IJARSCT

International Journal of Advanced Research in Science, Communication and Technology

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

ISSN: 2581-9429 Volume 5, Issue 10, March 2025 Impact Factor: 7.67

Green Synthesis of Silver Nanoparticles Using Medicinal Plants

Ankita Dattaram Mhaske

D. G. Tatkare Mahavidyalaya, Mangaon, Raigad, Maharashtra

Abstract: *Nanotechnology has marked a significant revolution in various areas of science. Nanoscience and nanotech- neology are involved in the production and application of nanoparticles that can be used in various fields. Silver nanoparticles (AgNPs), among other nanoparticles, have received substantial attention because of their unique properties. This review article focuses on the green synthesis of AgNPs using medicinal plant extracts. Green synthesized AgNPs offer numerous advantages, including energy efficiency, low toxicity, high yields, cost- effectiveness, eco-friendliness, and ready availability. The effects of pH, temperature, incubation time, light and plant extracts, and silver nitrate ($AgNO_3$) concentrations on the green synthesis of AgNPs are discussed. This review also discusses analytical techniques for the characterization of AgNPs. Furthermore, recent advances in the application of biosynthesized AgNPs from herbal plants as therapeutic agents against bacteria, fungi, and tumors are considered. Finally, the challenges and potential future research directions for the synthesis of AgNPs using green technology are discussed.*

Keywords: Green synthesis, Silver nanoparticles, Medicinal plants, Cancer therapy, Physical method, Chemical method.

I. INTRODUCTION

The green synthesis of silver nanoparticles (AgNPs) using medicinal plant extracts has become a significant area of research due to its eco-friendly nature and the potential advantages it offers over conventional chemical methods. In traditional methods, toxic chemicals are often used, which can be harmful to the environment and human health. In contrast, green synthesis utilizes plant extracts rich in bioactive compounds, such as flavonoids, alkaloids, and polyphenols, which act as reducing and stabilizing agents in the synthesis of silver nanoparticles.

This approach not only eliminates the need for hazardous chemicals but also harnesses the therapeutic properties of the plants used, enhancing the nanoparticles' biological activities. The nanoparticles produced through this method exhibit a variety of applications, particularly in medicine, including antimicrobial, anti-inflammatory, and antioxidant properties.

The green synthesis process generally involves mixing silver nitrate solution with plant extracts, leading to the reduction of silver ions into silver nanoparticles. Parameters such as pH, temperature, and the concentration of the plant extract are carefully controlled to produce nanoparticles of desired size, shape, and stability.

Medicinal plants like *Turmeric*, *Lavender*, *Pomegranate*, and *Barberry* have been commonly used in this process. Researchers are increasingly focused on optimizing the synthesis parameters and exploring the potential applications of these green-synthesized silver nanoparticles in fields such as drug delivery, wound healing, and biosensing.

Overall, this area of research highlights the combination of green chemistry and nanotechnology, offering a sustainable pathway to producing nanomaterials with broad biomedical applications.

Synthesis Methods:

The green synthesis of AgNPs typically involves mixing silver nitrate ($AgNO_3$) solution with plant extracts. The phytochemicals in the extract reduce Ag^+ ions to form AgNPs, which are then stabilized by the plant's biomolecules. Parameters such as pH, temperature, reaction time, and concentration of plant extract influence the size, shape, and stability of the nanoparticles.

Physical methods for the synthesis of silver nanoparticles (AgNPs) involve the use of physical forces or energy to reduce silver ions and produce nanoparticles. These methods generally require high energy and equipment, but they are precise in controlling the size and shape of the nanoparticles. Some common physical methods include:

1. Laser Ablation:

- **Principle:** In this method, a high-energy laser is focused on a silver target submerged in a liquid medium. The laser causes the silver material to vaporize, and the vaporized atoms condense into nanoparticles.
- **Advantages:** Produces high-purity nanoparticles without the need for chemical reagents.
- **Applications:** Used in precise nanoparticle synthesis and applications requiring high-quality silver nanoparticles.

