Al-Sibd Center
for Research and Scholarly Publishing

Iraqi Journal of Nanotechnology
synthesis and application

Journal Homepage : https://publications.srp-center.iq/index.php/ijn

Synthesis and Characteristics of (PAV-PAVC-Ti) Nanocomposites

Waleed Khalid Kadhim[1], Maha Khalid Alshmmari[2], Maryam Adnan Al-Ethary[3]

1- Ministry of Education, Directorate of Educational Babylon, Hela, Iraq email: welidkalid37@gmail.com,
2- Ministry of Higher Education and scientific research, College of Engineering, Department of Biomedical Engineering, University of Karbala, Karbala, Iraq, email: maha.k@uokerbala.edu.iq.
3- Ministry of Education, Directorate of Educational Babylon, Hela, Iraq, email: mariem20132420@gmail.com

Keywords:

Nanocomposite;
Fourier Transform Infrared Spectroscopy (FTIR);
Scanning Electron Microscope (SEM);
Poly (vinyl alcohol);
Poly (vinyl acetate);
Titanium Nanoparticles;

Abstract

PVA-PVAC-Ti nanocomposites have been prepared by using the 'casting method' with different weight percentages of titanium nanoparticles. The (PVA-PVAC-Ti) nanocomposites have been diagnosed by different routes such as the 'Fourier Transform Infrared Spectroscopy (FTIR)', 'scanning electron microscope (SEM)' images, and optical microscope images. The experimental results (FTIR) showed increasing the value of the absorbance of the (PVA-PVAC-Ti) nanocomposites with an increase in the proportion of titanium nanoparticles. All peak characteristics remain the same and the most bond in the same wavenumber. The morphology of the (PVA-PVAC-Ti) nanocomposites films has been studied using (SEM) technique, which showed grain distribution at surface morphology and grain aggregates with increasing of titanium nanoparticles. Photos optical microscope shows the distribution of titanium nanoparticles atoms for all nanocomposite's films, it also shows a continuous network of ions inside the polymers in a ratio (16 wt.%) of (Ti. nanoparticles).

Introduction

In recent days, Nanomaterials based on polymers are viewed as multi-use materials, including scientific applications and part of technological advances, this is due to the incorporation of nanoparticles into polymer synthesis that affects extensively the surface morphology, and visual qualities [1], While preserving the original characteristics. A new way to improve the performance of materials in many applications such as biomedical, medical, coating materials, optical devices, and biological sensors [2].

Nanocomposites can be defined as are substances that appear at least one dimension in the nanometer range", and the size of the addition to the nano-miter, and the interactions become highly significant and result in significant changes in the properties of the final material. The nanocomposite consists of two parts, "filler and matrix", a traditional material in addition to padding is a nanomaterial [3,4]. Polymers are made up of large parts as a result of the replication of small building units associated with the polymerization process [5]. Polyvinyl alcohol is commonly written (PVA) by polymers which are very well known, used in many applications and quite common ones are semiconductors. PVA is a water-soluble polymer used widely in adhesives, paints, sealants, coatings, textiles, plastics... etc. Visible light transmittance is extremely high, and polymers have been used in the manufacture of optical devices because they contain distinct natural properties. [6], Such as high flexibility, ease of operation and mechanical strength are acceptable etc. are particularly useful in technical applications as in Table 1 [7]. Produced commercially at the hydrolysis of polyvinyl acetate (PVAC) as in Figure (1).

