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Biopolymer blend or titanium nitride nanoparticles: synthesis and pressure sensor characterization for environmental application

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Abstract

The nanocomposites are used in a many fields such as biosensors, antibacterial, solar cell, transistors, diodes...etc. In this paper, polyvinyl alcohol (PVA)- poly-acrylic acid (PAA)- titanium nitride (TiN) nanocomposites films have been synthesized for pressure sensor with high sensitivity, low weigh and low cost. The nanocomposites were fabricated with different weight percentages of polyvinyl alcohol (PVA), poly-acrylic acid (PAA) and titanium nitride (TiN). The FTIR analysis for (PVA-PAA-TiN) have been studied. The pressure sensor measurements for (PVA-PAA-TiN) nanocomposites have been studied in pressure range (80-160) bar. The results showed that the electrical resistance of (PVA-PAA) blend decreases with increase in titanium nitride nanoparticles concentration. Also, the electrical resistance of (PVA-PAA-TiN) nanocomposites samples decreases with increase in pressure.

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Introduction

Nanocomposite is a multiphase material that made from a combination of two or more of constituent material (matrix and reinforcing phase) with different physical or chemical properties that, when they combined, the resulting material has characteristics differently from the individual compounds. Over the past decades, nanocomposites become a magnificent issue in our lives. Materials play the key role in every area of technology of the 21st century. It started to be used in medicals, industrials, computing, and sensor applications to make our lives more comfortable. One kind of nanocomposites according to the matrix is polymer nanocomposite. Polymer nanocomposites are a combination of polymer or copolymer and Nano-sized fillers. Addition of nanofiller to the polymer matrix improve properties and can use in different application [Hajeeassa *et al.* 2017]. The nanosize favours the use of smaller amounts of fillers and a more effective transfer to the polymer matrix of their unique molecular properties. Notably, in the nanoscale range, materials may present different optoelectronic properties, which in turn affects their optical, catalytic and other chemical properties, thus suggesting applications in the field of functional materials, such as, temperature sensors, linear polarizers, optoelectronic and chemiresistor devices. Among the polymeric matrices used in the preparation of nanocomposites, thermoplastic polymers represent a class of interest both for scientific research and application at industrial level [Coiai *et al.* 2015]. Recently, PVA has gained increasing attention from researchers for biomedical applications such as eye drops, contact lenses, tissue adhesion barriers, and artificial cartilage, owing to its exclusive properties including biocompatibility, hydrophilicity, nontoxicity, and biodegradability. It also has outstanding film-formation characteristics. Because of this property, combined with excellent chemical stability and hydrophilicity, it is blended with various synthetic and natural polymers like a water-soluble film and is used in food packaging. Further, PVA films have various biomedical applications; for example, contact lenses, hemodialysis, artificial pancreases, synthetic vitreous humors, and cartilage and meniscus tissue replacement [Yang *et al.* 2017]. The addition of nanoparticles to the polymer is aimed to improve the electrical, mechanicaland optical properties for various applications. One advantage of nanoparticles, as polymer additives appear to have is that compared to traditional additives, loading requirements are quite low. Microsized particles used as reinforcing agents scatter light, thus reducing light transmittance and optical clarity. Nanostructured materials promise fruitful development for applications in the aerospace sector due to their low density, high strength and thermal stability [Agool *et al.* 2015, Agool *et al.* 2015, Agool and Hashim, 2014]. Composites and nanocomposites have many modern industrial and medical applications because of their new properties [Al-Ramadhan *et al.*, 2011]. The most important applications are: humidity sensors [Hadi and Hashim, 2017, Hashim and Hadi, 2018, Hashim and Hadi, 2018, Hashim *et al.*,2017, Hashim and Hadi, 2017, Agool *et al.*,2017], radiation shielding [Hassan and Hashim, 2018, Hashim and Jassim, 2018, Hashim and Hadi, 2017, Hashim and Jassim, 2018, Habeeb *et al.*, 2017], pressure sensors and piezoelectric [Hashim *et al.*,2017, Hashim and Hadi, 2017, Hashim and Hadi, 2018, Hashim and Hadi, 2017], antibacterial and antifungal [Rashid *et al.*,2018, Al-Garah *et al.*,2018, Agool *et al.*,2015, Kadhim *et al.*,2016, Kadhim *et al.*, 2017], thermal energy storage and release [Hashim *et al.*, 2018, Agool *et al.*,2017, Hashim and Hadi, 2017, Agool *et al.*,2016]. Titanium nitride nanoparticles exhibit novel electronic, optical and mechanical properties such as high melting points and low sintering tendencies are beneficial for applications in high temperature catalysis [Al-Ghaban, *et al.*, 2018]. This paper aims to preparation of new type of nanocomposites used for environmental applications as pressure sensors.

