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Research Article

GREEN SYNTHESIS AND ITS APPLICATIONS OF MAGNESIUM OXIDE NANOPARTICLES FROM THE SEEDS OF LEPEDIUM SATIVUM

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ABSTRACT

Green synthesis of metal oxide nanoparticles is gaining importance due to the use of environmentally friendly reactants and room temperature synthesis. Green synthesis is the most preferred method as it encourages the use of non-toxic solvents such as plant extracts. The present study is proposed with an objective to synthesise MgO nanoparticles by the eco-friendly green synthesis approach using environmentally benign plant seed extract of Lepidium Sativum (MgL). The synthesized MgO nanoparticles have been characterized by UV-DRS Spectroscopy, Fourier Transform Infrared (FT-IR) spectroscopy, powder X-ray Diffractometer (XRD) and Scanning Electron Microscopy (SEM) studies. The as synthesized nanoparticles were analysed for their antibacterial and photocatalytic activities.

INTRODUCTION

Metal oxide nanoparticles have attracted attention because of their increased use in a variety of fields such as electronic, cosmetic, biomedicine, energy, environment, catalysis and material science *(Krishna Moorthy et al, 2015)*. Green techniques make use of moderately pollutant free chemicals for nanoparticle synthesis and it also enhances the use of benign solvents such as water, natural extracts *(Kavitha et al, 2013)*. Magnesium Oxide (MgO) nanoparticles have found several applications in catalysis *(Daniel et al, 2003)*, adsorption *(Mageshwari et al, 2013)*, refractory ceramics *(MohdSurfiMastuli et al, 2012)*, water purification and also as antibacterial agents *(Tony Jin and Yiping He, 2011)*. MgO is of particular interest as it is regarded as a safe material to human beings and animals.

In this work, MgO nanoparticles were synthesised using the seeds of Lepidium Sativum. The antibacterial and photocatalytic studies were carried out for the synthesized magnesium oxide nanoparticles. Therefore, biogenic fabrication is found to be the most efficient and cost effective technique compared to chemical method.

MATERIALS AND METHODS

Materials

Magnesium nitrate, $(Mg(NO_3)_2 \cdot 6H_2O)$ from NICE Chemicals Pvt. Ltd., (Kochi), Rectified spirit (E.I.D. Parry (I) Ltd., Nellikuppam), Sodium hydroxide solution, distilled water. The plant extracts for the synthesis of nanoparticles were prepared using the seeds of Lepidium sativum, collected from a local shop with the help of the Department of Botany, Stella Maris College.

Experimental

Preparation of the Lepidium sativum extract

Good quality *Lepidium sativum* seeds were selected and grinded to fine powder. To 50mL distilled water and equal volume of rectified spirit, 0.5g seed powder was dissolved using a magnetic stirrer. This solution was then kept undisturbed for a few hours so that the precipitate formed could settle down. The thick white supernatant was used as the plant extract for the syntheses of MgO nanoparticles while the residue was discarded.

Synthesis of MgO nanoparticles using Lepidium sativum extract

0.5g of Magnesium nitrate, $(Mg(NO_3)_2.6H_2O)$ was dissolved in 50mL of distilled water, then 2 mL of this solution was taken to which 2 ml of the prepared seed solution was added. This mixture was mixed well using a magnetic stirrer. After a few minutes NaOH solution was added drop by drop to achieve a pH between 10 - 12, due to which colloidal like formation was observed almost instantaneously. This mixture was stirred well

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with the magnetic stirrer for a few hours. It was then kept undisturbed till the colloidal suspension settled down. The colloidal suspension was then collected while discarding the supernatant. This suspension was then kept in a hot-air oven at 250˚C till all the water evaporated. The obtained product was then cooled and used for further studies.

RESULTS AND DISCUSSION

UV-DRS Spectroscopic studies

The UV absorption measurements were carried out using JASCO UV Vis spectrophotometer. The UV absorption spectrum of the synthesized MgL nanoparticles is shown below in Figure 1. The band gap energy of the magnesium oxide nanoparticles was calculated using the Planck's equation. The band gap energy is found to be 2.83 eV for magnesium oxide nanoparticles from Lepedium sativum extract.