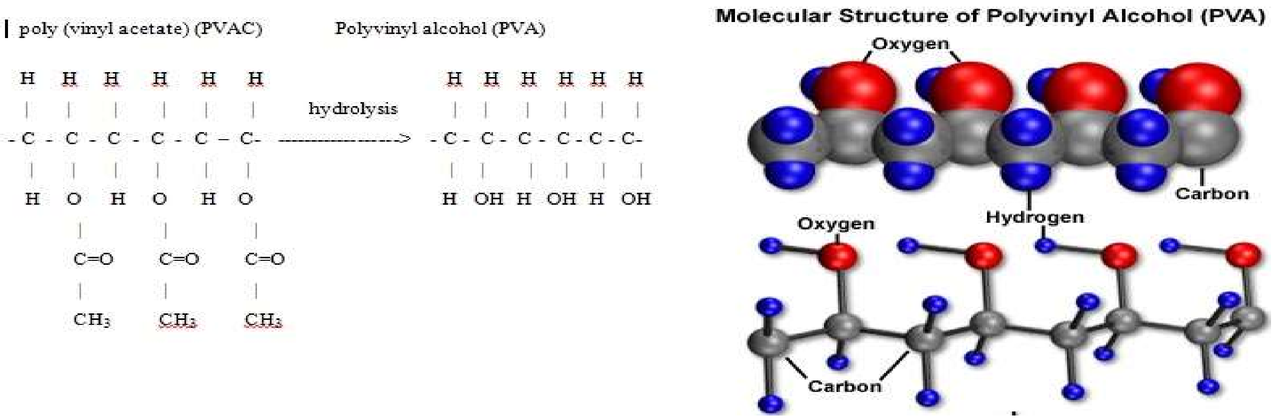


Figure 1 Preparation and molecular structure of polyvinyl alcohol

Table 1 Physical and chemical properties of polyvinyl alcohol [7, 8]

Appearance	White-to-cream granule powder
Molecular formula	(C2H4O) x
Resin density kg/m^3	1294
Specific gravity	1.3
Solution PH	5.0-7.0
Specific heat J/kg.K	1674
Refractive index	1.54
Melting point (unplasticized C^o)	230 for fully hydrolyzed grades

PVAC is a rubber polymer plant that holds the formula "C4H6O2"n, as in Figure 1. There are numerous labels for nanoparticles, nano-dot matrix, nano-powder, and titanium nanomaterials are usually (10-80) nm [9]. (Ti. Nan) have high purity and properties as shown in Table 2. (Ti. Nan) are resistant to radiation, strong, as well as have a high absorption of (U.V) rays and high transparency of (vis. L). Some applications of (Ti. Nan) are written below [10]: " nanowires and textiles, space materials, antimicrobials, antibiotics, and anti-fungal agents, plastic and soap, micro-microscopes, optical filters, coatings, nanoparticles, bandages". Applications of polymeric nanocomposites are suspended: matrix and nanofillers: Automobile bumpers, gasoline tanks, interior, and exterior panels, electronics and electrical (printed circuits, electric components), etc.

Table 2 Physical and chemical properties of titanium nanoparticles [9, 11]

Appearance	Black
True density g/cm^3	4.506
Melting point c^o	1600
Boiling point c^o	3287
Average particle point	25-40
Atomic number	22
Specific surface area m^2/g	50

FTIR spectra were recorded by the FTIR spectrometer in the wavenumber range (401 – 3999) cm-1. The peaks that are sharply defined are determined by which the vibration formulas correspond to the chemical bonds of all prepared films. The (SEM) is an electron microscope that takes a picture of sample surfaces with a packet of high-energy electrons in the form of a scan. The specimens for an SEM testing it is electrically connected from the surface and are electrically charged for not accumulating electrical charges on the surface [12].

©SRP 2020, DOI: https://doi.org/10.47758/ijn.vi1.25

Experimental Part

Materials used in this paper, (Ti nano.) "PVA - PVAC". Prepare a solution by mixing (PVA, PVAC) with (0.7, 0.3 mg) respectively with distilled water (40 ml) and make it more homogeneous use the(Magnetic Stirrer) at 70C. Use nano-titanium with a weight ratio of (0, 4, 8, 12, and 16 %) for some time (120-180)minutes, with the casting technique attended all samples. The samples (PVA-PVAC-Ti) nanocomposites are examined by using the "optical microscope", which is supplied from Olympus name (Toup View), under magnification (10 x) and (30 x). "FTIR spectra were recorded by FTIR (Bruker company, German origin, type vertex -70) Fourier transform infrared spectrometer in the wavenumber range (400 – 4000) cm-1". PVA, PVAC powder with (KBr) matrix was tested to prove the structure of polymerization product, we have also tested the films (polyvinyl alcohol - polyvinyl acetate) and testing of films after the addition of the weight ratios of titanium nanoparticles. The (SEM) accurate imaging device, which depicts the surface of the sample by a beam of high-energy electrons scanning.

Results and discussion

Figures (2) and (3) show the images of (PVA-PVAC-Ti) nanocomposites films by two magnification power, examine the samples in a magnification force (10x), and (30x) for different percentages of deflection. As shown in the image (A, B, C, D, E), the difference in the samples is indicated by the high proportion of "Ti. Nano" in poly films (PVA-PVAC), In the last film (E) with a weight of 16%, nanoparticles formed nets and chains within the polymer body, enabling these charge carriers to pass through, causing a change in the material properties [13, 14].

