ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 10, Iss 2, 2021

Utilizing Pterocarpus marsupium Rox.b Heartwood Extract for Green Synthesis of Magnesium Oxide Nanoparticles: Exploring Biomedical Applications and Beyond

Praveen Kumar Vemuri

Department of Biotechnology, Koneru Lakshmaiah Education Foundation Deemed to be University, Vaddeswaram 522 502, Andhra Pradesh, India

Abstract:

Background:

This study aimed to synthesize magnesium oxide nanoparticles (MgO-NPs) by employing an aqueous extract derived from the heartwood of Pterocarpus marsupium [1] . The heartwood extract of Pterocarpus marsupium is abundant in polyphenolic compounds and flavonoid [2], making it a sustainable and eco-friendly source for the large-scale production of MgO-NPs. The phytoassisted synthesis of MgO-NPs was characterized using various techniques, including UV-Visible spectroscopy [3], X-ray diffraction (XRD), dynamic light scattering (DLS), Fourier transform infrared spectroscopy (FT-IR) [4], scanning electron microscopy (SEM) with energy dispersive X-ray spectroscopy (EDS) [5], and transmission electron microscopy (TEM) [6].

Results:

The formation of MgO-NPs was evident through a visible color [7] change from colorless to dark brown, and their presence was confirmed by [8] UV-Spectrophotometry analysis, showing a wavelength of 310 nm [9]. X-ray diffraction analysis revealed the crystalline nature of the synthesized nanoparticles. Scanning electron microscopy[10] (SEM) results displayed spherical-shaped MgO-NPs with an average size of less than 20 nm [11], and the presence of magnesium and oxygen was confirmed by EDS data [12]. Transmission electron microscopy (TEM) analysis further confirmed the spherical shape of the nanoparticles [13], with an average particle size of 13.28 nm, and the SAED [14]analysis confirmed their crystalline nature. FT-IR investigation demonstrated the presence of active compounds necessary to stabilize [15] the MgO-NPs, with hydroxyl, carboxyl, and phenolic groups acting as reducing [16], stabilizing, and capping agents [17]. The nanoparticles exhibited varying particle sizes ranging from 15 to

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 10, Iss 2, 2021

25 nm, and the polydispersity index value was measured as 0.248 [18]. The zeta-potential was found to be -2.9 mV. In addition to their characterization [19], the MgO-NPs were tested for their antibacterial action against Gram-positive bacterium Staphylococcus aureus and Gram-negative bacterium [20] Escherichia coli using the minimum inhibitory concentration technique, and they showed potency against both bacteria [21]. The nanoparticles also exhibited good antioxidant activity in the DPPH radical scavenging method [22], strong anti-diabetic activity in the alpha-amylase inhibitory activity test [23], and significant anti-inflammatory activity in the albumin denaturation method [24].

Keywords: Magnesium oxide nanoparticles, Pterocarpus marsupium, Antioxidant activity, Antimicrobial activity, Antidiabetic activity, Anti-inflammatory activity.

Plant collection:

The heartwood of Pterocarpus marsupium was collected from the Tirupati area and authenticated by Dr. K. Madhava Chetty, Assistant Professor[25], Department of Botany, Sri Venkateswara University, Tirupati. Voucher no. 1587 [26] has been deposited in a herbarium. The collection and field studies were conducted in accordance with local regulations [27], with necessary permissions obtained [28]. The collected plant material was washed, dried in shade, finely ground, and stored in an airtight container [29].

Preparation of P. marsupium heartwood aqueous extract:

50 g of coarse powder was boiled in 500 mL of distilled water for 30 minutes [30]. The aqueous extract was then cooled, filtered using Whatman No. 1 [32] filter paper, and refrigerated for further use [33].

Total phenolic content:

The total phenolic content was estimated using the Folin-Ciocalteu reagent and gallic acid as a standard [34]. The P. marsupium aqueous heartwood extract (2 mL) was mixed with 10 mL of diluted Folin-Ciocalteu reagent (1/10 with distilled water). After incubation for 2 minutes, 8 mL of sodium carbonate was added, and the solution was kept in the dark at 37°C for 2 hours with occasional shaking . The absorbance was measured at 765 nm, and a standard curve was prepared using gallic acid at concentrations ranging from 50 to 500 µg/mL. The results were expressed in µg of equivalent gallic acid (GAE) per mL of P. marsupium extract.

