



# Sustainable Synthesis of MgO Nanoparticles from *Clerodendrum inerme* Bast Fiber Extract: Physicochemical Characterization and Antibacterial Performance

H. V. Ganvir<sup>1</sup>, Pramod G. Musrif<sup>2</sup>, P Satishkumar<sup>3\*</sup>, Anjali D. Kadam<sup>4</sup>, Rajasekaran Saminathan<sup>5</sup> and C. Krishnaraj<sup>6</sup>

<sup>1</sup>Department of Applied Physics, Yeshwantrao Chavan College of Engineering, Nagpur, MH, India

<sup>2</sup>Department of Physics, AISSMS, Institute of Information Technology, Shivajinagar, Pune, MH, India

<sup>3</sup>Department of Mechanical Engineering, Rathinam Technical Campus, Coimbatore, TN, India

<sup>4</sup>Department of Mechanical Engineering, Priyadarshini Bhagwati College of Engineering, Nagpur, MH, India

<sup>5</sup>Department of Mechanical Engineering, College of Engineering and Computer Science, Jazan University, Saudi Arabia

<sup>6</sup>Department of Mechanical Engineering, Rathinam Technical Campus, Coimbatore, TN, India

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\*spsatishkumar1986@gmail.com



## ABSTRACT

The need of sustainable and biocompatible nanomaterials has been driving environmentally friendly synthesis pathways related to biomedical purposes. In this research, magnesium oxide (MgO) nanoparticles were produced through a green technique using *Clerodendrum inerme* bast fiber extract as a plant-based reducing and stabilizing agent. X-ray diffraction showed the presence of crystalline MgO with typical peaks of 24.7°, 33.8° and 38.4° which indicates that it has a face-centered cubic structure and the crystallite size is between 22 and 34nm in size on average. Fourier-transform infrared spectroscopy showed the presence of significant functional groups with peaks at 3307, 2885, 1574, 953, and 450cm<sup>-1</sup>, which are related to phytochemical capping and the formation of Mg-O lattices. The SEM analysis revealed abnormal, porous nanostructures with particle sizes of less than 50nm and agglomerated clusters of 100-500nm. Elemental analysis using energy-dispersive X-ray analysis revealed the presence of Mg (56.4wt%), O (39.72wt%), and C (3.44wt%). Multi-stage thermal degradations with initial weight loss of 6-8% (0-100°C) and 12 -15%, and extensive decomposition of 40-55% were observed by thermogravimetric analysis. The structural integrity was preserved up to approximately 230°C with a residual mass of 22-25% at 600°C. The synthesized MgO nanoparticles were found to have an excellent antibacterial effect on *Pseudomonas aeruginosa* with inhibition zones of 36.5 ± 1.2 mm (100 µg) and 32.8 ± 1.0mm (50 µg). The standard erythromycin exhibited an inhibition zone of 35.0 ± 0.9mm.

**Keywords:** *Clerodendrum inerme*; MgO nanoparticles; Antibacterial activity; Phytochemical capping; Biocompatibility.

## 1. INTRODUCTION

Plant-mediated nanoparticle synthesis has emerged as a sustainable and versatile approach for developing advanced nanomaterials, driven by its eco-friendly nature, cost-effectiveness, and inherent biocompatibility. This bio-assisted approach not only minimizes environmental impact but also enhances surface functionality, dispersion stability, and biological activity of nanoparticles. Consequently, plant-derived nanomaterials offer a safer and scalable alternative for diverse technological, environmental, and biomedical applications (Manaa *et al.* 2025). In recent years, significant attention has been directed toward the development of metal oxide and hybrid nanocomposites synthesized by green and bio-assisted routes. ZnO/MgO-doped mesoporous bioactive glass (MZBG) synthesized through a modified sol-gel technique exhibited uniform

mesoporosity, enhanced hydroxyapatite formation, improved antibacterial activity, and superior osteoblast cell viability, making it suitable for bone tissue engineering and drug delivery systems (Dash *et al.* 2025). Similarly, *Tinospora cordifolia*-mediated hydrothermal synthesis produced pure and encapsulated MgO nanoparticles with reduced bandgap and enhanced surface functionalization, where encapsulated MgO showed superior antioxidant and antidiabetic activity due to phytochemical capping (Vamsi *et al.* 2024).

Further advancements include *Clerodendrum inerme*-mediated Ag nanoparticles (~37 nm), which exhibited strong antimicrobial activity and notable cytotoxicity (IC<sub>50</sub> ≈ 51.25 µg/mL) against cancer cell lines (Kalavathi *et al.* 2025). Co-doped SnO<sub>2</sub> nanoparticles synthesized via green combustion method demonstrated enhanced antimicrobial, antioxidant, and

anticancer activities (Khan *et al.* 2018a), while green-synthesized Cu-doped ZnO nanoparticles exhibited strong photocatalytic, antimicrobial, antioxidant, and antifungal properties (Khan *et al.* 2018b). Resveratrol-PVP-loaded MgO nanoparticles demonstrated improved controlled drug release and enhanced therapeutic performance (Shivappa *et al.* 2025). Similarly, *Murraya koenigii* essential oil-mediated MgO nanoparticles exhibited strong antibacterial and antioxidant activity along with hemocompatibility and food-preservative potential (Saggu *et al.* 2026).

Green-synthesized nanocomposites have also shown considerable potential in biomedical applications, including antimicrobial therapy, antioxidant activity, anticancer treatment, and wound healing. MgO-doped borate bioactive glasses synthesized *via* melt-quenching exhibited amorphous structure, hydroxyapatite formation, and non-cytotoxic antibacterial behavior, supporting their application in bone regeneration (Queiroz *et al.* 2024). Similarly, *Vitis vinifera* seed-mediated MgO nanoparticles exhibited cubic crystalline structure (~94.3 nm) with significant antimicrobial activity (Senthilkumar and Ilavenil, 2025).

