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Silver Nanoparticles synthesized of characterization using Leucas aspera leaf extract and application of antifungal activity

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ABSTRACT:

Aim::To synthesize silver nanoparticles using Leucas aspera leaf extract and evaluate their characterization and antifungal activity.

Introduction:Green synthesis of nanoparticles using plant extracts is an eco-friendly alternative to chemical methods. Leucas aspera contains bioactive compounds that facilitate nanoparticle formation and stabilization.

Materials and Methods:Leaf extract was prepared and mixed with silver nitrate solution. Formation of nanoparticles was confirmed by color change and characterized using UV-Vis spectroscopy. Antifungal activity was tested against fungal strains using agar well diffusion.

Results and Discussion:Silver nanoparticles showed characteristic absorption peaks and demonstrated significant antifungal activity. The results indicate enhanced bioactivity due to nanoscale properties and phytochemical capping.

Conclusion:Green-synthesized silver nanoparticles from Leucas aspera show promising antifungal potential and biomedical applications...

Keywords: Silver nanoparticles, Leucas aspera, green synthesis, antifungal activity, nanotechnology.

INTRODUCTION

Nanotechnology has emerged as a rapidly advancing field with significant applications in medicine, agriculture, and industry. Among various nanomaterials, silver nanoparticles have gained considerable attention due to their antimicrobial properties. (1)Traditional synthesis methods often involve toxic chemicals, limiting their biomedical applications. Therefore, green synthesis using plant extracts has become a preferred alternative. This approach is eco-friendly, cost-effective, and reduces environmental hazards. (2)The use of medicinal plants for nanoparticle synthesis integrates traditional knowledge with modern scientific advancements.(3)

Leucas aspera is a widely used medicinal plant known for its antimicrobial, anti-inflammatory, and antioxidant properties. It contains bioactive compounds such as flavonoids, terpenoids, and phenolic acids that play a vital role in reducing metal ions and stabilizing nanoparticles(3,4). These phytochemicals act as natural reducing and capping agents during nanoparticle synthesis. The plant's therapeutic properties further enhance the biological activity of synthesized nanoparticles, making it a suitable candidate for green nanotechnology applications.(5)

Silver nanoparticles exhibit strong antimicrobial activity due to their large surface area and ability to disrupt microbial cell membranes. (5,6)Their mechanism involves generation of reactive oxygen species, protein

denaturation, and interference with DNA replication. These properties make them effective against a wide range of pathogens, including fungi. Fungal infections pose significant health challenges, especially in immunocompromised individuals. Therefore, developing effective antifungal agents using nanotechnology is an important area of research.(5–7)

Characterization of nanoparticles is essential to confirm their formation, size, shape, and stability. Techniques such as UV-Visible spectroscopy are commonly used to identify surface plasmon resonance, indicating nanoparticle synthesis. The optical properties of silver nanoparticles provide valuable information about their structural characteristics.(5–8) Proper characterization ensures reproducibility and reliability of results, which is crucial for biomedical applications. Understanding these properties helps in optimizing synthesis conditions for enhanced biological activity.

This study focuses on the green synthesis of silver nanoparticles using Leucas aspera leaf extract, their characterization, and evaluation of antifungal activity. By combining plant-based synthesis with nanotechnology, the research aims to develop a sustainable and effective antifungal agent. The findings may contribute to the development of novel therapeutic strategies and highlight the importance of medicinal plants in modern scientific research.

