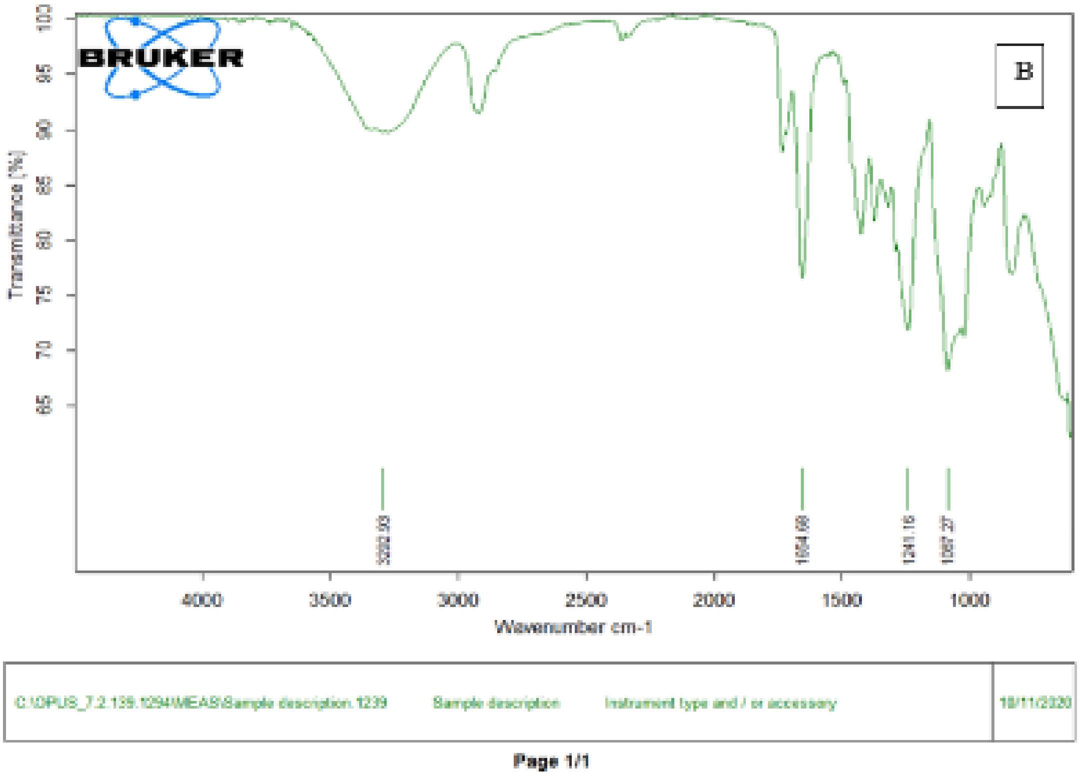
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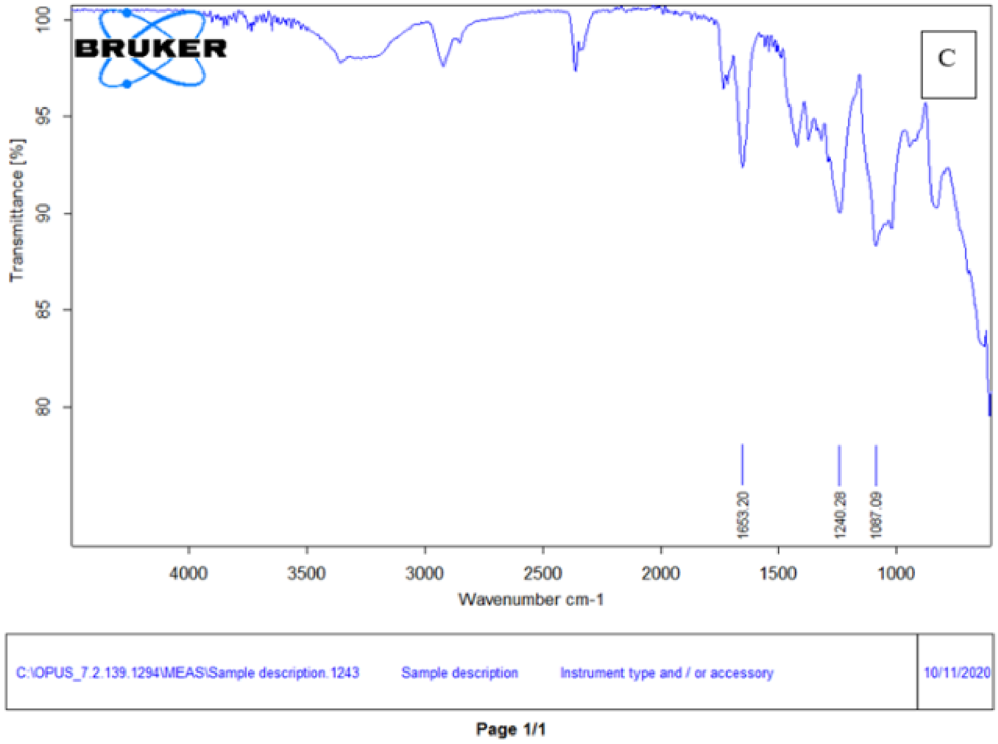
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