Investigation of Antibacterial Application of (PVA/PAA/$SrTiO_3$) New Nanocomposites Films

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Abstract

Film of pure polyvinyl alcohol (PVA) and poly-acrylic acid (PAA) blend and PVA/PAA blend mixed with Strontium titanate ($SrTiO_3$ NPs) were fabricated for antibacterial application against gram positive (S.aureus) and gram negative (E.coli) with high activity, .The nanocomposites films were synthesized with various content of $SrTiO_3$ NPs are o%,1.8%,3.6%,5.4% and 7.2% .The antibacterial application was determined by using the disc diffusion method .The results indicated that the inhibition zone was increased with the increase in $SrTiO_3$ NPs content . Finally, the results of antibacterial for PVA/PAA/$SrTiO_3$ nanocomposites films against organisms (S.aureus and E.coli).Showed high activity for antibacterial.

Keywords: antibacterial, nanocomposites, $SrTiO_3$, blend, films, inhibition zone**.**

التحقق من تطبيق رقائق المتراكب النانوي (PVA/PAA/$SrTiO_3$) كمضاد للبكتريا

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الخلاصة

تم تحضير رقائق المتراكب النانوي (PVA/PAA/$SrTiO_3$) وذلك من خلال مزج المواد البوليمرية PVA/PAA واضافة المادة النانوية $SrTiO_3$ للمزيج البوليميري PVA/PAA وكانت تراكيز المادة النانوية مختلفة (٠ ، ١,٨، ٣,٦، ٥,٤. ، ٧,٢) .وتم استخدام رقائق المتراكب النانوي كمضاد لبكتريا (S.aureus and E.coli) ومن خلال دراستنا تبين ان قطر التثبيط يزداد عند زيادة تركيز المادة النانوية $SrTiO_3$ واخيرا اظهرت النتائج ان رقائق المتراكب النانوي(PVA/PAA/$SrTiO_3$) لها فعالية عالية كمضاد للبكتريا

الكلمات المفتاحية : مضاد البكتريا ،المتراكب النانوي ،$SrTiO_3$ ، مزيج، رقائق ، قطر التثبيط

Introduction

The nanocomposite is a multiphase material made up of two or more constituent materials (matrix and reinforcing phase) with different chemical and physical properties that, when mixed, produce a material with features that are distinct from the individual compounds. Nanocomposites have grown in importance in our lives over the past few decades. In every aspect of 21st-century technology, materials play an important role. To make our lives easier, it began to be used in medical, automotive, computing, and sensor applications. Polymer nanocomposite is one type of nanocomposites based on the matrix. Polymer nanocomposites are made up of Nano sized fillers and a polymer or copolymer [1]. The researchers found that adding Nano filler to the polymer matrix improves properties and can be used in a variety of applications. The nanoscale allows for the use of less fillers and a more efficient transfer of their particular molecular properties to the polymer matrix [2].

Recently .Due to its unique properties such as biocompatibility, hydrophilicity, nontoxicity, and biodegradability, PVA is gaining growing interest from researchers for biomedical applications such as eye drops, contact lenses, tissue adhesion barriers, and artificial cartilage [3]. It also has exceptional film-forming properties. It's blended with different synthetic and natural polymers as a water-soluble film and used in food packaging because of this property, which is combined with excellent chemical stability and hydrophilicity [4]. Further PVA films have a variety of biomedical uses, including contact lenses, hemodialysis, artificial pancreases, synthetic vitreous humors, and cartilage and meniscus tissue replacement [5].

Because of their novel properties, composites and nanocomposites have a wide range of modern industrial and medical applications [6].Nanoparticle toxicity mechanisms against different bacteria are unknown, but NPs have the ability to disrupt bacterial cells. The toxicity of nanoparticles to bacteria is determined by their type and composition, as well as the bacteria involved. [7] They are electrostatically bound to bacteria's membranes and damage the membrane's integrity [8]. Its toxicity is caused by the formation of free radicals (Reactive Oxygen Species) as a result of oxidative stress induced by the administration of NPs. [9]. Both Gram-positive and Gram-negative bacteria have a lot of differences in their outer cell membranes, which makes antimicrobial action complicated and distinct. Nanoparticle toxicity mechanisms are thus dependent on the bacterial species against which they will function, as well as their structure, surface modifications, and intrinsic properties.

