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PROCEEDINGS ABSTRACT

Development, physicochemical characterisation, and antimicrobial activity assessment of selenium nanoparticles modified with chitosan and gallic acid

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Selenium (Se) nanoparticles (SeNPs) are widely considered as promising antimicrobial nanomaterials due to their biocompatibility, broad-spectrum biological activity, and relatively low toxicity compared to inorganic Se compounds. However, their poor stability and nanoparticle aggregation continue to be significant barriers to their use in biomedical applications. The aim of this study was to synthesise SeNPs that are stabilised and functionalised with chitosan and gallic acid, as well as to evaluate their physicochemical characteristics and antibacterial efficacy against *Staphylococcus aureus* and *Escherichia coli*. SeNPs were synthesised by chemical reduction using sodium selenite as the Se precursor and ascorbic acid as the reducing agent, in the presence of gallic acid and chitosan. The reaction mixture's obvious colour change from colourless to reddish–orange was the first indication of the nanoparticles' formation. Subsequently, Fourier-transform infrared (FTIR) spectroscopy, dynamic light scattering (DLS), zeta potential analysis, and scanning electron microscopy (SEM) were used in order to physiochemically characterise the produced SeNPs. Furthermore, the minimum inhibitory (MIC) and minimum bactericidal (MBC) concentrations against *S. aureus* and *E. coli* were calculated using the broth microdilution method in accordance with the 2020 CLSI M07 criteria. The undertaken FTIR analysis confirmed the successful functionalisation and stabilisation of the SeNPs by chitosan and gallic acid through hydrogen bonding and electrostatic interactions. The broad absorption band at 3331 cm^{-1} corresponded to overlapping O–H and N–H stretching vibrations, while the absorption band at 1637 cm^{-1} indicated interactions between the carbonyl and the deprotonated carboxylate groups of the gallic acid and the amino groups of chitosan. Additional absorption bands at the 1427–1316 cm^{-1} range corresponded to COO^- and C–N vibrations, whereas bands at the 1160–1035 cm^{-1} range confirmed the preservation of chitosan's backbone structure. The undertaken DLS analysis demonstrated that the average particle sizes of the chitosan-stabilised SeNPs (CS-SeNPs) and of the gallic acid-functionalised CS-SeNPs (GA/CS-SeNPs) were 142.0 and 137.6 nm, respectively. Following the addition of gallic acid, the polydispersity index values were found to be 0.241 and 0.209, thereby showing improved uniformity. The values of the undertaken zeta potential analysis were +38.3 mV for the CS-SeNPs and +38.5 mV for the GA/CS-SeNPs, indicating that these nanoparticles exhibit excellent colloidal stability. The creation of mostly spherical nanoparticles with particle sizes that are in line with the DLS findings was further verified by an SEM examination. Moreover, both nanoparticle formulations exhibited better antibacterial effectiveness against *S. aureus* than against *E. coli*, according to our *in vitro* studies. While the GA/CS-

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SeNPs exhibited increased antibacterial activity with MIC values down to 50 and 100 μg/mL against *S. aureus* and *E. coli*, respectively, the CS-SeNPs exhibited MIC values of 100 and 200 μg/mL against the same pathogens. At equal doses, gallic acid by itself did not stop bacterial growth, suggesting that the increased antibacterial action came from the functionalisation of the nanoparticles rather than from the free molecule. Moreover, according to our MBC analysis, the GA/CS-SeNPs exhibited values of 100 μg/mL against *S. aureus* and 200 μg/mL against *E. coli*, whereas the CS-SeNPs showed bactericidal action at 200 μg/mL against both bacterial strains. The developed GA/CS-SeNPs exhibit superior antibacterial activity, enhanced physicochemical stability, and improved nanoparticle uniformity, thereby indicating their potential as antimicrobial nanomaterials.

Keywords

antibacterials; chitosan; gallic acid; nanoparticles; selenium

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Conflicts of interest statement

None to declare.

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