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 10, Iss 2, 2021

Total flavonoid content:

The aluminum chloride colorimetric method was used to calculate the flavonoid content in P . marsupium aqueous extract. One milliliter of P. marsupium heartwood extract (50 mg/mL) was mixed with 4 mL of distilled water, and 0.3% sodium nitrate was added . After incubation for 10 minutes, 0.3% aluminum chloride was added , and the solution was kept for 6 minutes . Then, 2 mL of 1 mol/L sodium hydroxide solution was added, and the mixture was further incubated for 15 minutes. The absorption was measured at 415 nm, and the total flavonoid content (TFC) was calculated using the calibration curve of quercetin (10-50 µg/mL) as a standard. The results were expressed as mg quercetin equivalent (QE) per gram of dry extract weight. All tests were conducted in triplicate.

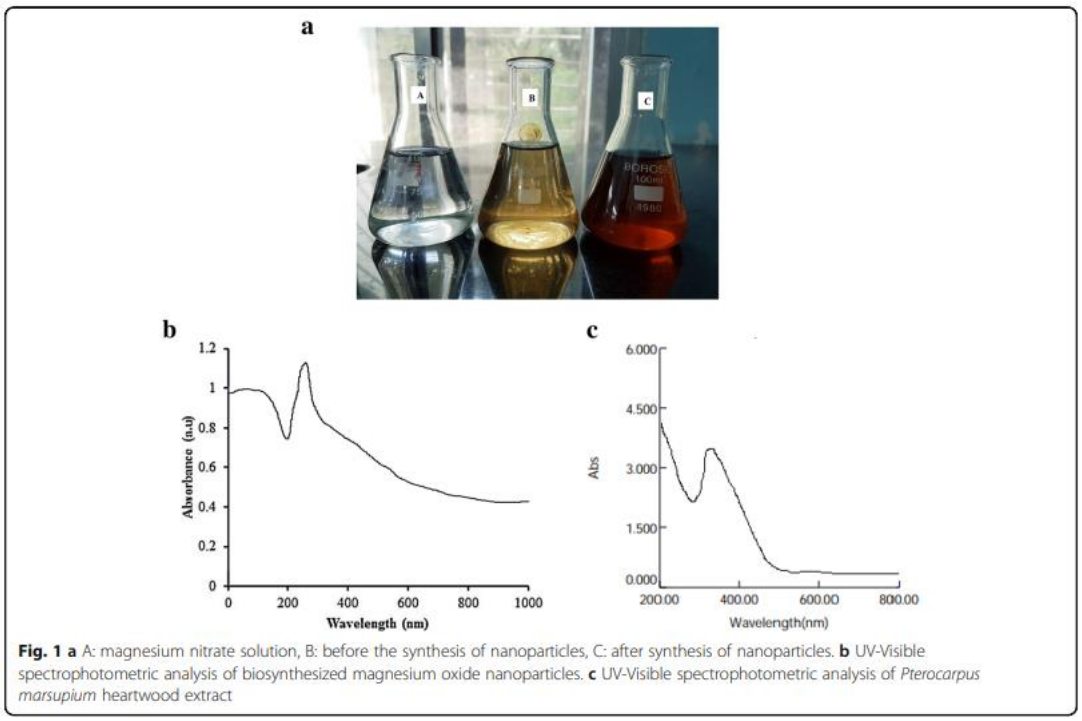

Fig. 1 a A: magnesium nitrate solution, B: before the synthesis of nanoparticles, C: after synthesis of nanoparticles. **b** UV-Visible spectrophotometric analysis of biosynthesized magnesium oxide nanoparticles. **c** UV-Visible spectrophotometric analysis of *Pterocarpus marsupium* heartwood extract

