Green Synthesis of Magnesium Oxide Nanoparticles using Aloe Vera and its Applications

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Abstract— Green synthesis of nano - sized magnesium oxide was carried out using the plant leaf extracts of aloevera. The metal oxide vibrational frequencies, morphology and crystallite size of the as synthesized nanoparticles were studied using UV-DRS, FT-IR, SEM and PXRD respectively. The antibacterial and photo catalytic activity of the same were also studied. It was found that magnesium oxide nanoparticles acts as a very good adsorbent and helps in removal of effluents from textile and dying industries.

Key words: Magnesium Oxide Nanoparticles (MgO Nps), Green Synthesis, Aloevera

I. Introduction

Green synthesis of nanoparticles is of significant interest in recent years and has become the one of the most desired methods for the production of metal oxide nanoparticles. Bio-synthesis have several advantages such as being simple, inexpensive, good stability of nanoparticles, less time consumption, non-toxic byproducts and hence it can be used in large-scale synthesis[1]. Aloe vera plant extract acts as an eco-friendly reducing agent and a non-hazardousgelling agent for stabilizing the nanostructures [2].

MgO nanoparticles has been used in wide range of applications such as catalysis, catalyst supports, toxic waste remediation, refractory materials and adsorbents, additive in heavy fuel oils, reflecting and anti-reflecting coatings, superconducting and ferroelectric thin films as the substrate, super-conductors, lithium ion batteries and so on [3-4].It is used in medicinal field for the relief of heartburn, sore stomach, bone regeneration and tumor treatment [5].

In this article, Magnesium oxide nanoparticles were synthesized using aloevera leaf extract. The photo catalytic and antibacterial activities of the as synthesized nanoparticles were evaluated.

II. Experimental Details

A. Materials

Magnesium nitrate, (Mg (NO3)2. 6H2O) from NICE Chemicals Pvt. Ltd. (Kochi), Rectified spirit (E.I.D. Parry (I) Ltd., Nellikuppam), Sodium hydroxide solution, distilled water. Aloevera leaves were collected from the Botanical garden of Stella Maris College, Chennai-86. Stock culture of bacteria for antibacterial studies was obtained from (Science House, Chennai). Mueller-Hinton agar, Nutrient broth, disposable sterile petridishes, cotton swabs, test tubes was purchased from HiMedia Laboratories Pvt Ltd and congo red from NICE Chemicals Pvt. Ltd.,(Kochi), were purchased and used for the study.

B. Experimental

1) Preparation of Aloe Vera leaf extract

50 g of Aloe Vera leaves were thoroughly washed, dried and then boiled in 50 ml of deionized water for half an hour. The resulting extract was cooled and used as a gelling agent for the synthesis of magnesium oxide nanoparticles.

2) Preparations of MgO nanoparticles using Aloe-Vera extract (MgA)

Ten mL of magnesium nitrate solution was added to 10 mL of aloevera extract. Then, the mixture was stirred in a magnetic stirrer for about half an hour. NaOH was added dropwise while stirring till a white precipitate of magnesium hydroxide was obtained. The precipitate was filtered and dried in an air oven for an hour. The content was washed repeatedly with distilled water to remove the basicity of the solution. Further, the calcination was done in the muffle furnace at 500°C for three hours.

III. Results and Discussion

A. Characterization of catalysts

1) UV-Visible Diffuse Reflectance Spectroscopic studies

The UV absorption measurements were carried out using JASCO UV Vis spectrophotometer and was scanned in the range of 150-1200nm. The UV- Reflectance spectrum of the synthesized MgA nanoparticles is shown below in Fig.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 Aloevera extract.

