Chapter 5
Biogenic Gold Nanoparticles:
Methods, Characterization, and Diverse Applications

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ABSTRACT

Metallic NPs, particularly (AuNPs), have attracted great attention due to their unique characteristics and applications. NPs have unique surface qualities as compared to bulk substances, including diagnostics and medicine administration. Therapeutic plant extracts exhibit stability, making them suitable for various applications as a result of their biocompatibility and flexibility, thereby minimizing their phytochemical properties. The biogenic NPs were characterized using UV-vis, FTIR, and SEM, demonstrating antibacterial activity and potential for large-scale synthesis. Green synthesis technique adopted ecological acceptable practices and showed the promise of plant-based synthesis in biomedical applications. Phytoextract is cost-effective and eco-friendly method for producing AuNPs, outperforming conventional chemical synthesis methods. Along with providing workable substitute for chemical synthesis in pharmaceutical, medical, and agricultural domains, it also demonstrates the viability of green synthesis for the production of bioactive AuNPs and shows it prospective applications.

1. INTRODUCTION

Nanoparticles (NPs) exhibit unique catalytic, electrical, and optical properties due to their nanoscale size (1–100 nm), high surface area-to-volume ratio, and quantum effects. These properties distinguish them from bulk materials in both physical and chemical terms. NPs can be synthesized using physical,

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chemical, and biosynthetic approaches, each with its own advantages and limitations. Various characterization techniques are commonly employed to analyze their properties (Lee et al., 2016).

Physical, chemical, and biological syntheses methods are employed to prepare the NPs. The conventional (Physical & chemical) methods are toxic, expensive, time-consuming, and sometimes have a negative impact on the environment. On the other hand, biological methods are cost-effective, non-toxic, and environmentally friendly. Moreover, NPs through biological (green) synthesis process are more biocompatible than the conventional ones. These approaches not only eliminate the need for hazardous reagents but also allow for better control over the size, shape, and properties of the NPs, enabling tailored applications in biomedicine and environmental science (Chandirika et al., 2018).

As a result, green synthesis of NPs using biological materials has emerged as a promising method (safe, non-hazardous, & environmentally friendly), specifically in the biological fields. Green synthesis of NPs, utilizing medicinal plant extracts (fruit, leaf, root, etc.,) has demonstrated cost-effectiveness and scalability. This method eliminates the need for hazardous reagents, ensuring safer production processes. Additionally, green-synthesized NPs exhibit enhanced biocompatibility and reduced toxicity, making them ideal for biological applications. Various parameters such as pH, temperature, type & concentration of plant extract, and reaction time influence the size, shape, characteristics, and applications of plant mediated biogenic metal NPs (Judy et al., 2012; Ahmada et al., 2021).

Biogenic gold nanoparticles (AuNPs) are among the most studied NPs due to their unique surface plasmon resonance properties, stability, and biocompatibility. These characteristics make AuNPs suitable for various applications such as drug delivery, water purification, wound healing/treatment, cosmetics, diary industries, environmental remediation, energy, food packaging, to name a few (Bawazeer et al., 2021; Huang et al., 2019).

In this chapter, we discussed characterizations and applications of medicinal plant mediated biogenic AuNPs.

2. DISCUSSION

In this section, we reviewed various works on plant mediated biogenic AuNPs.

Lee et al. (2016) used an aqueous peel extract of *Garcinia mangostana* (*G. mangostana*), (commonly known as mangosteen and belonging to the family *Guttiferae*), to synthesize AuNPs. *Mangosteen* has long been used as a traditional remedy for chronic ulcers, dysentery, and abdominal pain. The NPs were characterized using UV-Vis spectroscopy, which confirmed the role of the plant extract in forming AuNPs through the appearance of a strong peak (540-550 nm) following the addition of tetrachloroaurate, indicating the formation of monodispersed (FVF, BFB) spherical AuNPs. FTIR spectrum showed various peaks (2845, 2914, 2919 cm^{-1}, etc.), confirming the stretching and vibration of different phytochemical groups (O-H, C-H, C-C, O-C, etc.). The crystalline structure of the synthesized AuNPs was revealed by XRD analysis, which displayed strong peaks associated with specific crystal planes ((111), (200), (220), and (311)). TEM analysis further confirmed the generation of predominantly spherical nanoparticles of average size of ~ 33 nm and a size variation of around ±5 nm. The researchers primarily emphasized the growing need for ecologically friendly synthesis techniques, particularly for medical applications, that do not involve hazardous chemicals. Their study highlighted the benefits of plant-based synthesis, specifically the use of *Garcinia mangostana* (*G. mangostana*) fruit peels as a reducing agent. These peels contain phenolic acids, flavonoids, alkaloids, and terpenoids, which facilitate nanoparticle reduc-