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 10, Iss 2, 2021

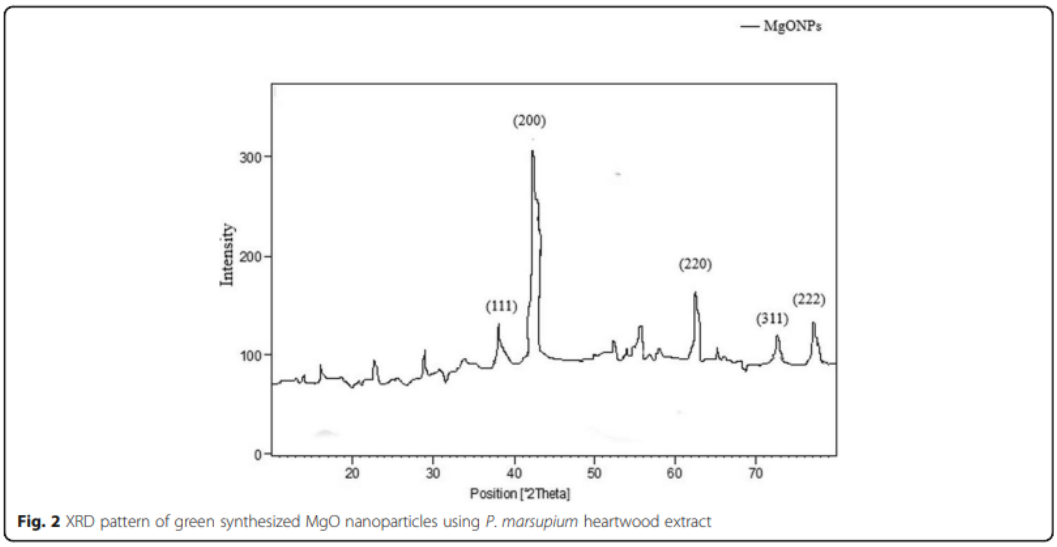

Fig. 2 XRD pattern of green synthesized MgO nanoparticles using *P. marsupium* heartwood extract

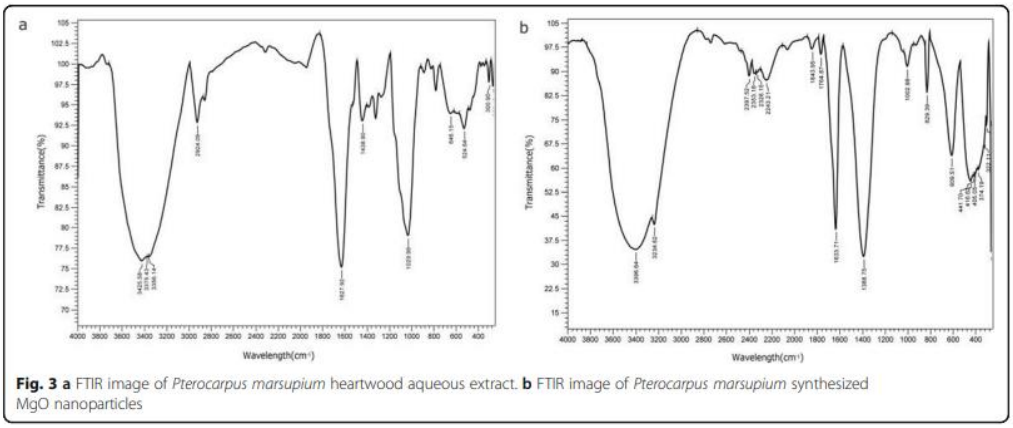

Fig. 3 a FTIR image of *Pterocarpus marsupium* heartwood aqueous extract. **b** FTIR image of *Pterocarpus marsupium* synthesized MgO nanoparticles

