Synthesis, characterization and antimicrobial activity of MgO nanoparticles

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Abstract

Nanoparticles of magnesium oxide were prepared using the water extract of the leaves of the Sesbania plant in presence of Mg(OH)2, the characterized of prepared molecules were studied using UV spectroscopy analysis, infrared (FTIR), X-ray diffraction (XRD) (SEM). XRD studies have confirmed that the crystalline structures of MgO nanoparticles were formed at an average size of 30 nm. The results of the antifungal activity confirmed the effectiveness of the nanoparticles prepared against T. rubrum in solid and liquid media. Also, when calculating the percentage of yield of the method used in preparation, the results produced the efficiency of this method.

1. Introduction:
Nanoparticles can be made in a variety of ways, including chemical and physical methods, but biological integrals are preferred over chemical and physical methods because the design process is quick, fast, and cost-effective, and it avoids the generation and use of hazardous materials. There are varies chemical method for synthesis of MgO nanoparticles that have been mentioned in various sources.[1]. On a large scale, biological methods for synthesizing these particles using plant materials have not been investigated [2]. Preparation methods using plant extracts such as neem leaves [3], Brassica oleracea, Punica granatum peels [4], and lemon [5] are mentioned in some sources. As a result, biological synthesis using plant extracts is still in its early stages of growth, providing us with numerous opportunities for discovery and scientific study. Also, these researches that dealt with the biosynthesis of this active particle did not include the calculations related to the yield of all these methods used in the synthesis, therefore the present study including biosynthesis of MgO nanoparticles from MgOH as a precursor in present Aqueous Sesbania grandiflora leaf extract and calculated the yield of this method.

2. Material & Methods:
2.1- Plant collection: Sesbania leaves were collected from the local region. In all of the tests, double-distilled water was used.
2.2- Preparation of aqueous leaf extract: To prepare aqueous leaves extract; 5 grams of leaves were washed well with distilled water and dried for 15-20 minutes at room temperature. The extraction solution was then prepared by boiling the dried leaves in a 500 mL beaker containing 200 mL distilled water for one hour at 100 ° C.
2.3- Synthesis of MgO Nanoparticles: five ml of fresh solution extract was added to 20 ml of deionized water in a beaker and heated at 60 ° C. Then 0.1g of magnesium hydroxide was added to the solution and it was heated at 80 ° C with continuous stirring. The formation of MgO was observed by changing the

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[1] Z. Essa Radhi, N. Obied Jasim, Synthesis, characterization and antimicrobial activity of MgO nanoparticles, in: First International Virtual Conference on Environment & Natural Resources, IOP Conf. Series: Earth and Environmental Science, 2021, pp. 012089.

[2] Z. Essa Radhi, N. Obied Jasim, Synthesis, characterization and antimicrobial activity of MgO nanoparticles, in: First International Virtual Conference on Environment & Natural Resources, IOP Conf. Series: Earth and Environmental Science, 2021, pp. 012089.

[3] Z. Essa Radhi, N. Obied Jasim, Synthesis, characterization and antimicrobial activity of MgO nanoparticles, in: First International Virtual Conference on Environment & Natural Resources, IOP Conf. Series: Earth and Environmental Science, 2021, pp. 012089.

[4] Z. Essa Radhi, N. Obied Jasim, Synthesis, characterization and antimicrobial activity of MgO nanoparticles, in: First International Virtual Conference on Environment & Natural Resources, IOP Conf. Series: Earth and Environmental Science, 2021, pp. 012089.

[5] Z. Essa Radhi, N. Obied Jasim, Synthesis, characterization and antimicrobial activity of MgO nanoparticles, in: First International Virtual Conference on Environment & Natural Resources, IOP Conf. Series: Earth and Environmental Science, 2021, pp. 012089.
color to yellowish brown. The percentage yield was calculated according to the below formula: % Yield = 
\[
\frac{\text{Weight of dried MgO nanoparticles}}{\text{Weight of MgOH used}} \times 100 
\]
2-4- Characterization of the synthesized MgO nanoparticles:

2.4.1- UV–vis absorption
UV–vis absorption spectrum of nanoparticles was studied using a spectrophotometer (U-V-Vis Spectroscopy) at room temperature.

