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Polyvinyl alcohol - Poly-Acrylic Acid Bio-Polymeric Blend with Titanium Nitride Nanoparticles Films For Antibacterial Activity against Staphylococcus aureus

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Abstract

Antibacterial application of (polyvinyl alcohol - poly-acrylic acid) blend and (polyvinyl alcohol - poly-acrylic acid) blend doped by titanium nitride nanoparticles has been investigated. The (PVA-PAA-TiN) nanocomposites were prepared by using casting method. The nanocomposites prepared by weight percentage of polymers: polyvinyl alcohol (85 wt.%) and poly-acrylic acid (15 wt.%). The titanium nitride nanoparticles were added to (PVA-PAA) blend with different concentrations are (1.5, 3, 4.5, and 6) wt.%. The nanocomposites were tested for antibacterial against staphylococcus aureus (S. aureus). The results showed that the (PVA-PAA-TiN) nanocomposites have good activity for antibacterial.

Key words: staphylococcus aureus, polymer blend, antibacterial, titanium nitride.

INTRODUCTION

The traditional approach to textile materials from only an aesthetic and comfort point of view must be considered as the past. Currently, in addition to conventional end-use properties, textile products must exhibit some advanced properties, such as UV protection, self-cleaning, antimicrobial and/or anti-electrostatic properties. These effects can be achieved using new technologies that can provide targeted functionalization and long-term durability, as well as environmental and economic feasibility. Developments in the synthesis of different metal and metal oxide nanoparticles (NPs) and the wide range of their successful applications opened up new perspectives for the engineering of desired properties of textile materials. The greatest interests are oriented towards the imparting of antimicrobial effects [1]. Biopolymers are widely used as scaffold materials in biomedical research due to their high biocompatibility and nontoxic nature. However, biopolymers have certain limitations (e.g. the non-bactericidal nature of pure polymers), which have been surmounted by preparing their bioinorganic hybrid nanocomposites. These nanocomposites have shown tremendous improvements in their magnetic, electrical, catalytic, biosensing, environmental, optical, and biological properties. Typical inorganic nanomaterials used for this purpose include metals (Au, Ag, etc.) and metal oxides (ZnO, TiO2, MgO, CaO, NiO, CoO, etc.). These nanomaterials have been used in a wide variety of applications in cell imaging, biosensing, drug/gene delivery, and cancer therapy [2]. Polyvinyl alcohol (PVA) has excellent film forming, water-soluble, adhesion, emulsification and barrier properties, which has been used in fibers, films and adhesive agents widely. The structure of PVA molecule has many hydroxyl groups, which can form hydrogen bonds, this hydrogen bonding gives PVA many excellent properties. But the PVA film has the defects of low elongation at break, poor decomposition temperature and high glass transition temperature [3]. It is prepared by hydrolysis of polyvinyl acetate and is widely used and studied as a nanocomposite material. PVA is more environment friendly and feasible alternative to polymers as polyethylene. Moreover, PVA has good thermal stability, optical properties and oxygen barrier properties. PVA composites are widely used in different applications including filters, packaging, tissue engineering scaffolds and CO2 membrane separation [4]. The excellent intrinsic biocompatibility of titanium nitride (TiN) is well documented in various biomedical applications [5]. Nanocomposites have unique properties that make them suitable for many applications in fields: antibacterial [6-11], radiation shielding [12-17], humidity sensors [18-23], thermal energy storage and release [24-26] and pressure sensors and piezoelectric [27-32]. TiN 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 [33]. This paper deals with fabrication of polyvinyl alcohol - poly-acrylic acid bio-polymeric blend with titanium nitride nanoparticles films for antibacterial activity against staphylococcus aureus.

MATERIALS AND METHEDS

Bioanocomposites films of (polyvinyl alcohol- poly-acrylic acid) blend as matrix and titanium nitride nanoparticles as additive were prepared by casting method by dissolving 1 gm of polyvinyl alcohol and poly-acrylic acid in 30 ml of distilled water by

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using magnetic stirrer to mix the polymers for 1 hour to obtain more homogeneous solution. The nanocomposites prepared with concentration (85 wt.% PVA, 15 wt.% PAA) blend and titanium nitride (TiN) nanoparticles were added to (PVA-PAA) blend with concentrations are (1.5, 3, 4.5 and 6) wt.%. Antibacterial activity application of the nanocomposites samples was investigated by using a disc diffusion method. The antibacterial activities were done by using gram positive organisms (Staphylococcus aureus). The disks of samples were placed over the media and incubated at 37°C for 24 hours. The inhibition zones diameters for all samples of (PVA-PAA-TiN) nanocomposites were measured**.**

RESULTS AND DISCUSSION

The SEM images of (PVA-PAA-TiN) nanocomposites with different weight percentages of TiN nanoparticles are shown in Figure 1 to study the surface morphology of (PVA-PAA-TiN) nanocomposites and arrangement of TiN nanoparticles inside the (PVA-PAA) blend.

