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SUSTAINABLE SYNTHESIS OF SILVER NANOPARTICLES VIA ALCHEMILLA VULGARIS PLANT EXTRACT: A GREEN APPROACH

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ABSTRACT

Silver nanoparticles (AgNPs) have emerged as key players in nanotechnology, celebrated for their antimicrobial, biocompatible, and environmentally friendly attributes. Traditional synthesis methods often involve hazardous chemicals and costly processes, prompting a shift towards greener alternatives. This study focuses on a one-pot synthesis of silver nanoparticles using Alchemilla vulgaris plant extract as a bio-reducing agent. This approach is not only simple and cost-effective but also aligns with green synthesis principles, eschewing the need for surfactants, catalysts, or templates.

Alchemilla vulgaris, chosen for its medicinal significance, facilitates the reduction of aqueous silver ions to silver nanoparticles without the involvement of additional chemicals. The resulting silver nanoparticles are characterized through various techniques, including UV-Vis spectrophotometry, Fourier-transform infrared (FTIR) spectroscopy, scanning electron microscopy (SEM), particle size analysis, and zeta potential measurements. The findings highlight the efficacy of Alchemilla vulgaris as a bio-reducing agent, emphasizing its potential in sustainable and medically relevant applications.

Keywords:

Green synthesis; Alchemilla vulgaris; Silver Nanoparticles; One pot synthesis.

INTRODUCTION

Nanomaterials have become integral in various applications within the realm of nanotechnology, owing to their unique properties . Metallic nanoparticles, characterized by their increased surface area, exhibit potential applications as antibacterial agents . The development of nanoparticles employs diverse methods, including physical, chemical, and biological approaches . However, the use of toxic compounds in chemical and physical methods hinders biomedical applications, necessitating the exploration of biological materials such as plants, plant components, and bacteria for nanoparticle synthesis. These biological methods offer safety, stability, biocompatibility, cost-effectiveness, and environmental friendliness .

Plant-based synthesis holds particular advantages, notably speed and stability, enabling the production of nanoparticles with varying sizes and shapes comparable to microorganisms. Silver and zinc nanoparticles have garnered

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attention for their antibacterial, antioxidant, and photocatalytic properties, making them sought-after products in nanotechnology due to their unique attributes, including antibacterial, anti-viral, antifungal, and anti-inflammatory activities, coupled with stability . These nanoparticles find widespread use in various industries, such as health, food packaging, and textiles.

The trend towards environmentally friendly practices in nanomaterial synthesis has led to the use of natural and green reducing and capping agents . Numerous studies have reported the successful synthesis of silver nanoparticles using leaves from different plants, including Azadirachta indica (neem), Ocimum tenuiflorum (black Tulsi), and Ficus benghalensis (Banyan tree) . Alchemilla vulgaris L., commonly known as lady's mantle, emerges as a plant of interest in this context due to its rich medicinal qualities. The plant, belonging to the genus Alchemilla (Rosaceae), possesses anti-aging, anti-inflammatory, antimicrobial, antioxidant, astringent, coagulant, diuretic, emmenagogue, hepatic, hypoglycemic, hypotensive, lithotriptic, pro-collagen, vasodilator, and vulnerary properties . Extracts from the aerial parts of the plant, particularly the leaves, contain compounds such as pedunculagin, salicylic acid, flavonoids, and triterpenes, contributing to its medicinal and cosmetic uses. Lady's Mantle has a traditional association with addressing issues related to the reproductive system, making it a valuable resource for conditions like painful periods, irregularities, excessive bleeding, and various reproductive disorders.

This study aims to synthesize silver nanoparticles utilizing aqueous Alchemilla vulgaris extract and subsequently characterize the nanoparticles through UV-VIS spectrophotometry, Fourier-transform infrared spectroscopy (FTIR), field-emission scanning electron microscopy (FE-SEM), and zeta potential measurements. The exploration of Alchemilla vulgaris as a bio-reducing agent for silver nanoparticle synthesis underscores its potential in the green and sustainable production of nanomaterials with potential biomedical applications.[5]

EXPERIMENTAL

Extraction of Alchemilla vulgaris:

The maceration method was employed for the extraction of Alchemilla vulgaris. The crushed plant material underwent a sequential extraction process using solvents of increasing polarity: petroleum ether, ethyl acetate, and methanol [18]. Subsequent to each extraction, the solvent was evaporated under reduced pressure using a rotary evaporator, eliminating excess moisture. The resulting dried extracts were stored in airtight containers, appropriately labeled.