2. Physical Vapor Deposition (PVD):

- **Principle:** In PVD, silver is evaporated under vacuum and the vapor condenses on a substrate to form nanoparticles. This process allows for precise control over the size of the nanoparticles.
- **Advantages:** Provides uniform and highly controlled nanoparticle films and coatings.
- **Applications:** Often used for producing thin films, coatings, and in microelectronics.

3. Sputtering:

- **Principle:** In sputtering, silver atoms are ejected from a solid silver target by bombarding it with energetic ions. These atoms are then deposited as nanoparticles on a substrate.
- **Advantages:** Allows for the deposition of silver onto substrates in a controlled manner.
- **Applications:** Used in electronics, sensors, and nanostructure fabrication.

4. Electrochemical Methods:

- **Principle:** Silver nanoparticles are synthesized by reducing silver ions in a solution through an electrochemical reaction. A voltage is applied between two electrodes, causing silver ions to reduce and form nanoparticles.
- **Advantages:** Allows for controlled size and distribution of nanoparticles by adjusting the voltage and other parameters.
- **Applications:** Often used for large-scale production of nanoparticles for applications in sensors and coatings.

5. Evaporation-condensation Method:

- **Principle:** Silver is evaporated at high temperatures and the vapors condense into nanoparticles as they cool down in a controlled environment.
- **Advantages:** Produces nanoparticles with well-defined sizes and narrow size distributions.
- **Applications:** Used in producing metal nanoparticles for a variety of industrial applications.

6. Ball Milling:

- **Principle:** Silver is ground into fine particles using a high-energy ball mill. This mechanical process induces shear forces that break the silver into nanoparticles.
- **Advantages:** Simple and scalable method.
- **Applications:** Used for mass production of nanoparticles, especially in powder forms for applications in catalysis and material sciences.

Advantages of Physical Methods:

- **Precise Control:** Physical methods allow for the precise control over particle size and morphology.
- **No Chemical Reagents Needed:** These methods do not require chemical reducing agents, which can be advantageous for certain applications.
- **High Purity:** Physical methods tend to produce high-purity nanoparticles.

Disadvantages:

- **High Energy Consumption:** These methods typically require significant energy input, making them less cost-effective compared to chemical or green methods.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 5, Issue 10, March 2025 Impact Factor: 7.67

- **Complex Equipment:** Physical methods often require specialized and expensive equipment, which may limit their scalability.

Overall, while physical methods are efficient for producing high-quality silver nanoparticles, their high energy demands and specialized equipment requirements make them less common for large-scale production compared to chemical and green synthesis methods.
Get smarter responses, upload files and images, and more.
Log in Sign up

Fig. 2. Green Synthesis of silver nanoparticles. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

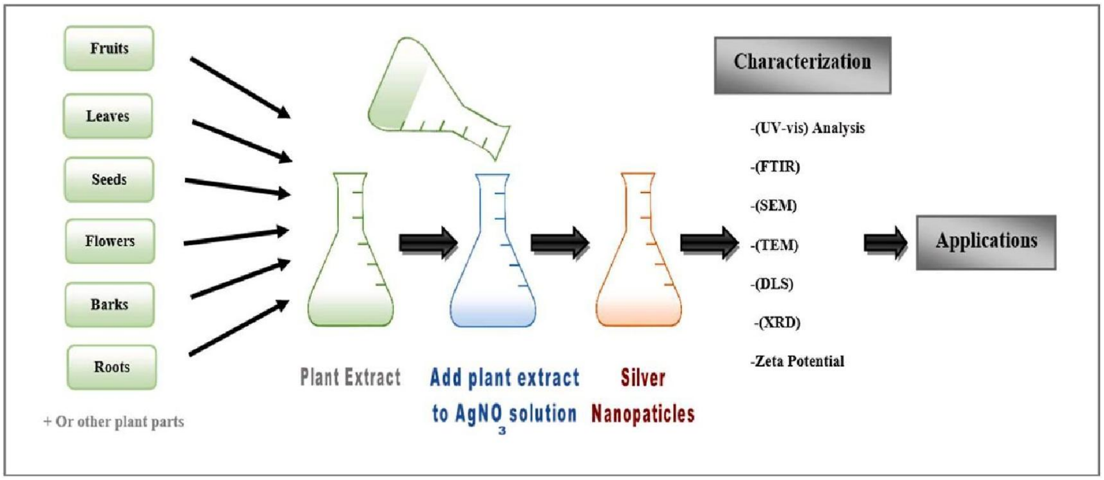
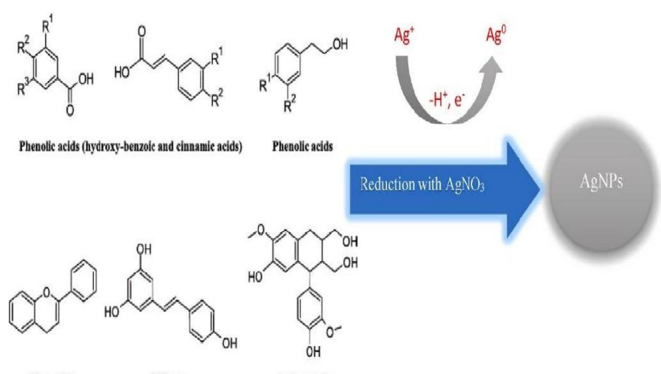


