IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

"Biogenic Synthesis Of Silver Nanoparticles From Mangrove Leaf Extracts: Characterization And Biological Applications"

Anitha katta, Suseela Lanka*

Department of Biosciences and Biotechnology, Krishna University, Machilipatnam-521004, Andhra Pradesh, India.

Abstract:

The biogenic synthesis of silver nanoparticles (AgNPs) using plant extracts has garnered significant attention due to its eco-friendly and sustainable approach. This review focuses on the synthesis of silver nanoparticles using mangrove leaf extracts, a promising green route for nanoparticle production. Mangroves, known for their rich bioactive compounds such as flavonoids, tannins, and polyphenols, serve as excellent reducing and stabilizing agents in the synthesis of AgNPs. The review provides an overview of the key techniques used for the characterization of these nanoparticles, including UV-Vis spectroscopy, Fourier-transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), and transmission electron microscopy (TEM). It also highlights the biological applications of AgNPs synthesized from mangrove leaves, particularly their antimicrobial, antioxidant, anti-inflammatory and anticancer properties. Additionally, the review explores the potential of these biogenic AgNPs in environmental and biomedical applications. This green synthesis method offers a viable alternative to conventional chemical approaches, promoting sustainability while producing nanoparticles with diverse biological activities.

Keywords: Mangroves, Leaf extract, Nanoparticles Synthesis, Characterization, and Biological Activities.

Introduction:

Nanotechnology has emerged as a revolutionary field with immense potential across various domains, including medicine, environmental science, and materials engineering. Among the various types of nanoparticles, silver nanoparticles (AgNPs) have garnered significant attention due to their remarkable antimicrobial, antioxidant, and anticancer properties. Traditional methods of synthesizing AgNPs often involve the use of hazardous chemicals, raising concerns about environmental impact and biocompatibility [1]. In response, there has been a growing interest in green synthesis approaches that utilize biological entities such as plant extracts, which offer a more sustainable and eco-friendly alternative.

Mangrove plants, which thrive in coastal and estuarine ecosystems, are a rich source of bioactive compounds, including flavonoids, tannins, and polyphenols, that can act as reducing and stabilizing agents in the synthesis of nanoparticles. Previous studies have demonstrated that the phytochemicals present in plant extracts can efficiently reduce silver ions to form AgNPs, with the added advantage of imparting biological functionality to the nanoparticles [2].

The biogenic synthesis of AgNPs using mangrove leaf extracts is particularly appealing due to the unique properties of these plants [12]. Mangroves are known for their resilience in harsh environments, and their leaves contain a diverse array of secondary metabolites that can enhance the stability and activity of the synthesized nanoparticles [3]. Additionally, the use of plant-based synthesis methods aligns with the principles of green chemistry, minimizing the need for toxic reagents and reducing the generation of harmful byproducts [4].

This review aims to explore the biogenic synthesis of silver nanoparticles using mangrove leaf extracts, focusing on the characterization of the resulting nanoparticles and their potential biological applications. By leveraging the natural reducing power of mangrove leaves, this review seeks to contribute to the development of sustainable nanotechnology with applications in antimicrobial therapy, antioxidant treatments, anti-inflammatory treatments and potentially in cancer therapy.

Synthesis of Silver nanoparticles

Biogenic synthesis of nanoparticles refers to the utilization of biological resources—such as plants, microbes, or enzymes—to produce nanoparticles in an environmentally friendly and sustainable manner. Among various biological entities, plant extracts are widely employed for nanoparticle synthesis due to their availability, ease of use, and rich content of bioactive compounds [5]. Mangrove plants, which thrive in saline coastal environments, are particularly rich in secondary metabolites like flavonoids, tannins, and polyphenols that can act as natural reducing and stabilizing agents in the synthesis of silver nanoparticles (AgNPs) [6].

In this review, the leaves of mangrove plants were collected, washed thoroughly, and dried at room temperature. The dried leaves were then ground into a fine powder and subjected to aqueous extraction by boiling in distilled water. The resulting extract was filtered to remove any particulate matter, yielding a clear solution rich in phytochemicals. This extract served as the reducing agent in the synthesis of AgNPs [7].