Materials and methods

Nanocomposites of (polyvinyl alcohol- poly-acrylic acid acrylic acid) blend as matrix and titanium nitride nanoparticles as additive have been prepared by using casting method. The samples of (PVA-PAA-TiN) nanocomposites were fabricated by dissolving 1 gm of polyvinyl polyvinyl alcohol and poly-acrylic acid in 30 ml of distilled water with weight percentages: 85 wt.% PVA and 15 wt.% PAA by using magnetic stirrer to mix the polymers for 1 hour to obtain more homogeneous solution. The TiN nanoparticles were added to (PVA-PAA) blend with concentrations are (1.5, 3, 4.5 and 6) wt.% . FTIR spectra for (PVA-PAA-NbC) nanocomposites were recorded by FTIR (Bruker company) in wave number range (400 – 4000)cm^{-1}. The pressure sensor test for nanocomposites investigated by measuring the electrical resistance between two electrodes on the top and bottom of the sample by using the Keithley electrometers type 2400 sources mater for different pressures range (80-160) bar.

Results and discussion

Fig. 1. shows the FTIR measurements of (PVA-PAA-TiN) nanocomposites.

Fig. 1. FTIR spectra for (PVA-PAA-TiN) nanocomposites A- Pure blend, B-1.5 wt.% TiN nanoparticles, C- 3 wt. TiN nanoparticles D- 4.5 wt.% TiN nanoparticles, E- 6 wt.% TiN nanoparticles.

The FTIR analysis shows the interactions in between polymer blend and nanoparticles. It can be showed broad bands at around 3200 cm⁻¹ for (PVA-PAA-TiN) nanocomposites are observed due to OH groups in the polymers matrix chain [Mohammad *et al.* 2013]. The band at around 2900 cm⁻¹ was attributed to the C-H groups.

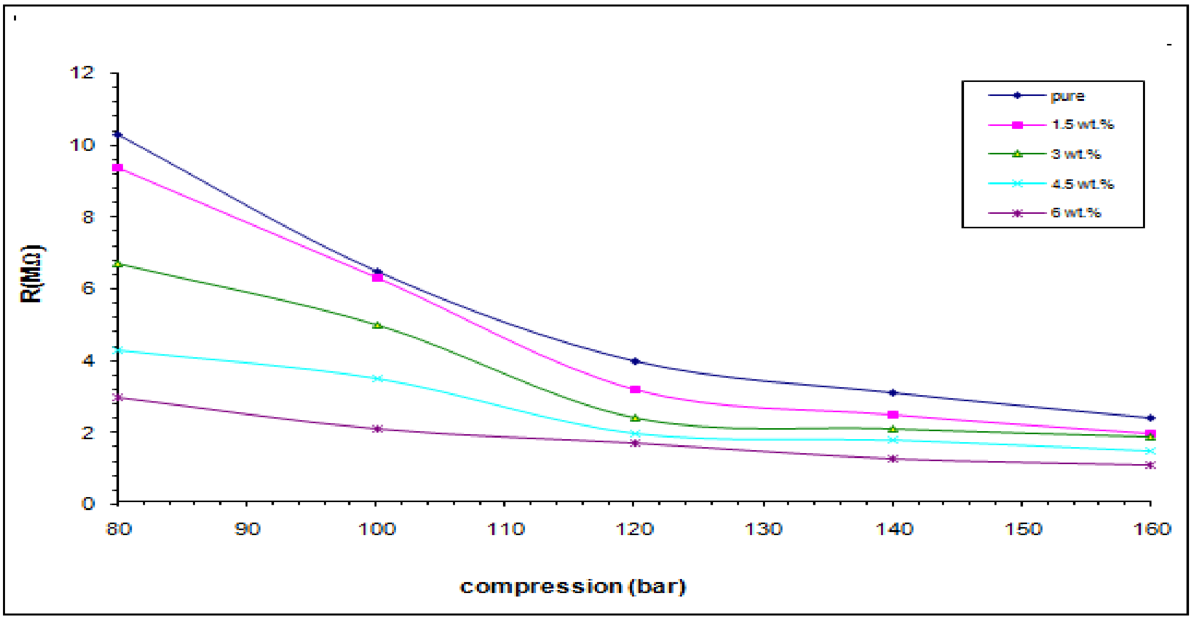

Fig. 2. Variation of electrical resistance for (PVA-PAA-TiN) nanocomposites with pressure for different weight percentages of TiN nanopaticles.