Fig. 3. Green synthesis of silver nanoparticles *via* plants. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

Mechanism of green synthesis of AgNPs

The biosynthesis of AgNPs from plants is an easy procedure that includes the interaction of silver nitrate ($AgNO_3$) with the biomolecule components of plant extracts. Nanoparticles are formed primarily in three phases: an ion reduction reaction leads to cluster formation and then induces the growth of nanoparticles. Each stage has unique characteristics depending on the reducing agent, its concentration, $AgNO_3$, and pH. The presence of hydroxyl groups (OH) in plant biomolecules, such as amino acids, proteins, alkaloids, flavonoids, polyphenols, en- zymes, tannins, carbohydrates, and saponins, is associated with the
stabilization and reduction of silver ions



Medicinal Plants Commonly Used for Green Synthesis:

Several medicinal plants have been studied for their ability to reduce silver ions and produce nanoparticles. Some examples include:

- **Turmeric (Curcuma longa):** Known for its antioxidant and antimicrobial properties, turmeric extract is commonly used in the green synthesis of AgNPs.
- **Lavender (Lavandula angustifolia):** The extract from lavender flowers can synthesize AgNPs with potential antimicrobial activity.
- **Pomegranate (Punica granatum):** The leaves of pomegranate are used to synthesize AgNPs, which show promising antimicrobial and antioxidant effects.
- **Neem (Azadirachta indica):** Known for its antibacterial and antifungal properties, neem leaves are commonly used to synthesize silver nanoparticles.

Applications:

The silver nanoparticles synthesized using plant extracts have a variety of applications:

- **Antibacterial and Antifungal:** The synthesized AgNPs exhibit potent antibacterial and antifungal properties, making them useful in wound healing and as antimicrobial agents in various industries.
- **Drug Delivery Systems:** Due to their biocompatibility, AgNPs are explored for targeted drug delivery and treatment of diseases like cancer.
- **Sensors and Biosensors:** Silver nanoparticles are used in detecting pathogens and environmental monitoring due to their high surface-to-volume ratio and optical properties.
- **Catalysis:** Green-synthesized AgNPs have shown promise as catalysts in chemical reactions, including degradation of toxic compounds.

Challenges:

- **Size and Shape Control:** Achieving consistent size and shape for nanoparticles is often challenging, as it depends on many factors such as pH, temperature, and the concentration of the plant extract.
- **Scalability:** While green synthesis is effective at the laboratory scale, scaling up the process for industrial applications remains a challenge.
- **Toxicity Assessment:** Though the process is eco-friendly, the toxicity of the nanoparticles must be thoroughly evaluated before their use in biomedical applications.w

II. CONCLUSION

The green synthesis of silver nanoparticles using medicinal plants offers a sustainable, eco-friendly alternative to conventional physical methods. It combines the benefits of nanotechnology with the therapeutic properties of plants, providing a pathway for the production of biocompatible and cost-effective nanomaterials. While there are some challenges in terms of control over particle size and scalability, the research in this field is rapidly advancing and holds great promise for various applications, particularly in medicine, environmental remediation, and materials science.

