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ANTIBACTERIAL ACTIVITY OF SILVER NANOPARTICLES BY GREEN SYNTHESIS METHOD

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Abstract

The green synthesis of silver nanoparticles (AgNPs) from biological waste, as well as their excellent antibacterial properties, is attracting a lot of attention in the scientific community right now. In this study, AgNPs were synthesised from various mango peel extract concentrations and their characteristics and antibacterial properties were investigated. The AgNPs were irregular, with rod-like, spherical shapes, and were detected in a range of 25 nm to 75 nm. The AgNPs demonstrated antibacterial activity against E. coli and Staphylococcus aureus (S. aureus), with a greater impact when synthesised with 0.20 g/mL mango peel extract. As a result, the antibacterial effect of various diluted AgNP concentrations on E. coli and S. aureus growth kinetic curves after synthesis with 0.20 g/mL mango peel extract was investigated. The results showed that AgNP had greater antibacterial activity against S. aureus than against E. coli, with the AgNP IC50 in these two strains being 1.557 mg/mL and 2.335 mg/L, respectively. This study sheds new light on the use of postharvest mango byproducts, as well as the possibility of developing additional AgNP composite antibacterial materials for fruit and vegetable preservation.

Keywords: mango peel, silver nanoparticles, green synthesis and antibacterial activity

Introduction

Nanotechnology literally refers to any technology on a nanoscale that has real-world applications. Nanotechnology is the fabrication and application of physical, chemical, and biological systems at scales ranging from individual atoms or molecules to submicron dimensions, as well as the incorporation of the resulting nanostructures into larger systems. Nanotechnology, like semiconductor technology, information technology, or cellular and molecular biology, is expected to have a profound impact on our economy and society in the early twenty-first century [1]. Materials and manufacturing, nanoelectronics, medicine and healthcare, energy, biotechnology, information technology, and national security all stand to benefit from nanotechnology research. Nanotechnology is widely regarded as the next Industrial Revolution.

Silver is known for its antimicrobial properties and has been used for years in the medical field for antimicrobial applications and even has shown to prevent HIV binding to host cells [2]. The Ag-NPs are also reported to be nontoxic to human and effective against bacteria, viruses, and other eukaryotic micro-organisms at very low concentration and without any side effects [3]. Silver nanoparticles, because of their large specific surface area, are highly active and can play a crucial role in inhibiting bacterial growth in aqueous and solid media. The antimicrobial activity of colloidal silver is influenced by the size of the particles. Smaller the particle size more is its antimicrobial effect [4]. Biosynthesis of metal nanoparticles, using plant leaf material as reductants as well as capping agent, is currently under exploitation. It is an eco-friendly, cost effective and more efficient alternative method for large scale synthesis of metal nanoparticles. Under the proposed research, kinetic study of silver ions reduction has been carried out using different plant leaf extracts as reductants and capping material. The antibacterial activities of as-synthesized silver nanoparticles against some pathogenic bacteria have been investigated.

Materials and Methods

Materials

Fresh, ripe mangoes were obtained from the local market in Tirupattur City, Taminadu, India. Silver nitrate (AgNO3), sodium dodecyl sulphate, Agar powder, Beef extract, tryptone, and yeast extract.

Green AgNP Synthesis

Preparation of the Mango Peel Extract

The mango peels were collected and washed thoroughly using distilled water to remove the dust particles adhering to the surface and cut into small pieces. The mango peels (10 g, 15 g, 20 g, 25 g, 30 g, and 35 g) were transferred to 100 mL of distilled water and pressed to obtain an extract using a juicer. The extract was boiled at 85 ◦C for 30 min to obtain polyphenols substances from the mango peels [5]. These substances were used as reducing and capping agents to synthesize the AgNPs, which were then centrifuged at 2000 rpm for 10 min. The supernatant was filtered through 0.45-micron-pore-size membranes to obtain the extract, which was stored at 4 ◦C for further use.

AgNP Synthesis

The AgNPs were prepared using AgNO3 as a precursor and mango peel extract as a reducing agent according to a method delineated by Turunc et al. [6], with slight modifications. A mixture consisting of 0.15 g sodium dodecyl sulfate, 25 mL 2.0 mmol/L AgNO3 solution, and 2 mL mango peel extract was prepared at concentrations of 0.10 g/mL, 0.15 g/mL, 0.20 g/mL, 0.25 g/mL, 0.30 g/mL, and 0.35 g/mL. The nanometer silver colloid was then obtained via heating and stirring for 1 h at 80 ◦C. A change in color from colorless to reddish-brown of the suspensoid certificated the green synthesis of AgNPs [39]. The reaction solution was centrifuged three times at 10,000 r/min for 10 min using a highspeed centrifuge. The subsequent precipitate was vacuum freeze-dried to obtain the AgNP powder, which was stored in anhydrous ethanol.

Antibacterial Activity against E. coli and S. aureus

The AgNP sols were prepared according to a method described by Vijayaraghavan et al. [7], with minor modifications. Each nanometer silver colloid was prepared using two different concentrations (40% and 20% of the original nanometer silver colloid solution) and the mango peel extract displaying the strongest antibacterial effect. The impact of different nanometer silver colloid concentrations on the growth curves of E. coli (5.0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, and 80% of the original nanometer silver colloid solution) and S. aureus (2.5%, 5.0%, 10%, 15%, 20%, 30%, 40%, 50%, and 60% of the original nanometer silver colloid solution) were determined to explore the half lethal concentration on these two bacterial strains. The antibacterial effect of AgNPs on E. coli and S. aureus was evaluated using ultraviolet spectrophotometry with slight modifications [45]. Here, 5 mL AgNP sol and 3 mL of E. coli or S. aureus suspension at a concentration of 107 CFU/mL were added to the sterile Luria-Bertani (LB) medium (LB, 5 g yeast extract, 10 g NaCl, 10 g tryptone, and 1000 mL water). The bacteria were cultured and maintained in LB broth and then incubated at 37 ◦C at 180 rpm, while the bacterial cell proliferation was monitored at intervals according to absorption at 600 nm [46]. Finally, the growth curve plot was created using the optical density (OD) value vs. time.

