Study of Green Synthesis of Zinc Oxide nanoparticles using Pentalinon Luteum Plant Extract

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Abstract

Aquatic ecosystems and human health are seriously threatened by the textile industry's excessive water consumption and consequent release of hazardous dye effluents. This study describes the environmentally benign, biogenic manufacturing of zinc oxide nanoparticles (ZnO NPs) utilizing Pentalinon luteum leaf extract. Fourier Transform Infrared Spectroscopy (FTIR), Scanning Electron Microscopy (SEM), and Energy Dispersive X-ray Analysis (EDAX) were used to analyze the produced NPs. The generation of spherical, somewhat agglomerated ZnO NPs with crystallite diameters ranging from 16.24 nm to 28.33 nm was confirmed by the results. The green synthesis approach turned shown to be an economical, safe, and effective substitute for traditional chemical synthesis.

1. Introduction

Significant water pollution has resulted from industrialization, especially in the tannery, paper, and textile industries. Because textile effluents include complex dyes that lower dissolved oxygen (DO) and sunlight penetration, they increase biological oxygen demand (BOD) and interfere with aquatic photosynthesis, making them especially dangerous. Metal oxide nanoparticle-based photocatalytic degradation has become a highly sought-after remedy to counter this. Zinc Oxide (ZnO) is favored above other options because of its high surface area, effective electron carrier capabilities, and chemical durability. We can create these nanoparticles without the use of hazardous reducing chemicals by

applying "Green Chemistry" principles, particularly with plant extracts like Pentalinon luteum.

2. Materials and Methods

2.1 Preparation of Leaf Extract

The leaves of Pentalinon luteum were gathered from Karjat Taluka in Ahilyanagar, India. After being cleaned with deionized (DI) water, the leaves were left to air dry for six days. After dispersing 10 g of the resultant leaf powder in 300 mL of DI water, the mixture was heated to 70°C for 30 minutes. Whatman No. 41 filter paper was used to collect the filtrate, which was then kept at room temperature.

2.2 Green Synthesis of ZnO NPs

A wet chemical method was applied: 2.875 g of zinc sulphate (0.1M) was combined with 100 mL of the leaf extract. To create a precipitate, the mixture was shaken at 70°C for an hour after being stirred for a full day. The mixture was repeatedly washed with ethanol after being centrifuged at 5000 rpm and dried for 12 hours at 100°C. The final product was calcined at 400°C for two hours in order to create pure ZnO NPs.

3. Results and Discussion

3.1 FTIR Analysis

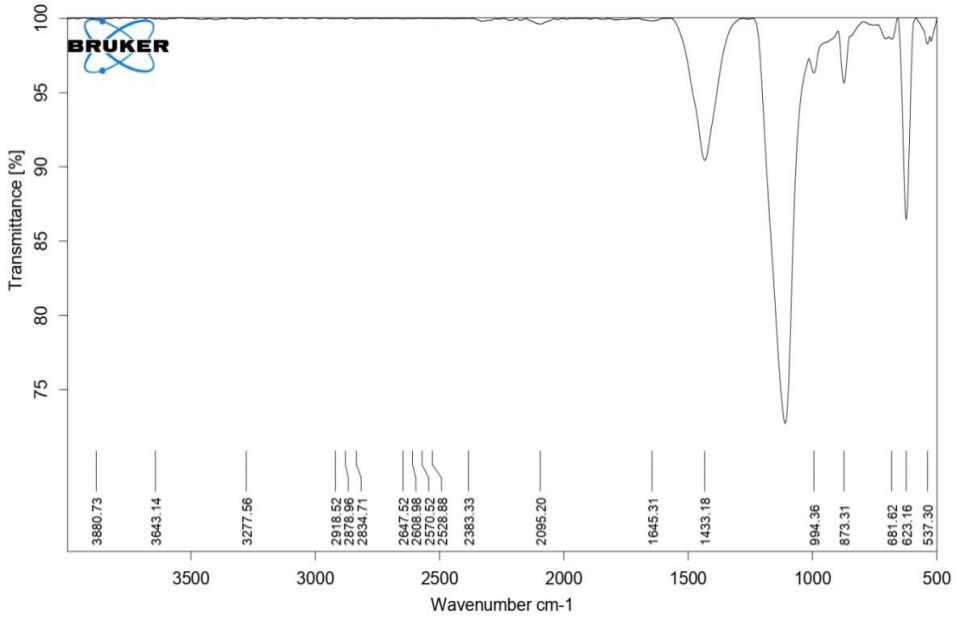


Fig. 1. FT-IR spectra of synthesized Zinc oxide nanoparticles

The biomolecules (carbohydrates, phenols, and flavonoids) in charge of the reduction and capping of the NPs were identified using FTIR. Zn-O Stretching: The development of the metal oxide framework is confirmed by distinct peaks at 537.30, 623.16, and 681.62 cm^{-1}.C-C Bands: Organic residues from the extract are indicated by a peak at 1433.18 cm^{-1}. Adsorbed Water: The O-H bending vibrations are associated with the peak at 1645.31 cm^{-1}.