Green Synthesis of Silver Nanoparticles:

Silver nanoparticles (AgNPs) were synthesized through a green approach using Alchemilla vulgaris extract. Solutions of different silver nitrate concentrations (0.2, 0.5, and 1 mM) were prepared by dissolving 0.003, 0.008, and 0.016 g of silver nitrate in 100 ml de-ionized water, respectively. The absorption spectra of these solutions were determined by scanning in the range of 200-600 nm using a UV-Vis spectrophotometer (Systronics PC-based double beam spectrophotometer 2202). The absorption peaks for 0.2 mM, 0.5 mM, and 1 mM $AgNO_3$ solutions were observed at 208 nm, 214 nm, and 217 nm, respectively. The 1 mM $AgNO_3$ solution, exhibiting the highest peak, was selected for silver nanoparticle synthesis.

A 100 mL aqueous solution of 1 mM silver nitrate was prepared, and varying volumes (1.0, 2.0, 3.0, 4.0, and 5.0 mL) of the Alchemilla vulgaris extract were separately added to the silver nitrate solution. The solutions were kept in the dark at room temperature until a color change from yellow to dark yellow occurred, indicating the formation of silver nanoparticles. The bioreduction of silver ions was monitored periodically using a UV spectrophotometer [6].

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Characterization Of Silver Nanoparticles:

The synthesized nanoparticles underwent comprehensive characterization using various techniques:

UV-VIS Spectrophotometry:Absorption spectra were recorded to confirm the reduction of silver ions, capturing the characteristic surface plasmon resonance peak of silver nanoparticles.

*FTIR (Fourier-transform Infrared) Spectroscopy:*Functional groups on the nanoparticle surface were identified by comparing FT-IR patterns with those of free groups.

FE-SEM (Field-Emission Scanning Electron Microscopy): High-resolution imaging was conducted to study the shape, morphology, and elemental mapping of AgNPs. The purity of the nanoparticle sample was also assessed.

Particle Size Analysis: The distribution of particle sizes was determined using a Particle Size Analyzer (PSA), crucial for understanding their relevance in nanomedicine.

*Zeta Potential Measurements:*Zeta potential, indicating the surface charge on particles, was measured using Horiba SZ-100. This measurement provided insights into the stability of the colloidal solution, as higher repulsive forces among particles contribute to stability by preventing aggregation.

The combination of these characterization techniques offered a comprehensive understanding of the synthesized silver nanoparticles, their structural features, and their potential applications in various fields, including nanomedicine.

RESULTS AND DISCUSSION

Visual Observations:

Upon the introduction of Alchemilla vulgaris extract into the 1mM $AgNO_3$ solution, a preliminary visual observation revealed that the initial color of the reaction mixture was nearly colorless. Subsequently, the color transitioned from pale-yellow to light brown and eventually to dark brown as the reaction progressed, indicating the reduction of silver nitrate to silver nanoparticles. This color change was attributed to the phytochemicals present in Alchemilla vulgaris, such as flavones, tannins, and polyphenols, which acted as reducing agents. Similar color changes were observed in the synthesis of AgNPs from other plant extracts like Ocimum sanctum, Moringa oleifera, and Carica papaya .

Measurement of Ag Nanoparticles by UV-Visible Spectrophotometry:

UV-Vis spectroscopy confirmed the formation of silver nanoparticles by documenting absorption spectra at different time intervals (4 h, 24 h, 48 h, 72 h, and 96 h). The absorption peaks at 436-411 nm indicated the Surface Plasmon Resonance (SPR) band of silver nanoparticles. The spectral analysis demonstrated that an increase in plant extract concentration led to a decrease in absorbance, confirming changes in particle size. The UV-Vis spectra revealed that the synthesis was stable after 24 hours, and the 1ml concentration of nanoparticles was chosen for further characterization. This finding aligned with similar absorption spectra observed in the synthesis of AgNPs using other natural extracts .

Particle Size and Shape Analysis by SEM:

SEM analysis revealed high-density AgNPs synthesized by Alchemilla vulgaris extract, with relatively spherical particles ranging from 96 to 113 nm. The interaction of hydrogen bonds and electrostatic interactions between bioorganic capping molecules was evident, ensuring stabilization of the nanoparticles. The larger particle size observed might be attributed to aggregation during SEM measurements, a phenomenon consistent with the green synthesis of AgNPs from other plant extracts ***Analysis of Ag Nanoparticles by FTIR:***

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FTIR analysis of Alchemilla vulgaris extract and silver nanoparticles confirmed the presence of functional groups. The identified peaks suggested the presence of amine, alkene, alkane, carbonyls, and other groups, consistent with the chemical composition of Alchemilla vulgaris. Similar FTIR peaks were observed in the synthesis of AgNPs using other plant extracts, indicating the presence of polyphenols and flavonoids [9].