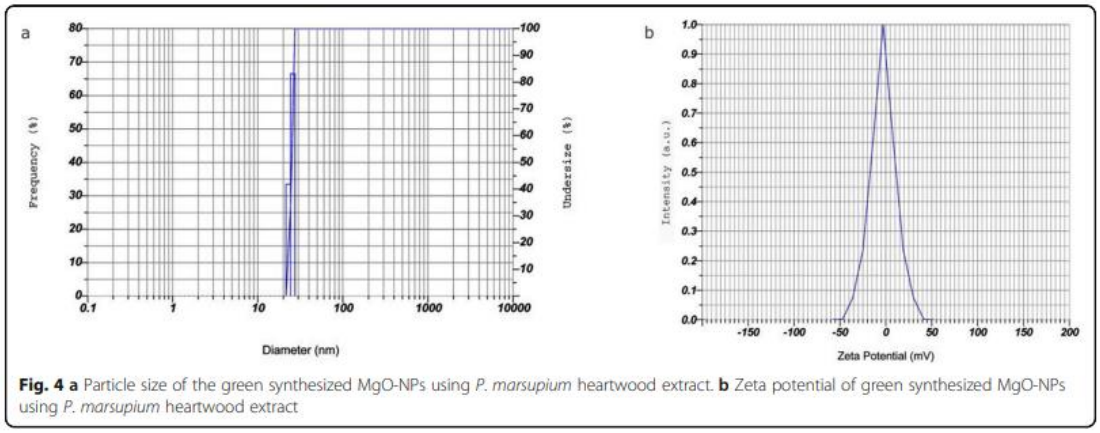

Fig. 4 a Particle size of the green synthesized MgO-NPs using *P. marsupium* heartwood extract. **b** Zeta potential of green synthesized MgO-NPs using *P. marsupium* heartwood extract

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 10, Iss 2, 2021

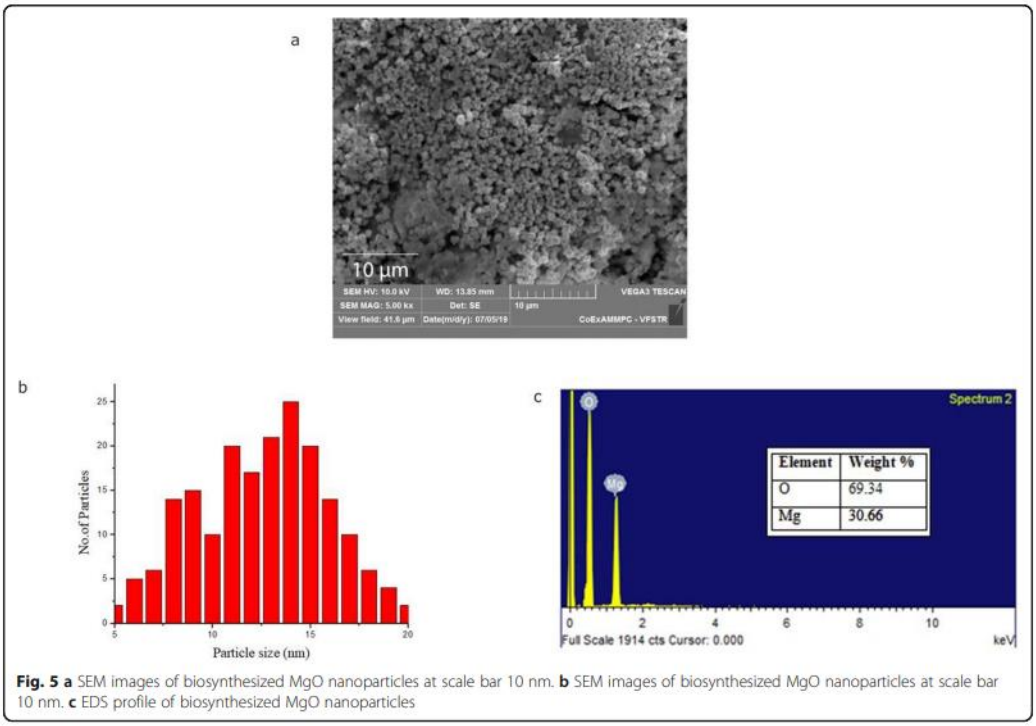

Fig. 5 a SEM images of biosynthesized MgO nanoparticles at scale bar 10 nm. **b** SEM images of biosynthesized MgO nanoparticles at scale bar 10 nm. **c** EDS profile of biosynthesized MgO nanoparticles

Conclusion:

