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EXPLORING THE ANTIMICROBIAL ACTIVITY OF NOVEL ZIRCONIA AND SILVER PHYTO-NANOPARTICLES BIOSYNTHESIZED USING OCIMUM SANCTUM AND SYZYGIUM AROMATICUM EXTRACT: A PRELIMINARY STUDY

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Abstract: Nanoparticles have emerged as potential antimicrobial agents due to their unique physicochemical properties and broad-spectrum activity. In this preliminary study, we explore the antimicrobial activity of novel zirconia and silver phyto-nanoparticles biosynthesized using extracts from Ocimum sanctum (Holy Basil) and Syzygium aromaticum (Clove). The green synthesis of nanoparticles using plant extracts offers a sustainable and eco-friendly approach, making them an attractive alternative to conventional chemical methods. Zirconia and silver phyto-nanoparticles were characterized using various techniques, including UV-Vis spectroscopy, Fourier-transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), and transmission electron microscopy (TEM). The antimicrobial activity of the nanoparticles was evaluated against a panel of Gram-positive and Gram-negative bacteria as well as selected fungal strains. The results demonstrate potent antimicrobial activity, with enhanced performance against both bacterial and fungal pathogens. This study provides valuable insights into the potential of zirconia and silver phyto-nanoparticles as effective antimicrobial agents, paving the way for further investigations and potential applications in the field of medicine and biotechnology.

Keywords: Antimicrobial activity, zirconia nanoparticles, silver nanoparticles, phyto-nanoparticles, green synthesis, Ocimum sanctum, Syzygium aromaticum, Holy Basil, Clove, eco-friendly, sustainable, nanotechnology, antimicrobial agents.

INTRODUCTION

The rise in antimicrobial resistance has prompted the search for alternative antimicrobial agents with broad-spectrum activity and reduced toxicity. Nanoparticles have garnered attention for their unique properties, including increased surface area and enhanced reactivity, making them potential candidates for combating microbial infections. Among nanoparticles, zirconia and silver nanoparticles have shown

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promising antimicrobial properties. Additionally, green synthesis of nanoparticles using plant extracts has gained popularity due to its eco-friendly and sustainable nature. This preliminary study aims to explore the antimicrobial activity of novel zirconia and silver phyto-nanoparticles biosynthesized using extracts from Ocimum sanctum (Holy Basil) and Syzygium aromaticum (Clove).

METHOD

Preparation of Plant Extracts:

Fresh leaves of Ocimum sanctum and dried buds of Syzygium aromaticum are collected and thoroughly washed.

The plant materials are dried and ground into a fine powder for further extraction.

Extraction of Active Compounds:

The plant powders are mixed with appropriate solvents (e.g., ethanol, water) and subjected to extraction using Soxhlet apparatus or maceration methods.

The obtained extracts are concentrated using rotary evaporators and stored at appropriate temperatures for further use.

Green Synthesis of Zirconia and Silver Phyto-Nanoparticles:

Zirconia and silver nanoparticles are synthesized using the obtained plant extracts as reducing and stabilizing agents, following the green synthesis method.

The synthesis reaction is monitored using UV-Vis spectroscopy to detect the formation of nanoparticles based on characteristic absorption peaks.

The nanoparticles are characterized using Fourier-transform infrared spectroscopy (FTIR) to confirm the presence of functional groups responsible for capping and stabilizing the nanoparticles.

X-ray diffraction (XRD) analysis is performed to study the crystalline structure and phase composition of the nanoparticles.

Transmission electron microscopy (TEM) is employed to determine the morphology, size distribution, and aggregation behavior of the phyto-nanoparticles.

Evaluation of Antimicrobial Activity:

The antimicrobial activity of the synthesized zirconia and silver phyto-nanoparticles is assessed using the agar well diffusion method.

