RESEARCH PAPER

Study of Structural Properties and Antibacterial Application of PVA/Ag_2O Nanocomposite: ZnO Films

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ABSTRACT

A range of liquid compositions based on poly (vinyl alcohol) (PVA) and including zinc and silver oxide nanoparticles have been developed. Other consistency-forming organic components were also present in the formulations. The products' physicochemical characteristics have been ascertained. They have had their density and pH evaluated. Moreover, the compositions were also examined under a microscope and by SEM. Adding metallic nanoparticles and metal oxide enhanced the items with antibacterial qualities. Their ability to impede the growth of germs has been verified in instances involving Gram-positive and Gram-negative bacteria, including *S. aureus, P. aeruginosa, and E. coli.* Owing to their solidification properties, the compositions can be applied to surfaces contaminated with bacteria. Once the microorganisms are destroyed and the material solidifies, it can be separated from the dead bacterial layer by peeling off.

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INTRODUCTION

Nanotechnology is one of the sciences that is reportedly developing the fastest. It allows for creating new technical solutions and improving existing ones through materials having at least one dimension between (1) and (100) nm [1].

The increasing body of information regarding nanomaterials and the advancement of science procedures make Is it feasible to regulate the final product's size and form nanoparticles, which in turn enables the development of new, favorable physic-chemical characteristics in the materials. The fields with the most significant breakthroughs are medical, Environmental engineering, biotechnology, electronics, food technology, and chemical and material engineering [2]. The battle against microbes is effectively waged with nanomaterials. The growth of antibiotic-resistant kinds of bacteria due to abuse of antibiotic medication has made the fantastic efficacy of nanoparticles against bacteria all the more important these days. There are multiple methods for destroying bacteria depending on the type of nanoparticle. When Nanoparticles create pores on the bacterial wall after penetrating it. membrane's surface, they release free radicals that burst the cell membrane [3]. Moreover, reactive oxygen species (ROS) and ions produced by Using nanoparticles, you can synthesis Proteins have an impact on DNA transcription [4]. Of all the

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nanomaterials, nanometric silver is of particular interest. The nano silver particle's size, form, and surface area are some of the factors that influence how effective its biocidal action is [5]. Studies have indicated that bacterial resistance is best exhibited by spherical and triangular forms up to 30 nm in size [5–6]. The antibacterial activity of silver nanoparticles is also influenced by the type of bacteria and the composition of their cell walls [7]. The peptidoglycan on the surface of Gram (+) bacteria's cell wall is necessary for the respiratory chain to function properly. These peptidoglycans are affected by nano silver, which makes them incapable of aiding in oxygen respiration and killing the bacteria [8]. Microbial cell ions produce reactive oxygen species, leading to lipid peroxidation and protein oxidation [9]. The biocidal effectiveness of nanometric metal oxides, such as ZnO and Ag_2O, has also been tested [10–11]. The literature [12, 13] does not explicitly specify how effective zinc oxide nanoparticles are against microorganisms that are Gram-positive (G (+)) and Gram-negative (G(−)).Tayel et al.'s [14] investigation of zinc nano oxide's antibacterial properties against nine bacterial strains revealed that Gram-positive bacteria are more vulnerable to the substance's antibacterial activities than Gram-negative bacteria. Similar conclusions were reached by Reddy and colleagues [15]. They showed that, in contrast to Gram-positive bacteria, the amount of zinc oxide nanoparticles needed to stop Gram-negative bacteria from developing must be three times higher. In turn, Pasquet, Applerot, and colleagues published several observations [12, 16]. According to their research, bacteria made up of outer cell membranes are more susceptible to the antibacterial effects of zinc oxide nanoparticles. As a result, numerous theories have been put out to describe the operation of nanos Zinc oxide is effective against Gram-positive bacteria. O. is thought to adhere The double lipid layer, or peptidoglycan, is assumed to be extremely sensitive to ROS produced due to ZnO activity [16]. to a specific receptor within a bacterial cell. This article presents research on compositions based on poly (vinyl alcohol) (PVA), including zinc and silver oxide nanoparticles, and the antibacterial activity of these materials. On surfaces polluted by microorganisms, a liquid application of the mixture is suggested. The products are great because they only take a few hours to solidify full the double-to-peptidoglycan combination may detach from the dead biological layer during application and solidification. Steakolococcus aureus, Escherichia coli, and Pseudomonas aeruginosa were used to measure the minimum inhibitory concentration (MIC) and bacterial cell reduction against Gram-positive and Gram-negative pathogens. The double lipid layer is the lipid layer, or peptidoglycan, which is y. were employed. Three times, they demonstrated [17].