There are several studies and reports on the antibacterial effects of NPs, and their toxicity mechanisms may be complicated by a number of factors. [10, 11]. CuO, NiO, ZnO, and Sb2O3 are some of the nanoparticles used against bacteria, and they have the ability to destroy E. coli, B. subtilis, and S. aureus. CuO>ZnO>NiO> Sb2O3 is the order of toxicity of these NPs against these bacteria [12]. Toxicity for metal oxide NPs depends on its natural toxic properties of heavy metals and not on its NPs itself. Activity also largely depends on the colony size, number of colonies and the concentration of metal oxide NPs [12]. The aim of this paper is to create a new class of nanocomposites that can be used in antibacterial applications.

Materials and methods

Nanocomposites of (polyvinyl alcohol- poly-acrylic acid acrylic acid) blend as matrix and Strontium titanate ($SrTiO_3$) nanoparticles (Us Research Nanomaterials, USA company (purity 99.95%, 100 nm)) as additive have been prepared by using casting method. The samples of (PVA-PAA-$SrTiO_3$) nanocomposites were fabricated by dissolving 1 gm of polyvinyl alcohol and poly-acrylic acid in 30 ml of distilled water with weight percentages: 88 wt. % PVA and 12 wt. % PAA by using magnetic stirrer to mix the polymers for 1 hour to obtain more homogeneous solution. The $SrTiO_3$ nanoparticles were added to (PVA-PAA) blend with concentrations are (0, 1.8, 3.6, 5.4 and7.2) .In this paper the antimicrobial activity of the nanocomposite samples (PVA-PAA-$SrTiO_3$) was determined using the disc- diffusion method. Gram positive (Staphylococcus aureus) and gram negative organisms Escherichia coli, bacteria (Staphylococcus aureus and Escherichia coli) cultured in Muller –Hinton agar were used to conduct antibacterial activities. The nanocomposite (PVA-PAA-$SrTiO_3$) disk was placed over the media and incubated for 24 hours at 37°C. The diameter of the inhibition zone was calculated

Result and discussion

The antibacterial properties of the (PVA-PAA-$SrTiO_3$) nanocomposites were investigated using gram-positive (Staphylococcus aureus) and gram-negative (Escherichia coli) bacteria, and the results are shown in figures (1) and (2). The inhibition zone becomes larger as the concentration of nanoparticles increases, as seen in the figures**.** The presence of reactive oxygen species (ROS) produced by nanoparticles is responsible for the bactericidal activity of (PVA –PAA-$SrTiO_3$) nanocomposites [13]. The potential mechanism of action is that the nanocomposites (PVA-PAA-$SrTiO_3$) have positive charges while the microbes have negative charges, resulting in an

electromagnetic attraction between the nanoparticles of nanocomposites and the microbes. The microbes are oxidized and die as soon as the attraction is made [14]. The key mechanism by which nanoparticles cause antibacterial activity in nanocomposites may be oxidative stress induced by ROS. ROS involves radicals like super oxide radicals (O-2), hydroxyl radicals (–OH) and hydrogen peroxide (H_2O_2); and singlet oxygen ($1O_2$) can be the cause of damage to bacteria's proteins and DNA. Most pathogenic bacteria, such as S. aureus and E. coli, were inhibited by ROS provided by the present (PVA-PAA-$SrTiO_3$) nanocomposites [13, 15].