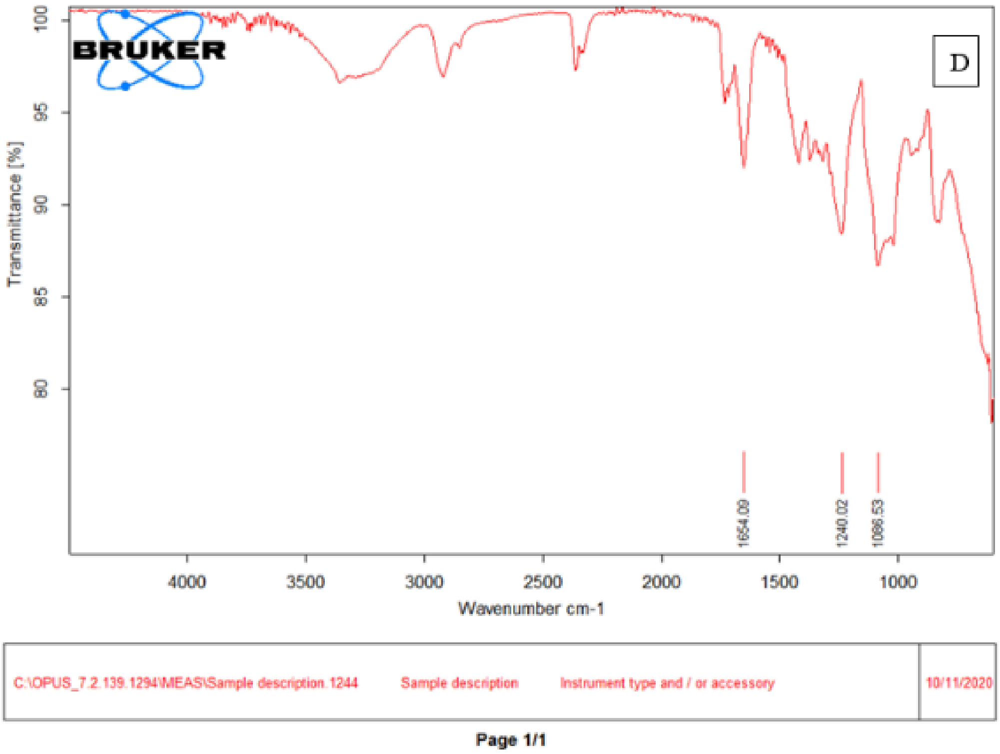
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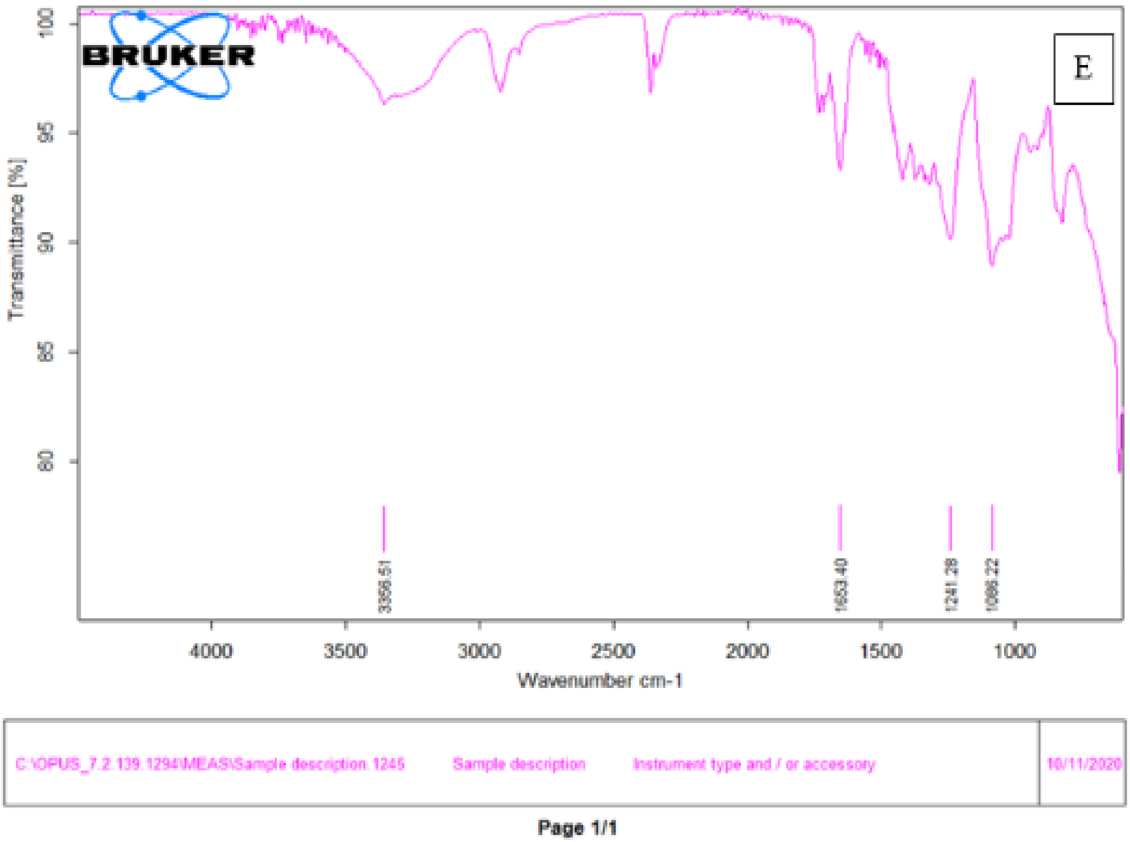

