Nanoscale Reports

3(3) (2020) 12-15

RESEARCH ARTICLE

DOI:10.26524.nr.3.19

OPEN ACCESS

# Synthesis and Characterization of Magnesium Oxide Nanoparticles by Sol-Gel Method

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## Abstract

Magnesium oxide was hygroscopic solid mineral that occurs naturally as periclase. Magnesium oxide had high thermal conductivity, it gets heated when the electricity was passed through it. Magnesia crucible had a stability of 2400°C in air. 1700°C in reducing atmosphere. Magnesium oxide nanoparticles were obtained from the mixture of magnesium nitrate as precursor and sodium hydroxide as precipitating agent by sol-gel method. Finally, the resultant white crystalline powder of MgO was annealed at various temperatures of 80°C, 135°C and 180°C. The analytical studies ( XRD, SEM FTIR. EDAX) reveals the morphological characterization of MgO nanoparticles. The Scanning Electron Microscopy (SEM) indicates the structures of MgO nanoparticles. The crystal size of MgO nanoparticles was obtained by X-Ray Diffraction ( XRD). The optical properties of the sample were obtained by UV- Visible spectroscopy. Fourier Transform infrared spectroscopy indicates powdered composition of the sample. EDAX indicates elementary composition of the MgO nanoparticles.

***Keywords:*** FTIR. Sol-Gel, UV. XRD. SEM. EDAX

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**How to cite this article:** A. Jegadeeswaria, S. Nivetha. Synthesis and Characterization of Magnesium Oxide Nanoparticles by Sol-Gel Method . *Nanoscale Reports* 3(3), 12-15. Retrieved from http://nr.eleyon.org/index.php/nr/article/view/3

**Source of support:** Nil

**Conflict of interest:** None.

**Received:** 5 August 2020 **Revised:** 3 September 2020 **Accepted:** 4 September 2020

## 1. Introduction

Nanoscience is one of the most important fields of research in modern science. Nanotechnology is allowing researchers to work at molecular and cellular levels, to achieve important developments in life science and health care. The dimension of atoms in the range 1-100 nm means nanoscopic range and the materials having dimension in this range are called nanomaterials. The nanomaterials show the novel properties which are absent in both the microscopic and macroscopic materials. In recent year, nanoparticles have attracted a great attention because of their unique physical and chemical properties such as high mechanical stability, good thermal conductivity and high surface reactivity.[1-5] Metals are able to form large number of oxides. These metal oxides play an important role in chemistry, physics and material science, Metal oxide nanomaterials having high surface area have attracted considerable interest in for scientific research due to their applications in the fields of optical electronics, sensing devices and nano electronics.[6] The synthesizing of inorganic or organic materials had novel properties when compared to the bulk materials. Magnesium oxide is an important in organic oxide which has been widely used in many fields. MgO is an efficient moisture absorbent used in many libraries for preserving books. It is also used as an additive in heavy fuel oils, (reflecting or anti-reflecting] coatings in optical applications,[7-10] it used as the substrate in super conducting and ferroelectric thin films. The magnesium oxide is a veiy suitable for insulation due to its low heat capacity and high melting point. The high surface reactivity, chemical and thermal stability of MgO makes a promising material for the application in sensor, catalysis, and paint etc., MgO has a good bacterial performance due to their formation of super oxide.[11-13] Here, magnesium oxide nanoparticles were synthesized by sol-gel method using magnesium nitrate.

## 2. Experimental Procedure

Magnesium oxide nanoparticles were synthesized using magnesium nitrate ($MgNo_3.6H_2O$) as a source material with sodium hydroxide. First 1.95g of magnesium nitrate was mixed with 50ml of distilled water, with stirring for 15 minutes. Thereafter 3.45g of NaOH was mixed with 20ml of distilled water. The sodium hydroxide solution was added drop wise to the prepared magnesium nitrate ($MgNO_3.6H_2O$) solution with continuous constant stirring for an hour. Then the solution was turned into white colour which shows the precipitate formation of gel of magnesium hydroxide.

$$Mg(NO_3)_2 + 2\,NaOH \text{ --------->} Mg(OH)_2 + 2\,NaNO_2$$

The pH value of 14 was obtained for the solution. The precipitate was washed with methanol three to four times to remove ionic impurities. Then precipitate was centrifuged for 15 minutes at 3000 rpm/min and dried at room temperature. The dried white powdered samples were annealed at temperatures of 80°C, 135°C and 180°C to obtain MgO powder.

$$Mg(OH_2) \text{ --------->} MgO + H_2O$$

## 3. Results and Discussion

### 3.1 X Ray Diffraction Analysis

XRD is a conventional technique used for phase identification of a sample possessing crystallinity. It also provides information on unit cell dimension. It is based on Bragg's law which relates the wavelength of radiation with the diffraction angle and lattice spacing in crystalline sample. The crystal structure of MgO nanoparticles was determined by XRD analysis. The peak in XRD pattern of the prepared MgO sample is observed at 2θ - 22.86, 32.55 and 52.56 as shown in Fig. 1.