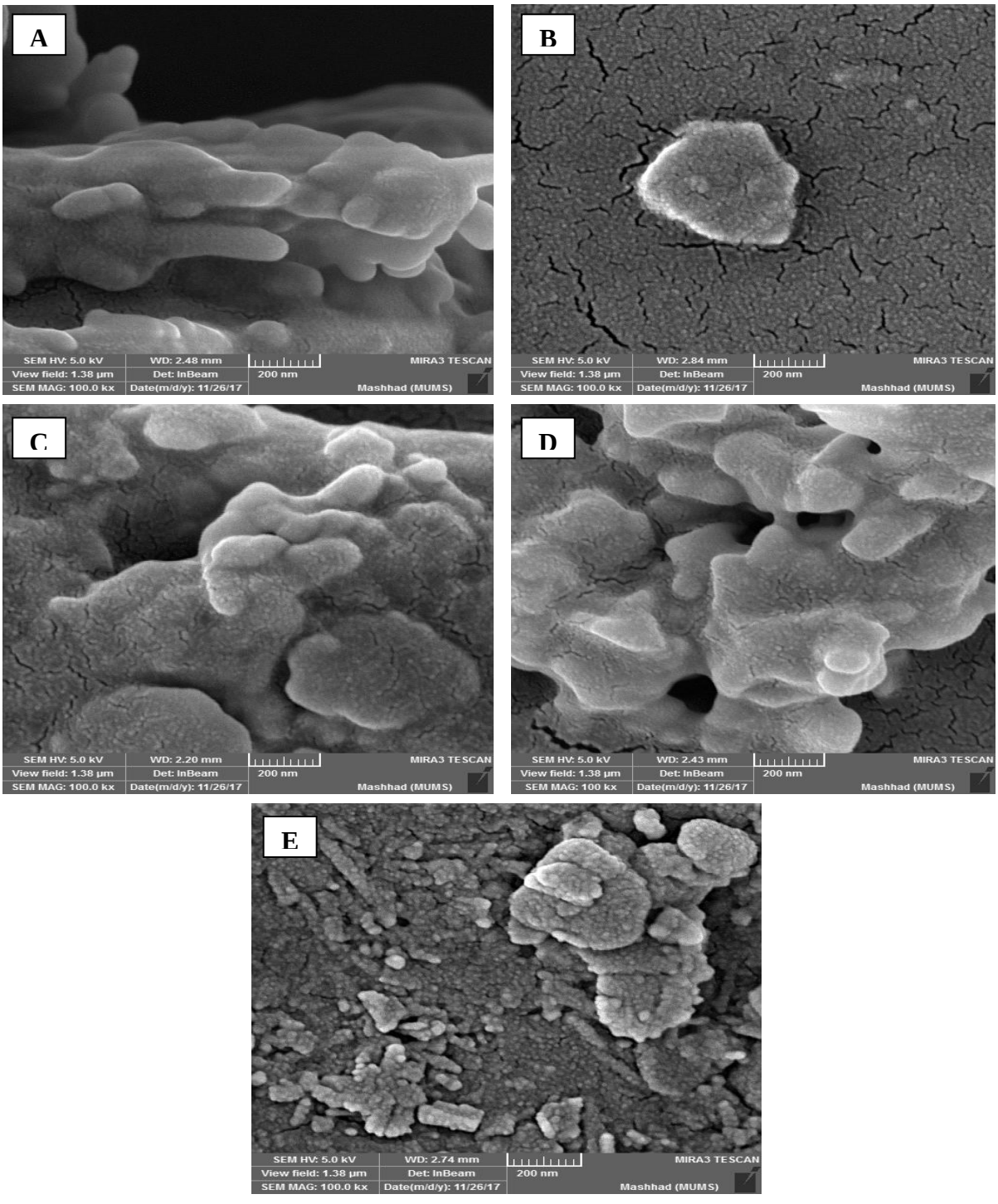

Fig. 1. SEM images for (PVA-PAA-TiN) nanocomposites:(A) for (PVA-PAA) blend, (B) for 1.5 wt.% TiN, (C) for 3 wt.% TiN,(D) for 4.5 wt.% TiN, (E) for 6 wt.% TiN.