Silver nitrate ($AgNO_3$) was used as the precursor for silver ions. The aqueous mangrove leaf extract was added dropwise to a solution of silver nitrate under continuous stirring at room temperature. The reaction mixture gradually changed color, indicating the reduction of Ag^+ ions to silver nanoparticles. This color change, typically from pale yellow to dark brown, is a hallmark of AgNP formation due to surface plasmon resonance (SPR), which is characteristic of metallic nanoparticles [8].

Characterization of Synthesized Silver Nanoparticles:

The synthesized AgNPs were subjected to a series of characterization techniques to confirm their formation, determine their size, shape, and crystallinity, and identify the functional groups involved in the synthesis process [14, 15].

1. **UV-Visible Spectroscopy:** The reduction of Ag^+ ions and the formation of AgNPs were initially confirmed by UV-visible spectroscopy. The surface plasmon resonance (SPR) peak, typically observed between 400 and 450 nm, is indicative of the presence of silver nanoparticles. The exact position of the SPR peak depends on factors such as particle size, shape, and the dielectric environment surrounding the nanoparticles.
2. **X-ray Diffraction (XRD):** The crystalline nature of the synthesized AgNPs was confirmed using X-ray diffraction. The XRD pattern showed distinct peaks corresponding to the face-centered cubic (FCC) structure of metallic silver. The diffraction peaks at 2θ values of approximately 38°, 44°, 64°, and 77° were indexed to the (111), (200), (220), and (311) planes of silver, respectively, confirming the crystalline nature of the nanoparticles.
3. **Transmission Electron Microscopy (TEM):** TEM analysis provided detailed information on the morphology and size of the AgNPs. The images revealed that the nanoparticles were predominantly spherical and uniformly distributed with an average size ranging from 10 to 50 nm. The high-resolution TEM images also confirmed the crystalline structure, consistent with the XRD findings.
4. **Fourier-Transform Infrared Spectroscopy (FTIR):** FTIR spectroscopy was employed to identify the functional groups in the mangrove leaf extract responsible for the reduction and stabilization of AgNPs. The FTIR spectra showed characteristic absorption bands corresponding to functional groups such as hydroxyl

(-OH), carbonyl (C=O), and amine (NH) groups. These groups are believed to play a crucial role in reducing Ag^{+} ions and stabilizing the nanoparticles, preventing their aggregation.

5. **Dynamic Light Scattering (DLS):** To assess the size distribution and stability of the synthesized AgNPs in colloidal form, DLS measurements were performed. The results showed a narrow size distribution, indicating a well-dispersed nanoparticle solution. The zeta potential measurements further confirmed the stability of the nanoparticles, with values typically indicating good colloidal stability.

Biological Activities

The biological activities of silver nanoparticles (AgNPs) synthesized through green methods, such as using mangrove leaf extracts, have garnered significant attention due to their potential applications in medicine and environmental science [11]. The bioactivity of these nanoparticles is largely influenced by their size, shape, surface chemistry, and the presence of phytochemicals from the plant extracts used in their synthesis. Mangrove-derived AgNPs exhibit a range of biological activities, including antimicrobial, antioxidant, anti-inflammatory and cytotoxic properties, making them promising candidates for therapeutic applications.

1. **Antimicrobial Activity:**

   The antimicrobial efficacy of AgNPs synthesized from mangrove leaf extracts has been widely reported, particularly against a broad spectrum of pathogenic microorganisms, including bacteria, fungi, and viruses. The antimicrobial activity is attributed to multiple mechanisms, including the disruption of microbial cell membranes, generation of reactive oxygen species (ROS), and interference with microbial DNA replication [9].

   Studies have shown that AgNPs synthesized using mangrove leaf extracts display significant antibacterial activity against both Gram-positive and Gram-negative bacteria, including *Staphylococcus aureus* and *Escherichia coli*. The presence of bioactive compounds from the mangrove leaves enhances the bactericidal effects, making these nanoparticles effective even at low concentrations. In addition to antibacterial effects, these nanoparticles also demonstrate antifungal activity against common fungal pathogens, such as *Candida albicans* and *Aspergillus niger* [10].