In this study, we successfully synthesized magnesium oxide nanoparticles (MgO-NPs) using Pterocarpus marsupium heartwood extract as a green and eco-friendly method. The organic molecules present in the extract acted as reducing and stabilizing agents during the synthesis. The MgO-NPs were extensively characterized using various techniques such as UV, DLS, FT-IR, XRD, SEM, and TEM. Confirmation of MgO-NP formation was achieved through a distinct absorption peak at 310 nm in the UV analysis. FT-IR analysis provided evidence of the functional groups of P. marsupium contributing to the reduction and stabilization of MgO nanoparticles. The average size of the MgO-NPs (16.76 nm) was determined using the Debye Scherer formula from XRD analysis. SEM and TEM analysis further confirmed the nanometer-sized spherical shape of the MgO-NPs. The EDS analysis successfully identified the chemical composition of the MgO nanoparticles. The MgO-NPs exhibited notable antioxidant activity with an IC50 value of 89.67 µg/mL in the DPPH scavenging activity. In terms of antibacterial activity, the MgO-NPs displayed significant inhibitory effects against both Gram-positive and Gram-negative bacteria with MIC values of 22 ± 0.168 and 24 ± 0.439 µg/mL, respectively. Furthermore, the phytoassisted MgO-NPs showed promising antidiabetic activity through α-amylase inhibition, with an IC50 value of 56.32. Additionally, the MgO-NPs demonstrated

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 10, Iss 2, 2021

strong anti-inflammatory activity with an IC50 value of 81.69, as assessed by the albumin denaturation method.

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 10, Iss 2, 2021

References:

1. Abdelghany TM, Al-Rajhi AMH, Al Abboud MA et al (2018) Recent advances in green synthesis of silver nanoparticles and their applications: about future directions—a review. Bionanoscience 8:5–16 2. Irshad R, Tahir K, Li B, Ahmad A, Siddiqui AR, Nazir S (2017) Antibacterial activity of biochemically capped iron oxide nanopartciles: a view towards green chemistry. J Photochem Photobiol B 170:241–246. https://doi.org/10.1016/j.jphotobiol.2017.04.020

3. Mirzaei H, Davoodnia A (2012) Microwave-assisted sol-gel synthesis of MgO nanoparticles and their catalytic activity in the synthesis of hantzsch 1, 4- dihydropyridines. Chin J Catal 33:1502–1507 4. Kalaiarasi R, Jayallakshmi N, Venkatachalam P (2010) Phytosynthesis of nanoparticles and its applications. Plant Cell Biotechnol Mol Biol 11:1–16

5. Jeevanandam J, Chan YS, Danquah MK (2016) Biosynthesis of metal and metal oxide nanoparticles. Chem Bio Eng. https://doi.org/10.1002/cben. 201500018

6. Iravani S (2014) Bacteria in nanoparticle synthesis: current status and future prospects. Int Sch Res Notices. https://doi.org/10.1155/2014/359316

7. Sastry M, Ahmad A, Khan MI, Kumar R (2003) Biosynthesis of metal nanoparticles using fungi and actinomycete. Curr Sci 85(2):162–170

8. Hulkoti NI, Taranath T (2014) Biosynthesis of nanoparticles using microbes—review. Colloids Surf B 121:474–483. https://doi.org/10.1016/j. colsurfb.2014.05.027

9. Makarov V, Love A, Sinitsyna O, Makarova S, Yaminsky I, Taliansky M, Kalinina N (2014) Green nanotechnologies: synthesis of metal nanoparticles using plants. Acta Naturae 6:35–44

10. Iravani S (2011) Green synthesis of metal nanoparticles using plants. Green Chem 13:2638–2650. https://doi.org/10.1039/C1GC15386B

11. Emmanuel R, Palanisamy S, Chen SM, Chelladurai K, Padmavathy S, Saravanan M, Prakash P, Ali MA, Al-Hemaid FM (2015) Antimicrobial efficacy of green synthesized drug blended silver nanoparticles against dental caries and periodontal disease causing microorganisms. Mater Sci Eng 56:374–379