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The SEM images show that paths network formed of TiN nanoparticles inside the (PVA-PAA) blend at high concentrations [34]. These are consistent with the results [35,36]. Figure 2 shows antibacterial properties of the (PVA-PAA-TiN) nanocomposites against gram-positive (Staphylococcus aureus). The inhibition zone increases with increase the TiN nanoparticles concentrations. The mechanism of this antibacterial activity varies from nanoparticle to nanoparticle. For all varieties of nanoparticles, the antibacterial mechanism is not fully understood. While some proposed mechanisms relate to the physical structure of the nanoparticles (membrane-damaging abrasiveness of the nanoparticle), others relate to the enhanced release of antibacterial metal ions from nanoparticle surfaces.

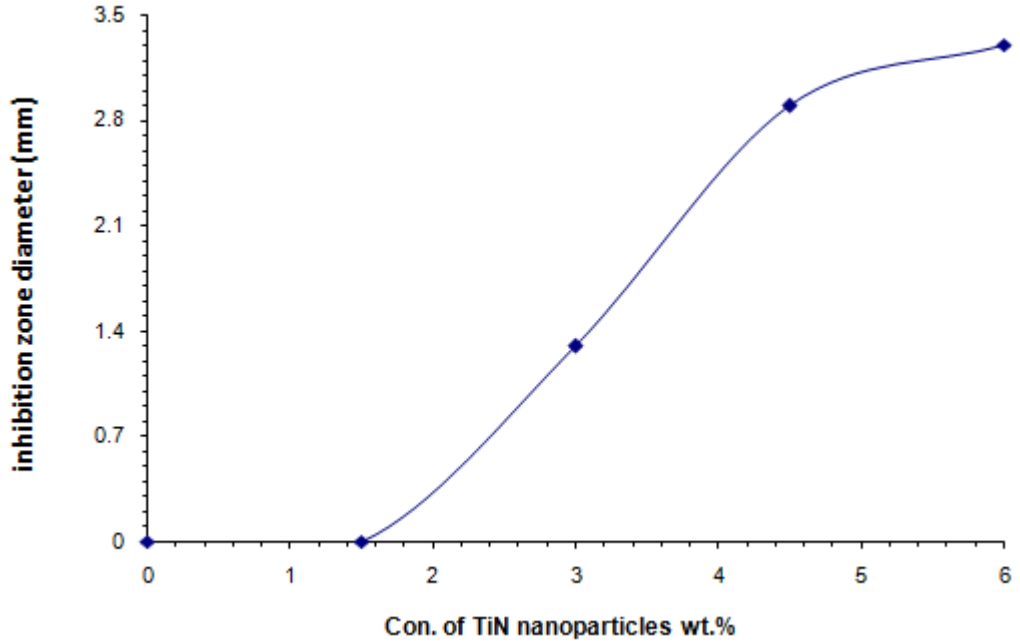

Fig. 2. Antibacterial properties of (PVA-PAA-TiN) nanocomposites against gram-positive (Staphylococcus aureus).

The specific surface area of a dose of nanoparticles increases as the particle size decreases, allowing for greater material interaction with the surrounding environment. Thus, for inherently antibacterial materials increasing the surface to volume ratio enhances the antibacterial effect. A nanoparticle of an inherently antibacterial material may, therefore, have multiple mechanisms of antibacterial activity, such as the release of antibacterial metal ions from the particle surface and the antibacterial physical properties of a nanoparticle related to cell wall penetration or membrane damage. Comparing results across a greater number of studies allows for the identification of nanoparticle parameters which are most relevant in designing the ideal antibacterial particle. Chemistry, particle size, particle shape, and zeta potential are among the most relevant variables affecting antibacterial activity [37].

CONCLUSIONS

1- The SEM images for (PVA-PAA-TiN) nanocomposites showed that the TiN nanoparticles is aggregated as a clusters at low concentrations. At high concentrations of TiN nanoparticles, the TiN nanoparticles form a paths network inside the polymer blend.
2- The inhibition zone diameter for S. aureus increases with increasing of the TiN nanoparticles concentrations.
3- The (PVA-PAA-TiN) nanocomposites for different concentration of TiN nanoparticles have high antibacterial activity against Staphylococcus aureus.

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