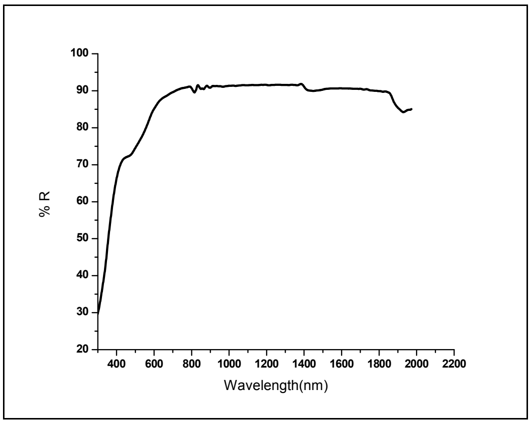

Figure 1 UV-DRS Spectrum of MgL nanoparticles

Infrared Spectroscopic studies

Figure 2 shows the FT-IR spectrum of MgL nanoparticles. The spectrum shows medium absorptions at 2354, 1647 and a strong sharp absoption at 1439 cm^{-1} which often implies the presence of an aromatic ring and in plane bending of C-H and C-C bonds of the alkyl groups and aromatic ring. The absorption at 918 cm^{-1} and 895cm^{-1} is due to C-N stretching as seen in amines. The broad and intense band between 3539-3442 cm^{-1} due to the stretching vibrations of O–H groups in water, alcohol and phenols and N–H stretching in amines. Absorption at 557 and 486 cm^{-1} correspond to the Mg-O linkage. The IR absorptions at 3465, 1644, 1446, 1392 cm^{-1} show the presence of hydroxyl group, aldehydes, amines and aromatic ring which confirm that the phytoconstituents are rich in polyphenols, carboxylic acid, polysaccharide, amino acid and proteins, which are involved in the reduction and stabilization (capping) of MgO NPs.

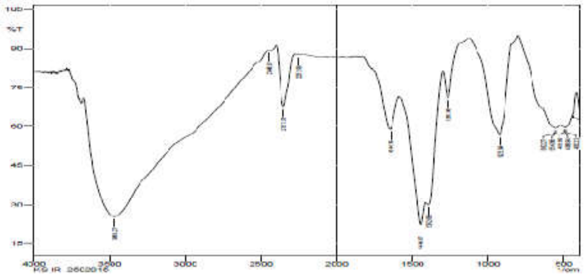

Figure 2 FT-IR Spectrum of MgL nanoparticles

Powder X-Ray Diffraction Studies (PXRD)

The XRD pattern of MgO nanoparticles (MgL) is shown in Figure 3. The XRD pattern of MgL showed some unidentified peaks. The broadness of the peak and amorphous nature pointed out the presence of impurities and inadequate calcination of the sample. The spectrum is in good agreement with the JCPDS data (89-7746). The 2θ values with (hkl) plane at 26.81 , 28.41 , 30.47 ,53.67 and 30.99 were observed.

The crystalline size D was calculated using debye-scherer formula.

$$A=0.89\lambda/\beta\cos\theta \qquad \text{------------------ (1)}$$

where λ is the wavelength of the intensity X-ray (λ=1.5418 A), β is the full width at half maximum (FWHM) in radians of the maximum intensity peak and θ is the angle at which the maximum peak occurs. The average crystalline size was calculated from the most intense peaks of their corresponding XRD pattern. The average crystalline size was determined by the debye-Scherer formula and found to be 32.83 nm