Figure 2. FTIR spectrum of (PVA/PVP: Sr_2NO_3) nanocomposites films with different concentrations of Sr_2NO_3 nanoparticles as a function of wavenumber (A) Pure Blend, (B) 1% wt.Sr_2NO_3 Nanoparticles, (C) 3% wt.Sr_2NO_3 Nanoparticles, (D) 5% wt.Sr_2NO_3 Nanoparticles, (E) 7% wt.Sr_2NO_3 Nanoparticles

Table 1. The functional groups of the (PVA/PVP:Sr_2NO_3) nanocomposites films as appeared in FTIR spectra

Functional Groups	**Type of Bonds**	**Stretching** cm-1	**Bending** cm-1
Alkanes			
Methylene group (CH2)	**C-H**	2912.87	1400
Alcohol group	**O-H**	3355.84	-----
	C-O	1240	-----
	C-O-H		1350
Amines	**C-N**	1323.93	-----
Ketone	**C=O**	1710.55	-----
Nitro	**N=O**	1300	-----

UV-Vis Spectroscopy

The absorbance of the (PVA/PVP:Sr_2NO_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:

$$A = \frac{I_A}{I_\circ} \qquad (1)$$

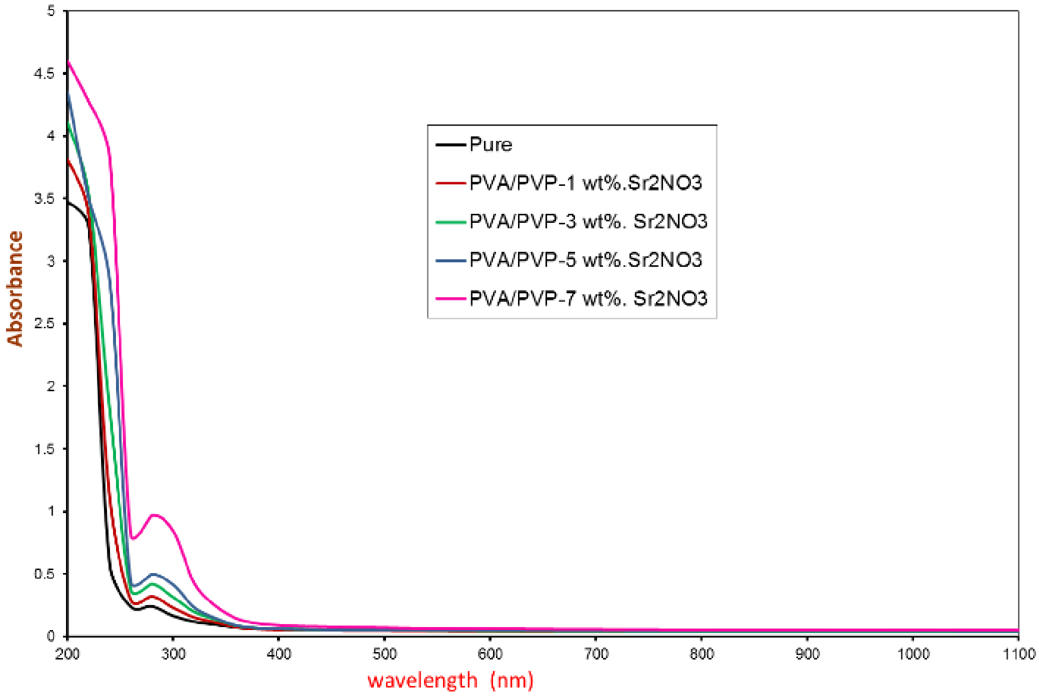

Figure 3. The Absorbance of the (PVA/PVP:Sr_2NO_3) nanocomposites films with different concentrations of Sr_2NO_3 nanoparticles as a function of wavelength