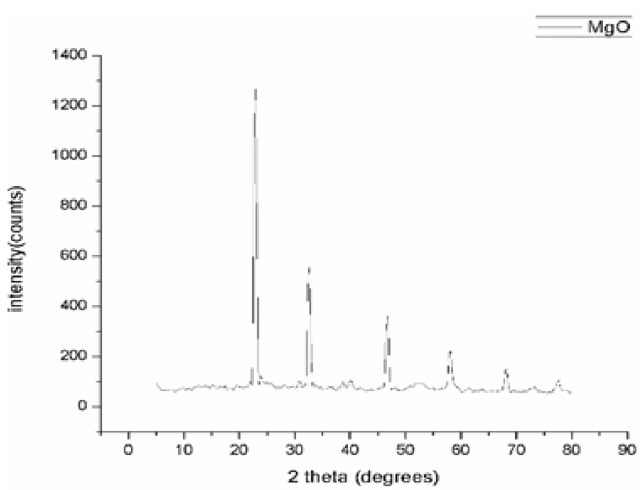


**Fig. 1:** XRD pattern of MgO nanoparticles

### 3.2 Fourier Transform Infrared Spectroscopy studies

FTIR analysis measures the range of wavelengths in the infrared region that are absorbed by a material. This is accomplished through the application of infrared radiation (IR) to samples of a material. The sample absorbance of the infrared light energy at various wavelengths is measured to determine the material's molecular composition and structure as shown in as shown in Fig. 2. Absorbance and transmittance studies of MgO nanoparticles for different wavelength range (500-4000 $cm^{-1}$) are shown in below Table 2.

### 3.3 Scanning Electron Microscope (SEM) analysis

Scanning electron microscopy is a great way to obtain information about a sample's surface topography and composition in industries such as microelectronics, semiconductors, medical devices and food processing. The high resolution SEM analysis is shown in as shown in Fig. 3. This graph shows rod like shape of MgO nanoparticles.

### 3.4 Energy Dispersive X-ray Analysis (EDX) analysis

Energy-Dispersive X-Ray spectroscopy sometimes called dispersive X-ray analysis or energy dispersive. X-Ray analysis is an analytical technique used for the identification of elemental composition or chemical characterization of the sample. This below graph shows the elemental composition of MgO nanoparticles.

### 3.5 UV Analysis

UV-visible spectroscopy is used to discuss the optical properties of the sample. It follows Beer Lamberts law which states that absorption is directly proportional to the incident radiation and concentration of sample. The optical properties of MgO nanoparticles were studied by means of UV-visible absorption spectra in the wavelength range of 200 to 1200 nm as shown in Fig. 5. The maximum absorption band of MgO nanoparticles was found by

$$E = h*c / A\ max$$

A max = maximum wavelength (m)
h = Plank's constant ($6.626*10^{-34}$ joules/sec)
c = speed of light ($3*10^{8}$m/s)

**Table 1:** Structural parameter of MgO nanoparticles

| MATERIAL | 2θ (deg) | θ (deg) | FWHM (deg) | Crystalline sized $10^{-3}$ (nm) | Dislocation density (δ)*$10^{15}$ | Micro- strain ε*$10^{-3}$ |
|---|---|---|---|---|---|---|
| MgO | 22.86 | 11.43 | 0.4541 | 18.65 | 2.87451 | 1.94106 |
| MgO | 32.55 | 16.27 | 0.4711 | 18.35 | 2.96740 | 1.97217 |
| MgO | 52.56 | 26.28 | 0.4838 | 19.13 | 2.73051 | 1.89181 |

**Table 2:** FTIR vibration frequency of MgO nanoparticles

| Frequency | Bond Stretching | Functional Group |
|---|---|---|
| 565.15(s) | C-I Stretching | Halo Compound |
| 840.97 (m) | C=C bonding | Alkene |
| 1041.56 (s) | CO-O-CO stretching | Anhydride |
| 1367.53 (m) | O-H Bonding | Phenol |
| 1730.15 (s) | C=O Stretching | a, (3 Unsaturated ester |
| 1795.73 (s) | C=O Stretching | Acid halide |
| 3022.45 (m) | C-H Stretching | Alkene |
| 3732.26 (m) | O-H Stretching | Alcohol |