MATERIALS AND METHODS

Using a casting approach, polyvinyl alcohol (13.7g) was dissolved in 160 ml of distilled water with a magnetic stirrer for 45 minutes at 60 °C to create a more uniform solution. This resulted in films of zinc oxide, silver oxide, and polyvinyl alcohol. ZnO-Ag_2O nanocomposites, zinc oxide and silver oxide nanoparticles were added to the polymer mixture to create PVA. To create PVA: ZnO-Ag_2O nanocomposites, on the other hand, add zinc oxide and silver oxide in varying weight percentages (1, 2, and 3). PVA: ZnO-Ag_2O polymer nanocomposites were created when the solution was dried for 24 hours at room temperature. The solution was then put into a petri dish and used for measurement. Samples with a thickness of about 100 nm ZnO-AgO NCs are PVA's structural and optical components.

RESULTS AND DISCUSSION

Scanning Electron Microscope (SEM)

Amount of nanoparticles in the polymer mixtures affects the surface profile Fig. 1 presents SEM images of the PVA mixture with varying concentrations of zinc oxide and silver oxide nanoparticles to examine the morphology of the nanocomposites and how the nanoparticle arrangement varies at low and high concentrations of nanoparticles. When charge carriers are let to go across the tracks in the PVA, SEM pictures show equally distributed nanoparticles [18]. On the surface of the nanocomposite membranes, numerous spherical particle agglomerates or pieces are widely separated and uniformly distributed. This could indicate a homeostatic mechanism for growth. The amount of nanoparticles in the polymer mixtures affects the surface profile. The grains clump together when Ag_2O and ZnO NPs increase. The outcomes will display the membranes ' surface morphology after adding 3-weight percent Ag_2O and ZnO NPs to PVA. The presence of a homogeneous growth mechanism

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is shown by the formation of many spherical particle aggregates or chunks on the surface of nanocomposites and by the steady increase in the Ag_2O and ZnO NPs ratio in PVA. It becomes softer as the concentration of both particles rises, and this is consistent with the researchers' findings, where nanoparticles aggregate and are evenly distributed inside PVA to form a continuous network within the polymers [19].

Application of PVA-Ag_2O-ZnO Nanocomposites for Antibacterial Activity

Fig. 2 shows photographs of the inhibitory zone containing Escherichia coli and Staphylococcus