The bands at around 1700 cm⁻¹ are assigned to the C=C stretching mode. The strong band at around 1060 cm⁻¹ for all samples of nanocomposites attributed to the stretching mode of C-O group [Karthikeyan *et al.* 2009]. The TiN nanoparticles are caused changes in spectral of (PVA-PAA) blend which include shift in some bonds and change in the intensities. These changes attributed to physical bonds of nanoparticles with polymers.

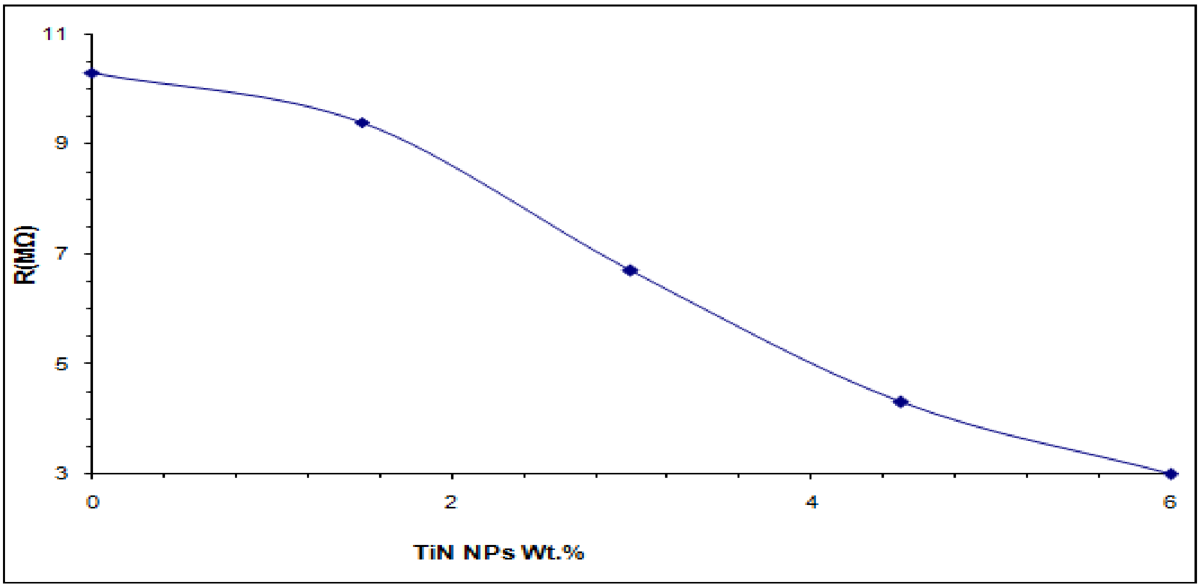

Fig. 3. Effect of TiN nanoparticles concentrations on D.C electrical resistance of (PVA-PAA) blend.

The FTIR studies show that there is no interactions between (PVA-PAA) blend and TiN nanoparticles. The transmittance in figures decreases slightly with the increase of TiN nanoparticles concentrations which attributed to increase the density of nanocomposites [Elmarzugi *et al.* 2014]. These are consistent with the results of researchers[Arsalani, *et al.*, 2010, Kumar *et al.*, 2012].

The variation of electrical resistance for (PVA-PAA-TiN) nanocomposites with pressure for different weight percentages of TiN nanopaticles is shown in Fig. 2. As shown in figure, the electrical resistance of (PVA-PAA-TiN) nanocomposites decreases with increase of the pressure which can be attributed to the samples have a crystalline region that has an internal dipole moment. Without any mechanical or electrical poling process, these dipole moments are randomly oriented and the net dipole moment is zero in this condition.

When stress is applied, it will change the local dipole distributions and induce an electric field. The induced electric field accumulates the charges at both the top and bottom of the sample [Kim, 2015].

The effect of TiN nanoparticles concentrations on D.C electrical resistance of (PVA-PAA) blend is shown in Fig. 3.

The D.C electrical resistance of polymer blend decreases with increase in TiN nanoparticles concentrations.

The decrease of resistance with increase in TiN nanoparticles concentrations attributed to the increase of the charges carriers number [Srikanth *et al.* 2014].

Conclusions

The electrical resistance of (PVA-PAA-TiN) nanocomposites decreases with increase in pressure for different concentration of TiN nanoparticles. The electrical resistance of (PVA-PAA) decreases with increase in TiN nanoparticles concentration.

The (PVA-PAA-TiN) nanocomposites have high sensitivity for pressure with lightweight and low cost.

