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# Polyethylene glycol ratio effect on magnesium oxide prepared by chemical precipitation: Impact on structure, morphology, and electrical properties

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ABSTRACT

In this work, we investigate the properties of magnesium oxide powders synthesized via simple chemical precipitation (SPC). The effect of polyethylene glycol PEG (300) ratio in electrical behavior of MgO is the main part of this study. Crystalline structure and particle size were investigated through X-ray diffraction (XRD). Crystallite size of obtained MgO powders was calculated using Scherer's formula. Fourier transforms infrared spectroscopy (FTIR), Differential Thermal Analysis (DTA) and Gravimetric Analysis (TGA) were used to investigate PEG (300) effect. In fact the mass loss decreases when the PEG (300) ratio increases. Two type of OH group in the MgO surface sites: Type A and Type B with different coordinations, one for the first type and more (2, 3, 4) for the second, were highlighted. The number of OH group decreases when the ratio of MgO/PEG (300) increases. Ratio effect, on dielectric phenomena and electrical conductivity properties of MgO powders, was studied to improve the conductivity. XRD revealed that obtained MgO powders are crystalline and of high purity. Complex impedance spectroscopy was used to examine electrical properties. The activation energies of the MgO powders in the temperature range of study were correlated with PEG (300) ratio.



## 1. Introduction

Magnesium oxide (MgO) has attracted the attention of many experimental and theoretical researches regarding its interesting properties such as large band gap, high thermal conductivity and stability, low dielectric constant, low dielectric loss and good lattice matching [1]. MgO has been widely used in various areas such as in catalysis [2,3], toxic waste remediation [4,5], antibacterial materials [6,7], refractory material industries, paints, and superconductor products [8,9]. Scientific researchers were deeply interested by nanostructures materials because of their unique properties. In fact, this importance is due to their interesting physico-chemical properties and wide range of potential possible applications in nanodevices. MgO is an excellent model material for adsorption phenomena for anion or cation. Under certain conditions, a hydrogen bond forms between neighboring OH group coordination one and greater coordination OH [10]. The highest band position at 3750 $cm^{-1}$ was assigned to isolated 1-coordinated OH groups (A type). Isolated OH groups of higher coordination (B type) were expected to absorb below 3630 $cm^{-1}$ [11]. Two types of OH groups were detected by infrared study, both types A and B describe the nature of the coordination identified in synthetic material.

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The concentrations of these groups affect the eclectic responses; in relation to the effect of PEG (300) in order to obtain better electrical and dielectrical conductivity of MgO. The present work deals with the effect of PEG (300) ratio on activation energies of synthesized MgO. Structural, thermal and mass loss of these materials were investigated. XRD, FTIR, DTA, TGA were applied to gain a deeper insight of synthesis process and phase transformation occurring in the thermal treatment procedure. The dielectric properties of synthetic materials were performed using impedance spectroscopy.

## 2. Experimental

### 2.1. Synthesis

MgO powders were synthesized via magnesium chloride Hexahydrate ($MgCl_2.6\ H_2O$, scharlau 98.9 %) and mixed with various mass of polyethylene glycol 300 (PEG 300). This surfactant is used to ensure the homogeneity of the solution, prevent agglomeration and have a good dispersion during the reaction, when the ratio ($R$=0.5, 1 and 2), in a solvent (ethanol, Aldrich 99%) to obtain a transparent solution. A mixture of ammonia and ethanol is added drop wise to the above solution, the obtained material dried at 100 °C (48 h) in order to remove water and solvents. Finally the dried MgO is calcined in air at 500 °C for 12 h.

