Biological Synthesis of Spilanthes Acmella Nanoparticles

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ABSTRACT
Premna integrifolia L. is extensively distributed in tropical and subtropical regions. In this study, green silver nanoparticles were efficiently synthesized by mixing 1 mmol/L AgNO3 and 4% aqueous leaf extract at a neutral pH (7.0) after 25 minutes of sunlight exposure. The aqueous leaf extract was rich in polyphenols, with a higher flavonoid content (67.23 ± 1.23 mg/mg gallic acid equivalent) than phenolic content (58.10 ± 2.29 mg/mg rutin equivalent). The synthesized silver nanoparticles were characterized using various spectroscopic and microscopic techniques. They exhibited a spherical shape and sizes ranging from 9 to 35 nm. The crystalline nature of the nanoparticles was confirmed through high-resolution transmission electron microscopy (HRTEM), high-resolution scanning electron microscopy (HRSEM), X-ray diffractometry (XRD), and selected area electron diffraction (SAED) analyses. The presence of silver ions in the biosynthesized nanoparticles was confirmed based on energy-dispersive X-ray (EDX) data (3.5 keV). Functional groups involved in nanoparticle synthesis were analyzed using FT-IR. The silver nanoparticles showed significant antibacterial activity against human pathogenic gram-positive (Staphylococcus aureus, Enterococcus faecalis) and gram-negative (Shigella dysenteriae, Shigella flexneri, and Vibrio parahaemolyticus) bacteria. Additionally, the silver nanoparticles exhibited good in vitro antioxidant and cytotoxic activity against a human cervical cancer cell line (SiHa).
Keywords: Spilanthes acmella, nanoparticles, Biological synthesis

Introduction

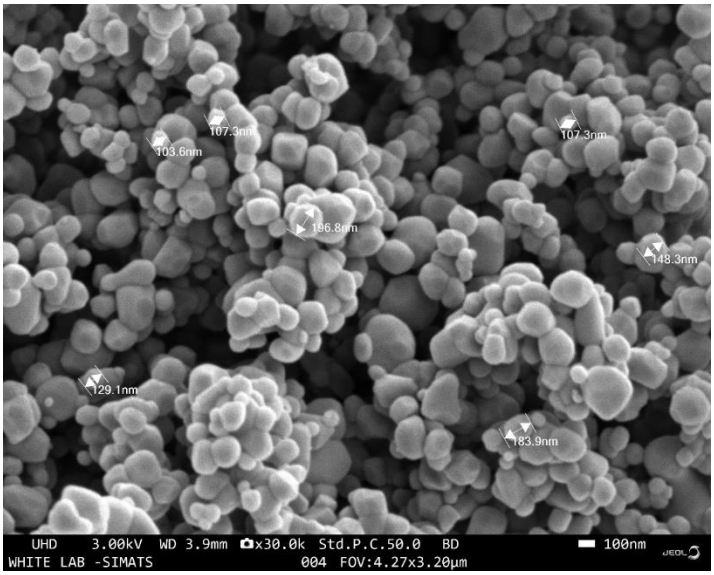
Nanotechnology represents a rapidly growing field with diverse applications in catalysis, solar energy, waste management, and sensing technology. In the medical field, nanomaterials are employed for drug delivery, disease diagnosis, treatment of cardiovascular ailments, wound healing, and the development of antimicrobial agents. Nanoparticles, especially those synthesized using noble metals, exhibit unique physicochemical properties not found in individual molecules or bulk metals. Silver nanoparticles, in particular, are widely used due to their versatile applications. However, conventional methods of nanoparticle synthesis are expensive and environmentally toxic, necessitating the exploration of alternative, eco-friendly synthesis methods. Green synthesis of silver nanoparticles using plant materials offers a cost-effective, rapid, and environmentally benign approach. Plant extracts, rich in phytoconstituents, serve as reducing agents for silver ions, facilitating nanoparticle synthesis. Factors such as temperature, pH, plant extract concentration, and silver nitrate concentration influence the synthesis process. Premna integrifolia L., found in tropical and subtropical regions, has long been utilized in traditional medicine for its antimicrobial and antioxidant properties. This study aimed to synthesize silver nanoparticles using aqueous leaf extract of P. integrifolia and evaluate their physicochemical characteristics and biological activities.