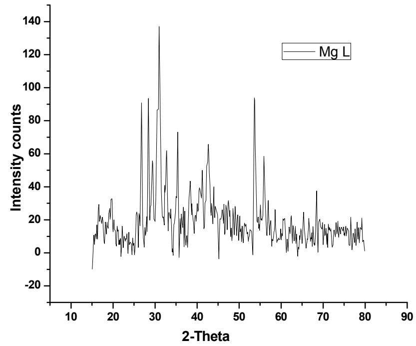

Figure 3 PXRD spectra of MgL nanoparticles

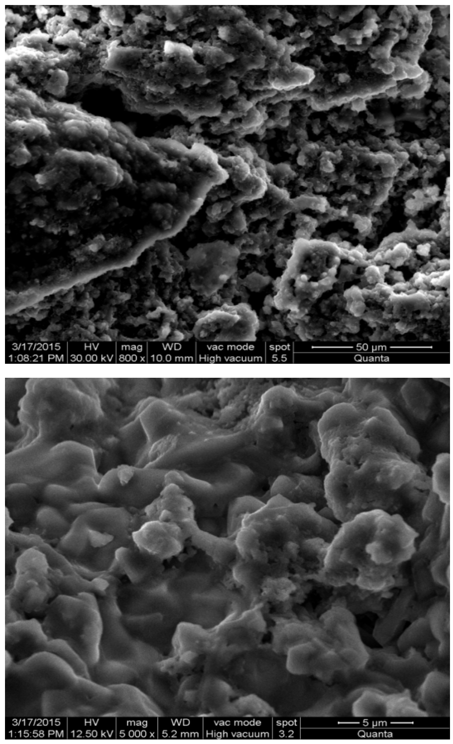

Figure 4 SEM micrographs of MgL nanoparticles

SEM Analysis

Scanning Electron micrographs (SEM) of MgO nanoparticles is shown in Fig.4. The surface morphology of the SEM images depicts the nanoparticles as, aggregated and dense irregular shaped flakes. Uniform distribution of MgO nanoparticles was observed on the entire surface. The images also revealed the presence of fine and large grains of product particles. The particle size of the synthesized MgO nanoparticles was 85-120 nm.

Antibacterial Studies

The antibacterial activity was studied using the well- diffusion method. *Staphylococcus aureus, Escherichia coli, Bacillus subtilis* and *Psudomonas aeruginosa* were grown overnight on the Nutrient media. A sterile cotton swab was dipped into the inoculum suspension and the swab was rotated several times with firm pressure on the inside wall of the tube to remove excess fluid. The swab was used to inoculate the dried surface of the Nutrient agar plate by swabbing over the surface of the agar, rotating the plate approximately by 90º to ensure an even distribution of the inoculum. Different concentrations (5, 10, 15 and 20 µl) of the solvent extracts of MgO nanoparticles prepared using lepidium sativum seed extract were added on to the well of 5mm diameter. The plates were incubated at 37ºC for 24 h. Clear zones of inhibition around the wells were measured and calculated.

The effect of magnesium oxide nanoparticles using lepedium sativum extract showed very less sensitivity towards antibacterial activity in 5, 10, 15 and 20 µl. But it was observed that the growth of bacteria was completely inhibited when higher concentration (0.1g/ml) was used *(Devi Meenakshi et al, 2012)*.

Photocatalytic Studies

The photocatalytic activity of the synthesized Magnesium oxide nanoparticles, MgL was studied by degrading Congo red dye. In 100 mL of 25 ppm concentrated dye, 100 mg of the catalyst was added, degradation was carried out as mentioned above and the results were recorded. The absorption curves showed very low photocatalytic activity but rather show very good adsoption properties for the synthesised MgL nanoparticles.

Efficiency of the Photocatalytic behaviour of the as prepared Catalyst

A comparison of the efficiency of the photocatalytic behaviour of MgL at three different concentrations such as 100, 50 and 25ppm was studied. It is observed from the Figure 7 that MgL of 25ppm exhibited higher photocatalytic activity. This may be due to the seed's mucilage where it acts as an pharmaceutically significant polysaccharide with ample range of applications as thickening gelling agent, binding, disintegrating, suspending, emulsifying, stabilizing and gelling agents ***(****Neela M. Bhatia et al, 2014****)*.**