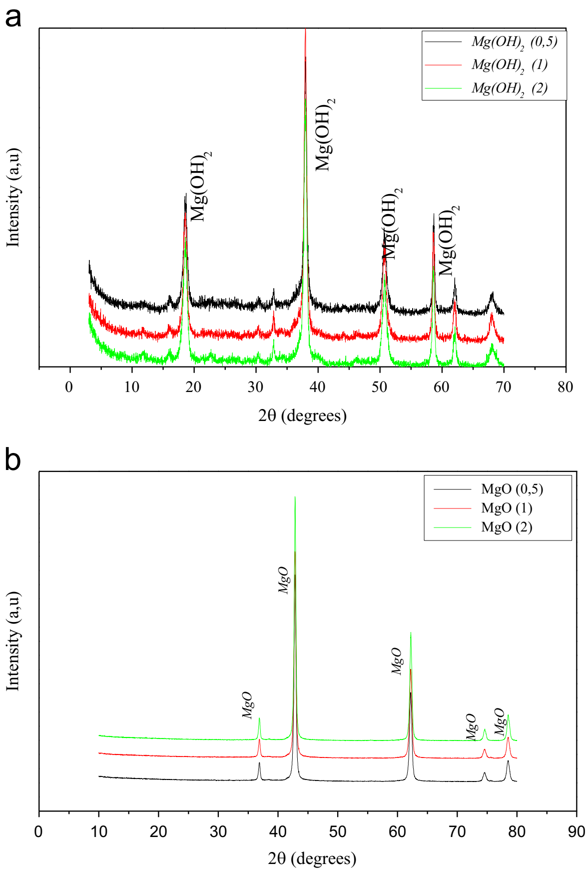


**Fig. 1.** XRD (a) before annulling (b) after annulling at 500 °C of MgO powders prepared by simple chemical precipitation.

### 2.2. Measurements

IR spectra of studied powders were recorded using a Fourier transform spectrometer (Fourier Perkin-Elmer 1600 series FTTR) for frequencies ranging from 400 to 4000 $cm^{-1}$. Samples were prepared as pellets with KBr. X-ray diffraction spectra were recorded by a diffractometer with radiation Philips X'pert POR Cu-Kα ($\lambda$=1.5406 Å). The acceleration voltage, the emission current and the scanning speed are respectively equal to 40 KV, 40 mA and 0.02 °/s. Data acquisition is performed by a control unit and diffraction processing spectra is performed using the software "X'pert High score" containing the database JCPDS cards. TGA–DTA measurements are performed simultaneously by the same type of device SETARAM SETSYS 1750. Temperature variation is performed in the area (25–1000 °C) with a speed of 10 °C $mn^{-1}$.

**Table 1**
Variation of crystallite size with PEG (300) ratio.

| Ratio $R$ | 0.5 | 01 | 02 |
|---|---|---|---|
| crystallite size (nm) | 46.4 | 42.5 | 84.5 |

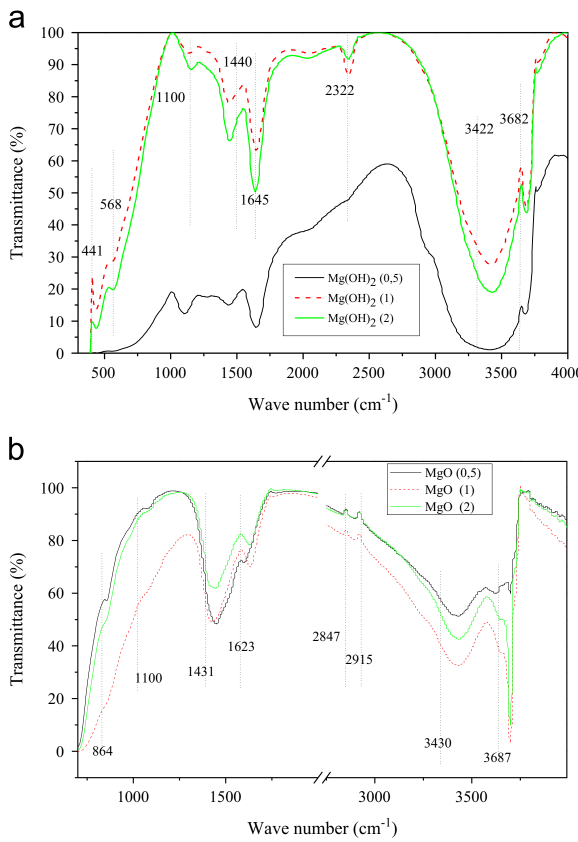


**Fig. 2.** FTIR (a) before annulling (b) after annulling at 500 °C.