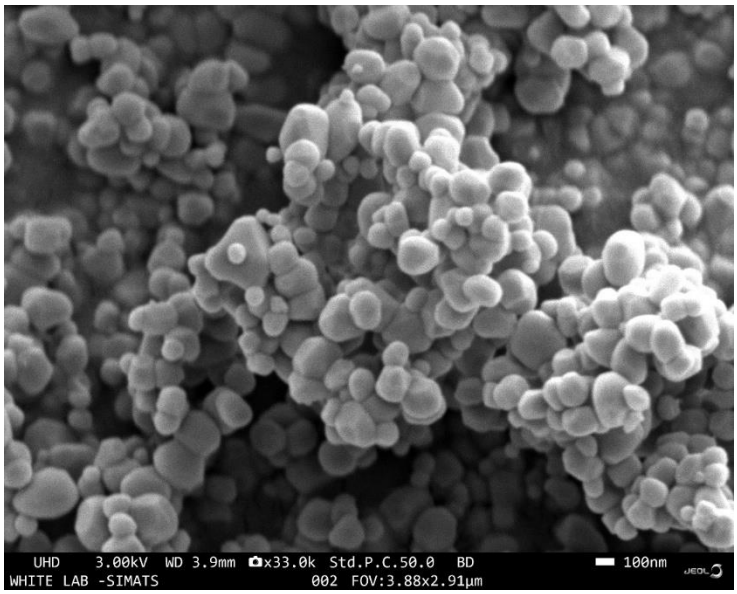
Materials and Methods

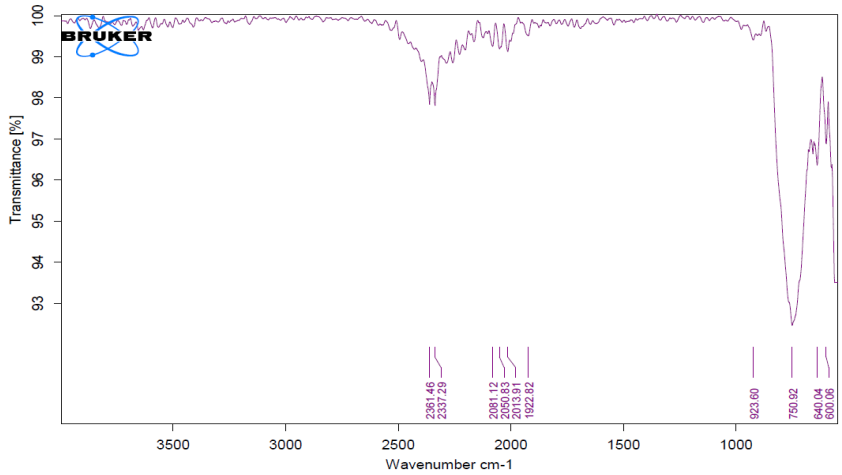
Fresh leaves of P. integrifolia were collected, washed, and heated in deionized water to obtain the aqueous leaf extract. Total phenolic and flavonoid contents were determined using Folin–Ciocalteu and AlCl3 colorimetric methods, respectively. Silver nanoparticles were synthesized by mixing the aqueous leaf extract with silver nitrate solution and exposing the mixture to sunlight. Various parameters such as sunlight exposure duration, silver nitrate concentration, and leaf extract concentration were optimized to achieve efficient nanoparticle synthesis. The synthesized nanoparticles were characterized using spectroscopic and microscopic techniques including UV–Vis spectroscopy, FT-IR, HRTEM, HRSEM, XRD, SAED, and EDX. Antioxidant activity was evaluated using the DPPH scavenging assay, while antibacterial activity was assessed against gram-positive and gram-negative pathogenic bacteria. Cytotoxicity was tested against a human cervical cancer cell line (SiHa) using the MTT assay.

Results and Discussion

The aqueous leaf extract of P. integrifolia exhibited substantial phenolic and flavonoid content, providing a rich source of reducing agents for nanoparticle synthesis. UV–Vis spectroscopic analysis confirmed the synthesis of silver nanoparticles, with a characteristic surface plasmon resonance peak at 417 nm. Optimization experiments revealed that a 4% leaf extract concentration, 1 mmol/L silver nitrate concentration, and 25 minutes of sunlight exposure were optimal conditions for nanoparticle synthesis. FT-IR analysis indicated the involvement of functional groups from the plant extract in nanoparticle synthesis. HRTEM and HRSEM images revealed spherical nanoparticles with sizes ranging from 9 to 35 nm. XRD and SAED analyses confirmed the crystalline nature of the nanoparticles. EDX analysis confirmed the presence of elemental silver in the synthesized nanoparticles. AFM analysis provided insights into surface texture and particle size distribution. The synthesized nanoparticles exhibited potent antioxidant activity, scavenging free radicals effectively. They also demonstrated significant antibacterial activity against both gram-positive and gram-negative pathogenic bacteria. Furthermore, the nanoparticles showed promising cytotoxicity against a human cervical cancer cell line, indicating their potential for cancer therapy.







Conclusion

The study successfully synthesized silver nanoparticles using the aqueous leaf extract of P. integrifolia. Characterization using various analytical techniques confirmed the physicochemical properties of the nanoparticles. The nanoparticles exhibited notable antioxidant, antibacterial, and cytotoxic activities, highlighting their potential applications in medicine and biotechnology. Further research is warranted to explore their therapeutic efficacy in vivo and optimize their synthesis for large-scale production.

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