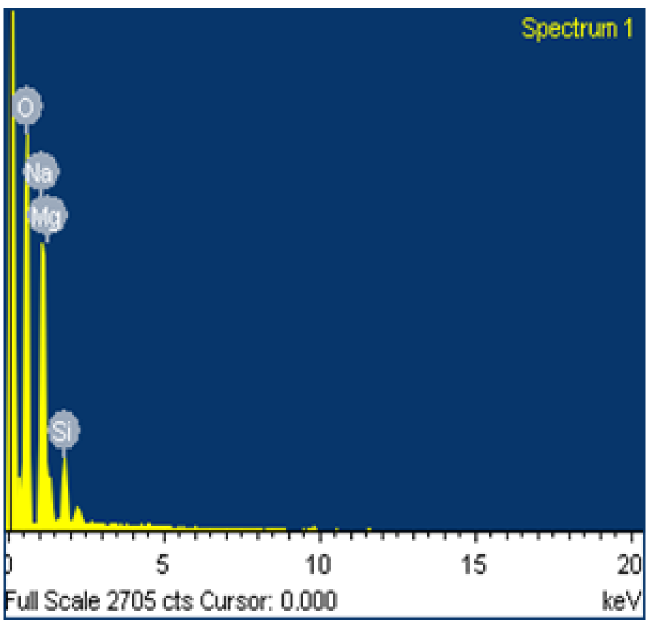


**Fig. 4:** Elemental composition of MgO nanoparticles

## 4. Conclusion

The magnesium oxide nanoparticles were synthesized by the sol-gel method using magnesium nitrate ($MgNO_3.6H_2O$) as a source material with sodium hydroxide. The dried white gel was annealed at 80°C, 135°C and 180°C. SEM observations clearly show the rod like structures magnesium oxide nanoparticles. XRD measurements revealed typical single crystalline size of MgO nanoparticles and peaks indicating the purity of the synthesize powder. FTIR measurement shows that the magnesium hydroxide is converted into magnesium oxide at the two different annealing temperatures. From UV-visible spectroscopy optical properties of MgO nanoparticles were known. From EDAX elemental composition of MgO nanoparticles were known. A magnesium oxide nanoparticle has various

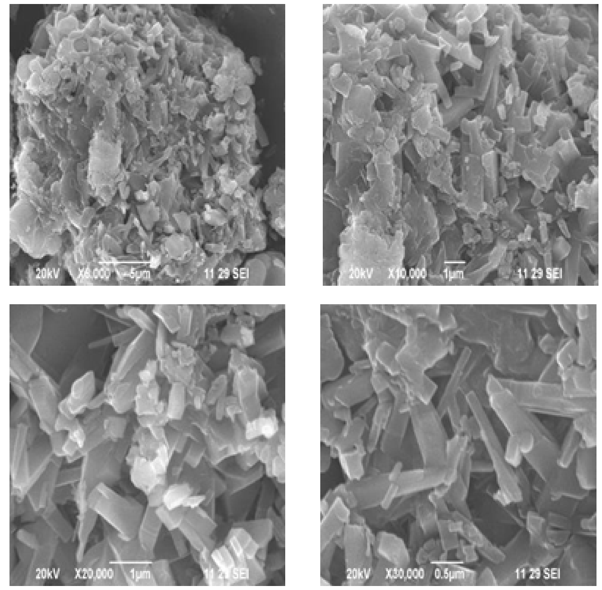

**Fig. 3:** SEM image of Rod like structure of MgO nanoparticles

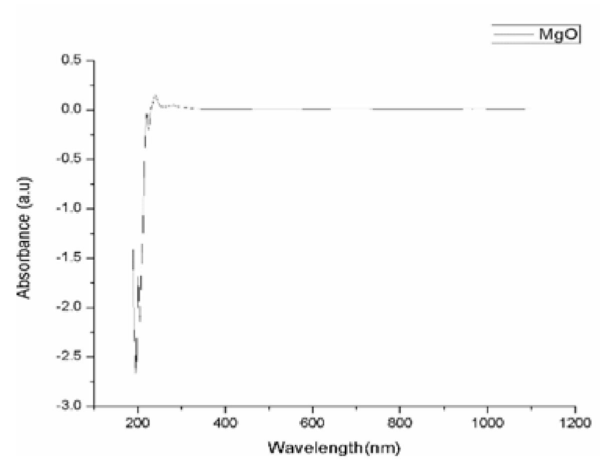


**Fig. 5:** Optical properties of MgO nanoparticles

applications in different field such as oils, paints, ceramics, medicine and drugs etc.

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