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Commentary

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Size-controlled silver nanoparticles synthesized over the range 5–50 nm and their antibacterial efficacy study on bacteria isolated from UTI infection

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DESCRIPTION

A systematic and detailed study for size-specific antibacterial efficacy of silver nanoparticles (AgNPs) synthesized using Tamarind kernel powder ang gum acacia is presented here. Nucleation and growth kinetics during the synthesis process was precisely controlled and AgNPs of average size 5,7,10,15,20,30 and 50 nm were synthesised with good yield and monodispersity.The bacteriostyatic/bactericidal effect of AgNPs also show dose-dependent activity. The Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC) of silver nanoparticles studied against four bacterial strains. Staphylococcus aureus 2039 and Escherichia coli 256 were identified as the least and most sensitive bacteria, respectively. They both are sensitive towards silver nanoparticles depending on the size of AgNPs. For AgNPs with less than 10 nm size, the antibacterial efficacy was significantly enhanced as revealed through delayed bacterial growth kinetics, MIC/MBC values and well diffusion test. AgNPs of smallest size i.e 5 nm give the best result and fastest bactericidal activity against all four strains. 7nm and 10 nm also have bactericidal activity but lesser then 5 nm. This enhanced antibacterial performance of smaller-sized AgNPs can be attributed to their larger surface area-to-volume ratio, which facilitates greater interaction with bacterial cell membranes. The increased surface reactivity allows for more efficient disruption of cell wall integrity, leading to leakage of intracellular contents and eventual cell death. Additionally, smaller nanoparticles are more likely to penetrate bacterial membranes and interfere with vital cellular processes, including enzyme function and DNA replication.

Among the tested sizes, the 5 nm AgNPs consistently demonstrated superior efficacy across all assays, indicating their strong potential for applications requiring rapid and effective bacterial control. In comparison, 7 nm and 10 nm particles also exhibited bactericidal properties, although their activity was moderately reduced. Larger particles, particularly those 15 nm and above, showed a noticeable decline in antibacterial action, emphasizing the critical role of particle size in determining the functional performance of AgNPs.

Overall, the study underscores the importance of precise control over nanoparticle synthesis to tailor their antibacterial effects. The results open avenues for developing highly effective, size-optimized silver nanoparticle-based antimicrobial agents using environmentally friendly synthesis routes such as those involving Tamarind kernel powder and gum acacia.

CONCLUSION

This study highlights the significant influence of particle size on the antibacterial efficacy of silver nanoparticles synthesized using eco-friendly agents like tamarind kernel powder and gum acacia. By carefully controlling the synthesis process, AgNPs ranging from 5 to 50 nm were produced with high monodispersity. The antibacterial tests revealed that smaller nanoparticles, particularly those around 5 nm, exhibited the most potent and rapid bactericidal activity against all tested bacterial strains. This enhanced performance is likely due to their higher surface area, which promotes stronger interaction with bacterial cells and disrupts essential cellular functions. The findings demonstrate that optimizing nanoparticle size is crucial for maximizing antibacterial effectiveness and suggest that green synthesis methods can produce highly efficient, size-specific antimicrobial agents.