A decrease in transmittance of the (PVA/PVP:Sr_2NO_3) nanocomposites films as the concentrations of Sr_2NO_3 nanoparticles increase as a function of wavelength region that calculated by the equation (2) (Tang et al, 2008).

$$T = \exp(-2.303A) \qquad (2)$$

Where T is the transmission, A is the absorption.

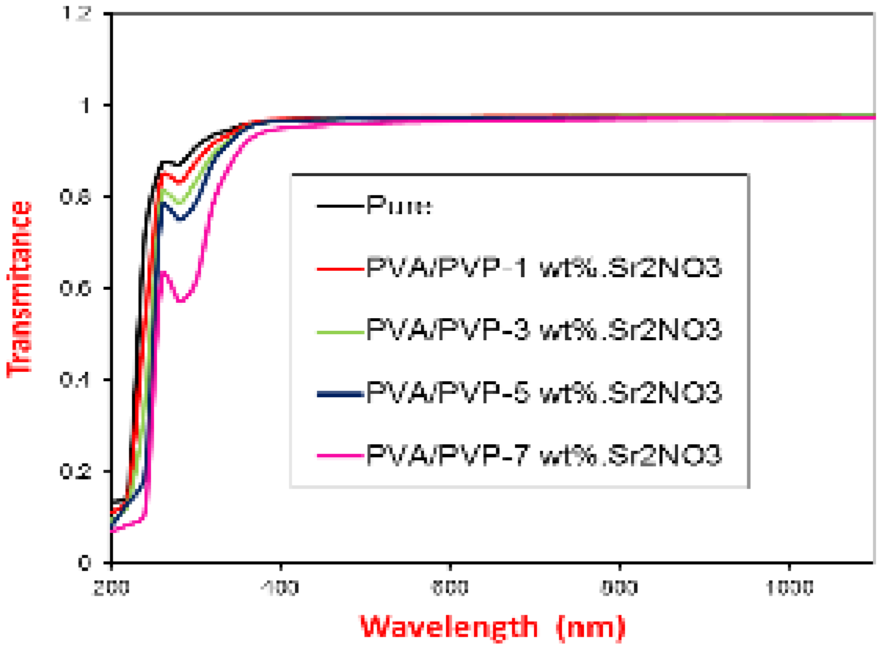

Figure 4. The Transmittance of the (PVA/PVP:Sr_2NO_3) nanocomposites films with different concentrations of Sr_2NO_3 nanoparticles as a function of wavelength

A decrease in the energy gap of (PVA/PVP:Sr_2NO_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).

$$\alpha = 2.303A/t \qquad (3)$$

where t is the thickness of sample, A the absorption.

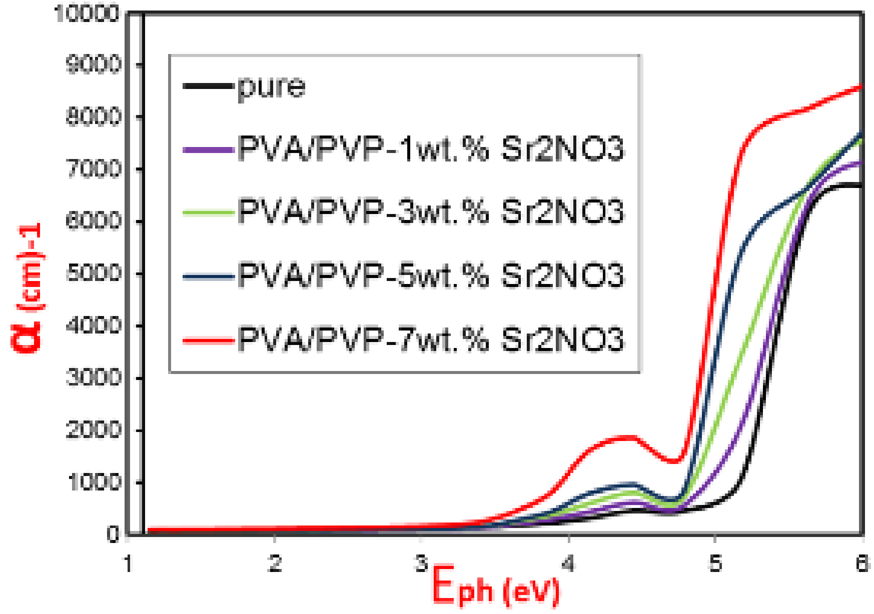

Figure 5. Absorbance coefficient of the (PVA/PVP:Sr_2NO_3) nanocomposites films with different concentrations of Sr_2NO_3 nanoparticles as a function of photon energy

