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Effective reduction of nitrophenols and colorimetric detection of Pb(II) ions by *Siraitia grosvenorii* fruit extract capped gold nanoparticles†

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This study presents a simple and green approach for the synthesis of *Siraitia grosvenorii* fruit extract capped gold nanoparticles (SG-AuNPs). The SG-AuNPs samples prepared under the optimized conditions were characterized by various techniques (UV-Vis, XRD, FTIR, HR-TEM, EDX, DLS). The biosynthesized nanoparticles were then studied for the reduction of 2-nitrophenol (2-NP) and 3-nitrophenols (3-NP) and for colorimetric detection of Pb^{2+} ions. The characterization results revealed that the crystals of SG-AuNPs were spherical with an average size of 7.5 nm. The FTIR and DLS analyses proved the presence of the biomolecule layer around AuNPs, which played an important role in stabilizing the nanoparticles. The SG-AuNPs showed excellent catalytic activity in the reduction of 3-NP and 2-NP, achieving complete conversion within 14 min. The catalytic process was endothermic and followed pseudo-first-order kinetics. The activation energy was determined to be 10.64 and 26.53 kJ mol^{-1} for 2-NP and 3-NP, respectively. SG-AuNPs maintained high catalytic performance after five recycles. The fabricated material was also found to be highly sensitive and selective to Pb^{2+} ions with the detection limit of 0.018 μM in a linear range of 0–1000 μM. The practicality of the material was validated through the analyses of Pb^{2+} in mimic pond water samples. The developed nanoparticles could find tremendous applications in environmental monitoring.

1. Introduction

Heavy metals and organic substances are considered as the major pollutants in wastewater, and have caused many serious problems for the environment and human health.[1–3] Heavy metals like Pb^{2+}, Cd^{2+}, Hg^{2+}, Ni^{2+}, and Cr^{6+}, even at trace level concentrations, in water bodies have been reported to be potential environmental pollutants.[4] Delay in detecting and estimating these metal contaminants in biological systems and the aquatic environment could cause several health issues in humans. There are several methods available for detecting and monitoring metal ions in solutions such as electrochemical method, atomic absorption spectrometry, inductively coupled plasma atomic emission spectroscopy, X-ray fluorescence spectrometry, and inductively coupled plasma mass spectrometry. Although those methods provide excellent sensitivity, high accuracy, and multi-element analysis, they have shortcomings associated with the complicated sample preparation, complex and costly instrumentation, and time-consuming procedures.[5] In recent years, nanomaterial-based colorimetric sensors have been extensively studied for the detection of heavy metal ions in environmental and biological samples owing to their simple operations, cost-effective, highly sensitive and selective detection, and rapid analysis.[6] This method can allow the direct tracking of target heavy metal ions by the naked eyes through color changes without expensive instruments compared with other methods. With this convenience, the development of various colorimetric sensors for detecting metal contaminants is now of great interest.

Along with heavy metals, organic pollutants containing aromatic structures are often characterized by high stability, non-biodegradability, and high toxicity, leading to various dangerous diseases for humans, including genetic mutations and cancer, when exposed to them.[7] Particularly, nitrophenols

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