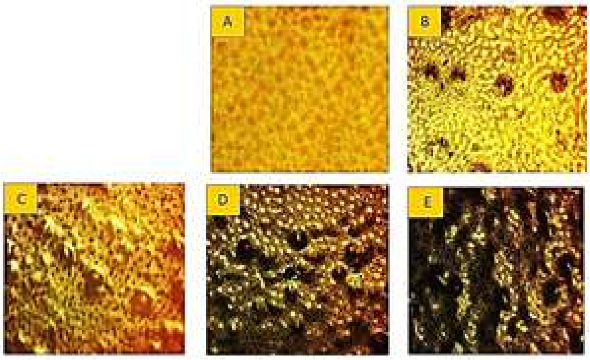


Figure 2 Photomicrographs (10x) for (PVA-PVAC-Ti) nanoparticles: (A) for (PVA-PVAC), (B) for 4wt.% Ti, (C) for 8wt.% Ti, (D) for 12wt.% Ti, (E) for 16wt.% Ti

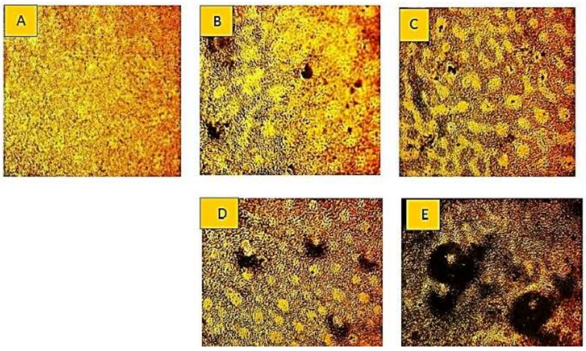


Figure 3 Photomicrographs (30x) for (PVA-PVAC-Ti) nanoparticles: (A) for (PVA-PVAC), (B) for 4wt.% Ti, (C) for 8wt.% Ti, (D) for 12wt.% Ti, (E) for 16wt.% Ti.

The interactions between ions and atoms (PVA-PVAC-Ti) nanocomposites were analyzed by the FTIR spectrometer, these interactions change due to changes in vibratory conditions of the nanocomposites. Figures 4 and 5 represent the FTIR spectra of powder PVA, PVAC, and(PVA-PVAC-Ti) nanocomposites films respectively, in the wavenumber range (400-4000) cm-1. In the case of pure PVA and PVAC Figure 4 curve a and b, a strong and broad signal at " 3200 - 3500 cm -1 is determined to the (O – H) expansion frequency, indicating the presence of hydroxyl groups ". The bands observed at "2920 and 1720 cm-1 correspond to (C–H) and (C=O) stretching vibrations respectively, and the absorption band at 1660 cm-1 arises due to(C=C) stretching "

©SRP 2020, DOI: https://doi.org/10.47758/ijn.vi1.25

In the bond 1380 cm -1 which shows the coupling (O-H), while the vibrations at 1430 cm -1 are the correlation (C - H) by oscillations. At the vibrations of (1140-1000) cm -1, a wide range of bonding bonds for these extensions were set within (C-O) and (C-O-C) groups in PVA powder, table (1.3) shows the links in polyvinyl alcohol and polyvinyl acetate. The FTIR spectroscopy of the original PVAC powder showed (C-H) bonds within strong frequencies in the range of (2800-3000 cm -1), a double bond between carbon and oxygen (C = O) at (1738 cm-1), single bonds (C-O-C) at (1241 cm-1) as (CH-O) at (1022 cm-1) and (O-CO) vibrations at (605 cm -1) and (794 cm -1), it is interesting to note that the weak absorption returns to the group of hydroxide (O–H) in the range of (3500 cm -1) [15].