A decrease in the energy gap for (allowed and forbidden) indirect transitions as a result of adding the nanoparticles of Sr_2NO_3 with different concentrations for the (PVA/PVP:Sr_2NO_3) nanocomposites films according to equation (4). As shown in figures (6) and (7) (Mousa et al, 2016).

$$\alpha h\nu = B(h\nu - Eg)^{r} \qquad (4)$$

Where B is a constant, hυ is the photon energy, Eg is the energy-gap and r = 2 for allowed-indirect transitions, r = 3 for forbidden indirect transitions.

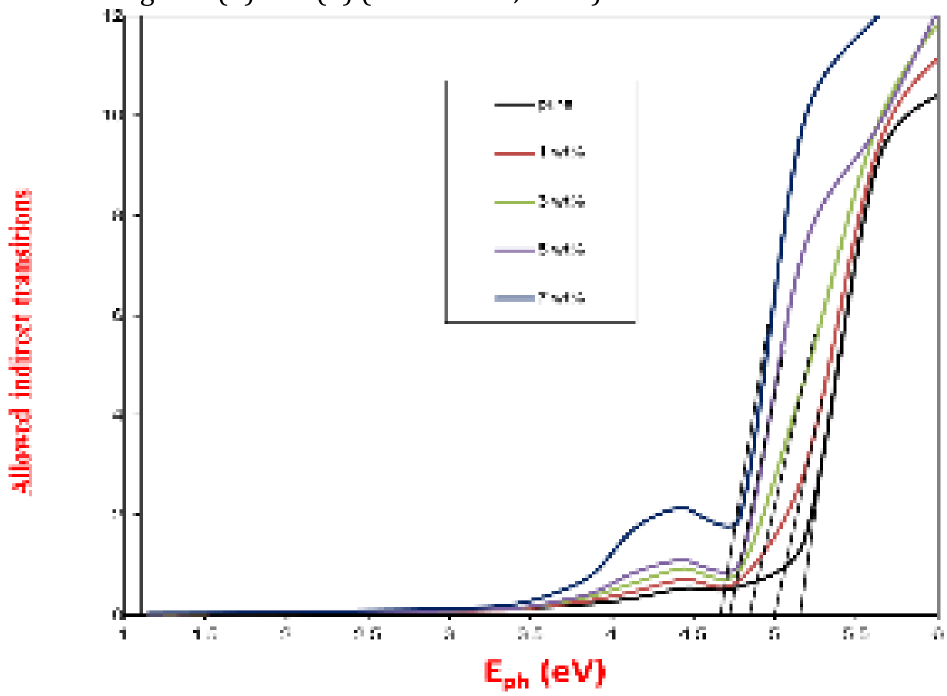

Figure 6. Allowed indirect transitions of the (PVA/PVP:Sr_2NO_3) nanocomposites films with different concentrations of Sr_2NO_3 nanoparticles as a function of photon energy

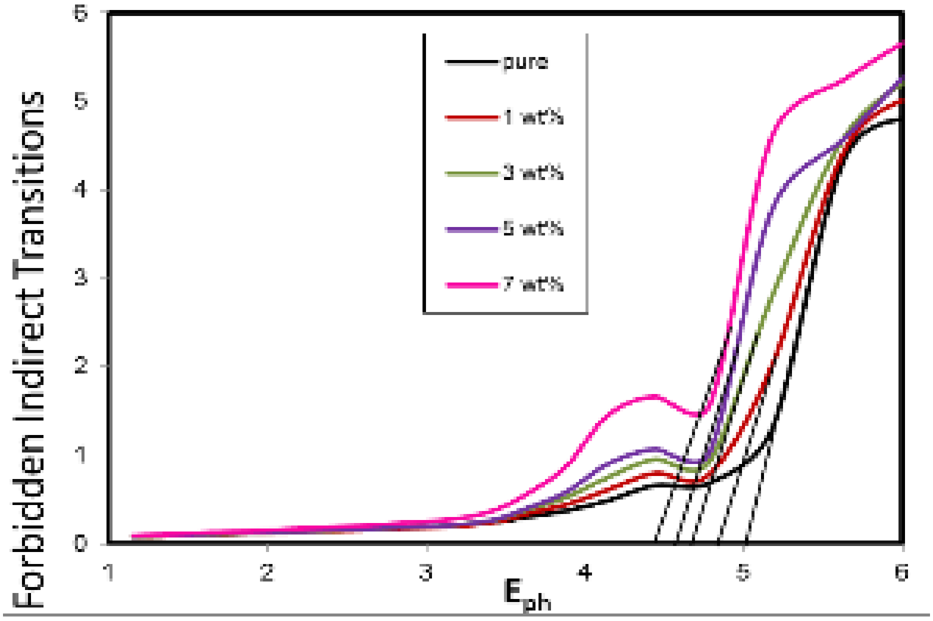

Figure 7. Forbidden indirect transitions of the (PVA/PVP:Sr_2NO_3) nanocomposites films with different concentrations of Sr_2NO_3 nanoparticles as a function of photon energy

