Synthesis of Metallic Nanoparticle Based Ecofriendly Disinfectants and Evaluation of Their Anti-Microbial Efficacy against the Multi-drug Resistant Bacteria

Abstract

Antibiotic resistance has become a noteworthy impendence, invalidating the disinfectants currently used in clinical practice. Furthermore, traditional chlorinated disinfectants and their byproducts pose a significant threat to the environment and human health. In the era of antibiotic resistance, the advent of nanotechnology can be a long-term solution, as recent studies have suggested the substantial antimicrobial properties of some metallic nanoparticles.

The mode of action and efficiency of nanoparticles in demonstrating antimicrobial behavior is majorly due to their size and shape, which influence their interaction with bacterial cells. However, the importance of these properties may vary based on interactions with other components in microbial cells, hinting at a need for multipronged approaches towards nanoparticle design optimization towards antimicrobial applications. The stability of metallic nanoparticles (MNPs) in relation to their antimicrobial activity depends on morphology, surface variations, and conditions of preparation; hence, modifying those parameters might help in obtaining more effective MNPs against microbial resistance. In general, higher stability is linked to improved antimicrobial efficiency in the case of MNPs; however, being too stable might impair their reactivity and limit their effectiveness. Therefore, an equilibrium between stability and reactivity holds the key to effectively using them in antimicrobial strategies.

The study will navigate the complex interplay between nanoparticle size and shape in order to design sustainable and effective nanoparticle-based disinfectants against multi-drug-resistant bacteria. This will be coupled with public health initiatives to develop green and eco-friendly disinfectants to minimize environmental footprints.

In this research, organic solvent-free synthesis of MNPs from their precursor salts will be carried out by chemical reduction and chemical coprecipitation methods using different capping, reducing, and stabilizing agents in varying concentrations. Following the purification by centrifugation, the MNPs will be freeze-dried and kept in a sealed glass container.

The synthesis of MNPs will be ensured by employing the UV-visible spectrophotometer, while Fourier-transform infrared spectroscopy (FTIR) will confirm the presence of capping agents. Particle size analyzers will be utilized to measure the size distribution and stability of the MNPs in solution through dynamic light scattering (DLS) and electrophoretic light scattering (ELS) techniques, respectively. Scanning electron microscopic (SEM), energy dispersive X-ray spectroscopic (EDS), X-ray diffraction (XRD) analysis will reveal the surface features, elemental compositions, and crystallite size respectively, of the freeze-dried MNPs.

Besides the cytotoxicity assay in cell line, comparative microbiological evaluation of MNPs-based disinfectants and standard disinfectants will be performed against the methicillin-resistant *Bacillus cereus*, *Escherichia coli, Staphylococcus aureus,* and *Pseudomonas aeruginosa*. The functional characterization included minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) against the planktonic bacterial cells. Additionally, minimum biofilm eradication concentration (MBEC) assay will be performed against the adherent bacterial cells. Furthermore, the efficacy of the MNPs will be evaluated by a time-kill kinetic assay.