Moreover, plant extracts themselves contribute significantly to biological functionality. *Clerodendrum inerme* leaf extracts demonstrated non-cytotoxic behavior and enhanced wound healing along with strong antibacterial and antifungal activity (Wisessombat and Tayeh, 2021). Ethanolic extracts of *Acalypha indica* and *Aerva lanata* showed effective antibacterial activity against opportunistic pathogens (Mickymaray *et al.* 2016). Additionally, *Terminalia chebula*-derived phytochemicals exhibit anti-quorum sensing activity, disrupting bacterial communication and reducing pathogenicity (Anitha and Mahalakshmi, 2012).

Hybrid nanocomposites such as ZnO-MgO, CuO-ZnO, and CuO-MgO systems synthesized using plant extracts demonstrate improved physicochemical and biological performance due to synergistic interactions between metal oxides (Kannan *et al.* 2024). Ag-doped MgO-ZnO nanocomposites synthesized using *Cassia alata* extract showed spherical morphology (~73 nm) with significant antimicrobial and anticancer activity (IC<sub>50</sub> = 45.8 µg/mL) against A549 cells (Kattookaran *et al.* 2025). Similarly, eco-friendly synthesis of CuO-MgO, CuO-ZnO, and MgO-ZnO nanoparticles using *Costus pictus* extract revealed strong antibacterial activity and enhanced stability (Kumar *et al.* 2024).

*Tinospora cordifolia*-mediated CuO-MgO nanocomposites synthesized *via* co-precipitation exhibited dual-phase structure with spherical morphology (~49 nm), demonstrating excellent antioxidant activity (IC<sub>50</sub> ≈ 20.89 µg/mL) and high biocompatibility (Vamsi *et al.* 2025). *Talinum fruticosum*-assisted Ag-MgO nanocomposites with

core-shell structure (~22 nm) showed superior bacterial activity against multidrug-resistant Gram-negative pathogens with low MIC values (0.25 mg/mL), indicating their suitability for advanced biomedical coatings (Fonye *et al.* 2026).

This study introduces *Clerodendrum inerme* bast fiber as an innovative and hitherto underutilized plant-based precursor for the environmentally friendly synthesis of MgO nanoparticles. Unlike conventional synthesis methods that utilize toxic reagents and complex processing conditions, the proposed technique adopts an environmentally friendly thermal conversion approach, thereby avoiding hazardous chemicals while ensuring process simplicity and sustainability. The synthesized MgO nanostructures have multifunctional properties, including improved structural integrity, elevated surface activity, and significant antibacterial efficacy.

## 2. MATERIALS AND METHODS

### 2.1 Synthesis of Nanoparticles

The eco-friendly synthesis of MgO nanoparticles utilizing *Clerodendrum inerme* bast fibers consists of a series of regulated procedures with specified materials and process parameters. Initially, distilled water served as the extraction medium to isolate bioactive phytochemicals at a fiber-to-solvent ratio of 1:20. The harvested *Clerodendrum inerme* bast fibers were meticulously washed with distilled water to remove any sticking impurities and dried in a hot air oven at 95 ± 2 °C for 5 hours to ensure the removal of moisture (Kar *et al.* 2021). The desiccated fibers were mechanically pulverized to increase surface area and promote the release of phytoconstituents. The resultant mixture was purified to isolate solid residues, and the filtrate was heated at 70 °C for 40 mins while being continuously stirred at 500 rpm to enhance extraction of phytochemicals. The synthesis of nanoparticles commenced with the dissolution of 2.36 g of magnesium nitrate tetrahydrate in 100 mL of DI water. The precursor solution was introduced to an equal amount of plant extract while continuously stirring, facilitating phytochemical-mediated reduction and stabilization. The reaction mixture was sustained at 80 °C with moderate agitation at 400 rpm to facilitate uniform nucleation and regulated development of MgO nanoparticles (Periakaruppan *et al.* 2025). After completion, the suspension was centrifuged at 7000 rpm for 30 mins to separate nanoparticles, which were washed many times with ethanol and DI water to eliminate residual contaminants. Purified product was freeze-dried for 24 hours under a vacuum of 0.05 mbar at -50 °C using a Laboratory Lyophilizer Machine to produce fine nanopowder. The resultant MgO nanoparticles were preserved in airtight, amber-hued glass containers at room temperature in a desiccator to prevent photodegradation and moisture absorption. Fig. 1 shows

the steps involved in the synthesis of MgO nanoparticles from *Clerodendrum inerme* bast fibers.