Table 2. The values of energy band gap for the allowed and forbidden indirect transition for (PVA/PVP:Sr_2NO_3) nanocomposites

Sr_2NO_3 Nanoparticles Concentrations	Eg (eV) Allowed	Forbidden
0	5.2	5
1	5	4.8
3	4.8	4.7
5	4.7	4.63
7	4.6	4.5

The extinction coefficient (k) and refractive index (n) of the (PVA/PVP:Sr_2NO_3) nanocomposites are shown in figures (8) and (9) respectively. Extinction coefficient (k) and refractive index (n) will increase with the increasing of Sr_2NO_3 nanoparticles, this is means that the adding of Sr_2NO_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).

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

Where (λ) is the wavelength of incident light

$$n = (1 + R^{\frac{1}{2}})(1 - R^{\frac{1}{2}}) \qquad (6)$$

Where R is the nanocomposites reflectance, given by:

$$R = 1 - \frac{A}{4} - T \qquad (7)$$

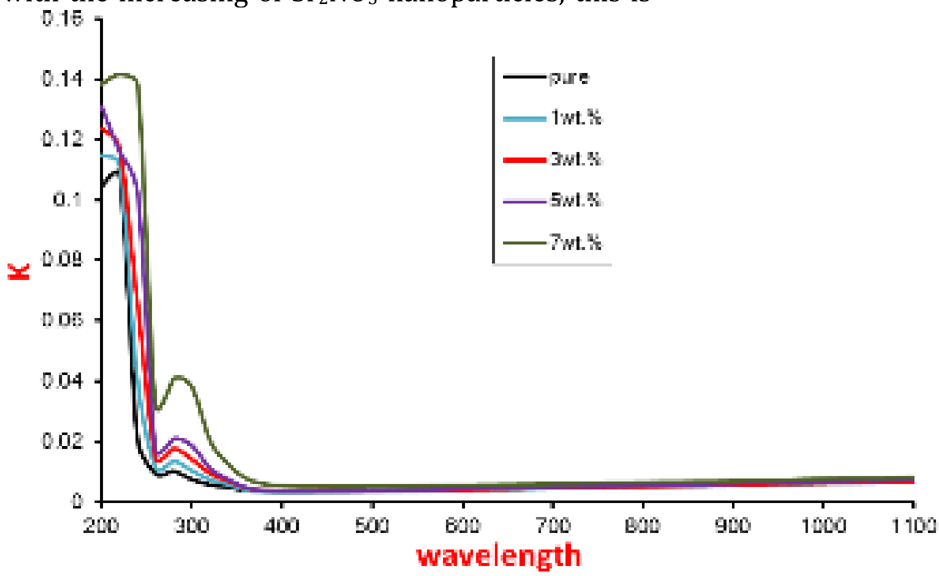

Figure 8. Extinction coefficient

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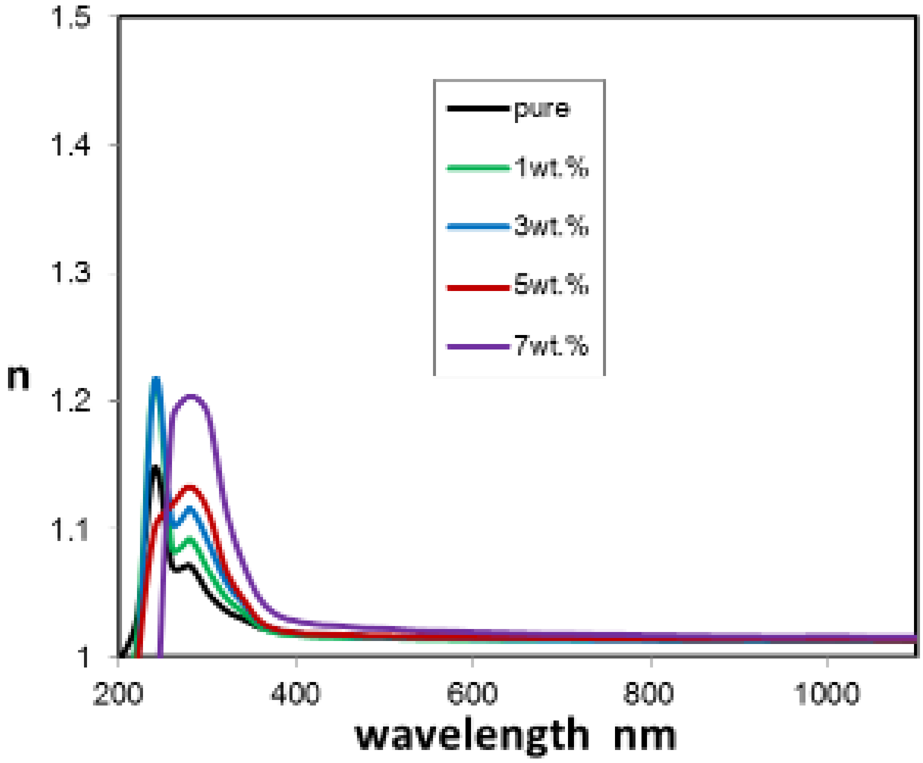