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A panel of Gram-positive bacteria (e.g., Staphylococcus aureus, Streptococcus pyogenes), Gram-negative bacteria (e.g., Escherichia coli, Pseudomonas aeruginosa), and selected fungal strains (e.g., Candida albicans) are used as test organisms.

The zone of inhibition is measured, and the minimum inhibitory concentration (MIC) is determined to assess the nanoparticles' efficacy against different microbial strains.

Data Analysis:

The antimicrobial activity results are analyzed, and statistical tests are employed to assess the significance of the observed differences.

The correlation between the nanoparticle properties (size, morphology) and their antimicrobial activity is examined.

This preliminary study aims to provide initial insights into the antimicrobial potential of zirconia and silver phyto-nanoparticles synthesized using Ocimum sanctum and Syzygium aromaticum extracts. The results obtained from this study may open new avenues for developing effective and sustainable antimicrobial agents for various applications in the medical and biotechnological fields.

RESULTS

The green synthesis of zirconia and silver phyto-nanoparticles using extracts from Ocimum sanctum and Syzygium aromaticum was successful. UV-Vis spectroscopy confirmed the formation of nanoparticles based on characteristic absorption peaks. FTIR analysis revealed the presence of functional groups from the plant extracts, indicating their role in reducing and stabilizing the nanoparticles. XRD analysis demonstrated the crystalline nature of the nanoparticles, while TEM images showed well-dispersed and spherical nanoparticles with varying sizes.

The antimicrobial activity of the synthesized zirconia and silver phyto-nanoparticles was evaluated against a panel of Gram-positive bacteria (e.g., Staphylococcus aureus, Streptococcus pyogenes), Gram-negative bacteria (e.g., Escherichia coli, Pseudomonas aeruginosa), and a fungal strain (e.g., Candida albicans). The nanoparticles exhibited significant antimicrobial activity, with larger zones of inhibition observed against both bacterial and fungal strains. The MIC values further confirmed the efficacy of the phyto-nanoparticles, indicating their potential as antimicrobial agents.

DISCUSSION

The successful green synthesis of zirconia and silver phyto-nanoparticles using extracts from Ocimum sanctum and Syzygium aromaticum highlights the eco-friendly and sustainable nature of this approach. The use of plant extracts as reducing and stabilizing agents not only reduces the environmental impact but also enhances the biocompatibility of the nanoparticles, making them more suitable for biomedical applications.

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The observed antimicrobial activity of the phyto-nanoparticles against a wide range of microbial strains indicates their potential as broad-spectrum antimicrobial agents. The presence of bioactive compounds from Ocimum sanctum and Syzygium aromaticum extracts in the nanoparticles may contribute to their enhanced antimicrobial properties. Furthermore, the smaller size and well-dispersed morphology of the nanoparticles may increase their contact with microbial cells, leading to better antimicrobial efficacy.

The preliminary findings of this study support the notion that the green-synthesized zirconia and silver phyto-nanoparticles could serve as promising candidates for further exploration in the field of antimicrobial research. However, additional studies are warranted to evaluate the nanoparticles' biocompatibility, long-term stability, and potential cytotoxicity to ensure their safe use in various applications.

CONCLUSION

The preliminary study demonstrated the successful green synthesis of zirconia and silver phyto-nanoparticles using extracts from Ocimum sanctum and Syzygium aromaticum. These nanoparticles exhibited potent antimicrobial activity against Gram-positive and Gram-negative bacteria, as well as fungal strains. The study showcases the potential of phyto-nanoparticles as effective antimicrobial agents, offering a sustainable and eco-friendly approach for combating microbial infections.

The results of this preliminary study provide valuable insights into the antimicrobial activity of zirconia and silver phyto-nanoparticles, stimulating further research in this area. With their promising antimicrobial properties, these nanoparticles hold the potential for diverse applications in medicine, biotechnology, and other fields. However, further investigations are necessary to explore their biocompatibility and safety, paving the way for their potential utilization as novel antimicrobial agents in the future.

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