References

Hajeeassa KS, Hussein MA, Al-amshany ZM. 2017. The influence of graphene nano-particles on the biological interest of polyvinyl alcohol nanocomposites. Int. J. Biosen. Bioelectron **3(1).**

Coiai S, Passaglia E, Pucci A, Ruggeri G. 2015. Nanocomposites Based on Thermoplastic Polymers and Functional Nanofiller for Sensor Applications. Materials 8.

Yang SB, Yoo SH, Lee JS, Kim JW, Yeum JH. 2017. Surface Properties of a Novel Poly(vinyl alcohol) Film Prepared by Heterogeneous Saponification of Poly(vinyl acetate) Film. Polymers **9(493).**

Agool IR, Mohammed FS, Hashim A. 2015. The Effect of Magnesium Oxide Nanoparticles on the Optical and Dielectric Properties of (PVA-PAA-PVP) Blend. Advances in Environmental Biology **9(11).**

Agool IR, Sabeeh F, Hashim A. 2015. Investigation of (PAA-PVA-PEG-TiO2) Nanocomposites and Study their Optical Properties. Research Journal of Medicine and Medical Sciences **10(1).**

Agool IR, Hashim A. 2014. Enhancement of Structural and Optical Properties of (PVA-PVP- TiO2) Nanocomposites. Australian Journal of Basic and Applied Sciences **8(17).**

Al-Ramadhan Z, Hashim A, Algidsawi AJK. 2011. The D.C electrical properties of (PVC-Al_2O_3) composites. AIP Conference Proceedings **1400 (1).**

Hadi A, Hashim A. 2017. Development of a new humidity sensor based on (carboxymethyl cellulose–starch) blend with copper oxide nanoparticles. Ukrainian Journal of Physics **62(12).**

Hashim A, Hadi Q. 2018. Structural, electrical and optical properties of (biopolymer blend/ titanium carbide) nanocomposites for low cost humidity sensors. Journal of Materials Science: Materials in Electronics **29,** 11598–11604.

Hashim A, Hadi Q. 2018. Synthesis of Novel (Polymer Blend-Ceramics) Nanocomposites: Structural, Optical and Electrical Properties for Humidity Sensors. Journal of Inorganic and Organometallic Polymers and Materials **28(4),** 1394–1401.

Hashim A, Habeeb MA, Hadi A. 2017. Synthesis of Novel Polyvinyl Alcohol–Starch-Copper Oxide Nanocomposites for Humidity Sensors Applications with Different Temperatures. Sensor Letters **15(9).**

Hashim A, Hadi A. 2017. Synthesis and Characterization of (MgO-Y_2O_3-CuO) Nano composites for Novel Humidity Sensor Application. Sensor Letters **15(10).**19-75

Agool IR, Kadhim JK, Hashim A. 2017. Fabrication of new nanocomposites: (PVA-PEG-PVP) blend-zirconium oxide nanoparticles) for humidity sensors. International Journal of Plastics Technology **21(2).** 76-32

Hashim A. and Jassim A. 2018. Novel of Biodegradable Polymers-Inorganic Nanoparticles: Structural, Optical and Electrical Properties as Humidity Sensors and Gamma Radiation Shielding for Biological Applications. J. of Bionanoscience 12.

Hashim A, Hadi A. 2017. novel lead oxide polymer nanocomposites for nuclear radiation shielding applications. Ukrainian Journal of Physics **62(11).**

Hashim A, Jassim A. 2017. Novel of (PVA-ST-PbO_2) Bio Nanocomposites: Preparation and Properties for Humidity Sensors and Radiation Shielding Applications. Sensor Letters **15(12).**

Habeeb MA, Hashim A, Hadi A. 2017. Fabrication of New Nanocomposites: CMC-PAA-PbO_2 Nanoparticles for Piezoelectric Sensors and Gamma Radiation Shielding Applications. Sensor Letters **15(9).**

Hassan D, Hashim A. 2018. Structural and Optical Properties of (Polystyrene–Copper Oxide) Nanocomposites for Biological Applications. Journal of Bionanoscience 12.

Hashim A, Habeeb MA, Hadi A, Jebur QM, Hadi W. 2017. Fabrication of Novel (PVA-PEG-CMC-Fe3O4) Magnetic Nanocomposites for Piezoelectric Applications. Sensor Letters **15(12).**

Hashim A, Hadi A. 2017. A Novel Piezoelectric Materials Prepared from (Carboxymethyl Cellulose-Starch) Blend-Metal Oxide Nanocomposites. Sensor Letters **15(12).**

Hashim A. and Hadi A. 2018. Novel Pressure Sensors Made From Nanocomposites (Biodegradable Polymers–Metal Oxide Nanoparticles): Fabrication And Characterization. Ukrainian Journal of Physics **63(8).** 120-127

Hashim A, Hadi Q. 2017. Novel of (Niobium Carbide/Polymer Blend) Nanocomposites: Fabrication and Characterization for Pressure Sensor. Sensor Letters 15.

