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ORIGINAL ARTICLE

An effective bio-inspired synthesis of palladium nanoparticles using *Crateva religiosa* G.Forst. leaf extract: a multi-functional approach for environmental and biomedical applications

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Abstract

The biogenic synthesis of metal nanoparticles (MNPs) through the reduction of metal ions using secondary metabolites extracted from plants is considered an eco-friendly and bio-safe method. In this study, palladium nanoparticles (Pd-NPs) were synthesized through biogenic synthesis. Pd-NPs were obtained using an aqueous leaf extract of *Crateva religiosa*, exhibiting the desired physicochemical properties in terms of structure, optics, and photocatalytic activity. The characterization of prepared biogenic Pd-NPs was achieved by UV-Vis spectroscopy, FT-IR, XRD, SEM, EDX, and HR-TEM. As a result of characterization, UV-Vis spectrum exhibited a maximum absorbance at a wavelength of 420 nm. In the XRD analysis, five basic peaks attributed to Pd-NPs, and an average crystallite size was 10.31 nm. In addition, SEM and HR-TEM determined that Pd-NPs have a quasi-spherical shape, and an average size of 15–20 nm was tested antimicrobial activity with *Bacillus subtilis*, *Klebsiella pneumonia*, *Aspergilus niger*, and *Aspergillus tamarii.* Pd-NPs at 30 µg/mL exhibited bacteriocidal and anti-fungistatic activity. In addition, Pd-NPs inhibited the formation of the biofilm layer by *B. subtilis* and *K. pneumoniae* by 85.63% and 92.78%, respectively. Pd-NPs also exhibited potential free radical scavenging activity in a dose-dependent manner. Pd-NPs displayed a remarkable anti-inflammatory activity of 96.68% according to the albumin denaturation inhibitory assay. Furthermore, they exhibited anticancer activity against A549 cell lines, with an IC-50 value of 28.25 µg/mL determined through *in vitro* cytotoxicity assessment using the MTT assay. The photocatalytic activity was observed by the degradation of fast green dye (95.28%) and Rose Bengal dye (95.15%) at pH 3 and 150 min of exposure time and under sunlight. Moreover, the Pd-NPs positively impacted seed germination on horse gram. Overall, the results indicate that Pd-NPs, obtained through biogenic synthesis, have the potential to serve as agents for various biological and environmental applications.

Keywords *Crateva religiosa* G.Forst. · Palladium nanoparticles · Green synthesis · Anti-biofilm · Photocatalytic activity · Seed germination

1 Introduction

In today's world, pollution is a significant threat, mainly driven by industrial developments like the paper industry, textiles, and tanneries, which contaminate water sources [1]. Among these industries, textiles are particularly problematic due to their release of dye effluents, reducing dissolved oxygen solubility and increasing biological oxygen demand in aquatic ecosystems. Dye effluents harm aquatic ecosystems, reducing sunlight penetration and disrupting photosynthesis in plants, affecting aquatic life's food sources and causing lasting pollution [2]. Fortunately, nanotechnology's rapid advancement has given nanomaterials a vital role in treatment processes, drawing attention

Highlights
- An effective bio-inspired synthesis of Pd-NPs using *Crateva religiosa* extracts (CRE)
- Pd-NPs' distinct properties make them highly promising for biomedical use
- Synthesized Pd-NPs help FGD and RBD degradation in industrial effluents
- Pd-NPs positively impacted seed germination applications on horse gram
- This study offers a practical, affordable, and safe approach to producing inorganic NPs

Extended author information available on the last page of the article

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