Table 3 FT-IR Transmittance bands positions and their assignments for pure PVA and PVAC

Vibration frequency (cm^{-1})	Band assignment of PVA powder
3500-3200	O-H stretching
2950	CH_2, C-H stretching vibrations
1720	C=O stretching vibrations
1660	C=C stretching
1430	C-H wagging vibrations
1380	O-H bending
1140-1000	C-O and C-O-C stretching vibrations
3500	O-H stretching
3000-2800	C-H stretching vibrations
1738	C=O stretching vibrations
1241	C-O-C stretching
1022	CH-O stretching
794	O-CO bending
605	O-CO bending

In Spectra (FTIR) of (PVA-PVAC-Ti) nanocomposite films, with the different ratio of (Ti) nanoparticles are shown in figure 5 a-b-c-d and e. The complete mission for the frequencies of distinct groups and vibrational formulas of (PVA-PVAC-Ti) nanocomposite, is presented in Table 4. From the IR spectra, we observe the proportions of different nanoparticles (Ti) differentiated by the observed changes in the spectrum (PVA-PVAC). Some of the bonds and minor changes in absorption bonds, defects, and distortions resulting from the reaction are connected to chains carrying the charge between the dopant and the polymer chain. From the spectra, the FTIR Figure (1.4): The FTIR spectra of powder (a) PVA, (b) PVAC. and strong bands are observed at (3264 cm-1) is assigned to(O–H) stretching vibration of hydroxyl groups and(2911 cm-1)is assigned to (C–H)stretching vibration. A weak band is observed at (1733 cm^{-1}), which has been assigned to the combined frequency of (C=C). The bands at (1660 cm^{-1}) correspond to an acetyl (C=O) group. The strong band at (1417-1141 cm-1) has been attributed to the stretching mode of (C-H) and (C-O) groups. In the case of (PVA-PVAC-Ti) with different Ti ratio, when comparing spectra with pure PVA-PVAC films, it shows the change and transformation of some bands and their intensity. This reinforces the lack of significant interaction between polymers and Ti nanocomposites [15], as shown in Table 4, and Figures 5 and 6.

As shown in Figure 6 a decrease in transmittance at increasing the proportion of titanium nanoparticles. Because of the increased density of the films, and this means an increase of atoms and ions in the light path and increases the absorbance at UV inverse the IR.

©SRP 2020, DOI: https://doi.org/10.47758/ijn.vi1.25

Table 4 FT-IR transmittance band's positions and their assignments for (PVA-PVAC-Ti) films with different ratios of Ti nanoparticles.

Band assignment		0 wt.% Ti	4 wt.% Ti	8 wt.% Ti	12 wt.% Ti	16 wt.% Ti
O-H stretching	**Vibration frequency (cm^{-1})**	3264	3255	3255	3257	3264
C-H stretching vibrations		2911	2920	2919	2921	2920
C=C stretching		1733	1711	1732	1716	1731
C-H stretching		1660	1579	1577	1575	1655
C-H bending		1417	1413	1417	1414	1415
C-O stretching		1141	1083	1141	1085	1084