2.4.2- Functional group analysis using FTIR:
FTIR spectroscopy is used to study the change in chemical composition, impurity content and interaction between different groups.

2.4.3-XRD pattern
To study the purity and structure of prepared MgO nanoparticles were determined from XRD patterns which were performed with an X-ray diffractometer.

2.4.4- Scanning electron microscope (SEM):
used a scanning electron microscope (SEM) to study the nanoparticles formed and measure their size.

2.5-Antifungal activity of the synthesized MgO nanoparticles:
The biological efficacy of the prepared particles was tested against Trichophyton rubrum (which was isolated from a patient with skin lesions attending Al Diwaniyah Teaching Hospital) by using Sabouraud's dextrose agar and Sabouraud's dextrose broth.

2.5.1- Estimation of the radial growth:
This test was performed by inoculating the center of dishes containing a Sabouraud's dextrose agar with (5, 10,20) % concentration of nanoparticles and other plate without nanoparticles as control treatment, with a fungal disk (5 mm) of the growth of fungus (7 Days of age). The plates were incubated at 37 °C. After incubation period the growth of the fungus was calculated by measured the of radial growth. And the percentage of Inhibition of mycelial growth by the following calculate:
Inhibition of mycelial growth (%) = \( \frac{C - T}{C} \times 100 \)
where ‘C’ is average diameter of fungal colony in control plates and ‘T’ is average diameter of fungal colony in poisoned plates [7].

2.5.2- Estimate the dry weight
Conical flasks (250 mL) were used for this test, each containing 50 mL of Sabouraud's dextrose broth containing (5,10,20) % from the prepared nanoparticles and others without nanoparticles as a control treatment, were inoculated with a fungal disc from a fungus colony (at the age of one week) and incubated at 37 °C. After the incubation period, the fungal growth was filtered and the growth was dried at 60°C for 24 h. Then the dry weight was measured [8].

3. Results & Discussion:
3.1- Synthesis of MgO Nanoparticles:
The change in color from yellow to brown of the mixture indicates MgO nanoparticle formation Fig. (1). This change occurs due to the excitation of surface Plasmon vibrations with the Nanoparticles [9]. The aqueous extract of the leaves of the Sesbania plant contains substances That play a role as reducing and stabilizing agents during the formation of nanoparticles in addition to phenol compounds such as tannins, flavonoids, and phenolic acids that also have oxidation and reduction activities as the extract acts as a reducing agent that led to the reduction of MgOH into MgO nanoparticles according to the following equation:
\[
\text{Mg(OH)}_2 \rightarrow \text{MgO} + H_2O
\]

Fig (1): biosynthesis of MgO nanoparticles
The percentage of yield of the method was calculated, and by applying the above equation, it was found that the percentage is 50%.

3.2-- Characterization of the synthesized MgO nanoparticles:
3.2.1- UV–vis absorption analysis:
The most commonly used method for characterizing the optical properties and electrical properties of nanoparticles is UV absorption spectroscopic analysis, in which the absorption ranges are proportional to the diameter of the metallic nanoparticles, Fig. (2) illustrates the UV-visible spectra of MgO nanoparticles. The absorption spectrum of the reaction at the wavelength of 310nm confirmed the formation of nanoparticles [10].

3.2.2- FTIR analysis:
FTIR analysis illustrates that alkyl groups are responsible for the reduction of NPs [11]. The peak at 426.0 cm⁻¹ confirm Mg-O bond stretching, indicating that the substance obtained was formed. Fig. (3). this result according to the reported by Raghavendra [12] and Delbruck [13].

