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# Preparation and study of Magnesium oxide nanoparticles using combustion method

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## Abstract:

Magnesium oxide nanoparticles were synthesized through the combustion method utilizing magnesium nitrate as the oxidizing agent and tartaric acid, citric acid and urea as fuels. The synthesized magnesium oxide nanoparticles were analyzed using X-ray Diffraction (XRD), Fourier Transform Infrared Spectroscopy (FT-IR), UV-Visible spectroscopy (UV-Vis) and Diffuse reflectance spectroscopy. Crystal sizes of the synthesized samples were determined from XRD. Band gap and color axes were determined from DRS tool.

**Keywords:** Magnesium oxide nanoparticles, XRD, band gap, DRS.

## 1. Introduction

In the past few years, there has been significant attention on nanostructured materials and nanotechnology as a whole, particularly in the techno-economic sector [1-3]. Particles with a minimum diameter of 1–100 nm are referred to as nanoparticles. Nanomaterials find widespread application in food packaging, antimicrobial coatings, biosensors, stain resistant apparel, athletic goods, drug delivery, detergents, food packaging, wound dressings, therapies and cosmetics. They are also used in smaller and faster digital electronic devices [4].

Applications for metal oxide nanoparticles are numerous and include environmental cleanup, sensors, catalysis, and (opto) electronic materials [5]. It has been demonstrated that common metal oxide nanocrystals, such as MgO, CaO, and ZnO, are extremely effective and active absorbents for a wide range of hazardous substances, such as air pollutants, chemical

warfare agents, and acidic gases [6, 7]. In comparison to various metal oxide nanoparticles that find applications across numerous fields, magnesium oxide nanoparticles are attracting more attention due to their significant potential as structural materials for biological implants, attributed to their high strength-to-weight ratio, low density, large surface area, excellent thermal stability, low dielectric constant and refractive index [8], nontoxic nature, good functionality, hygroscopic nature and recycling activity [9, 10]. These qualities also increase the versatility of magnesium oxide nanoparticles, which they also have a cost-effective production, biocompatibility, high melting point and biodegradability. Magnesium oxide nanoparticles are widely used in various industries and biomedical fields, toxic waste management, dye removal and, chemical reaction catalysis [9, 11].

There exist multiple synthesis pathways for magnesium oxide (MgO) materials, including combustion, sol–gel, precipitation, microwave-mediated synthesis, electrospinning techniques and wet chemical microemulsion method. One quick, simple, and affordable way to directly produce extremely pure, uniform powders of metal oxide nanoparticles (NPs) is using solution combustion synthesis [12-21]. This process employs an organic fuel as a reduction agent and metal nitrate as an oxidizing agent for the oxidation/reduction processes [22, 23].

The optical properties of the synthesized products were determined. In this research, magnesium oxide nanoparticles were prepared using combustion method and different fuels.

## 2. Experimental

### 2.1 Materials and reagents

chemicals used in this study were purchased and applied without any further purification. Magnesium nitrate hexahydrate ($Mg(NO_3)_2.6H_2O$, 98% ; Alpha chemica company),anhydrous citric acid ($C_6H_8O_7$ ; Elnasr pharmaceutical chemicals company), tartaric acid $C_4H_6O_6$ ; Alpha chemica company ) and urea ($NH_2CONH_2$ ; Alpha chemica company).

### 2.2 Preparation

Magnesium nitrate (5.13 g, 0.02 mol) , citric acid (2.15 g, 0.01 mol ), tartaric acid (3 g, 0.02 mol )and urea(2 g, 0.03 mol ) as fuels were dissolved in 25mL distilled water separatly and stirring to finish the solubility process. After being homogenized, the mixture was heated to 120 °C to form a gel. The viscous gel was lit on a hotplate that was heated to 250 °C. It took a few minutes for auto-ignition to finish, releasing gases and creating a white and black ash. The as-prepared ashes were

calcinated at 500°C for 1 hour, named by (MC5, MT5 and MU5) respectively.

### 2.3 Characterization

Diffractometer was used to measure powder X-ray diffraction (XRD) of the products (Rigaku; model MiniFlex 600) with monochromnated Cu-Ka radiation, 1.54178 (˚A) in the 2θ range of 10-80°. FT-IR spectra were obtained with a FT-IR spectrometer (Bruker; model Alpha II ) from 4000 to 400 $cm^{-1}$ at room temperature. The measurement of UV-Visible absorption is conducted using a spectrophotometer (Jasco; model V 670).

