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Development of eco-friendly hybrid nanocomposites for enhanced thermal and mechanical performance in structural applications

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Statement: With the rise of antibiotic-resistant pathogens, there is a growing need for sustainable antimicrobial materials. This study explores the green synthesis of zinc oxide (ZnO) nanoparticles using extracts from Egyptian medicinal plants and evaluates their potential as antimicrobial coatings for biomedical surfaces.

Methodology: Aqueous extracts of Nigella sativa and Ziziphus spina-christi, both indigenous to Egypt, were used as reducing and stabilizing agents for the synthesis of ZnO nanoparticles. The synthesis was carried out at ambient temperature, and the resulting nanoparticles were characterized using UV–Vis spectroscopy, X-ray diffraction (XRD), Scanning Electron Microscopy (SEM), and Fourier-transform infrared spectroscopy (FTIR). The antimicrobial activity was tested against Escherichia coli and Staphylococcus aureus using the agar well diffusion method. Coating tests were performed on glass slides and evaluated for zone of inhibition and surface morphology.

Conclusion: The study demonstrates an eco-friendly, low-cost approach to producing antimicrobial ZnO nanoparticles using Egyptian plant extracts. The nanoparticles exhibited strong and sustained antibacterial properties, making them suitable for use in medical device coatings and hospital surfaces. This green synthesis method contributes to sustainable nanotechnology and supports the use of local plant resources in advanced materials development.