2. **Antioxidant Activity:**

   The antioxidant properties of biogenic AgNPs are crucial for their potential use in preventing and treating oxidative stress-related diseases. The presence of phytochemicals from mangrove leaf extracts on the surface of AgNPs plays a significant role in their antioxidant activity. These phytochemicals can scavenge free radicals, thereby reducing oxidative damage in biological systems [13].

   The antioxidant potential of mangrove-derived AgNPs has been evaluated using various assays, such as the DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging assay and the ABTS (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid)) assay. Results indicate that these nanoparticles exhibit strong free radical scavenging activity, comparable to that of standard antioxidants like ascorbic acid. This suggests their potential application in managing conditions associated with oxidative stress, such as cardiovascular diseases, neurodegenerative disorders, and aging [15].

3. **Anti-inflammatory Activity:**

   In addition to their antimicrobial and anticancer properties, biogenic AgNPs from mangrove leaf extracts have shown promise as anti-inflammatory agents. The anti-inflammatory effects are primarily mediated by the inhibition of pro-inflammatory cytokines and enzymes, such as COX-2, involved in the inflammatory response [15].

   Studies have reported that these AgNPs can significantly reduce the production of inflammatory markers in macrophages and other immune cells. This activity is particularly beneficial in the context of inflammatory diseases, such as arthritis and inflammatory bowel disease, where reducing inflammation can alleviate symptoms and improve patient outcomes [16].

4. **Cytotoxic Activity and Anticancer Potential:**

   The cytotoxic effects of AgNPs synthesized from mangrove leaf extracts have been investigated against various cancer cell lines. The cytotoxicity of these nanoparticles is dose-dependent and is influenced by their size, concentration, and the type of cancer cells.

   In vitro studies have demonstrated that mangrove-derived AgNPs exhibit significant cytotoxicity against cancer cell lines such as *HeLa* (cervical cancer), *MCF-7* (breast cancer), and *A549* (lung cancer) cells. The mechanism of cytotoxicity is thought to involve the induction of apoptosis (programmed cell death), disruption of the mitochondrial membrane potential, and generation of ROS within cancer cells. The selective toxicity of AgNPs towards cancer cells, while sparing normal cells, highlights their potential as a novel anticancer agent [11].

Conclusion:

The review on the biogenic synthesis of silver nanoparticles (AgNPs) using mangrove leaf extracts has demonstrated a promising and eco-friendly approach to nanoparticle production. The use of mangrove leaves, which are rich in various phytochemicals, provides a sustainable alternative to traditional chemical methods of synthesis, aligning with green chemistry principles.

The characterization of the synthesized AgNPs revealed that the mangrove leaf extracts effectively reduced silver ions to form nanoparticles with distinct optical, structural, and morphological properties. UV-visible spectroscopy confirmed the formation of AgNPs through characteristic surface plasmon resonance peaks. X-ray diffraction (XRD) and transmission electron microscopy (TEM) further validated the crystalline nature and size distribution of the nanoparticles, while Fourier-transform infrared spectroscopy (FTIR) identified the functional groups involved in the reduction and stabilization processes.

The biological activities of the synthesized AgNPs underscore their potential applications in various fields. The nanoparticles exhibited significant antimicrobial properties against a range of pathogenic bacteria and fungi, highlighting their potential as effective alternatives to conventional antibiotics. Their strong antioxidant activity suggests potential use in combating oxidative stress-related disorders, providing a therapeutic avenue for managing diseases associated with free radical damage. Additionally, the cytotoxicity studies indicated promising anticancer properties, with AgNPs showing selective toxicity towards cancer cells, which could be further explored for cancer therapy applications. The observed anti-inflammatory activity adds another layer of therapeutic potential, suggesting their usefulness in managing inflammatory conditions.

Overall, the biogenic synthesis of silver nanoparticles from mangrove leaf extracts represents a sustainable and effective method for producing nanoparticles with valuable biological activities. This review focuses on optimizing the synthesis process, exploring the full range of biological applications, and assessing the environmental impact and safety of these nanoparticles in various settings. This approach not only advances nanotechnology but also supports the principles of environmental sustainability and green chemistry.