## 3. Results and discussion

### 3.1 Powder X-ray diffraction (XRD)

The XRD of MgO during an hour of calcination at 500 °C was displayed in Figure 1. After the calcination at 500°C for 1 hour MC5 and MU5 samples have only pure phase of MgO according to standard ICSD card no (4111968 and 9000499) respectively. The Debye-Scherrer formula number 1 was used to find out the average crystal sizes of magnesium oxide. Average crystal sizes are estimated for MC5, MU5 and MT5 to be 10.60 nm, 20.48 nm and 8.06 nm

$$D = K\lambda / \beta Cos\theta \quad (1)$$

where λ stands for wavelength (1.5406A for Cu Kα), K stands for the Scherrer constant (0.98), D for the nanoparticles' crystalline size, and β for full width at half maximum (FWHM). On the other hand, tartaric acid fuel generated impure MgO with $Mg(OH)_2$ according to standard ICSD card no (9000493 and 9002348) respectively.

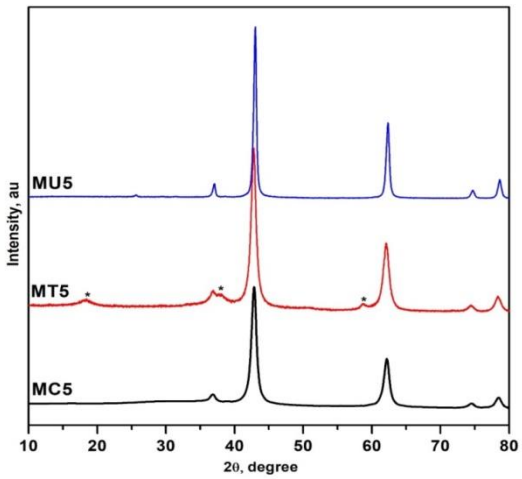


**Fig (1)** X-ray diffraction (XRD) patterns for MgO (MU5, MT5, and MC5) following a one-hour calcination at 500 °C.

From the data collected, it was discovered that the combustion method using citric acid and urea results in a pure MgO phase.

### 3.2 Fourier transforms infrared analysis (FTIR)

The FT-IR spectra of magnesium oxide powder following an hour of calcination at 500 °C are displayed in Figure (2).

The Mg-O-related peaks in the 400–600 $cm^{-1}$ range of the MgO lattice [24, 25].

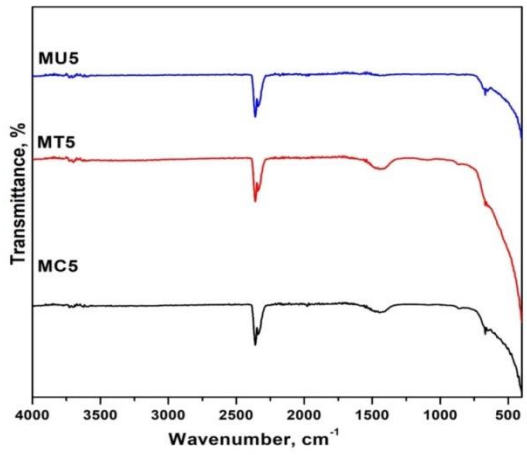


**Fig (2)** shows the FT-IR spectra of MgO nano particles following a 1-hour calcination at 500°C.

### 3.3 Optical studies

The samples were analyzed diffuse reflectance spectroscopy and absorbance spectra recorded as shown in figure 3 (a and b).

Figure 3(a) illustrates the reflectance edge of the calcined magnesium oxide in the 200-400 nm range as seen on the spectra. The spectra exhibits the absorbance threshold between 200 and 300 nm for the produced MgO, as illustrated in figure 3(b). The experiment reflectance data was used to determine the absorption coefficients (α) through the Kubelka Munk function as defined in equation No (2) [26].

$$F(R) = (K - M) = \alpha = (1 - R)^2 / 2R \qquad (2)$$

R represent the experiment reflectance, F(R) is K-M function, α represent the absorption coefficients.