Results and Discussion

The antibacterial effect of AgNP sol on E. coli and S. aureus was studied using 0.20 g/mL as the optimal AgNP sol concentration. As shown in Figures 1 and 2, the experimental group differed from the control group in terms of antibacterial effect against E. coli and S. aureus at different AgNP concentrations. At a 5.0% stock solution and AgNP concentration, the E. coli growth curve was similar to that of the control, as shown in Figure 4a, indicating weak antibacterial activity against this strain. However, at an 80% stock solution concentration, E. coli proliferation tended to be horizontal, indicating that this AgNP concentration completely inhibited E. coli growth. As a result, the minimum inhibitory concentration (MIC) required for E. coli restriction was approximately 80% AgNP precursor sol, with the fastest E. coli growth rate observed after 6 hours of incubation. Figure 2 shows that the survival rate of E. coli was 50% when the concentration of nano-silver was 30% of the concentration of nano-silver solution, implying that the IC50 of nano-silver on E. coli was approximately 30% of the concentration of nano-silver solution. As shown in Figure 1, the fastest S. aureus proliferation occurred within 8 hours, except at 40%, 50%, and 60% concentrations. The MIC against S. aureus was represented by a 60% AgNP solution, while the half lethal concentration was represented by a 20% AgNP solution. According to the findings, E. coli was inhibited by an AgNP MIC of about 8.303 mg/L and a median lethal concentration of about 3.113 mg/L. Furthermore, an AgNP sol MIC of about 6.227 mg/L and a median lethal concentration of about 2.067 mg/L inhibited S. aureus.

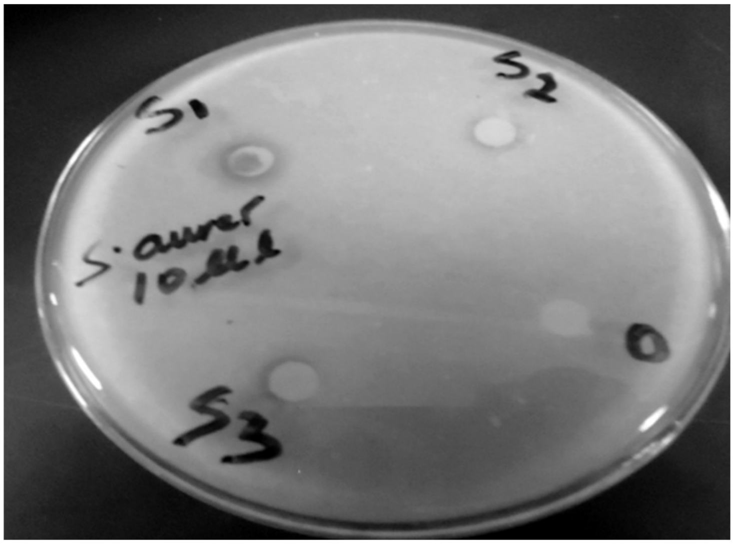

Fig. 1. Zones of inhibition of silver nanoparticles synthesized against *Staphylococcus aureus*

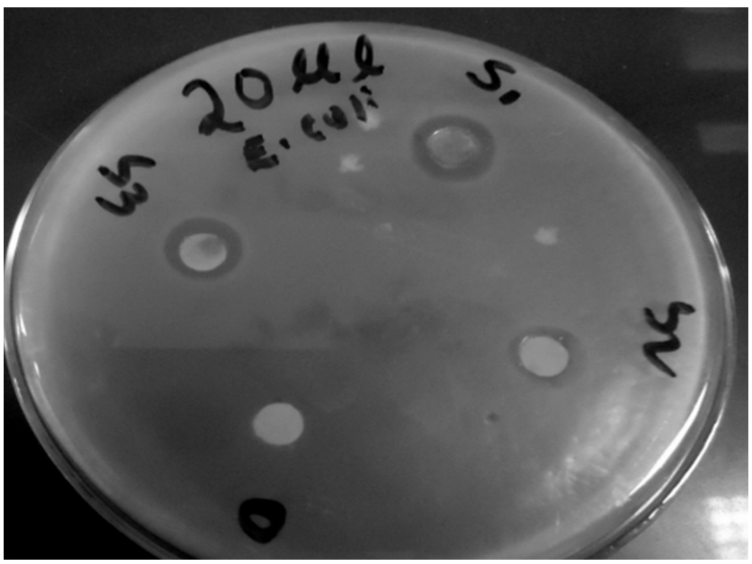

Fig. 2. Zones of inhibition of silver nanoparticles synthesized against *Escherichia coli.*

Conclusion

Silver nanoparticles demonstrated significant antibacterial activity against the pathogens tested. As a result, AgNPs could be a promising antibacterial agent against Staphylococcus aureus and Escherichia coli. The use of AgNPs could lead to important discoveries in fields such as medical devices and antimicrobial systems.

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