References:

1. Prathna, T.C., Chandrasekaran, N., Raichur, A.M., & Mukherjee, A. (2011). Biomimetic Synthesis of Silver Nanoparticles by Citrus limon (Lemon) Aqueous Extract and Theoretical Prediction of Particle Size. Colloids and Surfaces B: Biointerfaces, 82(1), 152-159.
2. Awwad, A.M., Salem, N.M., & Abdeen, A.O. (2012). Green Synthesis of Silver Nanoparticles Using Carob Leaf Extract and Its Antibacterial Activity. International Journal of Industrial Chemistry, 3(1), 1-6.
3. Kathiresan, K., & Bingham, B.L. (2001). Biology of Mangroves and Mangrove Ecosystems. Advances in Marine Biology, 40, 81-251.
4. Iravani, S. (2011). Green Synthesis of Metal Nanoparticles Using Plants. Green Chemistry, 13(10), 2638-2650.
5. Mittal, A.K., Chisti, Y., & Banerjee, U.C. (2013). Synthesis of Metallic Nanoparticles Using Plant Extracts. Biotechnology Advances, 31(2), 346-356.
6. Iravani, S., Korbekandi, H., Mirmohammadi, S.V., & Zolfaghari, B. (2014). Synthesis of Silver Nanoparticles: Chemical, Physical and Biological Methods. Research in Pharmaceutical Sciences, 9(6), 385-406.
7. Song, J.Y., & Kim, B.S. (2009). Rapid Biological Synthesis of Silver Nanoparticles Using Plant Leaf Extracts. Bioprocess and Biosystems Engineering, 32(1), 79-84.
8. Gurunathan, S., Han, J.W., Kwon, D.N., & Kim, J.H. (2014). Enhanced Antibacterial and Anti-biofilm Activities of Silver Nanoparticles Against Gram-negative and Gram-positive Bacteria. Nanoscale Research Letters, 9(1), 373.
9. Ghosh, S., Patil, S., Ahire, M., & Kitture, R. (2012). Synthesis of Silver Nanoparticles Using Dioscorea bulbifera Tuber Extract and Evaluation of Its Synergistic Potential in Combination with Antimicrobials. International Journal of Nanomedicine, 7, 483-496.
10. Shankar, S.S., Rai, A., Ahmad, A., & Sastry, M. (2004). Rapid Synthesis of Au, Ag, and Bimetallic Au Core–Ag Shell Nanoparticles Using Neem (Azadirachta indica) Leaf Broth. Journal of Colloid and Interface Science, 275(2), 496-502.
11. Sulaiman, G.M., Mohammed, W.H., Marzoog, T.R., & Al-Amiery, A.A. (2013). Green Synthesis, Antimicrobial and Cytotoxic Effects of Silver Nanoparticles Using Eucalyptus chapmaniana Leaves Extract. Asian Pacific Journal of Tropical Biomedicine, 3(1), 58-63.
12. Rai, M., Yadav, A., & Gade, A. (2009). Silver Nanoparticles as a New Generation of Antimicrobials. Biotechnology Advances, 27(1), 76-83.
13. Guzmán, M.G., Dille, J., & Godet, S. (2009). Synthesis of Silver Nanoparticles by Chemical Reduction Method and Their Antibacterial Activity. International Journal of Chemical and Biomolecular Engineering, 2(3), 104-111.
14. Mittal, A.K., Chisti, Y., & Banerjee, U.C. (2013). Synthesis of Metallic Nanoparticles Using Plant Extracts. Biotechnology Advances, 31(2), 346-356.
15. Singh, P., Kim, Y.J., Zhang, D., & Yang, D.C. (2016). Biological Synthesis of Nanoparticles from Plants and Microorganisms. Trends in Biotechnology, 34(7), 588-599.
16. Geethalakshmi, R., & Sarada, D.V.L. (2012). Synthesis of Plant-Mediated Silver Nanoparticles Using Trianthema decandra Extract and Evaluation of Their Antimicrobial Activities. International Journal of Engineering Science and Technology, 2(5), 970-975.