3.2.3- XRD pattern:
Fig. 5 shows the XRD diffraction patterns of the prepared Magnesium Oxide nanoparticles. MgO has peaks at 222, 311, 220, and 111, with no subsequent peaks for Mg (OH) 2, Mg, or other elements. The average size of the prepared nanocrystals was measured using Scherer's equation [14] and found to be 30 nm.

3.2.4-SEM analysis:
To determine the structure of the reaction products, a scanning electron microscope analysis was used, and the images in Fig (4) showed a number of individual and aggregate particles, all of which took a spherical shape and ranged on the nanoscale.
3.3- Antifungal activity

3.3.1- Estimation of the radial growth:
Fig. (6) shows significantly effect of the prepared nanoparticles on radial growth of *T. rubrum* at all different concentration especially in 20%, this result accordant with Sharma [14] that reported about effect of MgO nanoparticles on growth of *T. mentagrophytes*. And with Kong [15], who mention that MgO nanoparticles effect on *Candida albicans*.

3.3.2- Estimate the dry weight:
The results shown in Fig. (7) indicate that nanoparticles have a significant effect on the dry weight of the fungus and that this effect is influenced by increasing the concentration, as it is inversely proportional to the concentration.

The operation mechanism of MgO NPs has been studied in a number of studies. Most authors consider the mechanism of ROS oxidative damage in bacteria [16, 17], and ROS destroys bacterial membranes, resulting in bacterial death [18]. However, only a few studies have focused on the effect of MgO NPs on fungi, the interaction of nanoparticles with the membrane causes changes in the membrane, which appear as "pits" on the membrane surfaces. Pore formation later progresses to cell death [19,20]. This could explain why MgO NPs showed antigenic activity to *T. rubrum*.

4.Conclusion:
This study presents a simple and Eco-friendly way for synthesis of nanoparticles without the need to use hazardous chemicals, and obtaining particles have properties that enable them to be used in the range of antifungal agents. This method has a high yield rate of 50%.

References:
[1] Mirzaei, H. and Davoodnia, A., 2012. Microwave assisted sol-gel synthesis of MgO nanoparticles and their catalytic activity in the synthesis of hantzsch 1, 4-dihydropyridines. Chinese journal of catalysis, 33(9-10), pp.1502-1507.
[2] Sushma, N.J., Prathyusha, D., Swathi, G., Madhavi, T., Raju, B.D.P., Mallikarjuna, K. and Kim, H.S., 2016. Facile approach to synthesize magnesium oxide nanoparticles by using Clitoria ternatea—characterization and in vitro antioxidant studies. Applied Nanoscience, 6(3), pp.437-444.
[3] Moorthy, S.K., Ashok, C.H., Rao, K.V. and Viswanathan, C., 2015. Synthesis and characterization of MgO nanoparticles by Neem leaves through green method. Materials Today: Proceedings, 2(9), pp.4360-4368.
[4] Sugirtha, P., Divya, R., Yedhukrishnan, R., Suganthi, K.S., Anusha, N., Ponnusami, V. and Rajan, K.S., 2015. Green synthesis of magnesium oxide nanoparticles using brassica oleracea and Punica granatum peels and their anticancer and photocatalytic activity. Asian Journal of Chemistry, 27(7), p.2513.
[5] Awwad, A.M. and Ahmad, A.L., 2014. Biosynthesis, characterization, and optical properties of magnesium hydroxide and oxide nanoflakes using Citrus limon leaf extract. Arab J Phys Chem, 1(2), p.66.

[6] Sood, R. and Chopra, D.S., 2017. Improved yield of green synthesized crystalline silver nanoparticles with potential antioxidant activity. Int. Res. J. Pharm, 8(4), pp.100-104.

[7] Gupta, S.K. and Tripathi, S.C., 2011. Fungitoxic activity of Solanum torvum against Fusarium sacchari. Plant Protection Science, 47(3), pp.83-91.