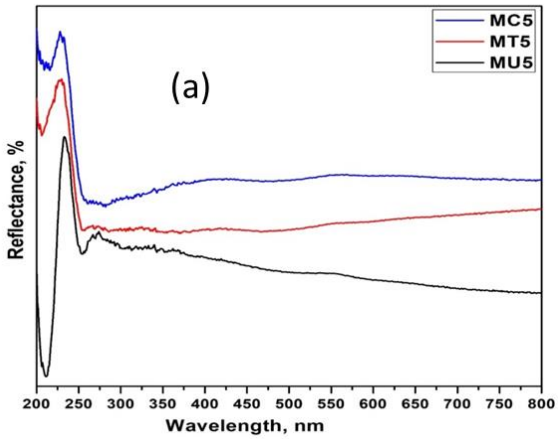


**Fig 3(a)** displays the reflectance spectra of MgO nanoparticles following a 1-hour calcination at 500°C.

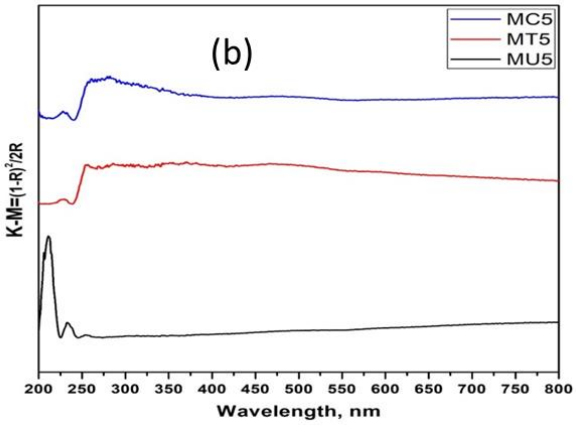


**Fig 3(b)** displays the absorption spectra of MgO nanoparticles following one hour of calcination at 500°C.

The band gap of the magnesium oxide that was produced can be calculated by utilizing equation no.(3) [26].

$$(F(R)h\upsilon)H = A(h\upsilon - Eg) \qquad (3)$$

The experiment reflectance sample is denoted as R and the H value equals two

(representing direct allowed electronic transitions). By using equation (3) the direct band gap values of the magnesium oxide obtained after being calcinated at 500°C (MU5, MT5 and MC5) were determined to be 4.69 eV, 4.56 eV, and 4.47 eV respectively , the Tauc formula as illustrated in figure (4).

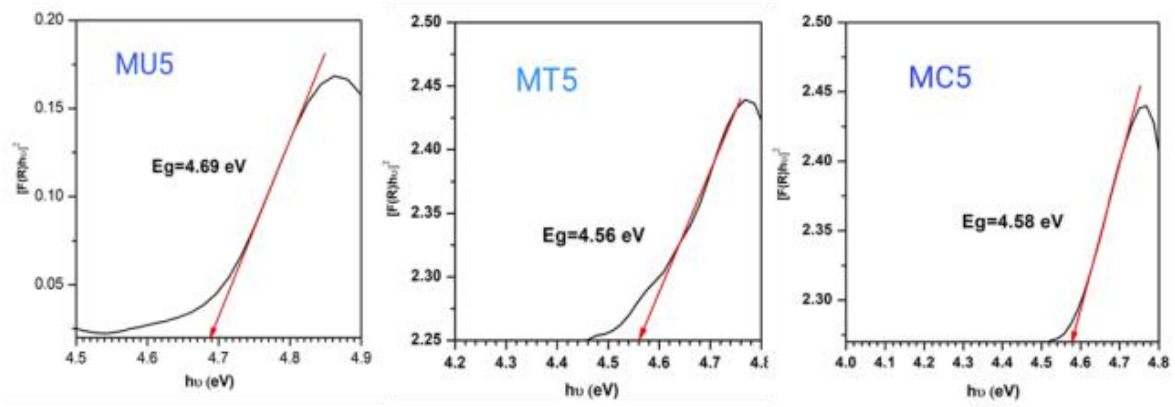


**fig 4** show the direct band gap of the synthesized MgO after calcination at 500°C for 1 hour.

Color parameters were identified through colorimetric techniques utilizing CIE-lab and CIE-LCH analysis methods. The values of L/a/b/c/H for MU5, MT5 and MC5 calculated to be (94.33/ -0.38/ -1.74/ 1.78/ 257.67), (88.86/ 0.61/ 1.30/ 1.44/ 64.80) and (88.86/ 0.61/ 1.30/ 1.44/ 64.80) respectively. The magnesium oxide nanoparticles acquired exhibit a high degree of lightness based on color parameters. the light and solar reflectance were analyzed using JIS A5759:2008 and JIS K5602:2008 methods.

The light and solar reflectance value was calculated for MU5, MT5 and MC5 using JISA5759: 2008 to be (86.04 % / 79.22 %), ( 73.88 % / 71.02 %) and (73.88 % / 71.02 %) respectively. the solar reflectance calculated for MU5, MT5 and MC5 with the IISI K5602: 2008 method for UV-Visible, near infrared, and total solar reflectance to be ( 85.84 %/ 68.77 %/ 78.33 %), ( 74.29 %/ 64.89 %/ 70.08 %) and ( 74.29 %/ 64.89 %/ 70.08 %). According to reflectance parameter, the synthesized MgO have high light and solar reflectance values.

## 4. Conclusion

Utilizing the combustion process with fuels such as citric acid, urea, and tartaric acid, the nanosized MgO nanoparticles were successfully produced. Different methods like XRD, FTIR, and diffuse reflectance spectroscopy were utilized to analyze the magnesium oxide nanoparticles. Using the crystallite size (10.60 nm and 20.48) of MgO nanoparticles was generated by the citric acid and urea fuels respectively. The calculated direct band gaps of the produced magnesium oxide nanoparticles (MU5, MT5, and MC5)

are identified as (4.69 eV, 4.56 eV and 4.58 eV) respectively.

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