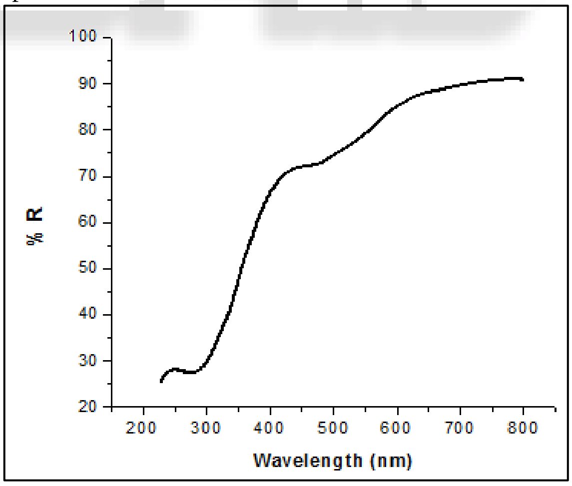


Fig. 1: UV-DRS spectrum of MgA nanoparticles

2) *FT-IR Spectroscopic Studies*

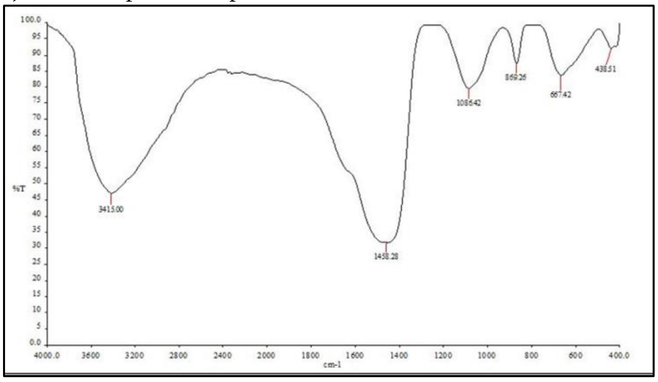


Fig. 2: FT-IR Spectrum of MgA nanoparticles

The strong sharp absorption at 1458 cm^{-1} 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 869cm^{-1} is due to C-N stretching in amines. The band at 668 and 438 cm^{-1} confirmed the metal oxide linkage (MgO). The broad and intense band at 3415 cm^{-1} indicates the presence of stretching vibrations of O–H groups in water.

3) *Powder X-Ray diffraction studies*

The XRD spectra of as synthesized nanoparticles was carried out using XRD (Bruker AXS D8 Advance) for 2θ values ranging from 10 to 80° using CuKα radiation at λ = 1.5406Å. The 2θ values at 78.42, 62.09 and 42.66for MgA were observed. The crystallite size was calculated using Debye-Scherrer formula. The average crystallite size of MgA nanoparticles was found to be 8.6 nm.

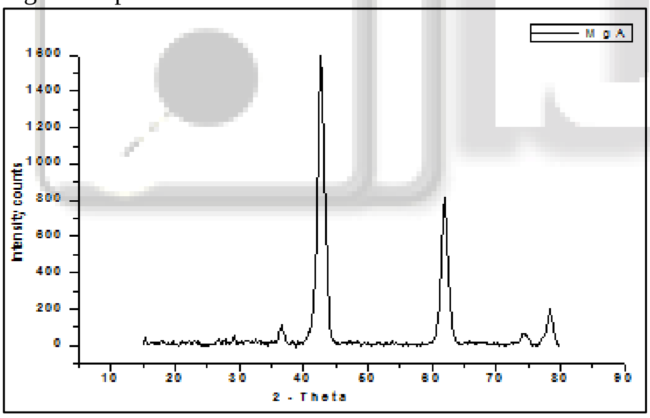
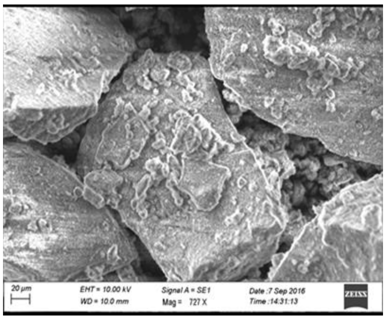


Fig 3: PXRD Spectrum of MgA nanoparticles

4) *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 rock shaped flakes. Uniform distribution of MgO nanoparticles was observed on the entire surface.



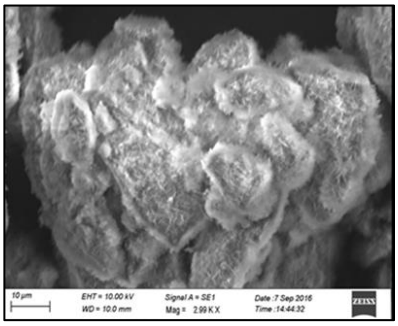
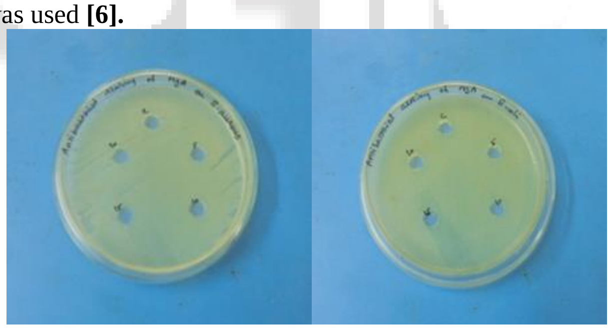


Fig. 4: SEM micrographs of MgA nanoparticles

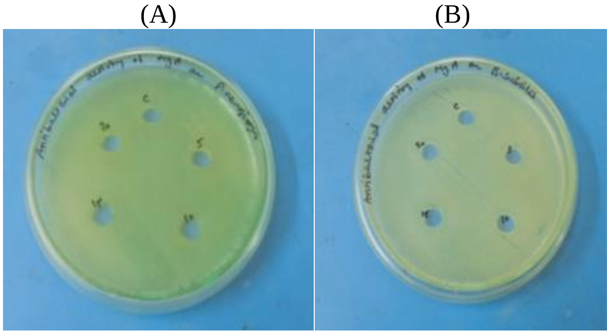
B. *Antibacterial studies*

The antibacterial activity was studied using the well-diffusion method. Staphylococcus aureus, Escherichia coli, Bacillus subtilis and Psudomonasaeruginosa 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 aloe-vera plant 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 aloevera extract showed very minimum antibacterial activity in 5, 10, 15 and 20 µl. The growth of bacteria was completely inhibited when higher concentration (0.1g/ml) was used **[6].**