[8] Pinto, M., Gencale, E., and Rossi, M. (2001). Study of some plant oils effect on Aspergillus flavus growth on corn. Brazilian Journal of Microbiology, 7(1):32-127.

[9] Mulvaney, P., 1996. Surface plasmon spectroscopy of nanosized metal particles. Langmuir, 12(3), pp.788-800.

[10] Nemade, K.R. and Waghule, S.A., 2014. Synthesis of MgO nanoparticles by solvent mixed spray Pyrolysis technique for optical investigation. International Journal of Metals, 2014.

[11] Socrates, G., 2004. Infrared and Raman characteristic group frequencies: tables and charts. John Wiley & Sons.

[12] RagHAVENDRA, M., Lalithamba, H.S., Sharath, B.S. and Rajanaika, H., 2017. Synthesis of Nα-protected formamides from amino acids using MgO nano catalyst: Study of molecular docking and antibacterial activity. Scientia Iranica. Transaction C, Chemistry, Chemical Engineering, 24(6), pp.3002-3013.

[13] Dobrucka, R., 2018. Synthesis of MgO nanoparticles using Artemisia abrotanum herba extract and Their antioxidant and photocatalytic properties. Iranian Journal of Science and Technology, Transactions A: Science, 42(2), pp.547-555.

[14] Rani, N., Chahal, S., Chauhan, A.S., Kumar, P., Shukla, R. and Singh, S.K., 2019. X-ray analysis of MgO nanoparticles by modified Scherer’s Williamson-Hall and size-strain method. Materials Today: Proceedings, 12, pp.543-548.

[15] Sharma, N., Jandaik, S., Kumar, S., Chitkara, M. and Sandhu, I.S., 2016. Synthesis, characterisation and antimicrobial activity of manganese-and iron-doped zinc oxide nanoparticles. Journal of Experimental Nanoscience, 11(1), pp.54-71.

[16] Kong, F., Wang, J., Han, R., Ji, S., Yue, J., Wang, Y. and Ma, L., 2020. Antifungal activity of magnesium oxide nanoparticles: effect on the growth and key virulence factors of Candida albicans. Mycopathologia, 185(3), pp.485-494.

[17] Hao, Y.J., Liu, B., Tian, L.G., Li, F.T., Ren, J., Liu, S.J., Liu, Y., Zhao, J. and Wang, X.J., 2017. Synthesis of {111} facet-exposed MgO with surface oxygen vacancies for reactive oxygen species generation in the dark. ACS applied materials & interfaces, 9(14), pp.12687-12693.

[18] Rao, Y., Wang, W., Tan, F., Cai, Y., Lu, J. and Qiao, X., 2014. Sol–gel preparation and antibacterial Properties of Li-doped MgO nanoplates. Ceramics International, 40(9), pp.14397-14403.

[19] Al-Hazmi, F., Alnowaiser, F., Al-Ghamdi, A.A., Al-Ghamdi, A.A., Aly, M.M., Al-Tuwirqi, R.M. and El-Tantawy, F., 2012. A new large-scale synthesis of magnesium oxide nanowires: structural and antibacterial properties. Superlattices and Microstructures, 52(2), pp.200-209.

[20] Gajbhiye, M., Kesharwani, J., Ingle, A., Gade, A. and Rai, M., 2009. Fungus-mediated synthesis of silver nanoparticles and their activity against pathogenic fungi in combination with fluconazole. Nanomedicine: Nanotechnology, Biology and Medicine, 5(4), pp.382-386.

[21] Li, H., Gong, H., Qi, Y., Li, J., Ji, X., Sun, J., Tian, R., Bao, H., Song, X., Chen, Q. and Liu, G., 2017. In vitro and in vivo antifungal activities and mechanism of heteropolytungstates against Candida species. Scientific reports, 7(1), pp.1-9.