3.2 SEM and Morphology

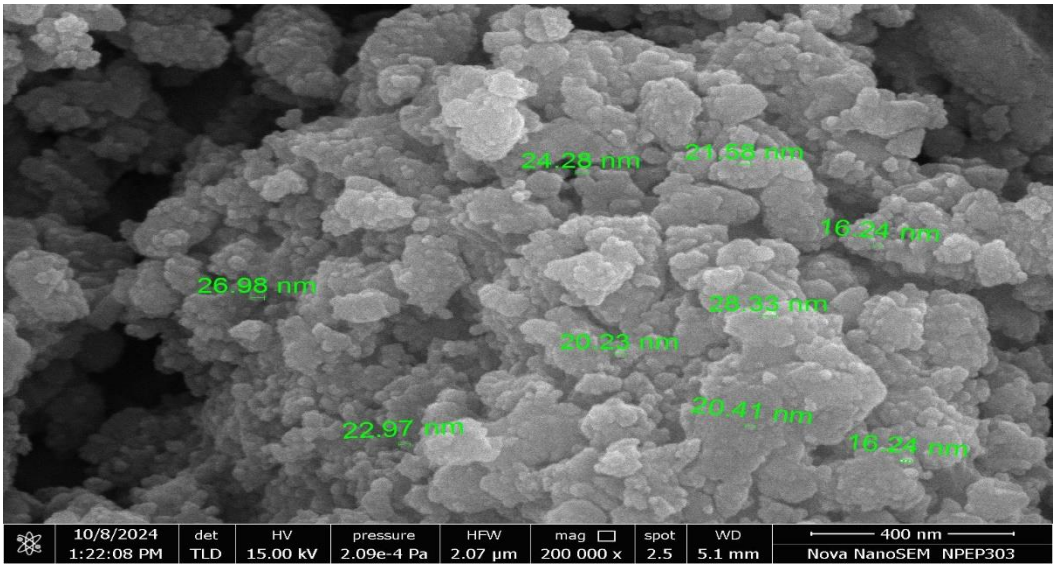


Fig. 2. SEM images of zinc oxide nanoparticles

The ZnO NPs are mostly spherical but have some irregular shapes because of aggregation, according to SEM images. The synthetic material's nanoscale scale was confirmed by the particle size measurements, which ranged from 16.24 nm to 28.33 nm.

3.3 EDAX and Elemental Mapping

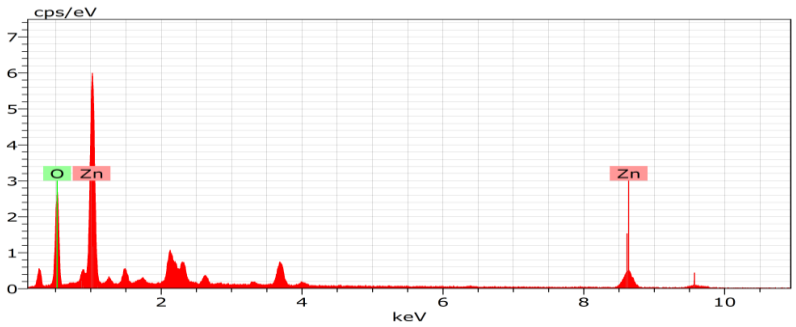


Figure3.EDAX Spectra of ZnO nanoparticles

The sample's excellent purity was validated by EDAX analysis. The composition of elements revealed: • Zinc (Zn): Weight percentage: 73.47% • Weight percentage of oxygen (O): 26.53% .Although the ratio indicates a slight oxygen shortfall relative to zinc, which is common in biogenic ZnO formation, the mapping showed a uniform distribution of elements.

4. Conclusion

The simple, affordable, and "green" production of ZnO nanoparticles was carried out using Pentalinon luteum. Characterization confirmed the crystallinity and nanostructure of the particles. Because of these qualities, these NPs show great promise as catalysts for the photocatalytic degradation of industrial dyes, providing a sustainable way to remediate waste water.

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