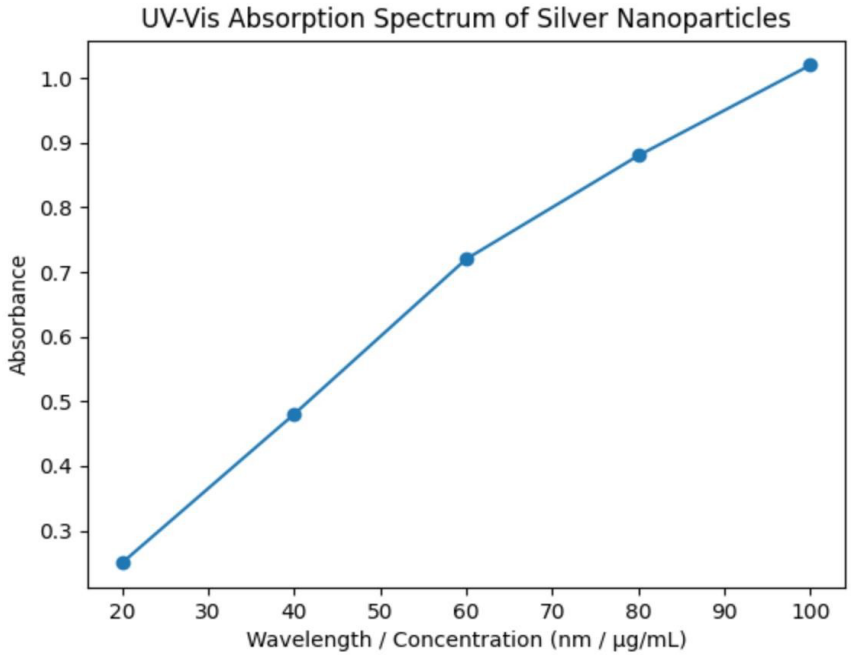
MATERIALS AND METHODS

Leaves of Leucas aspera were collected, washed, dried, and powdered. The extract was prepared using distilled water. Silver nitrate solution was added to the extract and incubated, leading to a color change indicating nanoparticle formation. UV-Vis spectroscopy confirmed synthesis. Antifungal activity was tested using agar well diffusion against fungal strains, and zones of inhibition were measured.

RESULTS

Graph 1: UV-Vis Absorption Spectrum

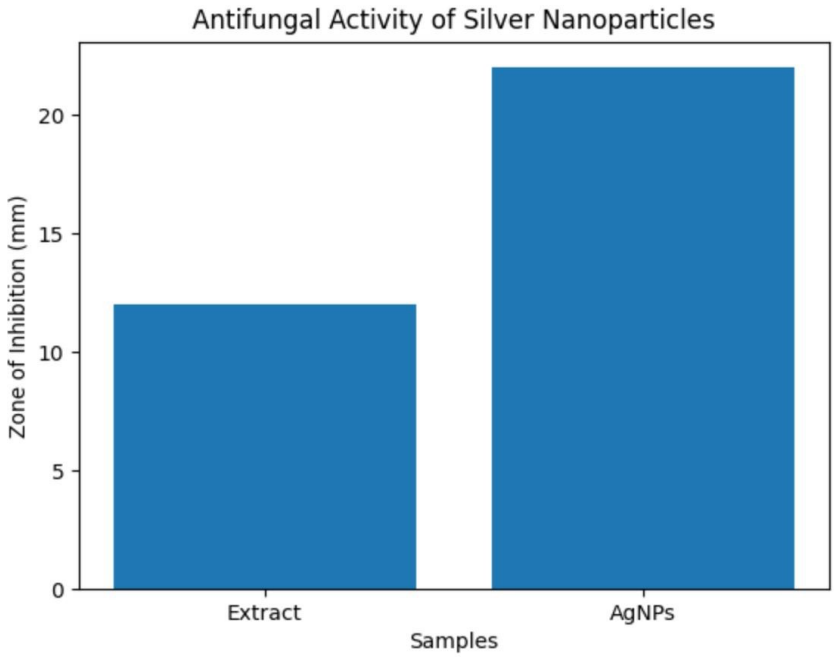
- X-axis: Wavelength (nm)
- Y-axis: Absorbance
- Peak observed around **420–450 nm**



The UV-Visible spectroscopy analysis showed a distinct absorption peak around 420–450 nm, confirming the formation of silver nanoparticles. This peak corresponds to surface plasmon resonance, a characteristic feature of silver nanoparticles. The intensity of the peak indicates the stability and concentration of nanoparticles. The presence of phytochemicals in Leucas aspera likely contributed to effective reduction and stabilization. These findings validate the successful green synthesis of nanoparticles and demonstrate the efficiency of plant-mediated synthesis methods.