(A) (B)



(C) (D)

Fig. 5: Antibacterial activity of MgA nanoparticles of (A) E.coli (B) S.aureus (C) P.aeruginosa (D) B. Subtilis

C. *Photocatalytic activity studies*

The synthesized magnesium oxide nanoparticles from the alovera plant extract was subjected to photodegradation studies.The photocatalytic activity of MgA was studied by degrading Congo red(CR) dye. To 100 mL of 25 ppm concentrated dye, 100 mg of MgA catalyst was added and the degradation was carried out as mentioned above and the results were recorded.Initially UV absorption of the CR dye is measured followed which the absorption is measured periodically at an interval of 30 min for 3 hrs with the addition of the catalyst.

1) Effect of amount of MgA catalyst on decolourization of congo red dye

After equilibration time of 20 minutes, photocatalytic experiments were carried out for 3 hours. Concentration of CR at different time intervals was determined spectrophotometrically and the results are shown as a plot of ln(C/CO) Vs time in Fig. 6, where C is the concentration at various time intervals and CO the initial concentration. A linear fit plot obtained indicated that the reaction follows pseudo first order rate kinetics. Rate constant was calculated from the linear plot. Increase in the pseudo first order rate constant with increase of MgA catalyst indicated that the decolourization was truly photocatalytic.

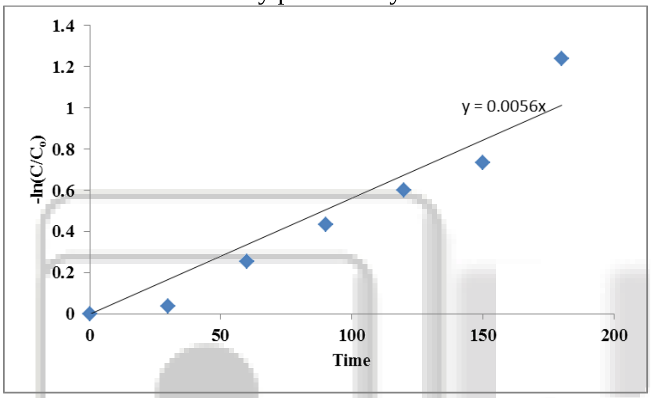


Fig. 6: Plot of ln(C/Co) Vs Time for the degradation of CR on MgA nanoparticles

IV. Conclusion

The current study focused on the biogenic synthesis of magnesium oxide nanoparticles in an ecofriendly manner. The synthesized nanoparticles were characterized and its applications such as antibacterial and photocatalytic activities were observed. On comparison with the magnesium oxide nanoparticles synthesized by chemical method, the crystallite size was found to be 50 nm for chemically synthesized and 8 nm for biogenically produced nanoparticles. Therefore, green technique is more preferred and cost-effective for the synthesis. It was alsoobserved that magnesium oxide nanoparticles synthesized using Aloevera acts as an excellent sorbent from the photocatalytic studies. Therefore, it can be used in the removal of toxic metal ions and also provide unprecedented opportunities to develop more efficient water-purification catalysts.

References

[1] P.Ouraipryvan, T. Sreethawong and S.Chavadej, "Synthesis crystalline MgO nanoparticle with mesoporous-assembled structure via a surfactant-modified sol-gel process". Materials Letters, 2009 63, 1862-1865.

[2] H.Mirzaei and A.Davoodnia, "Microwave assisted sol-gel synthesis of MgO nanoparticles and their catalytic activity in the synthesis of hantzsch 1, 4-dihydropyridines". Chinese Journal of Catalysis, 2012,33, 1502-1507.

[3] L. Bertinetti, C. Drouet, C. Combes, C. Rey,A. Tampieri, S. Coluccia, and G. Martra, "Surface characteristics of nanocrystallineapatites: Effect of MgO surface enrichment on morphology, surface hydration species, and cationic environments", Langmuir, 2009, 25, 5647-5654.

[4] C. M. Boubeta, L. Bacells, R. Cristofol, C. Sanfeliu, E. Rodriguez, R. Weissleder, S. Piedrafita, K. Simeonidis, M. Angelakeris, F. Sandiumenge, A. Calleja, L. Casas, C. Monty and B. Martinez, "Self-assembled multifunctional Fe/MgO nano-spheres for magnetic resonance imaging and hyperthermia", Nanomedicine, 2010, 6, 362-370.

[5] D. R Di,Z. Z He, Z. Q. Sun, and J. Liu, "A new nano-cryosurgical modality for tumor treatment using biodegradable MgO nanoparticles",Nanomedicine, 2012, 8, 1233-1241.

[6] S. Devi Meenakshi, M. Rajarajan, Susai Rajendran, Z. Robert Kennedy and G. Brindha., "Synthesis and characterization of magnesium oxide nanoparticles", Elixir Nanotechnology, 2012, 50 10618-10620

