

Title: Synthesis and Characterization of Nanoparticles and Metal Doping Effects

Introduction:

Nanoparticles have emerged as a cornerstone of modern materials science due to their unique size-dependent physical and chemical properties. These properties can be further tuned through metal doping, enabling enhanced functionality for applications in optoelectronics, catalysis, sensing, energy storage, and biomedical fields. This research proposal focuses on the controlled synthesis of semiconductor or oxide-based nanoparticles and the systematic study of how metal doping alters their structural, optical, and electronic behavior.

Research Objectives:

1. To synthesize uniform, stable nanoparticles using scalable chemical and green synthesis techniques.
2. To incorporate various metal dopants (e.g., Ag, Cu, Mn, Fe) into the host lattice to modify properties.
3. To analyze the structural, morphological, optical, and thermal properties of doped and undoped nanoparticles.
4. To explore their potential application in photocatalysis, sensors, or energy devices.

Methodology:

Nanoparticles will be synthesized using sol-gel, hydrothermal, and co-precipitation techniques. Metal doping will be achieved by introducing dopant precursors during the synthesis phase. Characterization will be conducted using techniques such as:

- **XRD** for crystal structure,
- **SEM/TEM** for particle size and morphology,
- **UV-Vis and Photoluminescence spectroscopy** for optical behavior,
- **FTIR and Raman spectroscopy** for chemical bonding,
- **TGA/DSC** for thermal stability.

Expected Outcomes:

The project aims to provide insights into how different dopants influence nanoparticle behavior, particularly in terms of band gap engineering, charge transport, and surface reactivity. The findings will support the development of high-performance materials for specific technological applications and offer design guidelines for next-generation functional nanomaterials.

Significance:

Understanding metal doping effects at the nanoscale is essential for tailoring materials for real-world applications. This research will contribute to fundamental materials science while also addressing practical needs in energy, environment, and electronics.

Conclusion:

By exploring the synthesis and doping of nanoparticles in a systematic manner, this Ph.D. research will expand the scientific knowledge base and open new avenues for the design of advanced materials with tailored properties.