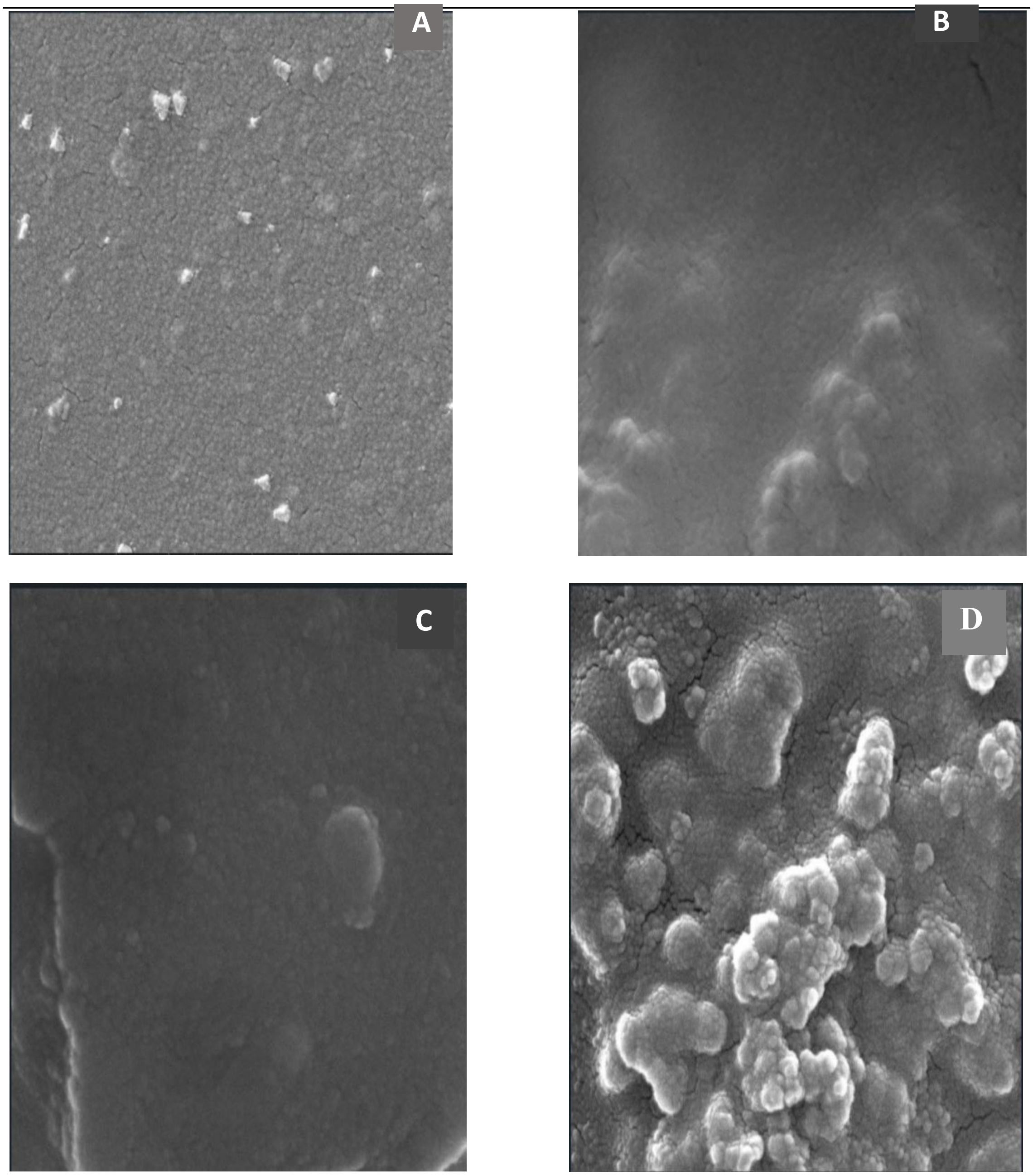

Fig. 1. SEM for PVA-Ag_2O-ZnO NCs are shown in (A) for PVAPure, (B) for 1 wt% Ag_2O-ZnO, (C) for 2 wt% Ag_2O-ZnO, and (D) for 3 wt% Ag_2O-ZnO

ry microorganisms. The antibacterial properties of the (PVA: Ag_2O-ZnO) nanocomposites against gram-positive (Staphylococcus aureus) and gram-negative (Escherichia coli) bacteria are depicted in Fig. 3 and (4). These plots show that the diameter of the inhibitory zone grows along with an increase in Si_3N_4 nanoparticle concentration. Reactive oxygen species (ROS) formed by various

