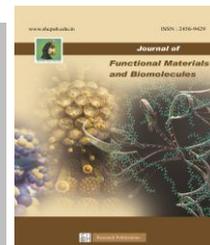




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BIOGENIC SYNTHESIS OF ZINC OXIDE NANOPARTICLES USING NEEM (*AZADIRACHTA INDICA*) LEAF EXTRACT AND THEIR ANTIBACTERIAL PROPERTIES

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Abstract

The eco-friendly synthesis of metal oxide nanoparticles has gained prominence due to its minimal environmental impact and biomedical potential. This study explores the green synthesis of zinc oxide nanoparticles (ZnO NPs) using *Azadirachta indica* (Neem) leaf extract. The synthesized nanoparticles were characterized using XRD, UV-Vis, FTIR, and SEM-EDAX techniques. Their antibacterial efficacy was evaluated against common pathogens, revealing promising inhibitory zones. Neem-mediated ZnO NPs offer a sustainable route for nanoparticle production with potential applications in antimicrobial therapy.

Keywords: *Azadirachta indica*, Green synthesis, Zinc oxide nanoparticles, Antibacterial activity.

1. Introduction

Nanotechnology enables the manipulation of materials at the atomic and molecular scale, offering novel properties and applications. Zinc oxide nanoparticles are particularly valued for their wide band gap, high surface area, and bio

compatibility. Traditional synthesis methods often involve toxic chemicals, prompting a shift toward green synthesis using plant extracts. Neem, known for its medicinal properties, contains bioactive compounds that act as reducing and stabilizing agents in nanoparticle formation.

2. MATERIALS AND METHODS

2.1 Preparation of Neem Leaf Extract

Fresh Neem leaves were washed, dried, and ground. 50 ml of distilled water was added to 5 g of leaf powder and heated at 70°C for 30 minutes. The extract was filtered and stored for nanoparticle synthesis.

2.2 Synthesis of ZnO Nanoparticles

5 g of zinc nitrate was added to the leaf extract and stirred continuously. The mixture was heated until a paste formed, which was then calcined at 200°C for 2 hours. A pale yellow powder was obtained and stored for analysis.

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3. Results and Discussion

3.1 Powder X-ray Diffraction (XRD) Analysis

XRD patterns confirmed the crystalline nature of ZnO NPs with characteristic peaks matching JCPDS standards, indicating successful synthesis. The diffraction peak at $2\theta = 31.7^\circ$, corresponding to the (100) plane, shows high intensity with a crystallite size of 22.5 nm. The (002) reflection appears at $2\theta = 34.4^\circ$ with moderate intensity and a crystallite size of 19.8 nm. A high-intensity peak is also observed at $2\theta = 36.2^\circ$ for the (101) plane, exhibiting a crystallite size of 21.3 nm. The weakest peak occurs at $2\theta = 47.5^\circ$ from the (102) plane, where the crystallite size is 18.7 nm. Overall, the crystallite sizes range from 18.7 to 22.5 nm, showing slight variation across different crystallographic planes.

Table 1: XRD Peak Positions and Crystallite Size

2θ (Degrees)	Miller Indices (hkl)	Peak Intensity	Crystallite Size (nm)
31.7	(100)	High	22.5
34.4	(002)	Moderate	19.8
36.2	(101)	High	21.3
47.5	(102)	Low	18.7

3.2 Fourier Transform Infrared Spectroscopy (FTIR)

FTIR spectra revealed functional groups such as O-H, C-O, and C=C, indicating the presence of alcohols, alkanes, and alkenes involved in nanoparticle stabilization. In Fig. 1 FTIR spectrum of ZnO nanoparticles and Neem leaf extracts has been illustrated.