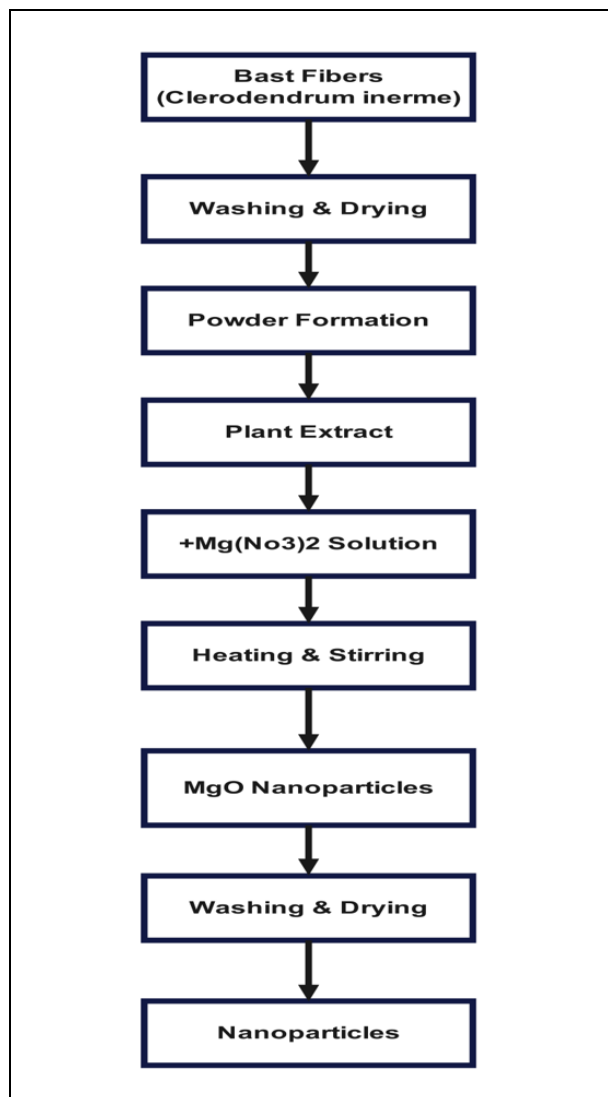


**Fig. 1: Synthesis of MgO nanoparticles from *Clerodendrum inerme* bast fiber extract**

## 2.2 Methodology

The MgO nanoparticles synthesized using *Clerodendrum inerme* bast fibers were studied for their crystalline structure, surface chemistry, morphology, thermal stability, and antimicrobial efficacy. All experimental studies were conducted in accordance with standardized testing techniques aligned with ASTM standards or generally recognized international guidelines, ensuring the reliability and repeatability of the results.

## 2.3 X-ray Diffraction

X-ray diffraction (XRD) analysis was conducted to analyse the crystalline phase and evaluate the properties of the nanoparticles. Measurements were

made using a Bruker D8 Advance diffractometer with Cu-K $\alpha$  radiation, at a scanning rate of 2°/min and a step size of 0.02° across a 2 $\theta$  scanning range of 10°–80°. The acquired diffraction peaks were compared with conventional ICDD reference database patterns for phase identification. The mean crystallite size was calculated with Debye–Scherrer equation.

## 2.4 Fourier-transform Infrared Spectroscopy

The nanoparticles were analysed for the functional groups of the phytoconstituents by FTIR (Thermo Scientific Nicolet 360 FT-IR Model, wavenumber range 4000–400 cm<sup>-1</sup>, resolution 4 cm<sup>-1</sup>). The investigation facilitated the identification of distinct vibrational peaks of carbonyl, ether and hydroxyl functional groups on the nanoparticle surface.

## 2.5 Scanning Electron Microscopy and Energy-Dispersive X-ray Spectroscopy

The elemental composition, morphology, and surface characteristics of the nanoparticles were investigated using SEM coupled with EDX. Microstructural imaging was performed using a ZEISS Gemini SEM operated at an accelerating voltage of 5–20 kV. Prior to analysis, the samples were coated with a thin conductive gold layer using a Quorum Q150R ES sputter coater to minimize charging effects and enhance image quality. The EDX analysis was carried out to verify the presence and distribution of magnesium, oxygen, and residual carbon within the nanoparticles.

## 2.6 Antibacterial Activity

The antibacterial efficacy of the MgO nanoparticles was analysed against *Pseudomonas aeruginosa* by agar diffusion technique on Mueller–Hinton agar culture medium (Hernández-Figueroa *et al.* 2025). Bacterial inoculum was calibrated to 0.5 McFarland turbidity and evenly distributed across the agar surface to guarantee homogeneous microbial proliferation. Wells were formed on agar plates aseptically into which nanoparticle suspensions at concentrations of 50 and 100  $\mu$ g were introduced. The plates were incubated at 37 °C for 1 day, after which zones of inhibition was quantified to evaluate the antibacterial activity of nanoparticles.

## 2.7 Thermogravimetric Analysis

The thermal stability and degrading properties of the MgO nanoparticles were analyzed by thermogravimetric analysis (TGA) with a Shimadzu Thermogravimetric analyzer. Approximately 15 mg of the sample was subjected to heating from 30 °C to 600 °C at rate of 10 °C/min in nitrogen environment with a regulated flow rate of 50 mL/min, with ASTM E1131–20 standard protocols. The resultant thermograms elucidated

weight loss trends, disintegration phases, residual mass, and the heat stability of MgO nanoparticles.

The employed experimental methodologies enabled thorough evaluation of chemical, thermal, structural and biological characteristics of MgO nanomaterials synthesized using *Clerodendrum inerme* bast fiber extract, underscoring their appropriateness for applications in biomedical and materials science fields. All experiments were conducted in triplicate and the published values denote the mean of three separate measurements to assure data correctness, reproducibility, and dependability.

### 3. RESULTS AND DISCUSSION

#### 3.1 XRD Analysis of MgO Nanoparticles

Fig. 2 depicts the X-ray diffraction (XRD) pattern of MgO nanoparticles derived from *Clerodendrum inerme* bast fiber extract.

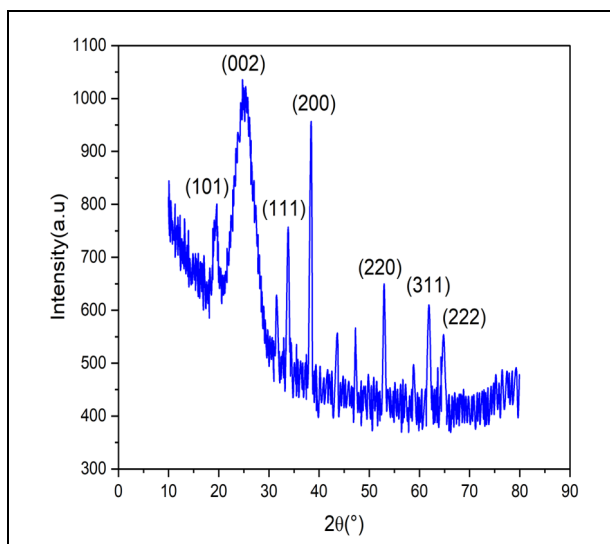


**Fig. 2: XRD pattern of MgO nanoparticles**

The diffraction pattern of the MgO nanoparticles obtained from *Clerodendrum inerme* bast fibers was recorded over a  $2\theta$  range of  $10^\circ$  to  $80^\circ$  to capture all distinctive reflections. The XRD profile displayed significant peaks at  $24.7^\circ$ ,  $33.8^\circ$ , and  $38.4^\circ$ , corresponding to the crystallographic planes of face-centered cubic MgO. Minor peaks found at around  $18.2^\circ$  and  $37.4^\circ$  can be attributed to minor levels of  $\text{Mg}(\text{OH})_2$ , or residual carbonate species such as  $\text{MgCO}_3$ , which may result from incomplete precursor breakdown or interaction with ambient moisture during processing. The very modest intensity of these secondary peaks suggests that such phases exist in minimal amounts and do not substantially affect the phase purity of MgO. Distinct and well-defined diffraction peaks affirm crystalline characteristics of the nanoparticles, although a minor peak broadening indicates nanoscale crystallite sizes.