REFERENCES

[1]. Chemical Engineering, 7(3), Article 103094. https://www.sciencedirect.com/science/article/pii/S2213343719302179.

[2]. .Kumari, R., et al. (2020). Apoptosis induction in lung and prostate cancer cells through silver nanoparticles synthesized from Pinus roxburghii bioactive fraction. J

[3]. Journal of Biological Inorganic Chemistry, 25(1), 23–37. https://link.springer.com/ar ticle/10.1007/s00775-019-01729-3.

[4]. Kumar, D. A., Palanichamy, V., & Roopan, S. M. (2014). Green synthesis of silver nanoparticles using Alternanthera dentata leaf extract at room temperature and their antimicrobial activity. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy, 127, 168–171.

[5]. Kumar, B., Smita, K., & Cumbal, L. (2016). Biosynthesis of silver nanoparticles using Lantana camara

IJARSCT

International Journal of Advanced Research in Science, Communication and Technology

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

ISSN: 2581-9429

Volume 5, Issue 10, March 2025

Impact Factor: 7.67

flower extract and its application. Journal of Sol-Gel Science and Technology, 78, 285–292.

[6]. hmad, A., et al. (2003). Extracellular biosynthesis of silver nanoparticles using the fungus Fusarium oxysporum. Colloids and Surfaces B: Biointerfaces, 28, 313–318. https://www.sciencedirect.com/science/article/pii/S0927776502001741.

[7]. hmad, N., & Sharma, S. (2012). Green synthesis of silver nanoparticles using extracts of Ananas comosus. Green and Sustainable Chemistry, 2(4), 141–147. https://www.scirp.org/journal/paperinformation.aspx?paperid=24781

[8]. kbari, B., et al. (2011). Particle size characterization of nanoparticles–a practicalapproach. Iranian Journal of Materials Science and Engineering, 8(2), 48–56. http://ijmse.iust.ac.ir/browse.php?a_code=A-10-3-149&sid=1&slc_lang=en.

[9]. Akintelu, S. A., Bo, Y., & Folorunso, A. S. (2020). A review on synthesis, optimization, mechanism, characterization, and antibacterial application of silver nanoparticles synthesized from plants. Journal of Chemistry, 2020.

[10]. Al-Zubaidi, S., et al. (2019). Biosynthesis, characterization and antifungal activity of silver nanoparticles by Aspergillus Niger isolate. Journal of Nanotechnology Research, 1(1), 23–36. https://www.fortunejournals.com/articles/biosynthesis-characteri zation-and-antifungal-activity-of-silver-nanoparticles-by-aspergillus-niger-isolate.ht ml.

[11]. Alahmad, A., Al-Zereini, W. A., Hijazin, T. J., Al-Madanat, O. Y., Alghoraibi, I., Al- Qaralleh, O., Al-Qaraleh, S., Feldhoff, A., Walter, J.-G., & Scheper, T. (2022). Green synthesis of silver nanoparticles using Hypericum perforatum L. Aqueous extract with the evaluation of its antibacterial activity against clinical and food pathogens. Pharmaceutics, 14(5), 1104. https://doi.org/10.3390/pharmaceutics14051104, 21.

[12]. Alaqad, K., & Saleh, T. A. (2016). Gold and silver nanoparticles: Synthesis methods, characterization routes and applications towards drugs. Journal of Environmental & Analytical Toxicology, 6, 525–2161.

[13]. Ali Abuderman, A., et al. (2019). Green synthesized silver Nanoparticles of Myrtus communis L (AgMC) extract inhibits cancer hallmarks via targeting aldose reductase (AR) and associated signaling network. Processes, 7(11), 860. https://www.mdpi. com/2227-9717/7/11/860.

