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Waste-Grass-Mediated Green Synthesis of Silver Nanoparticles and Evaluation of Their Anticancer, Antifungal, and Antibacterial Activity: A Review

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Abstract: *Silver nanoparticles (AgNPs) have gained significant attention due to their diverse biomedical and environmental applications. Green synthesis using plant-based materials provides a sustainable and eco-friendly alternative to conventional chemical methods. Waste grass, an abundant and underutilized biomass, has emerged as an efficient reducing and stabilizing agent in the synthesis of AgNPs. This review comprehensively discusses the role of waste grass in the green synthesis of AgNPs, their physicochemical characteristics, and their potential applications in anticancer, antifungal, and antibacterial therapies. The biosynthesized AgNPs exhibit remarkable biological activities, making them promising candidates for future biomedical applications. The review also highlights the mechanistic aspects of their therapeutic properties, challenges in their development, and future perspectives for large-scale applications*

Keywords: Silver nanoparticles, green synthesis, waste grass, antimicrobial activity, anticancer properties, nanobiotechnology, eco-friendly synthesis

I. INTRODUCTION

The development of nanotechnology has revolutionized various scientific fields, particularly in biomedical and environmental sciences. Among metal nanoparticles, silver nanoparticles (AgNPs) have shown immense potential due to their excellent antimicrobial, anticancer, and antifungal properties. Traditional synthesis methods involve hazardous chemicals and energy-intensive processes, prompting researchers to explore green synthesis techniques.

Plant-mediated synthesis of AgNPs has gained attention due to its sustainability, cost-effectiveness, and environmental benefits. Waste grass, an abundant and renewable resource, contains bioactive phytochemicals such as flavonoids, phenolics, and terpenoids, which facilitate the reduction of silver ions ($Ag+$) to AgNPs. The utilization of waste grass not only contributes to sustainable nanotechnology but also addresses biomass waste management issues. This review provides an in-depth analysis of waste-grass-mediated AgNP synthesis, characterization techniques, and their biomedical applications.

II. GREEN SYNTHESIS OF SILVER NANOPARTICLES USING WASTE GRASS

2.1 **Selection of Waste Grass for AgNP Synthesis** Various species of waste grass, including Cynodon dactylon (Bermuda grass), Pennisetum purpureum (Napier grass), and Saccharum officinarum (Sugarcane bagasse), contain phytoconstituents that act as natural reducing and capping agents. These plants are widely available and have bioactive compounds beneficial for nanoparticle synthesis.

2.2 **Synthesis Mechanism** The green synthesis of AgNPs using waste grass typically involves:

Preparation of Grass Extract: Waste grass is washed, dried, and boiled in distilled water to obtain an extract rich in phytochemicals.

Reduction Process: The extract is mixed with silver nitrate ($AgNO3$) solution, leading to the bioreduction of $Ag+$ ions into AgNPs.
Stabilization: The bioactive compounds in waste grass serve as capping agents, stabilizing the synthesized AgNPs and preventing aggregation.
Characterization: The synthesized AgNPs are analyzed using UV-Vis spectroscopy, FTIR, XRD, TEM, and DLS to determine their size, shape, and stability.

III. CHARACTERIZATION TECHNIQUES FOR AGNPS

3.1 **UV-Visible Spectroscopy**: Confirms the formation of AgNPs by detecting surface plasmon resonance (SPR) peaks in the range of 400-450 nm.
3.2 **Fourier Transform Infrared Spectroscopy (FTIR)**: Identifies functional groups involved in the reduction and stabilization of AgNPs.
3.3 **X-Ray Diffraction (XRD)**: Determines the crystalline structure and phase purity of AgNPs.
3.4 **Transmission Electron Microscopy (TEM) and Scanning Electron Microscopy (SEM)**: Provide insights into the size, shape, and morphology of synthesized AgNPs.
3.5 **Dynamic Light Scattering (DLS) and Zeta Potential Analysis**: Assess particle size distribution and stability in solution.

IV. ANTIMICROBIAL PROPERTIES OF WASTE-GRASS-MEDIATED AGNPS

4.1 **Antibacterial Activity** Silver nanoparticles exhibit potent antibacterial effects against Gram-positive (Staphylococcus aureus, Bacillus subtilis) and Gram-negative (Escherichia coli, Pseudomonas aeruginosa) bacteria. The mechanism involves:
Disruption of bacterial cell membranes,Generation of reactive oxygen species (ROS), Inhibition of bacterial DNA replication

4.2 **Antifungal Activity** AgNPs synthesized from waste grass have demonstrated antifungal properties against Candida albicans, Aspergillus niger, and Fusarium species. The nanoparticles disrupt fungal cell walls, alter membrane permeability, and induce oxidative stress, leading to cell death.

V. ANTICANCER PROPERTIES OF WASTE-GRASS-DERIVED AGNPS

AgNPs have shown promising cytotoxic effects against cancer cells, including breast (MCF-7), lung (A549), and cervical (HeLa) cancer cells. The anticancer mechanism includes:
Apoptosis Induction: Activation of caspase-dependent pathways leading to programmed cell death.
ROS Generation: Inducing oxidative stress in cancer cells, triggering mitochondrial dysfunction.
Cell Cycle Arrest: Halting cancer cell proliferation at specific phases.

VI. CHALLENGES AND FUTURE PERSPECTIVES

Despite promising results, challenges in the large-scale production and biomedical application of AgNPs include
Standardization Issues: Variability in nanoparticle size and concentration.
Toxicity Concerns: Understanding the cytotoxicity and biocompatibility of AgNPs in humans.
Regulatory Approvals: Compliance with safety and ethical guidelines for medical applications.
Scalability and Cost-Effectiveness: Developing efficient large-scale production methods for industrial use.
Future research should focus on optimizing synthesis parameters, improving stability, and conducting extensive in vivo studies to evaluate long-term effects.

VII. CONCLUSION

Waste-grass-mediated green synthesis of AgNPs offers an environmentally sustainable approach to nanoparticle production. The biosynthesized AgNPs exhibit remarkable antibacterial, antifungal, and anticancer activities, making them potential candidates for biomedical and pharmaceutical applications. Further studies are required to explore their clinical applicability and ensure safety for human use.

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