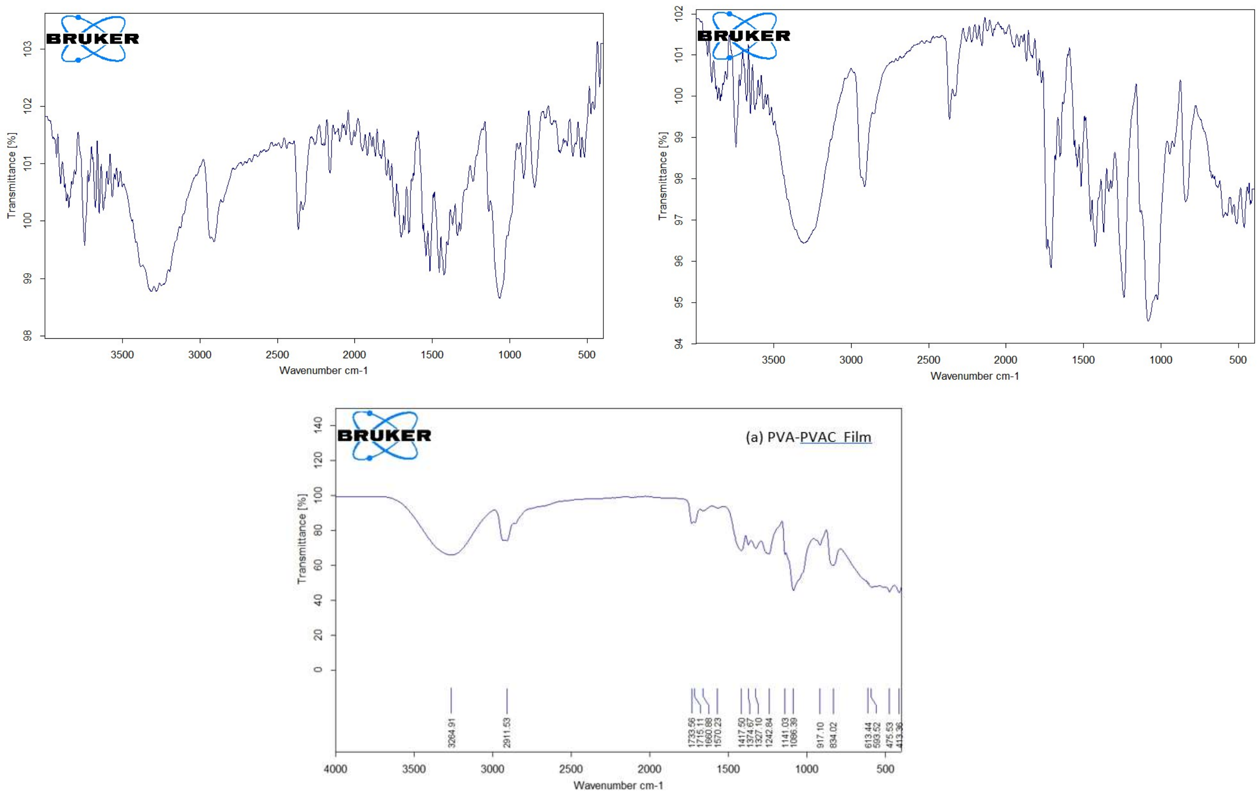
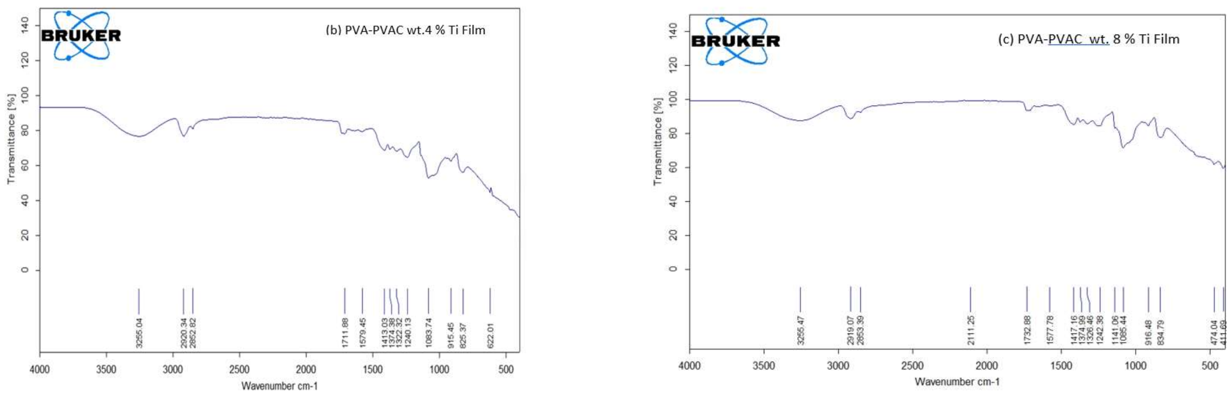


Figure 4 FTIR spectra of powder (a) PVA, (b) PVAC



©SRP 2020, DOI: https://doi.org/10.47758/ijn.vi1.25

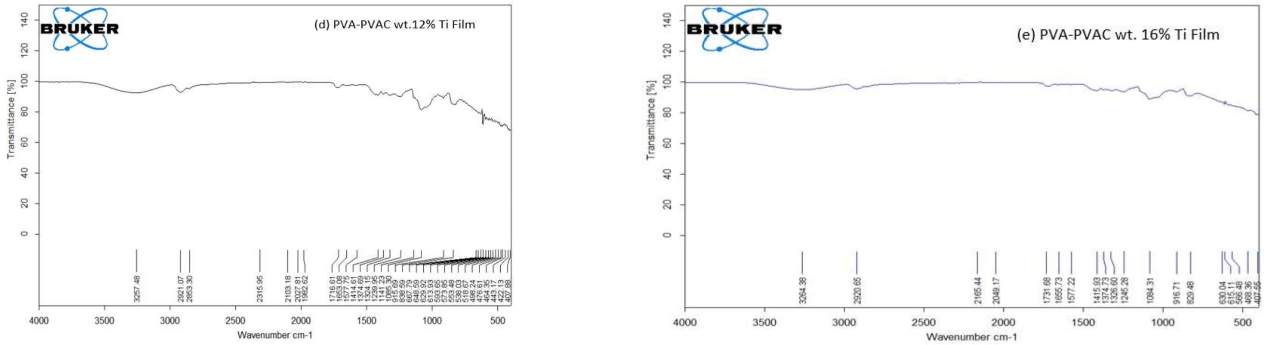


Figure 5 The FTIR spectra for (PVA-PVAC-Ti) nanocomposites film, a- pure(PVA-PVAOC)film ,b- 4wt.% Ti ,c- 8wt.% Ti, d- 12wt.% Ti, e l6wt.% Ti.