Determination of Particle Size and Zeta Potential:

Zeta potential analysis revealed an average particle size of 93.1 nm and a negative potential value of -23.6 mV, indicating nanoparticle stability. The entrapment of bioactive compounds contributed to the negative potential value. This analysis aligned with similar studies on the synthesis of AgNPs using other plant extracts, emphasizing the importance of zeta potential in predicting nanoparticle fate and assessing colloidal system stability[7,8].

CONCLUSION

In addressing the imperative need for a sustainable and environmentally friendly approach to metallic nanoparticle synthesis within the field of nanotechnology, this study successfully showcased the potential of Alchemilla vulgaris plant extracts as a natural and cost-effective biological reducing agent. The utilization of this green nanochemistry methodology eliminates the reliance on toxic solvents, contributing to an eco-friendly and efficient synthesis process.

The results of this study underscore a straightforward, swift, and economical pathway for the synthesis of silver nanoparticles. The use of Alchemilla vulgaris as a biological reducing agent not only ensures a green synthesis approach but also opens avenues for integration into nanotechnology processing industries. The nanoparticles produced through this method hold promise for various applications, including bactericidal properties, wound healing, and water purification. Furthermore, their potential in the medical field, particularly in drug delivery and therapeutic applications, positions this method as an exciting prospect for large-scale nanoparticle synthesis.

As the demand for sustainable practices in nanotechnology grows, the use of Alchemilla vulgaris extracts stands out as a viable solution. The versatility of the synthesized nanoparticles suggests their potential impact on diverse fields, offering a glimpse into a future where green synthesis methods play a pivotal role in advancing nanoparticle applications for the betterment of human health and the environment.

REFERENCES

1. Demirezen-Yilmaz D, Koca F, Ertaş-Onmaz N. Asian J App Chem Res., 2019; 2(2):1-11.
2. Khalil KA, Fouad H, Elsarnagawy T, Almajhdi FN. Int J Electrochem Sci., 2013; 8:3483-93.
3. Journal of Advanced Scientific Research, 2022; 13 (9): Oct.-2022Jain et al., J Adv Sci Res, 2022; 13 (9): 62-69
4. Mahdavi S, Jalali M, Afkhami A. Chem Eng Commun., 2013; 200:448-470.
5. Arockiya F, Parthiban C, Ganesh-Kumar V, Anantharaman P. Spectrochim Acta- A: Mol Biomol
6. Spectrosc., 2012; 99:166-173.
7. Shriniwas P, Subhash KT. Biochem and Biophysics Reports., 2017; 1076-1081.
8. Ahmed S, Ikram S. J Nanomed Nanotechnol., 2015;
9. Prasad TNVKV, Elumalai EK. Asian Pac J Trop
10. Biomed., 2011; 1:439.
11. Banala RR, Nagati VB, Karnati PR. Saudi J Biol Sci.,
12. 2015; 22:637.
13. 9. Trifunschi S, Munteanu MF, Agotici V, Pintea S,
14. Gligor R. Int Curr Pharm J., 2015; 4:382.

15. 10. Jyoti K, Baunthiyal M, Singh A. J Radiat Res Appl
16. Sci., 2016; 9:17.
17. 11. Anandalakshmi K, Venugobal J, Ramasamy V.
18. Appl Nanosci., 2016; 6:399.
19. 12.Preeti Nigam, Shobha Waghmode, Michelle Louis, Shishanka Wangnoo, Pooja Chavan and Dhiman Sarkar. Graphene quantum dots conjugated albumin nanoparticles for targeted drug delivery and imaging of pancreatic cancer. J. Mater. Chem. B, 2014, 2, 3190-3195, DOI: 10.1039/C4TB00015C.
20. 13.Omkar Pawar, Neelima Deshpande, Sharada Dagade, Preeti Nigam-Joshie,Shobha Waghmode. Green synthesis of silver nanoparticles from purple acid phosphatase apo-enzyme Omkar isolated from a new source Limonia acidissima. J.of Expt.Nanoscience.,doi.org/10.1080/17458080.2015.1025300, Published online: 27 Mar 2015.
21. 14.Graphene Foam: Next Generation Graphene Analogue, Butala Deepali and Waghmode Shobha, Research Journal of Chemistry and Environment Vol. 24 (8)August (2020), 1-11.
22. 15.Patil, U.D., Waghmode, S., Pingale, S.S. et al. Quinoline-infused graphene carbon cages: an ecofriendly approach towards environmental remediation. Res Chem Intermed 49, 4217–4237 (2023). https://doi.org/10.1007/s11164-023-05098-0.
23. 16.Shobha Waghmode, Pooja Chavan,Vidya Kalyankar,and Sharada Dagade.Synthesis of Silver Nanoparticles Using Triticum aestivum and Its Effect on Peroxide Catalytic Activity and Toxicology. Journal of Chemistry, Volume 2013, Article ID 265864, 5 pages, http://dx.doi.org/10.1155/2013/265864.