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University of Technology
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Hot Metal Nanoparticles Prepared by Laser Radiation for Antibacterial Effect

A Thesis

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ABSTRACT

This study synthesizes, optimizes, characterizes, and tests the antibacterial activity of bismuth nanoparticles (Bi NPs) produced by Pulsed Laser Ablation in Liquid (PLAL) utilizing a 532 nm Nd:YAG laser. Bi NPs samples were generated using different pulse repetition frequencies (PRF), laser energy, number of pulses, and liquid temperatures. Ultraviolet-Visible (UV-Vis) analysis was conducted to determine the optimal preparation parameters. X-ray diffraction (XRD) analysis confirms successful preparation of Bi NPs. Field emission scanning electron microscopy (FESEM) shows that laser parameters drastically impact NPs' size and morphology. Optimal parameters effectively reduced the particle size from 80 nm to 59 nm on average, while the average Bi NP size at 60 ˚C was 28 nm, considerably smaller than the 55 nm observed at 10 ˚C. Bi NPs were tested against gram-negative *E. coli* and gram-positive *S. aureus*. The antimicrobial effect assay showed a larger inhibition zone in *S. aureus* than *E. coli* for all samples, with optimally prepared Bi NPs showing increased potency, which was further enhanced at 60 °C. Moreover, this work investigates, for the first time, the characteristics and antibacterial activity of Bi NPs synthesized using PLAL coated with silica using the alcohol-ammonia-Tetraethyl Orthosilicate (TEOS) method, producing Bi@SiO_2 core–shell NPs, and evaluated the effect of centrifuge selection. UV-Vis measurements suggest silica coating of Bi NPs improves colloidal solution stability. XRD confirms the preparation of pure metallic Bi NPs coated by SiO_2. Transmission electron microscopy (TEM) images showed Bi NPs were adequately coated and the silica shell thickness increased with TEOS. Coated NPs had been tested against *E. coli* and *S. aureus*. Bi@SiO_2 NPs exhibited remarkable antibacterial activity with an increase in efficacy and a higher potency against *E. coli* compared to uncoated Bi NPs. The inhibition zones increased with silica shell thickness and NPs' concentration.