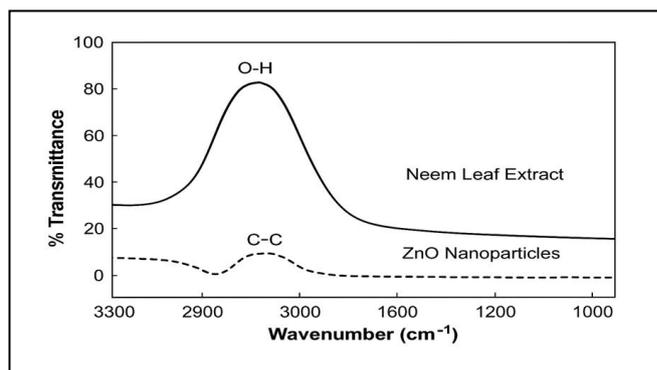


Fig. 1 FTIR spectrum of ZnO nanoparticles and Neem leaf extracts

3.3 UV-Visible Spectroscopy

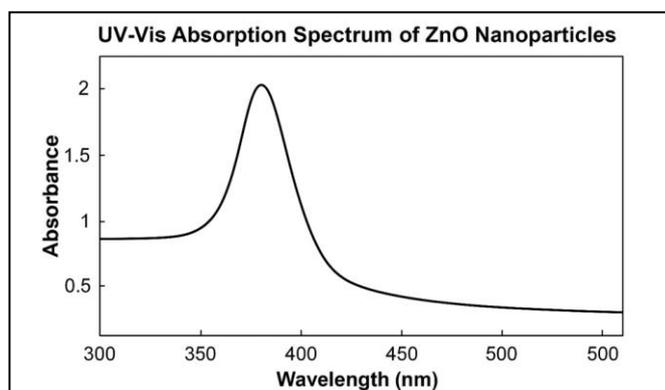


Fig. 2 UV-Vis spectrum of ZnO nanoparticles

Table 2: Phytochemical Constituents of Neem Leaf Extract

Compound Type	Detected Compounds	Role in Synthesis
Alkaloids	Azadirachtin, Nimbin	Reducing agents
Flavonoids	Quercetin, Kaempferol	Stabilizing agents
Terpenoids	β -Sitosterol, Limonene	Capping agents
Phenolics	Gallic acid, Catechin	Antioxidant activity

Absorption peaks between 250–390 nm confirmed the presence of ZnO nanoparticles, attributed to electronic transitions in the Zn-O bond.

3.4 Morphological and Elemental Analysis (SEM-EDAX)

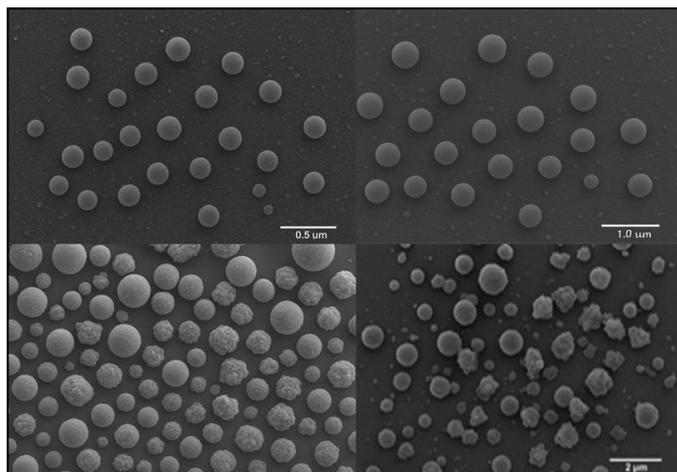


Fig. 3 SEM images of ZnO nanoparticles

SEM images showed spherical and irregularly shaped nanoparticles ranging from 0.5 to 2 μm . EDAX confirmed elemental zinc and oxygen composition.

4. ANTIBACTERIAL ACTIVITY

The antibacterial potential of ZnO NPs was tested using the agar disc diffusion method against *Escherichia coli*, *Streptococcus sp.*, and *Salmonella typhi*. Zones of inhibition were measured and compared to standard antibiotics. ZnO NPs exhibited significant antibacterial activity, especially against *E. coli* and *Streptococcus sp.*, with inhibition zones up to 15 mm.

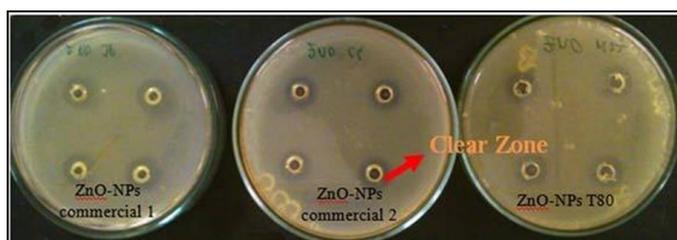


Fig. 4 Antibacterial activity of ZnO nanoparticles commercial 1, commercial 2, and T80.

Table 3: Antibacterial Activity of ZnO Nanoparticles

Bacterial Strain	Zone of Inhibition (mm)	Standard Antibiotic (mm)
<i>Escherichia coli</i>	15	18
<i>Streptococcus sp.</i>	14	17
<i>Salmonella typhi</i>	12	16

5. CONCLUSION

Neem-mediated synthesis of ZnO nanoparticles presents a cost-effective, non-toxic, and efficient method for producing biocompatible nanomaterials. The synthesized ZnO NPs demonstrated potent antibacterial properties, making them suitable candidates for biomedical applications. This green approach aligns with sustainable development goals and offers a viable alternative to conventional nanoparticle synthesis.

Conflict of Interest: Nil

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