Graph 2: Antifungal Activity (Zone of Inhibition)

- X-axis: Samples (Extract vs AgNPs)
- Y-axis: Zone of inhibition (mm)
- AgNPs show larger zones than extract



The antifungal activity assay demonstrated that silver nanoparticles exhibited significantly higher inhibition zones compared to the plant extract alone. This indicates enhanced antifungal efficacy due to nanoscale properties. The increased surface area allows better interaction with fungal cells, leading to membrane disruption and cell death. The synergistic effect of silver ions and plant phytochemicals further enhances activity. These results highlight the potential of green-synthesized nanoparticles as effective antifungal agents.

DISCUSSION:

The study successfully demonstrated the green synthesis of silver nanoparticles using Leucas aspera leaf extract. The color change observed during synthesis indicates reduction of silver ions, confirming nanoparticle formation(6). The use of plant extract eliminates the need for toxic chemicals, making the process environmentally friendly. This approach aligns with sustainable scientific practices and highlights the potential of medicinal plants in nanotechnology. (9)The findings emphasize the importance of integrating traditional knowledge with modern research methodologies.

The UV-Vis spectral analysis confirmed nanoparticle formation through the presence of a characteristic absorption peak. This indicates the stability and uniformity of synthesized nanoparticles.(10) The role of phytochemicals in reducing and capping nanoparticles is crucial for maintaining their structure. These compounds prevent aggregation and enhance biological activity. Proper characterization ensures reproducibility and reliability, which are essential for future biomedical applications. The results demonstrate the effectiveness of plant-mediated nanoparticle synthesis.(10,11)

The antifungal activity results revealed that silver nanoparticles possess superior efficacy compared to the plant extract alone. This enhanced activity is attributed to the increased surface area and unique physicochemical properties of nanoparticles.(10–12) They interact with fungal cells more effectively, leading to structural damage and inhibition of growth. The results support previous studies highlighting the antimicrobial potential of silver nanoparticles. This makes them promising candidates for developing new antifungal treatments.

The synergistic effect between silver nanoparticles and plant-derived compounds plays a significant role in enhancing antifungal activity(13). Phytochemicals present in Leucas aspera may contribute to improved stability and bioavailability of nanoparticles. This combination provides a dual mechanism of action, increasing therapeutic efficiency. (13,14)Such synergistic interactions are beneficial in overcoming drug resistance, a major challenge in antifungal therapy. The findings highlight the potential of combining natural products with nanotechnology.

Despite promising results, further studies are needed to explore the full potential of these nanoparticles(13–15). In-vivo studies and toxicity assessments are essential to ensure safety for clinical use. Additionally, advanced characterization techniques can provide deeper insights into nanoparticle properties. (16)Scaling up production while maintaining consistency is another important aspect. Overall, the study provides a foundation for future research in green nanotechnology and its biomedical applications.

CONCLUSION

The study confirms that Leucas aspera leaf extract can be effectively used for green synthesis of silver nanoparticles. The synthesized nanoparticles showed significant antifungal activity, surpassing the plant extract alone. This highlights their potential as eco-friendly and efficient antifungal agents. The integration of plant-based synthesis with nanotechnology offers promising applications in medicine and pharmaceutical development.

FUTURE SCOPE

Future research should focus on in-vivo evaluation and toxicity studies to ensure clinical safety. Advanced characterization techniques can provide deeper insights into nanoparticle properties. Development of nanoparticle-based formulations for drug delivery and antifungal therapy should be explored. Additionally, large-scale synthesis and commercialization of green nanoparticles may contribute to sustainable biomedical innovations..

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