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ORIGINAL RESEARCH PAPER

Biogenic synthesis of copper oxide nanoparticles using leaf extracts of *Cissus quadrangularis* and *Piper betle* and its antibacterial effects

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Owing to its environment-friendly, biocompatible, non-toxic nature of nanoparticles attained from green plant extract, it has remarkable significance in the field of nanotechnology towards effective biomedical application. This work reports the synthesis of copper oxide nanoparticles by means of *Cissus quadrangularis* and *Piper betle* via green-synthesis route. The medicinal leaf extracts possessing phytochemicals such as alkaloids and polyphenols act as a reducing agent in the current synthesis. The characterization of functional groups of CuO NPs by two different leaf extracts was investigated by FTIR analysis which measures reduction and stabilization of CuO NPs. X-ray diffraction confirms the orthorhombic structure with an average crystallite size of about 32.54 and 32.09 nm. The irregular spherical-shaped morphology of the samples is evidenced from scanning electron microscopy analysis. The transmission electron microscopy images demonstrated 50 nm sized prepared CuO nanoparticles. The bioactivity of the prepared sample is confirmed from antibacterial studies and zeta potential.

1 | INTRODUCTION

Nanotechnology has shown explosive growth worldwide in the past few years in the development of engineered nanomaterials with a wide range of applications in various fields ranging from material sciences to biomedicine [1]. The novel properties of nanoparticles (NPs) have been exploited in a wide range of possible applications such as medicines, renewable energies, environmental remediation, and biomedical devices. Nanobiotechnology is an interdisciplinary field that has emerged as an interaction between biotechnology and nanotechnology for developing new biosynthetic devices and eco-friendly technology with advantages in the field of drug delivery to bio-chips

[2, 3]. Thanks to the controlled size and composition, metal oxide NPs gains provide fundamental and technological attention as they offer solutions to technological and environmental challenges [4–7]. The green synthesis of NPs employs plant material to meet the growing need in developing environmentally friendly approaches [8–11]. Medicinal plants have been playing a crucial role in maintaining human health and civilizing the quality of human life for thousands of years. Ayurveda, unani, homeopathy, naturopathy, siddha, and other alternative medicinal systems have been utilizing plants as effective medicines to cure various diseases [12–14]. Plants are valuable source of compounds with reductive abilities called antioxidants. The higher bioactivity of as-synthesized

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