PhD Research Proposal

Title:

Green Synthesis and Characterization of Inorganic Nanoparticles Using Plant Extracts for Environmental and Catalytic Applications

1. Introduction:

Nanotechnology has emerged as one of the most dynamic areas of research due to the unique physical and chemical properties of materials at the nanoscale. Traditional methods for synthesizing inorganic nanoparticles often involve toxic chemicals, high energy consumption, and environmentally hazardous byproducts.

Green synthesis provides a sustainable alternative by using plant extracts as reducing and capping agents to produce nanoparticles under mild, eco-friendly conditions. Plant metabolites such as polyphenols, flavonoids, alkaloids, and terpenoids play a crucial role in reducing metal ions to nanoparticles while stabilizing them naturally.

This project aims to synthesize metal and metal oxide nanoparticles (Ag, ZnO, Fe□O□) using locally available plant extracts and explore their environmental and catalytic applications, particularly in the degradation of organic pollutants and microbial control.

2. Objectives:

1. To synthesize inorganic nanoparticles using selected plant extracts via green routes.

2. To optimize synthesis conditions such as pH, concentration, temperature, and reaction time.

3. To characterize the synthesized nanoparticles using accessible analytical tools.

4. To evaluate the catalytic and photocatalytic activities of the nanoparticles in environmental remediation.

5. To assess the antimicrobial potential of the synthesized nanoparticles.

3. Methodology:

a. Selection and preparation of plant extract:

Collect and identify plant materials rich in bioactive compounds (e.g., Azadirachta indica, Moringa oleifera, Ocimum sanctum).

Prepare aqueous or ethanolic extracts through maceration or boiling, followed by filtration.

b. Synthesis of nanoparticles:

Mix metal salt solutions (e.g., $AgNO_3$, $Zn(NO_3)_2$, $FeCl_3$) with plant extracts under controlled conditions.

Monitor color changes indicating nanoparticle formation.

Optimize parameters such as extract ratio, temperature, and pH.

c. Characterization techniques:

UV–Vis spectroscopy – to confirm nanoparticle formation and optical properties.

FTIR spectroscopy – to identify functional groups involved in reduction and stabilization.

XRD – to determine crystal structure and average particle size.

SEM / TEM (collaborative access) – to study surface morphology and particle distribution.

d. Application studies:

Photocatalytic activity: Test degradation of dyes like methylene blue or rhodamine B under sunlight.

Antimicrobial activity: Evaluate using disk diffusion or MIC methods against common bacterial strains.

4. Expected Outcomes:

Development of a low-cost, green synthesis protocol for inorganic nanoparticles.

Understanding of the role of phytochemicals in nanoparticle formation and stabilization.

Demonstration of catalytic and antibacterial potential for environmental remediation.

Contribution to sustainable inorganic chemistry and nanomaterial research.

5. Significance of the Study:

This research combines green chemistry principles with nanotechnology to create environmentally benign materials using readily available plant resources. The outcomes can support eco-friendly industrial processes, wastewater treatment, and antimicrobial applications, aligning with global goals for sustainable development.