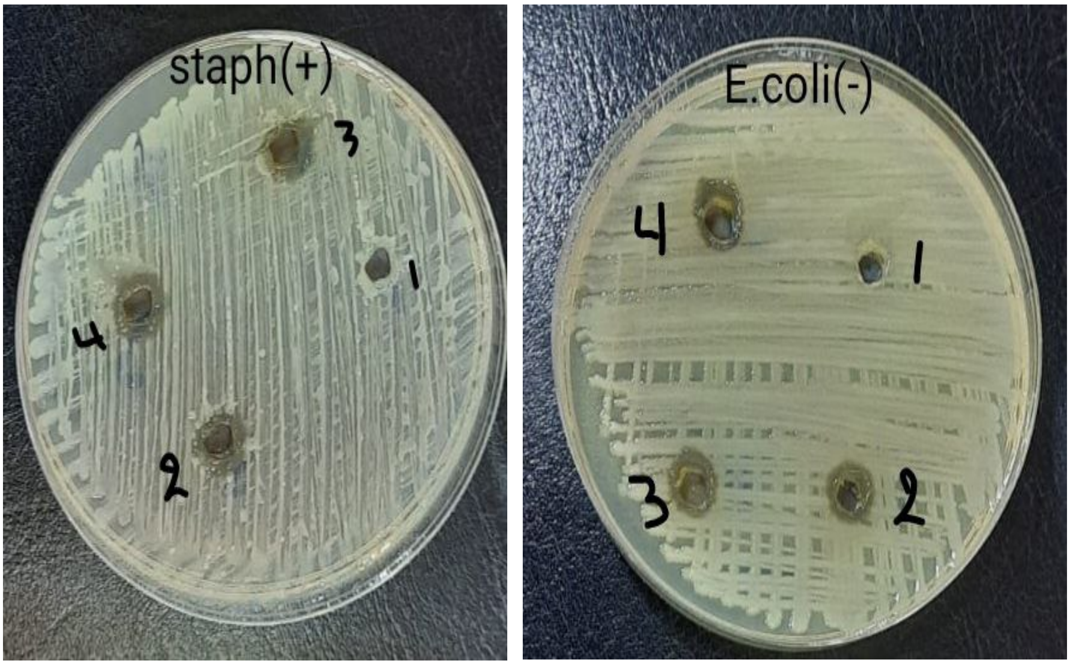

Fig. 2. Images of inhibition zone for (1) *Staphylococcus* and (2) *Escherichia coli*.

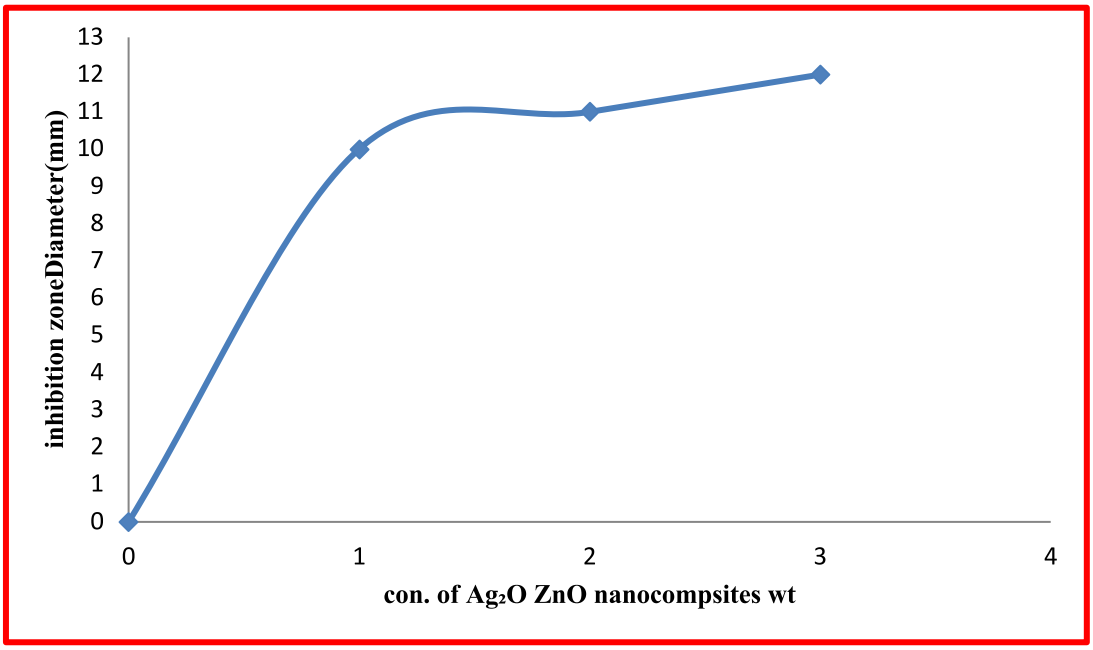

Fig. 3. Inhibition zone diameter of (PVA: Ag_2O-ZnO) nanocomposites against *Staphylococcus aureus* bacterial.