The previous interpretation connecting amorphous content to nanocellulose components has been amended, as calcined MgO nanoparticles fail to preserve organic fiber phases post-thermal treatment. The crystallite size were determined by Debye-Scherrer equation, represented as:  $D = K\lambda / \beta \cos\theta$ , where  $\theta$  is the Bragg angle,  $\beta$  indicates the full width at half maximum (FWHM),  $\lambda$  represents the X-ray wavelength ( $1.5406 \text{ \AA}$ ),  $K$  signifies the shape factor (0.9), and  $D$  denotes the crystallite size. The crystallite size were ascertained to be 22–34 nm, affirming nanocrystalline characteristics of the synthesized MgO. The nanoscale size distribution increases the reactivity and surface-to-volume ratio, rendering the material exceptionally appropriate for applications like catalysis, drug administration, and composite reinforcement. In previous research, the XRD pattern confirmed the successful formation of a CuO/MgO nanocomposite with interwoven phases and an average crystallite size of  $\sim 44 \text{ nm}$ , indicating its nanocrystalline structure (Priyadharshini *et al.* 2026).

The significant diffraction intensities and relatively narrow full width at half maximum values indicate a well-defined crystalline structure of MgO nanoparticles. An increased level of crystallinity is typically linked to enhanced mechanical strength, stiffness, and resistance to physicochemical degradation. The diffraction pattern aligns with typical crystalline phases of MgO, validating the effective transformation of *Clerodendrum inerme*-derived precursors into inorganic nanomaterials. The distinct and well-defined peaks suggest an organized atomic structure and larger crystallite size. The lack of substantial amorphous halos indicates the prevalence of a crystalline MgO phase. The crystallographic characteristics indicate that the synthesized MgO nanoparticles exhibit high structural integrity, nanoscale dimensions, and stable crystalline properties.

#### 3.2 FTIR Characterization of MgO Nanoparticles

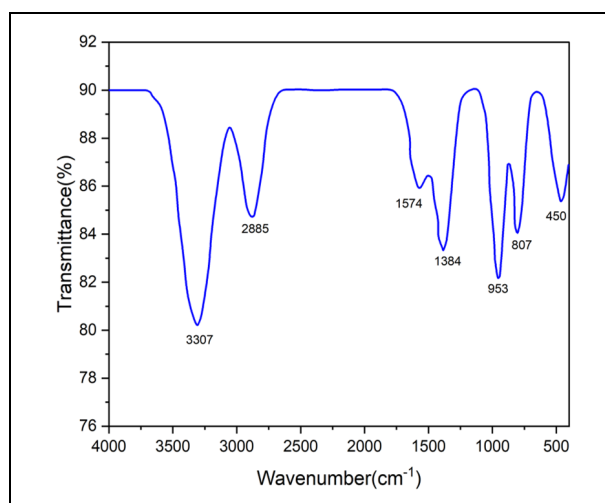


**Fig. 3: FTIR spectrum of MgO nanoparticles**

Fig. 3 depicts FTIR spectrum of MgO NPs derived using *Clerodendrum inerme* bast fibers. The analysis was conducted to clarify the chemical interactions and identify surface functional groups involved in nanoparticle stability and production.

The FTIR spectrum of the MgO nanoparticles obtained using *Clerodendrum inerme* bast fibers showed several prominent peaks. The peak at  $3307\text{ cm}^{-1}$  is ascribed to stretching vibrations of hydroxyl groups, linked to adsorbed moisture and residual phytochemical capping agents on surface of MgO nanoparticles. The hydroxyl groups facilitate nanoparticle stabilization by boosting hydrogen bonding, which diminishes agglomeration and improves dispersion at aqueous mediums. Moreover, the surface capabilities might serve reactive areas for further modification. A notable peak at  $2885\text{ cm}^{-1}$  is attributed to asymmetric stretching vibrations of surface-bound carbonate species ( $\text{CO}_3^{2-}$ ) or adsorbed  $\text{CO}_2$ , potentially resulting from air interaction during synthesis or storage.

The peak at  $1574\text{ cm}^{-1}$  is ascribed to symmetric stretching vibrations of carbonate ( $\text{CO}_3^{2-}$ ) species, typically generated by ambient  $\text{CO}_2$  adsorption on the surface of MgO nanoparticles. The band observed at  $953\text{ cm}^{-1}$  is associated with surface hydroxyl (Mg–OH) vibrations and residual oxygen-containing functional groups, confirming the formation of MgO nanoparticles while suggesting the presence of surface-bound phytochemical residues that contribute to nanoparticle stabilization. The peak at  $807\text{ cm}^{-1}$  is associated with Mg–O vibrations.

The FTIR study offers critical understanding of the mechanism underlying the formation of MgO nanoparticles by green synthesis. The bioactive phytochemicals in *Clerodendrum inerme* bast fibers, which include hydroxyl and other oxygenated functional groups, work as natural stabilizing and reducing agents at synthesis process. These molecules enable conversion of the magnesium precursor into MgO nanoparticles without employing toxic chemical reducing agents, hence promoting an eco-friendly synthesis pathway. The peak at  $450\text{ cm}^{-1}$  is indicative of MgO lattice vibrations, typical of crystalline magnesium oxide, hence affirming successful synthesis of MgO nanoparticles. The lack of extra metal oxygen bands signifies negligible impurity phases.

