



Eco-Friendly Synthesis, Characterization and Multifunctional Bioactivity of Phyto-Capped Zinc Oxide Nanoparticles Derived from *Kalanchoe fedtschenkoi*

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This work reports an eco-friendly approach of synthesis of zinc oxide nanoparticles (Kf-ZnNPs) using leaf extract from *Kalanchoe fedtschenkoi* and evaluates their physico-chemical characteristics along with a broad spectrum of biological activities. The UV-Visible spectroscopy confirmed the formation and optical stability of the nanoparticles through a distinct absorption peak at 349 nm, indicative of monodispersity. Dynamic light scattering and zeta potential analyses revealed a narrow particle size distribution with an average hydrodynamic diameter of approximately 34.20 nm (PDI: 0.001-0.306) and moderate colloidal stability (-11.66 mV). Scanning electron microscopy (SEM) further demonstrated a quasi-spherical morphology with particle sizes ranging between 13.49 and 24.28 nm. FTIR analysis confirmed the involvement of proteins, phenolics and other phytochemicals from the plant extract in nanoparticle reduction and stabilization. The crystalline nature of the nanoparticles was established by X-ray diffraction, which showed a characteristic wurtzite ZnO phase with crystallite sizes between 17.7 to 26.4 nm and an average crystallite size of 21.78 ± 3.42 nm. Biological results revealed the remarkable antibacterial activity of Kf-ZnNPs against *Staphylococcus aureus* and *Escherichia coli*, with inhibition zones of 25 ± 1.00 mm and 22 ± 1.00 mm, respectively, along with significant antifungal efficacy against *Candida albicans* (23 ± 1.00 mm). The nanoparticles also exhibited significant antioxidant, anti-inflammatory and antidiabetic activities, with IC₅₀ values of 92 µg/mL, 70.98 µg/mL and 97.13 µg/mL, respectively. Furthermore, the cytotoxicity assays demonstrated substantial anticancer potential against MCF-7 and A549 cell lines, with IC₅₀ values of 15 µg/mL and 20.15 µg/mL, respectively.

Keywords: Biological activities, *Kalanchoe fedtschenkoi*, Zinc oxide nanoparticles.