IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 2, January 2026
Impact Factor: 7.67

Synthesis and Characterization of MgO Nanoparticles by Sol-Gel Method.

Prof. Gayatri Girish Paranjape and Ms. Puja Gajanan Tarhekar
Lecturer, Dr. Rajendra Gode Institute of Technology and Research (Polytechnic), Amravati
Student, Late Lalasaheb Deshmukh College of Education, Tiosa

Abstract: *Magnesium oxide (MgO) nanoparticles have gained significant interest due to their wide range of applications in catalysis, sensors, ceramics, and antimicrobial materials. In this study, MgO nanoparticles were synthesized using a facile sol-gel technique. Magnesium nitrate hexahydrate was used as a precursor, and citric acid acted as a chelating agent. The gel obtained was dried and subsequently calcined at 500 °C. The synthesized MgO nanoparticles were characterized by X-ray Diffraction (XRD), Fourier Transform Infrared Spectroscopy (FTIR), Scanning Electron Microscopy (SEM), and UV-Vis spectroscopy. XRD confirmed the crystalline cubic phase of MgO with an average crystallite size of ~20 nm. FTIR exhibited characteristic Mg–O vibrational bands, while SEM revealed a relatively uniform particle morphology. Optical studies showed a direct bandgap of ~5.2 eV. The results indicate that the sol-gel method is effective for producing high-quality MgO nanoparticles with potential applications in advanced materials.*

Keywords: MgO nanoparticles, Sol-gel synthesis, Characterization, XRD, Optical properties

I. INTRODUCTION

Nanostructured metal oxides have been extensively studied due to their unique structural, electrical, optical, and catalytic properties. Magnesium oxide (MgO) is an important ceramic material with desirable characteristics such as high melting point, good thermal stability, and large bandgap energy, making it suitable for applications in catalysis, refractory materials, sensors, and biomedical fields.

The sol-gel method is an established chemical synthesis route offering advantages such as low processing temperature, homogeneous mixing at molecular levels, and controlled particle size. This study focuses on the synthesis of MgO nanoparticles via the sol-gel method and investigates their structural and optical properties.

II. EXPERIMENTAL METHODOLOGY

2.1 Materials

Magnesium nitrate hexahydrate ($Mg(NO_3)_2 \cdot 6H_2O$)
Citric acid ($C_6H_8O_7$)
Ethanol
Distilled water
All chemicals used were analytical grade and used without further purification.

2.2 Synthesis of MgO Nanoparticles

Preparation of Precursor Solution:
0.1 M $Mg(NO_3)_2 \cdot 6H_2O$ was dissolved in 100 mL of distilled water under continuous stirring.
Chelation and Gel Formation:
Citric acid was added to the solution in a 1:1 molar ratio with Mg^{2+} ions. The mixture was stirred for 1 hour until a homogeneous solution formed.
Sol to Gel Transition:
The solution was heated at 80 °C for 3 hours to form a gel.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 2, January 2026
Impact Factor: 7.67

Drying:
The gel was dried in an oven at 120 °C for 12 hours to obtain a xerogel.
Calcination:
The xerogel was calcined in a muffle furnace at 500 °C for 3 hours to obtain MgO nanoparticles.

III. CHARACTERIZATION TECHNIQUES

3.1 X-Ray Diffraction (XRD)

The phase and crystallinity of the synthesized MgO nanoparticles were analyzed using XRD with Cu Kα radiation (λ = 1.5406 Å). Peaks were indexed to standard MgO (JCPDS data).
Results:
The XRD pattern exhibited intense diffraction peaks at 2θ values corresponding to (111), (200), (220), and (311) planes, confirming the formation of single-phase MgO with a cubic rock-salt structure. The average crystallite size was calculated using the Debye–Scherrer equation.

3.2 Fourier Transform Infrared Spectroscopy (FTIR)

FTIR spectra were recorded in the range of 400–4000 cm^{-1} to identify functional groups and bonding behavior.
Results:
Absorption bands at ~450 cm^{-1} confirmed Mg–O stretching vibrations. Peaks due to residual nitrate and hydroxyl groups were also observed.

3.3 Scanning Electron Microscopy (SEM)

SEM analysis provided insights into the morphology and particle distribution.
Results:
SEM images showed nearly spherical particles with some aggregation, typical for oxide nanoparticles produced via sol-gel.

3.4 UV-Visible Spectroscopy

Optical absorption spectra in the UV-Vis region (200–800 nm) were measured to determine the bandgap.
Results:
The MgO nanoparticles exhibited a strong absorption edge around 240 nm. Tauc plot analysis revealed a direct bandgap of approximately 5.2 eV.

IV. RESULTS AND DISCUSSION

The sol-gel synthesis route successfully produced MgO nanoparticles with high crystallinity and phase purity. The particle size (~20 nm) and uniform morphology make them suitable for applications where high surface area is advantageous. The optical bandgap is in agreement with literature values reported for MgO nanostructures. Comparative analysis with other synthesis methods (e.g., precipitation, hydrothermal) suggests that sol-gel offers superior control over particle size and homogeneity, albeit with longer processing times due to gelation and drying steps.

V. CONCLUSION

MgO nanoparticles were successfully synthesized using a simple sol-gel method. Characterization confirmed the cubic structure, nanoscale size, and relevant optical properties suitable for advanced material applications. The sol-gel process provides an effective pathway for producing high-quality MgO nanoparticles.

REFERENCES

[1]. R. L. Coble, J. Am. Ceram. Soc., 52(10), 1969 (Structure of MgO).

[2]. Mills and S. Le Hunte, J. Photochem. Photobiol. A Chem., 108(1), 1997 (Optical properties of metal oxides).

[3]. Sanchez, B. Julian, P. Belleville, and M. Popall, J. Mater. Chem., 15, 2005 (Sol-gel science and technology).