Rashid FL, Hadi A, Al-Garah NH, Hashim A. 2018. Novel Phase Change Materials, MgO Nanoparticles, and Water Based Nanofluids for Thermal Energy Storage and Biomedical Applications. International Journal of Pharmaceutical and Phytopharmacological Research **8(1).**

Al-Garah NH, Rashid FL, Hadi A, Hashim A. 2018. Synthesis and Characterization of Novel (Organic–Inorganic) Nanofluids for Antibacterial, Antifungal and Heat Transfer Applications. Journal of Bionanoscience 12.

Agool IR, Kadhim JK, Hashim A. 2015. Synthesis of (PVA- PEG-PVP-MgO) Nanobiomaterials and their Application. Advances in Environmental Biology **9(27).**624-688

Kadhim JK, Agool IR, Hashim A. 2016. Enhancement in Optical Properties of (PVA-PEG-PVP) Blend By the Addition of Titanium Oxide Nanoparticles For Biological Application. Advances in Environmental Biology **10(1).**

Kadhim JK, Agool IR, Hashim A. 2017. Effect of Zirconium Oxide Nanoparticles on Dielectric Properties of (PVA-PEG-PVP) Blend for Medical Application, Journal of Advanced Physics **6(2).**

Hashim A, Agool IR, Kadhim KJ. 2018. Novel of (Polymer Blend-Fe_3O_4) Magnetic Nanocomposites: Preparation and Characterization For Thermal Energy Storage and Release, Gamma Ray Shielding, Antibacterial Activity and Humidity Sensors Applications. Journal of Materials Science: Materials in Electronics **29(12),** 10369–10394.

Agool IR, Kadhim JK, Hashim A. 2017. Synthesis of (PVA-PEG-PVP-ZrO_2) Nanocomposites For Energy Release and Gamma Shielding Applications. International Journal of Plastics Technology **21(2).** 157-167

Hashim A, Hadi A. 2017. Synthesis and characterization of novel piezoelectric and energy storage nanocomposites: biodegradable materials–magnesium oxide nanoparticles. Ukrainian Journal of Physics **62(12).**33-42

Agool IR, Kadhim JK, Hashim A. 2016. Preparation of (polyvinyl alcohol–polyethylene glycol– polyvinyl pyrrolidinone–titanium oxide nanoparticles) nanocomposites: electrical properties for energy storage and release. International Journal of Plastics Technology **20(1).**177-179

Al-Ghaban A, Shabeeb KM, Hamaza AH. 2018. Influence of Titanium Nitride Nanoparticles on Microstructureal, Physical and Mechanical Properties of Titanium Carbide. Materials Focus **7(1).**27-31

Mohammad A, Hooshyari K, Javanbakht M, Enhessari M. 2013. Fabrication and Characterization of Poly Vinyl Alcohol/ Poly Vinyl Pyrrolidone/MnTiO Nanocomposite Membranes for PEM Fuel Cells. Iranica Journal of Energy & Environment **4(2).**88-96

Karthikeyan K, Poornaprakash N, Selvakumar N, Jeyasubrmanian. 2009. Thermal Properties and Morphology of MgO-PVA Nanocomposite Film. Journal of Nanostructured Polymers and Nanocomposites **5(4).**22-25

Elmarzugi N, Adali T, Bentaleb A, Keleb EI, Mohamed AT, Hamza AM. 2014. Spectroscopic Characterization of PEG- DNA Biocomplexes by FTIR. Journal of Applied Pharmaceutical Science **4(8).**123-133

Arsalani N, Fattahi H, Nazarpoor M. 2010. Synthesis and characterization of PVP-functionalized superparamagnetic Fe_3O_4 nanoparticles as an MRI contrast agent. Journal of eXPRESS Polymer Letters **4(6).**55-60

Kumar D, Jat SK, Khanna PK, Vijayan N, Banerjee S. 2012. Synthesis, Characterization, and Studies of PVA/Co-Doped ZnO Nanocomposite Films. International Journal of Green Nanotechnology 12.

Kim TH. 2015. Characterization and applications of piezoelectric polymers thesis of Master of Sci. Electrical Engineering and Computer Sciences, University of California.

Srikanth C, Sridhar C, Nagabhushana BM, Mathad RD. 2014. Characterization and DC Conductivity of Novel CuO doped Polyvinyl Alcohol (PVA) Nano-composite Films. J. of Eng. Res. and Appl. **4(10).** 120-133