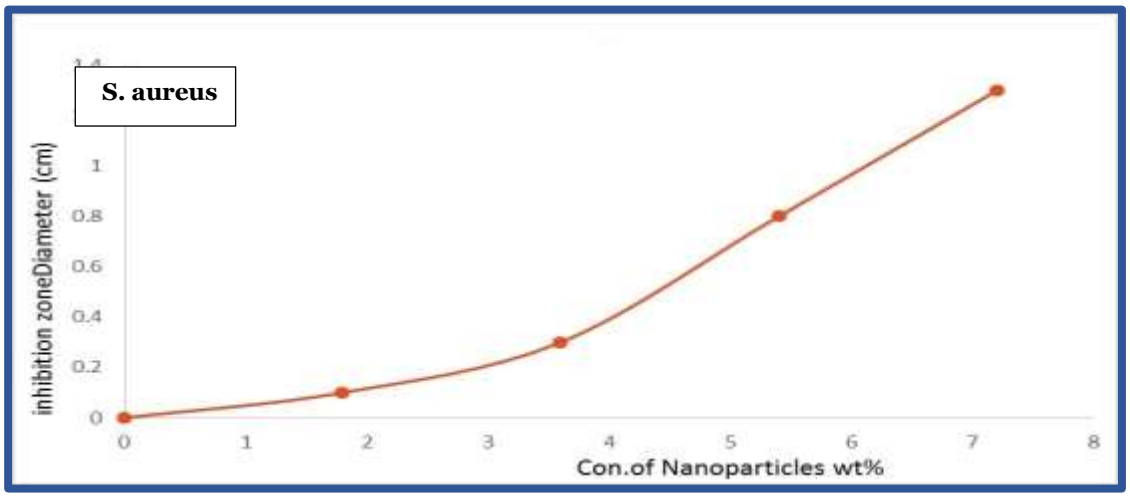

Figure (1): antibacterial effect of (PVA-PAA) blend as a function of SrTiO3 nanoparticles concentrations on S. aureus

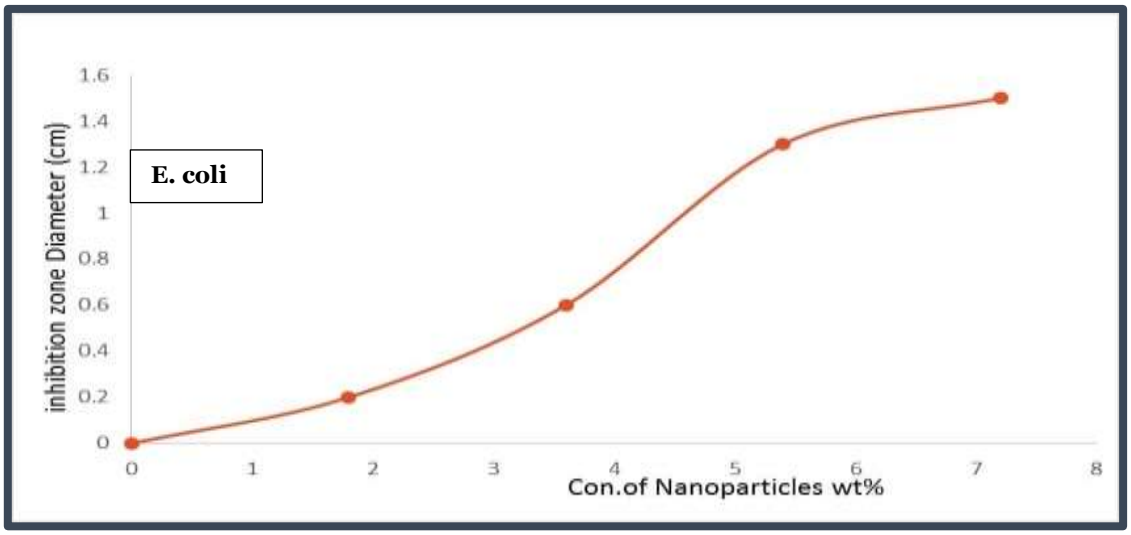

Figure (2): antibacterial effect of (PVA-PAA) blend as a function of SrTiO3 nanoparticles concentrations on E. coli

Conclusion

The present work includes preparation of PVA/PAAP$SrTiO_3$ nanocomposites films for antibacterial application against with high activity, flexible and low cost .The films were fabricated by various ratios of $SrTiO_3$ NPs and PVA/PAA results , it can noted that the inhibition zone increase with the rise in $SrTiO_3$ NPs ratio .The antibacterial results of PVA/PAA $SrTiO_3$ films against organisms (S.aureus and E.coli)showed that the (PVA-PAA-$SrTiO_3$) nanocomposites films have high antibacterial activity

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