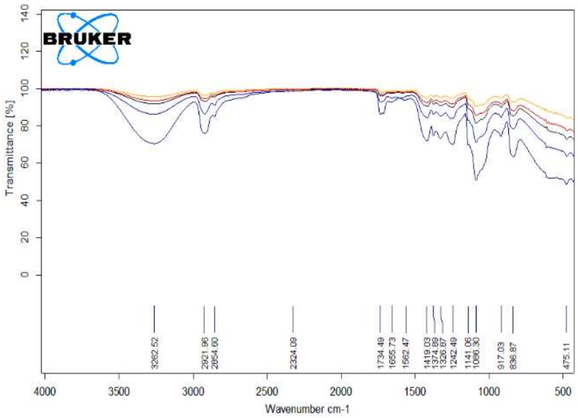


Figure 6 FTIR spectra for (PVA-PVAC-Ti) nanocomposites films to all samples.

Use the SEM micro-microscope to find images of samples and the effect of nanoparticles in the crystal structure of polymer chains. Figures 7 and 8 show images of concentrations of titanium molecules in different films (PVA-PVAC-Ti) nanocomposites. He explains, film (a) in Figures 7 and 8 shows homogeneous and softer polymers. Make sure that the addition of the (Ti) nanoparticle of the composite (PVA-PVAC-Ti) changes in the surface morphology see images (b-c-d and e), the images can be seen and we notice an increase in the titanium pool with increasing ratios in the film. It appears on all films with ratios of (Ti) nanoparticles cut on the surface making transitions and chains randomly distributed.

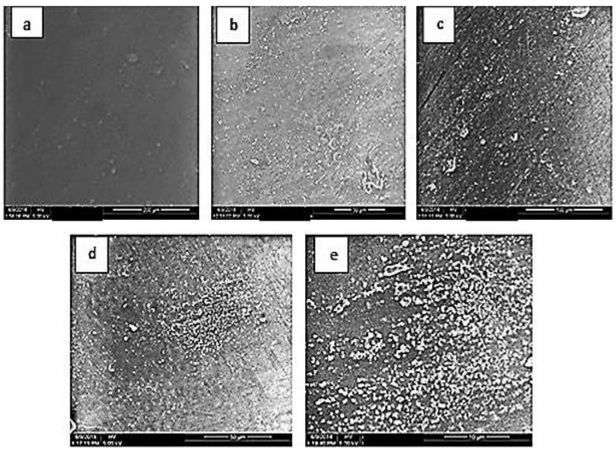


Figure 7 SEM images of (2500x) a-(0.7-0.3) PVA-PVAC film, b- 4wt.% Ti, c- 8 wt.% Ti, d- 12 wt.% Ti, e-16 wt.% Ti nanoparticles.

©SRP 2020, DOI: https://doi.org/10.47758/ijn.vi1.25

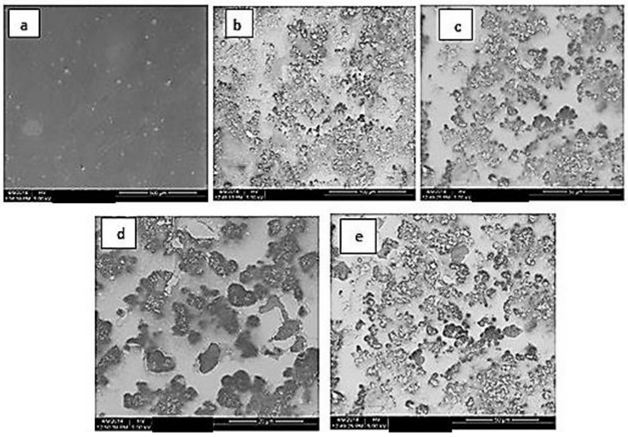


Figure 8 SEM images of (4000x) a-(0.7-0.3) PVA-PVAC film, b- 4wt.% Ti, c- 8 wt.% Ti, d- 12 wt.% Ti, e-16 wt.% Ti nanoparticles.