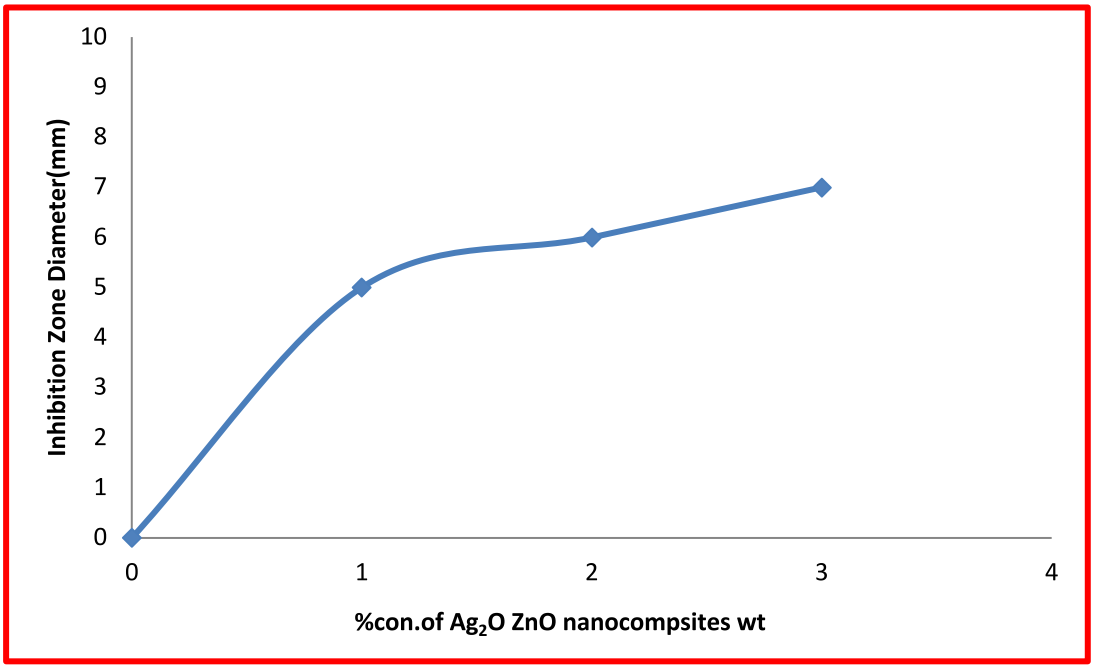

Fig. 4. Inhibition zone diameter of (PVA: Ag_2O-ZnO) nanocomposites against *Escherichia coli*.

Table 1. inhibition zone diameter of (PVA: Ag_2O-ZnO) nanocomposites.

Concentrations (Ag_2O-ZnO)wt%	Inhibitions zonediameter(mm)of Staphylococcus	Inhibitions zonediameter(mm) ofEscherichia coli
pure	0	0
1	10	5
2	11	6
3	12	7

processes may cause the antibacterial activity of nanocomposites [20, 21]. Tiny particles the primary mechanism behind the antibacterial properties of nanocomposites created by nanoparticles could be oxidative stress caused by ROS. Reactive oxygen species (ROS), which comprise radicals like superoxide radicals (O_2), hydroxyl radicals (-OH), hydrogen peroxide (H_2O_2), and singlet oxygen (1O2), have the potential to damage proteins and DNA in bacteria [22]. The ROS that produced metal oxides may have inhibited most harmful microorganisms. Nonetheless, the bacteria and the nanoparticles are attracted to one other electromagnetically because the nanoparticles in the nanocomposites are negatively charged. As the attraction develops, the bacteria oxidize and die [23]. Table 1 shows nanocomposites' inhibitory zone diameter (PVA: Ag_2O-ZnO).

CONCLUSION

The surface morphology was well distributed and had good quality in the SEM scans. According to SEM pictures, the substance and sample have a smooth distribution at 3 weight per cent concentration. The antimicrobial treatment outcomes for Ag_2O-ZnO (PVA) The inhibitory zone for S. aureus and E. coli expanded with increasing concentrations of Ag_2O and ZnO nanoparticles, as evidenced by nanocomposites. At a concentration of 3 weight per cent, the results demonstrated the good antibacterial activity of the (PVA: Ag_2O-ZnO) nanocomposites.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this manuscript.

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