### 3.3 Morphological Analysis of MgO Nanoparticles

Fig. 4 illustrates the SEM image of MgO NPs derived using *Clerodendrum inerme* bast fibers. The micrograph displays a densely agglomerated morphology, signifying the emergence of particle clusters resulting from increased surface energy and nanoscale

dimensions, as well as interparticle interactions including electrostatic attractions and van der Waals forces.

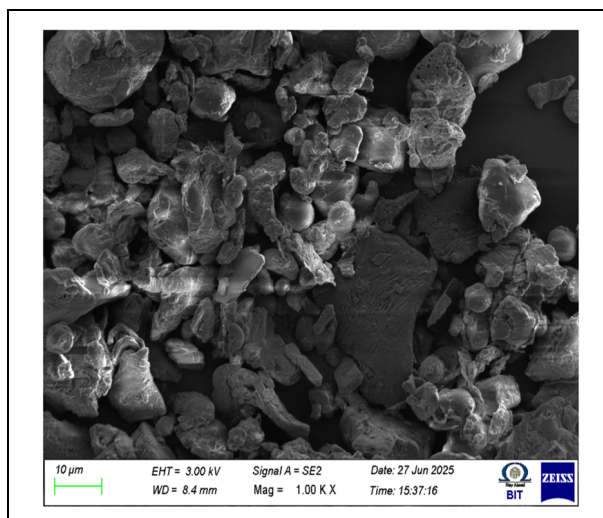


**Fig. 4: SEM image of MgO nanoparticles**

The microstructure has an uneven morphology, characterized mostly by largely spherical to near-spherical nanoparticles, alongside some faceted and clustered forms. The morphology reveals a crystalline structure with distinct particle boundaries. The particle size distribution is within nanometer range with primary particles generally under 50 nm, and large agglomerated clusters of roughly 100 nm to 500 nm.

The fine granular shape suggests successful nanoparticle formation aided by phytochemical components from *Clerodendrum inerme* extract, which served as stabilizing and reducing agents during synthesis. The porous and coarse surface texture indicates high surface-to-volume ratio. In a reported work, the Mg/ZnO nanocomposites exhibited aggregated nanostructures indicating high surface area favorable for photocatalytic and antibacterial performance (Rana *et al.* 2025).

### 3.4 EDX Spectrum of MgO Nanoparticles

Fig. 5 illustrates the elemental composition of MgO NPs. The EDX spectrum displayed distinct peaks for O, C and Mg, thereby verifying the basic elemental components of the MgO nanostructures.

Quantitative elemental analysis showed that oxygen comprised 39.72 wt.%, carbon composed of 3.44 wt.%, and magnesium of 56.4 wt.%. The data shows a predominant presence of MgO alongside surface-associated carbon species derived from residual phytochemical capping agents or adsorbed atmospheric carbon, rather than from bulk organic fiber components. The elevated oxygen content aligns with the Mg–O lattice structure and surface hydroxyl or adsorbed

species, validating the effective synthesis of MgO nanoparticles with minimal surface-bound components.

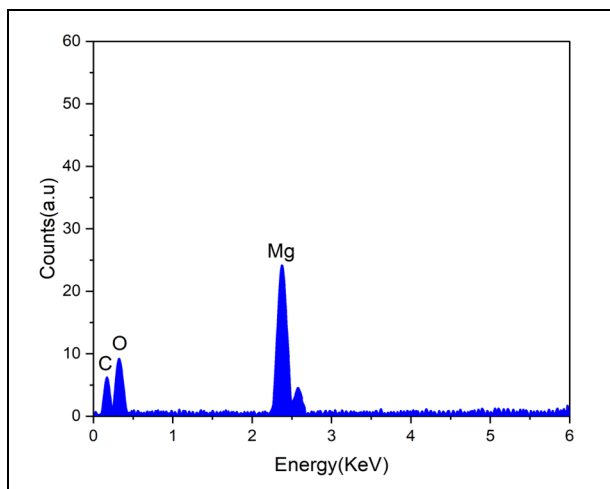


**Fig. 5: Elemental analysis of MgO nanoparticles**

The oxygen detected in the EDX spectrum predominantly relates to the Mg–O lattice structure and surface-associated oxygen species, such as adsorbed hydroxyl groups and small carbonate species resulting from air contact. The oxygen-related surface characteristics improve the hydrophilicity, surface reactivity, and interaction capacity of MgO nanoparticles, promoting their dispersion and compatibility in biological and polymeric contexts. Furthermore, the oxygen-abundant surface facilitates production of reactive oxygen species under certain conditions, which significantly enhances antibacterial activity of MgO nanoparticles.

The carbon identified in the EDX spectrum is ascribed to surface-bound carbon species resulting from leftover phytochemical capping agents or adsorbed air pollutants, rather than an intrinsic organic nanoparticle structure. The magnesium signal verifies the formation of MgO as the predominant inorganic phase.

The presence of magnesium in the MgO nanoparticles underscores their potential in applications like biomineralization, dental materials and bone regeneration. Magnesium-based nanostructures also facilitate cell adhesion. Moreover, MgO NPs possess intrinsic antibacterial characteristics. In an earlier research, EDX analysis confirmed the elemental composition of the synthesized MgO nanoparticles, showing prominent peaks corresponding to magnesium and oxygen. The absence of significant impurity peaks indicated the high purity of the nanoparticles produced by green synthesis (Patil *et al.* 2024).

### 3.5 Bacterial Inhibition by MgO Nanoparticles

Fig. 6 depicts the antibacterial efficacy of MgO NPs synthesized using *Clerodendrum inerme* bast fibers.

The antibacterial activity of these nanoparticles was assessed against *Pseudomonas aeruginosa*, a Gram-negative bacteria recognized for inherent resistance to standard antibiotics.