Figure 9. Refractive index

The real and imaginary dielectric constant of the (PVA/PEG:Sr_2NO_3) nanocomposites films as a function of wavelength are shown in figures (10) and (11) respectively. A similar behave of the real dielectric constant Ɛ1 as the refractive index and its depends on n^2, there is a direct relationship between α and k, so the imaginary part depend on k. $Ɛ_1$and $Ɛ_2$ are both increasing by increasing the nanoparticles amount (Zhou et al, 2009), which represented by equations (8,9):

$$Ɛ1 = n^2 - k^2 \quad (8)$$

$$Ɛ2 = 2nk \quad (9)$$

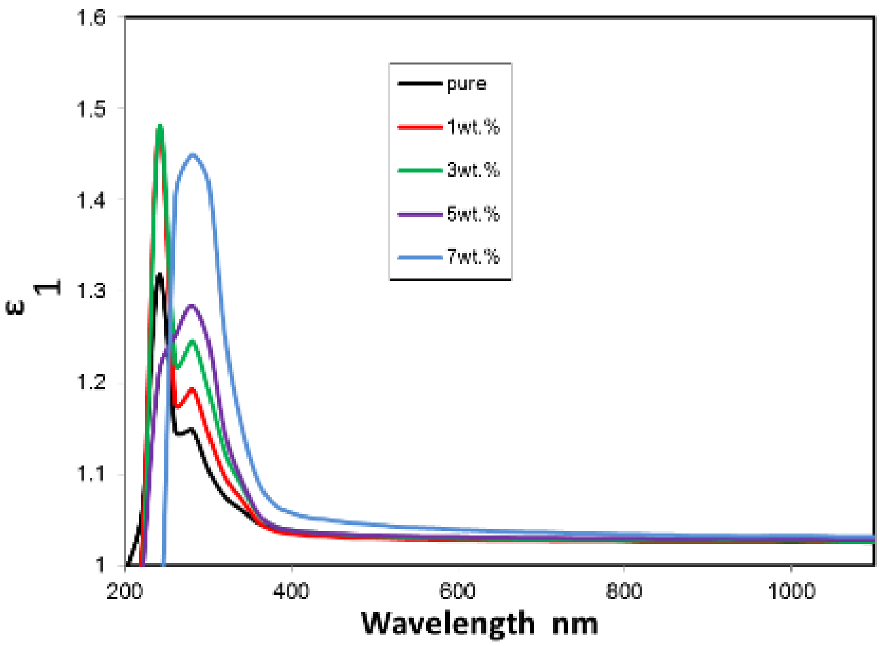

Figure 10. The real dielectric constant of the (PVA/PVP:Sr_2NO_3) nanocomposites films with different concentrations of Sr_2NO_3 nanoparticles as a function of wavelength

