

# Synthesis of ZnO nanoparticles using plant extracts containing saponins and investigation of their antibacterial activity

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Zinc oxide (ZnO) nanoparticles are widely recognized for their biomedical potential due to the unique physicochemical properties and antibacterial capabilities. This study presents a plant extract-based synthesis approach utilizing ethanol extracts from *Ricinus communis*, *Sapindus trifoliatus*, and *Neolitsea cassia*, which contain surface-active phytochemicals such as saponins, to enhance particle stability. The objective was to develop a phytochemical-mediated synthesis method and evaluate the antimicrobial activity. The biosynthesis of ZnO nanoparticles was performed using co-precipitation method in ethanol extracts of selected plant species in the presence of zinc acetate dihydrate as the precursor. Synthesized particles were characterized by UV-vis, FTIR spectroscopies, X-ray diffraction (XRD), scanning electron microscopy (SEM), and thermogravimetric analysis (TGA). Results confirmed particle sizes ranging from 110 to 128 nm and distinct morphologies, including flake like (*Ricinus communis*), hexagonal (*Neolitsea cassia*), and sheet-like (*Sapindus trifoliatus*) forms, depending on the plant extract used in the synthesis. FTIR spectra indicated the presence of saponin-associated functional groups suggesting their incorporation into ZnO nanoparticles. XRD analysis demonstrated the crystalline nature of the particles. Based on the TGA studies, particles were stable up to 400 °C. Also, UV-vis spectra of ZnO nanoparticles synthesized using the three plant extracts exhibited characteristic absorption peaks around 365 nm, consistent with the formation of ZnO nanostructures. Antimicrobial activity of synthesized materials was performed using the percentage inhibitory method by calculating the percentage of number of colony forming units present compared to the neutral control. Antimicrobial activity against *Escherichia coli* (Gram-negative) and *Staphylococcus aureus* (Gram-positive) showed pronounced antibacterial effects for all plant-mediated ZnO nanoparticles, with inhibitions ranging from 51.7–82.7 % against *E. coli* and 45.5–86.4 % against *S. aureus*. ZnO particles without plant extract showed an inhibition of ~70% for both strains. Notably, ZnO nanoparticles synthesized from *R. communis* exhibited the highest inhibition, 86.4% and 82.7%, against *E. coli* and *S. aureus*, respectively. These findings indicate an enhanced antibacterial response by *R. communis*-mediated ZnO nanoparticles, which may be attributed to potential generation of reactive oxygen species facilitated by bioactive compounds from plant extract.

**Keywords:** *Phytochemicals, Zinc oxide nanoparticles, Saponins, Gram-negative bacteria, Antimicrobial activity*