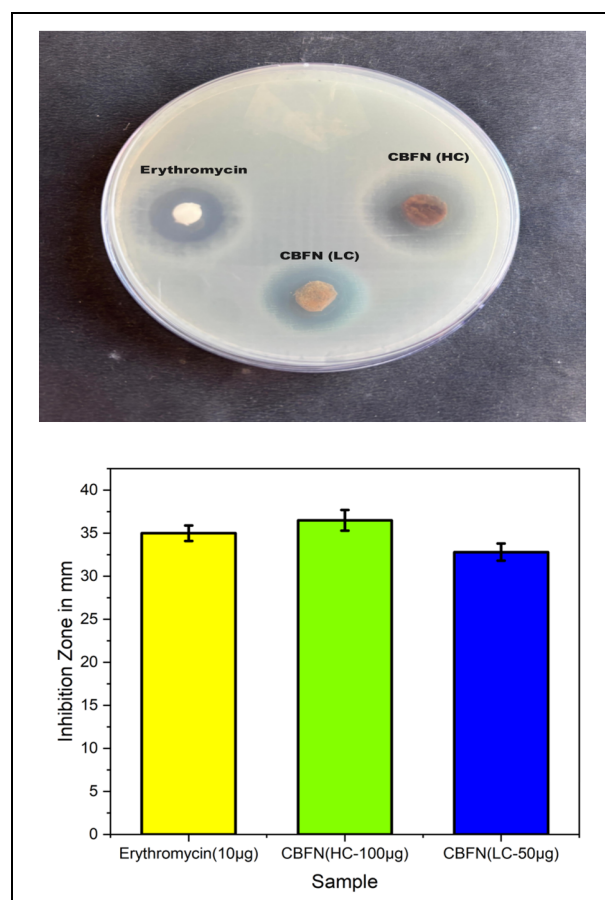


**Fig. 6: Bactericidal effect of MgO nanoparticles**

The antibacterial efficacy of the MgO NPs was assessed by agar well diffusion technique at concentrations of 100 and 50 µg, and compared to the conventional antibiotic erythromycin (10 µg). The higher concentration (100 µg) demonstrated an inhibitory zone of  $36.5 \pm 1.2$  mm, somewhat surpassing the  $35.0 \pm 0.9$  mm zone recorded for erythromycin, suggesting enhanced or equivalent antibacterial efficacy. The lower concentration (50 µg) showed an inhibitory zone of  $32.8 \pm 1.0$  mm, indicating substantial activity with diminished efficacy, thereby affirming a concentration-dependent antibacterial response. In prior studies, biogenic MgO NPs exhibited strong concentration-dependent antibacterial activity, with maximum inhibition against *Pseudomonas aeruginosa* (24.1 mm, MIC 3.125 µg/mL) followed by *E. coli* and *Staphylococcus aureus*. Molecular docking revealed effective interaction with bacterial proteins, suggesting a potential mechanism for enhanced antimicrobial action (El-Sharkawy *et al.* 2025). The improved performance at elevated concentrations is due to improved nanoparticle–cell interactions, resulting in membrane rupture, loss of cellular integrity, and

changes in permeability. The nanoparticles facilitate the production of reactive oxygen species like, hydroxyl radicals, hydrogen peroxide and superoxide radicals, leading to oxidative stress and damage to proteins, nucleic acids and lipids. The internalization of nanoparticles may disrupt protein synthesis and DNA replication, resulting in cell death. Unlike erythromycin, which selectively obstructs protein synthesis by attaching to 50S subunit, MgO nanoparticles employ a multi-target, non-specific method, hence diminishing the probability of emergence of resistance. Similarly, in a prior research MgO nanoparticles exhibited effective antibiofilm activity, particularly against *Pseudomonas aeruginosa*, indicating their ability to disrupt biofilm formation and persistence (Radulescu *et al.* 2025).

### 3.6 Thermogravimetric Analysis of MgO Nanoparticles

Fig. 7 depicts thermal stability of MgO NPs synthesized using *Clerodendrum inerme* bast fibers. The TGA curve recorded in the temperature range 0 °C to 600 °C displays specific weight loss phases that align with the progressive elimination of adsorbed moisture, remaining surface entities and small decomposition-related changes.

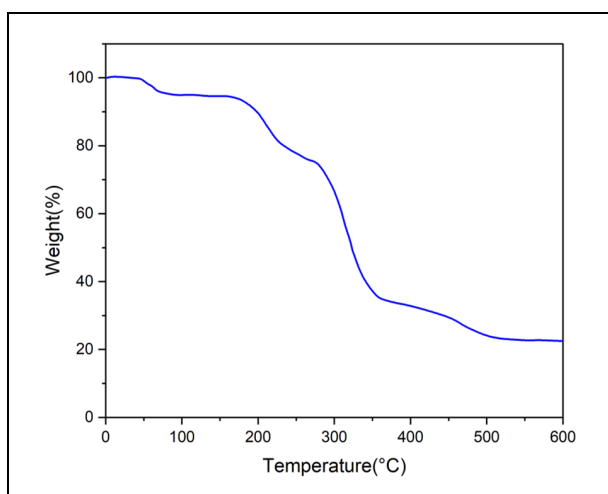


**Fig. 7: TGA assessment of MgO nanoparticles**

The initial mass loss recorded between 0 °C and 100 °C reflects mass decrease of roughly 6-8%, attributable to elimination of low-molecular-weight volatile compounds and physically adsorbed moisture on surface of the MgO nanoparticles. This behavior is linked to surface-adsorbed water and hydroxyl groups rather than cellulose or hemicellulose constituents. The second phase between 120 °C and 230 °C, leads to moderate mass loss of 12–15%, primarily associated with decomposition of residual surface-bound organic species and the elimination of chemically adsorbed groups from phytochemical capping agents employed during green

synthesis, rather than the degradation of bulk biopolymeric constituents.

The thermal profile demonstrates that the produced MgO nanoparticles possess commendable stability under moderate temperature conditions. A significant mass change occurs between 230 °C and 330 °C, resulting in a weight loss of roughly 40–55%, ascribed to the dissolution of remaining surface-bound organic species and the conversion of intermediate magnesium compounds, such as  $\text{Mg}(\text{OH})_2$  or  $\text{MgCO}_3$  to MgO. This weight reduction is linked to the emission of volatile substances, like water vapor and carbon dioxide, rather than the degradation of glycosidic bonds or cellulose chains.