Conclusions

From the above, we have reached the following points:

1- We gave photos of the optical microscope to create a continuous network of the (Ti) nanoparticles in the nanocomposite when proportion (16wt.%).

2- The FTIR spectrum shows changes in some bonds between films with titanium ratios and pure (PVA-PVAC) film polymers, which indicates a great interaction. Increasing the proportion of titanium particles increases absorption, due to the increased density of films, which means increasing the ions and atoms in the light path.

3- Many randomly distributed pieces and aggregates formed on the surface of samples appear homogeneous and coherent, in images (SEM).

References

[1] A.K. Tomar , Rishi Pal Chahal , Suman Mahendia , Shyam Kumar ,S. Sultan , Rafiuddin, M.Z. Khan, K. Umar, (γ-Irradiated PVA/Ag nanocomposite films) Materials for optical applications J. Alloys Compd. (2012), doi: http://dx.doi.org/10.1016/j.jallcom.2012.04.081

[2] J. Zhao, X. Zhang, C.R. Yonzon, A.J. Haes, R.P.V. Duyne, " Nanomedicine 1", pp. 219–228 (2006).

[3]C. Uzunpinar, "Effect of Dispersion of Swanston the Viscoelastic and Final Properties of Epoxy Based Nanocomposites",M.Sc. Thesis, Graduate Faculty , Auburn University,(2010).

[4]J. Robertson, "Realistic applications of CNTs" ,Materials Today,Vol.7,No.5, pp.46- 52, (2004).

[5] M. Richardon, " Polymer Engineering Composites" , Ist Ed. Applied Science Publishers Ltd. London , (1977) .

[6] A.Tawansi and H. M.Zidan, "Tunnelling and Thermally Stimulated Phenomena in Highly Filled PMMA Composites", Int. J. Polym. Mater., Vol.15 ,No. 2,pp.77-83,(1991).

[7] B.L. Lopez, A.I. Mejia and L. Sierra , "Biodegrade ability of polyvinyl alcohol", Poly. Eng. and Sci. ,Vol.39, No. 8, pp.1346-1352,(1999).

[8] James E. Mark ," Polymer data Handbook", Oxford University Press, Inc., (1999).

[9] Debraj Ghosh, Sulolit Pradhan, Wei Chen and Shaowei Chen ," Titanium Nanoparticles Stabilized by(Ti-C)Covalent Bonds ", Journal Chem. Mater., Vol.20,No. 4, pp. 1248-1250,(2008).

[10] Zhonghe Bi, M. Parans Paranthaman, Paul A. Menchhofer , Ryan R. Dehoff, Craig A. Bridges , Miaofang Chi , Bingkun Guo , Xiao-Guang Sun and Sheng Dai ," Self-organized amorphous TiO2 nanotube arrays on porous Ti foam for rechargeable lithium and sodium ion batteries ", Journal of Power Sources, 222 ,pp. 461- 466, (2013).

[11] Xiaohui Wei, Ralph Skomski, B. Balamurugan, and D. J. Sellmyer ," Magnetism of core-shell Ti:TiO nanoparticles", J. Appl. Phys. 107, 09B516,pp.1-4, (2010).

[12] Abdul Kareem Thottoli and Anu Kaliani Achuthanunni ," Effect of polyvinyl alcohol concentration on the ZnS nanoparticles and wet chemical synthesis of wurtzite ZnS nanoparticles",Journal of Nanostructure in Chemistry, Vol.3,No.31,pp.1-9, (2013).

[13] Maher H. R. AL-humairi , "Study the Optical and Electrical Properties of (PVA-Ag) and (PVA-TiO2) Nanocomposites", M.Sc. thesis ,College of Education for pure sciences, University of Babylon ,(2013) .

[14] J . Gurland,"Electrical resistivity", J. Polym. Plast. Technol. Eng., Vol.19, No.1, pp.21-51,(1982).

[15] K. Sivaiah, K. Naveen Kumar, V. Naresh and S. Buddhudu," Structural and Optical Properties of Li+: PVP & Ag+: PVP Polymer Films ", J. Materials Sciences and Applications, Vol. 2,No.11, pp.1688-1696, (2011).

©SRP 2020, DOI: https://doi.org/10.47758/ijn.vi1.25