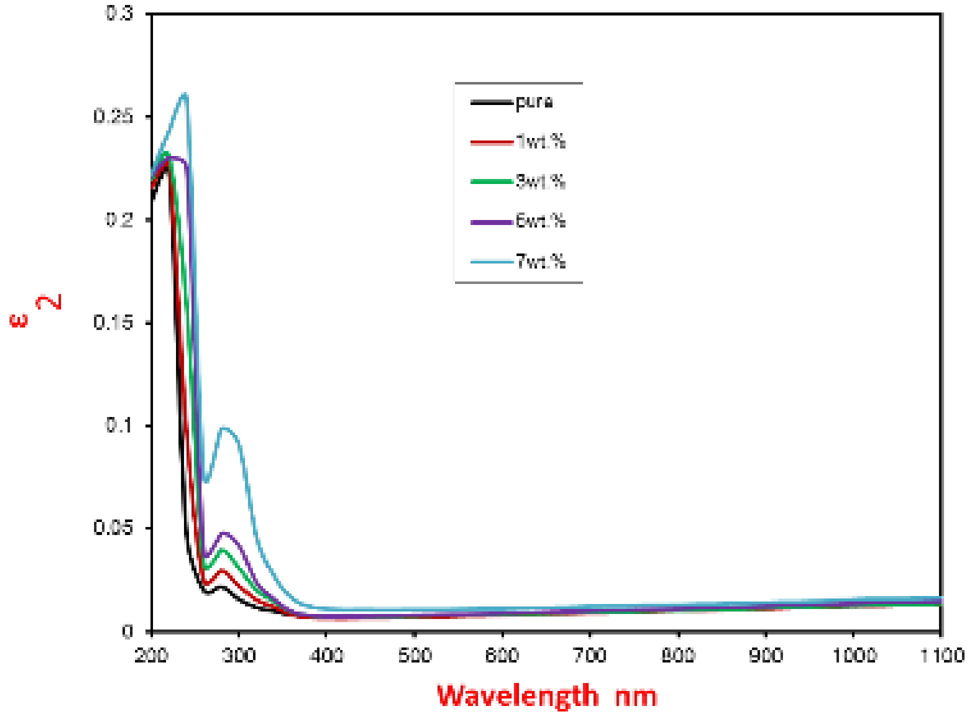

Figure 11. The imaginary dielectric constant of the (PVA/PVP:Sr_2NO_3) nanocomposites films with different concentrations of Sr_2NO_3 nanoparticles as a function of wavelength

Conclusions

Optical microscopy images showed a fine homogeneity of the matrix with a good distribution of Sr_2NO_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_2NO_3 amount increased.

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References

Carraher Jr, Charles E. *Introduction to Polymers.* Introduction to polymer chemistry 4th Ed. Taylor & Francis Group 2017: FL 33487- 2742.

Chiellini E, Chiellini F, Cinelli P. Polymers from renewable resources. Scott G (ed.) *Degradable polymers. principles and applications.* Dordrecht (Kluwer Academic Publisher) 2002; 163-234.

Gaaz TS, Sulong AB, Akhtar MN, Kadhum AAH, Mohamad AB, Al-Amiery AA. Properties and applications of polyvinyl alcohol, halloysite nanotubes and their nanocomposites. *Molecules* 2015; 20(12): 22833-22847.

Guimarães Jr, M, Botaro VR, Novack KM, Teixeira FG, Tonoli GHD. Starch/PVA-based nanocomposites reinforced with bamboo nanofibrils. *Industrial Crops and Products* 2015; 70: 72-83.

Hu W. *Introduction. Polymer Physics A Molecular Approach.* Springer Wien Heidelberg. New York Dordrecht. London 2013.

Mousa MH, Dong Y, Davies IJ. Recent advances in bionanocomposites: preparation, properties, and applications. *International Journal of Polymeric Materials and Polymeric Biomaterials* 2016; 65(5): 225-254.

Sapalidis AA, Katsaros FK, Kanellopoulos NK. PVA/ montmorillonite nanocomposites: development and properties. *Nanocomposites and polymers with analytical methods* 2011: 29-50.

Singha AS, Priya B, Pathania D. Cornstarch/poly (vinyl alcohol) biocomposite blend films: Mechanical properties, thermal behavior, fire retardancy, and antibacterial activity. *International Journal of Polymer Analysis and Characterization* 2015; 20(4): 357-366.

Ray SS, Bousmina M. Biodegradable polymers and their layered silicate nanocomposites: in greening the 21st century materials world. *Progress in materials science* 2005; 50(8): 962-1079.

Tănase EE, Popa ME, Râpă M, Popa O. Preparation and characterization of biopolymer blends based on polyvinyl alcohol and starch. *Romanian Biotechnological Letters* 2015; 20(2): 10306- 10315.

Tang S, Zou P, Xiong H, Tang H. Effect of nano-SiO2 on the performance of starch/polyvinyl alcohol blend films. *Carbohydrate polymers* 2008; 72(3): 521-526.

Tang X, Alavi S. Recent advances in starch, polyvinyl alcohol based polymer blends, nanocomposites and their biodegradability. *Carbohydrate polymers* 2011; 85(1): 7-16.

Zhou J, Ma Y, Ren L, Tong J, Liu Z, Xie L. Preparation and characterization of surface crosslinked TPS/PVA blend films. *Carbohydrate polymers* 2009; 76(4): 632-638.

Khalaph KA, Jafar AM. Lead-free two-dimensional perovskite solar cells cs3 fe2 cl9 using mgo nanoparticulate films as hole transport material. *NeuroQuantology* 2020; 18(2): 127-132.