In the final phase (550-600 °C), TGA curve reaches a plateau, resulting in a residual mass of roughly 22–25%, indicative of the synthesis of thermally stable MgO. The residual stability validates the appropriateness of MgO nanoparticles for high-temperature applications, such as thermally durable coatings, catalysis, and reinforcement in advanced composite materials. In a previous study, TGA showed initial weight loss due to moisture evaporation followed by major degradation from cellulose decomposition. The MgO NP coating improved thermal stability compared to untreated cotton fabric (Harikrishnan *et al.* 2023).

## 4. CONCLUSION

MgO nanoparticles were successfully synthesized using *Clerodendrum inerme* bast fiber extract through a simple, sustainable, and cost-effective green synthesis approach. Characterization confirmed the formation of crystalline MgO nanoparticles with nanoscale dimensions, high purity, and good thermal stability. The nanoparticles exhibited significant antibacterial activity against *Pseudomonas aeruginosa*, demonstrating their potential as effective antimicrobial agents. The combined physicochemical and biological properties highlight their suitability for applications in antimicrobial coatings, drug delivery, tissue engineering, and environmental remediation. Future studies should focus on cytotoxicity evaluation, MIC/MBC determination, and in vivo investigations to further validate their biomedical potential and scalability.

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## CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

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## REFERENCES

- Anitha, K. and Mahalakshmi, T., Screening of south Indian herbs for quorum quenching property, *Int. J. Pharma. Bio. Sci.*, 3(4), 974–979(2012).
- Dash, P. A., Mohanty, S. and Nayak, S. K., Synthesis and characterization of ZnO/MgO doped mesoporous bioactive glass: Enhanced bioactivity and antibacterial properties for bone tissue engineering applications, *Ceram. Int.*, 51(23), 38129–38140(2025).  
<https://doi.org/10.1016/j.ceramint.2025.06.049>
- El-Sharkawy, R. M., Khairy, M., Zaki, M. E. A. and Al-Tabbakh, A. S. M., Endophytic *Aspergillus japonicus* mediated biosyntheses of magnesium oxide nanoparticles: sustainable dye removal and in silico molecular docking evaluation of their enhanced antibacterial activity, *Microbial Cell Factor.*, 24(1), 44(2025).  
<https://doi.org/10.1186/s12934-025-02648-6>
- Fonye, N. G., Eya'ane, M. F., Ondoh, A. M., Kwati, L., Ndzeidze, G. N. and Paboudam, G. A., Biosynthesis, Characterization, and Potential Antimicrobial Studies of Silver–Magnesium Oxide Nanocomposites Mediated from *Talinum fruticosum* Leaf Extract, *J. Inorg. Organomet. Polym. Mater.*, 36(4), 2243–2265(2026).  
<https://doi.org/10.1007/s10904-025-04027-5>
- Harikrishnan, A., Purushothaman, M., Alagarasan, D., Viswanath, A. K., Pandiaraj, S., Rajabathar, J. R. and Karnan, M., A Variant Gel-Combustion Approach to Impregnate Nanostructured MgO Coating on Cotton Fibers for Antibacterial Textile Applications, *Fib. Polym.*, 24(11), 3927–3936(2023).  
<https://doi.org/10.1007/s12221-023-00340-3>
- Hernández-Figueroa, B., Herrera-Pérez, G., Uribe-Chavira, J. S., Luna-Velasco, A., Castillo-González, A., Sánchez-Ramírez, B., Ramírez-Valdespino, C. A., Peralta-Pérez, M. R., Salas-Leiva, D. E., Espinoza-Sánchez, E. A. and Salas-Leiva, J. S., Antimicrobial activity enhancement of MgO nanoparticles through Zn doping against multidrug-resistant bacteria, *Appl. Surf. Sci. Adv.*, 28, 100797(2025).  
<https://doi.org/10.1016/j.apsadv.2025.100797>
- Kalavathi, R., Vijayakumar, S. and Vidhya, E., Silver nanoparticles derived from *Clerodendrum inerme* L. using biosynthesis: an infection curing and enhancing the feasibility of various cell proliferation efficiencies, *Vegetos*, 38(5), 1923–1931(2025).  
<https://doi.org/10.1007/s42535-024-00979-0>
- Kannan, K., Hemavathi, B., Radhika, D., Manjunath, H. R., Kumar, K., Lakkaboyana, S. K., Kakarla, R. R., and Raghu, A. V., Facile synthesis of novel ZnO-MgO nanohybrids and its photocatalytic degradation of toxic pollutants, *Desalin. Water Treat.*, 317, 100125(2024).  
<https://doi.org/10.1016/j.dwt.2024.100125>
- Kar, P., Mishra, D. K., Roy, A., Chakraborty, A. K., Sinha, B. and Sen, A., Elucidation of phytomedicinal efficacies of *Clerodendrum inerme* (L.) Gaertn. (Wild Jasmine), *South Afr. J. Bot.*, 140, 356–364(2021).  
<https://doi.org/10.1016/j.sajb.2020.07.027>
- Kattookaran, C. V., Govindasamy, R., Selvam, S. P. and Viswanathan, D., Biosynthesis of Ag doped MgO-Zno nanocomposite with *Cassia alata* plant leaves extract and assessment of their biological applications, *Next Mater.*, 8, 100820(2025).  
<https://doi.org/10.1016/j.nxmater.2025.100820>
- Khan, S. A., Kanwal, S., Rizwan, K. and Shahid, S., Enhanced antimicrobial, antioxidant, in vivo antitumor and in vitro anticancer effects against breast cancer cell line by green synthesized un-doped SnO<sub>2</sub> and Co-doped SnO<sub>2</sub> nanoparticles from *Clerodendrum inerme*, *Microbial Pathogenesis*, 125, 366–384(2018a).  
<https://doi.org/10.1016/j.micpath.2018.09.041>
- Khan, S. A., Noreen, F., Kanwal, S., Iqbal, A. and Hussain, G., Green synthesis of ZnO and Cu-doped ZnO nanoparticles from leaf extracts of *Abutilon indicum*, *Clerodendrum infortunatum*, *Clerodendrum inerme* and investigation of their biological and photocatalytic activities, *Mater. Sci. Eng. C*, 82, 46–59(2018b).  
<https://doi.org/10.1016/j.msec.2017.08.071>
- Kumar, P., Ramesh, M. R., Doddamani, M. and Suresh, J., Plant (*Costus pictus* D. Don) Assisted Green Synthesis of Double Oxide Nanoparticles for Antibacterial Applications, *Chem. Afr.*, 7(7), 3749–3762(2024).  
<https://doi.org/10.1007/s42250-024-00954-x>
- Manaa, A. O., Baghdadi, H. H., Heikal, L. A. and El-Hosseiny, L. S., Antibacterial synergistic behaviour of phytosynthesized magnesium oxide nanoparticles with clove essential oil, *Sci. Rep.*, 15(1), (2025).  
<https://doi.org/10.1038/s41598-025-18967-y>
- Mickymaray, S., Al Aboody, M. S., Rath, P. K., Annamalai, P. and Nooruddin, T., Screening and antibacterial efficacy of selected Indian medicinal plants, *Asian Pacific J. Trop. Biomed.*, 6(3), 185–191(2016).  
<https://doi.org/10.1016/j.apjtb.2015.12.005>