[14]. Amaliyah, S., Sabarudin, A., Masruri, M., et al. (2022). Characterization and antibacterial application of biosynthesized silver nanoparticles using Piper retrofractum Vahl fruit extract as bioreductor. Journal of Applied Pharmaceutical Science, 12, 103–114.

[15]. Anandalakshmi, K., et al. (2016). Characterization of silver nanoparticles by green synthesis method using Pedalium murex leaf extract and their antibacterial activity. Applied Nanoscience, 6(3), 399–408. https://link.springer.com/article/10.100 7/s13204-015-0449-z.

[16]. Anandan, M., et al. (2019). Green synthesis of anisotropic silver nanoparticles from the aqueous leaf extract of Dodonaea viscosa with their antibacterial and anticancer activities. Process Biochemistry, 80, 80–88. https://www.sciencedirect.com/science/ article/pii/S1359511318318415.

[17]. Arif, R., & Uddin, R. (2021). A review on recent developments in the biosynthesis of silver nanoparticles and its biomedical applications. Medical Devices & Sensors, 4(1), Article e10158. https://doi.org/10.1002/mds3.10158

[18]. Ashraf, J. M., et al. (2016). Green synthesis of silver nanoparticles and characterization of their inhibitory effects on AGEs formation using biophysical techniques. Scientific Reports, 6(1), 20414. https://www.nature.com/articles/srep20414.

[19]. Asimuddin, M., Shaik, M. R., Adil, S. F., Siddiqui, M. R. H., Alwarthan, A., Jamil, K., & Khan, M. (2020). Azadirachta indica based biosynthesis of silver nanoparticles and evaluation of their antibacterial and cytotoxic effects. Journal of King Saud University Science, 32(1), 648–656. https://doi.org/10.1016/j.jksus.2018.09.014

[20]. Bahrami-Teimoori, B., et al. (2017). Characterisation and antifungal activity of silver nanoparticles biologically synthesised by Amaranthus retroflexus leaf extract. Journal of Experimental Nanoscience, 12(1), 129–139. https://www.tandfonline.com/ doi/full/10.1080/17458080.2017.1279355.

IJARSCT

International Journal of Advanced Research in Science, Communication and Technology

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

ISSN: 2581-9429 Volume 5, Issue 10, March 2025 Impact Factor: 7.67

[21]. Balachandar, R., et al. (2019). Plant-mediated synthesis, characterization and bactericidal potential of emerging silver nanoparticles using stem extract of Phyllanthus pinnatus: A recent advance in phytonanotechnology. Journal of Cluster Science, 30(6), 1481–1488. https://link.springer.com/article/10.1007/s10876-019-01591-y.

[22]. Balashanmugam, P., et al. (2013). Mycosynthesis, characterization and antibacterial activity of silver nanoparticles from microporus xanthopus: A macro mushroom. International Journal of Innovation Research and Science Engineering, Technology, 2(11), 6262–6270. http://www.ijirset.com/upload/2013/november/48_MYCOSYNTHESIS,.pdf.

[23]. Baldassarre, F., et al. (2015). A predictive model of iron oxide nanoparticles flocculation tuning Z-potential in aqueous environment for biological application. Journal of Nanoparticle Research, 17(9), 1–21. https://link.springer.com/article/10.1007/s11051-015-3163-6.

[24]. Bamal, D., Singh, A., Chaudhary, G., et al. (2021). Silver nanoparticles biosynthesis, characterization, antimicrobial activities, applications, cytotoxicity and safety issues: An updated review. Nanomaterials, 11, 2086.

[25]. Bar, H., et al. (2009). Green synthesis of silver nanoparticles using latex of Jatropha curcas. Colloids and Surfaces, A: Physicochemical and Engineering Aspects, 339(1–3), 134–139. https://www.sciencedirect.com/science/article/pii/S0927775709000739.

[26]. Bawazeer, S., et al. (2021). Green synthesis of silver nanoparticles using Tropaeolum majus: Phytochemical screening and antibacterial studies. Green +Processing and Synthesis, 10(1), 85–94. https://doi.org/10.1515/gps-2021-0003