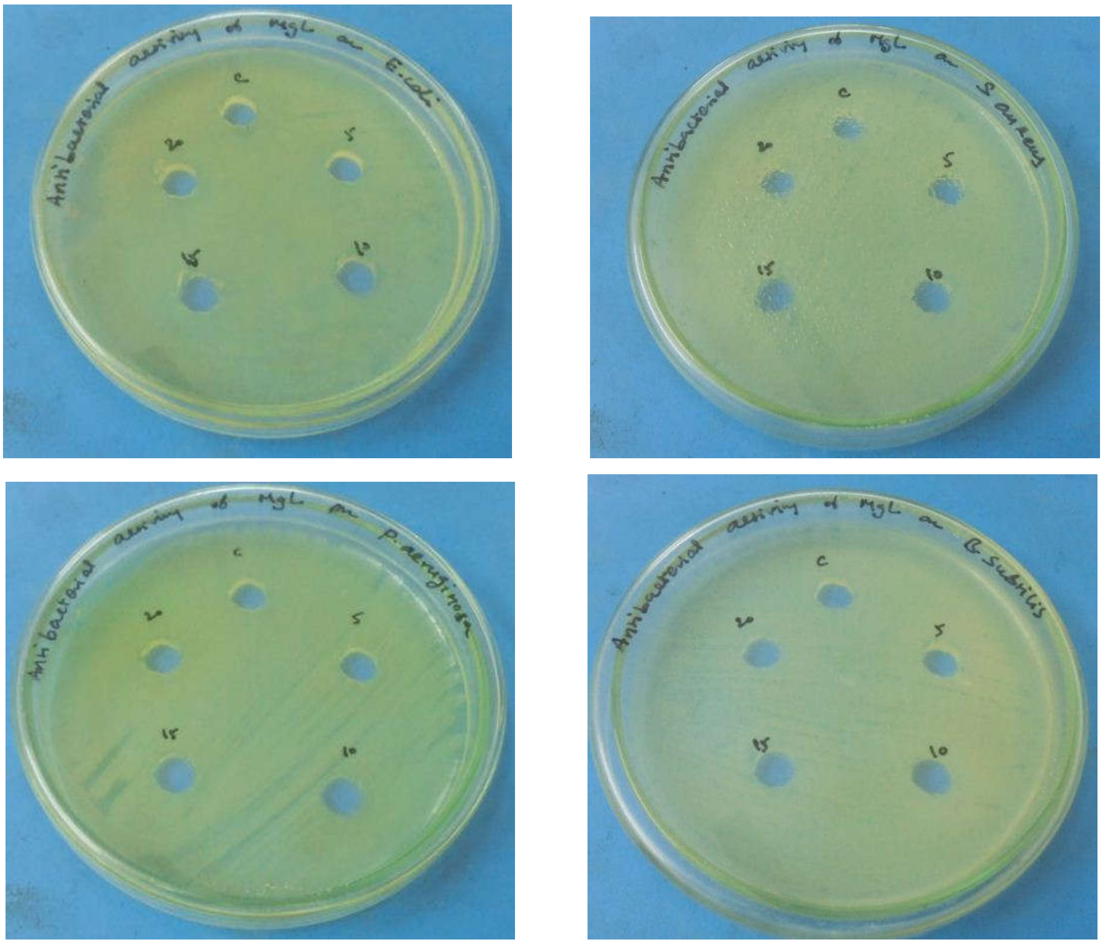

Figure 5 Antibacterial activity of MgA nanoparticles on (A) *E.coli* (B) *S.aureus* (C) *P.aeruginosa* (D) *B. subtilis*

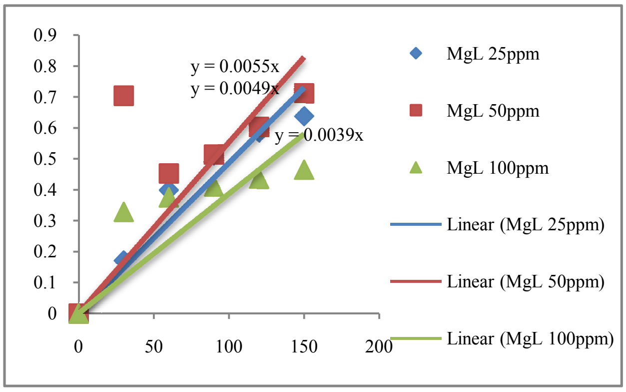

Figure 6 Plot of ln(C/Co) Vs Time for the degradation of CR on MgL nanoparticles

Hence, it promotes good adsorption property of the catalyst even at lower concentration levels.

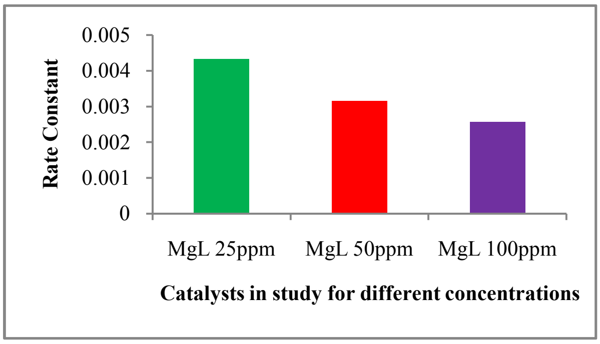

Figure 7 Plot of Rate Constant against MgL catalyst for different concentrations

CONCLUSION

The study is proposed for the development of a cost effective and eco-friendly method of synthesizing MgO nanoparticles. The antibacterial studies of MgL indicated that the synthesized nanoparticles showed very less sensitivity to both Gram negative and Gram positive bacteria. This method of preparation of magnesium oxide will be useful in a cost effective way in the above mentioned industries. The photocatalytic activity of the synthesized MgL nanoparticles showed very good adsorption properties. Thus we envision that the synthesised nanoparticles will become critical components of industrial and public water purification systems.

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