- Patil, P. V., Nerlekar, N. A., Kuldeep, A. R., Patil, P. P., Dandge, P. B., Dongale, T. D., Dandge, P. B. and Rashinkar, G. S., Terminalia bellirica (Gaertn.) Roxb. extract-mediated green synthesis of magnesium oxide nanoparticles for multifunctional applications, *Plant Nano Bio.*, 8, 100069(2024). <https://doi.org/10.1016/j.plana.2024.100069>
- Periakaruppan, R., Chandrasekaran, N., Vijai Selvaraj, K. S., Thenmozhi, M. and Das, N. M., Synthesis, characterization, and antioxidant activity of Chrysanthemum indicum flower-mediated magnesium oxide nanoparticles, *Biomass Convers. Biorefine.*, 15(20), 27315–27320(2025). <https://doi.org/10.1007/s13399-024-05839-0>
- Priyadharshini, S., Karnan, M., Ayyanar, M., Jenipher, C., Thirumurugan, A. and Chidhambaram, N., Green synthesis and biomedical applications of CuO/MgO nanocomposite: Antibacterial, antioxidant, and antidiabetic efficacies, *Coordination Chem. Rev.*, 555(2026). <https://doi.org/10.1016/j.ccr.2026.217637>
- Queiroz, M. N., Morais, T. S., Dias, T. G., Barros, J. D. S., Dutra, R. P., Reis, A. S., de Menezes, A. S., Steimacher, A. and Pedrochi, F., Magnesium borate-glasses for biomedical application: Physicochemical and in vitro bioactive properties, antibacterial activity and cell viability, *J. Non-Crystal. Sol.*, 646, 123239(2024). <https://doi.org/10.1016/j.jnoncrysol.2024.123239>
- Radulescu, D. M., Neacsu, I. A., Vasile, B. S., Surdu, V. A., Oprea, O. C., Trusca, R. D., Chircov, C., Popescu, R. C., Ilie, C. I., Ditu, L. M., Drumea, V. and Andronescu, E., Green-Synthesized MgO Nanoparticles: Structural Insights and Antimicrobial Applications, *Int. J. Mol. Sci.*, 26(18), 9021(2025). <https://doi.org/10.3390/ijms26189021>
- Rana, G., Rao, S. K. and Chauhan, A., The efficient visible light assisted photocatalytic degradation of tetracycline and crystal violet using phyto-mediated magnesium oxide-zinc oxide nanocomposites, *J. Ind. Chem. Soc.*, 102(1), 101545(2025). <https://doi.org/10.1016/j.jics.2024.101545>
- Saggu, M. K., Kaushal, S. and Vyas, P., Biofabrication of magnesium oxide nanoparticles with Murrya koenigii essential oil with enhanced antibacterial and antioxidant potential, *J. Food Measure. Characteriz.*, 20(5), 9264-9288(2026). <https://doi.org/10.1007/s11694-026-04265-2>
- Senthilkumar, V. and Ilavenil, K. K., Grape Seed Extract as a Green Route for Mgo Nanoparticle Synthesis: Antibacterial Insights, *Rasayan J. Chem.*, 18(1), 14–21(2025). <https://doi.org/10.31788/RJC.2025.1819012>
- Shivappa, P., Gaddigal, A. T., Mirjankar, M. R., Ganeshkar, M. P., Goder, P. H., Karoshi, V. R. and Kamanavalli, C. M., Characterization and Bioactivity Enhancement of Resveratrol with PVP-Loaded MgO Nanoparticles. *BioNanoScience*, 15(3), 397(2025). <https://doi.org/10.1007/s12668-025-01987-3>
- Vamsi, K. B. V., Tirupathi, R. P., Durga, L. B., Vasudha, K., Esub, B. S., Putra, K. B., Kiran, P. S. S., Shreyas Chandra, K. and Ramachandra, R. K., Green fabrication of *Tinospora cordifolia*-derived MgO nanoparticles: Potential for diabatic control and oxidant protection, *Next Mater.*, 3, 100171(2024). <https://doi.org/10.1016/j.nxmater.2024.100171>
- Vamsi, K. B. V., Durga, L. B., Tirupathi, R. P. and Ramachandra, R. K., Structural, optical, and antioxidant properties of biocompatible CuO-MgO nanocomposites, *Res. Mater.*, 26, 100695(2025). <https://doi.org/10.1016/j.rinma.2025.100695>
- Wisessombat, S. and Tayeh, M., In vitro wound healing potential and antimicrobial activity of *Clerodendrum inerme* leave extracts, *Pharmacognosy J.*, 13(6), 1542–1548(2021). <https://doi.org/10.5530/PJ.2021.13.196>