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 10, Iss 2, 2021

12. Gour A, Jain NK (2019) Advances in green synthesis of nanoparticles. Artif Cells Nanomed Biotechnol 47(1):844–851. https://doi.org/10.1080/21691401. 2019.1577878

13. Subhan A, Irshad R, Nazir S, Tahir K, Ahmad A, Khan AU, Khan ZUIH (2019) A new study of biomediated Pd/tiO2: a competitive system for Escherichia coli inhibition and radical stabilization. Mater Res Express 6:125430. https://doi. org/10.1088/2053-1591/ab5eaa

14. Rafique M, Sadaf I, Rafique MS et al (2017) A review on green synthesis of silver nanoparticles and their applications. Artif Cells Nanomed Biotechnol 45:1272–1291

15. Nguyen NHA, Padil VVT, Slaveykova VI, Cernik M, Sevcu A (2018) Green synthesis of metal and metal oxide nanoparticles and their effect on the Unicellular alga Chlamydomonas reinhardtii. Nanoscale Res Lett 13:159. https://doi.org/10.1186/s11671-018-2575-5

16. Varma RS (2012) Greener approach to nanomaterials and their sustainable applications. Curr Opin Chem Eng 1:123–128

17. Singh J, Kumar V, Kim K-H, Rawata M (2019) Biogenic synthesis of copper oxide nanoparticles using plant extract and its prodigious potential for photocatalytic degradation of dyes. Environ Res 177:108569

18. Mathur P, Jha S, Ramteke S et al (2017) Pharmaceutical aspects of silver nanoparticles. Artif Cells Nanomed Biotechnol 46:1–12

19. Liang SH, Gay ID (1986) A carbon-13 solid-state NMR study of the chemisorption and decomposition of ethanol on magnesium oxide. J Catal 101(2):293–300

20. Tsuji H, Yagi F, Hattori H, Kita H (1994) Self-condensation of n butyraldehyde over solid base catalysts. J Catal 148(2):759–770

21. Hussain AA, Nazir S, Irshad R, Tahir K, Raza M, Khan ZUIH, Khan AU (2020) Synthesis of functionalized mesoporous Ni-SBA-16 decorated with MgO nanoparticles for Cr (VI) adsorption and an effective catalyst for hydrodechlorination of chlorobenzene. Mater Res Bull 133:111059. https:// doi.org/10.1016/j.materresbull.2020.111059

22. Bhargava A, Alarco JA, Mackinnon ID, Page D, Ilyush-echkin A (1998) Synthesis and characterisation of nanoscale magnesium oxide powders and their application in thick films of Bi2 Sr2 CaCu2 O8. Mater Lett 34(3–6):133–142

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 10, Iss 2, 2021

23. Yuan YS, Wang SS (1996) Solid-state processing and phase development of bulk (MgO)w/BPSCCO high-temperature superconducting composite. J Mater Res 11(1):8–17

24. Yang PD, Lieber CM (1996) Nanorod-superconductor composites: a pathway to high critical current density materials. Science 273:1836–1849

25. Kaur J, Singh J, Rawat M (2019) An efficient and blistering reduction of 4- nitrophenol by green synthesized silver nanoparticles. SN Appl Sci 1:1060. https://doi.org/10.1007/s42452-019-1088-x

26. Singh J, Kumar V, Jolly SS, Kim K-H, Rawata M, Kukkara D, Tsange YF (2019) Biogenic synthesis of silver nanoparticles and its photocatalytic applications for removal of organic pollutants in water. J Industr Eng Chem 80:247–257

27. Singh J, Mehta A, Rawata M, Basub S (2018) Green synthesis of silver nanoparticles using sun dried tulsi leaves and its catalytic application for 4- Nitrophenol reduction. J Environ Chem Eng 6:1468–1474

28. Singh J, Kukkar P, Sammi H, Rawat M, Singh G, Kukkar D (2017) Enhanced catalytic reduction of 4-nitrophenol and congo red dye By silver nanoparticles prepared from Azadirachta indica leaf extract under direct sunlight exposure. Particul Sci Technol. https://doi.org/10.1080/02726351. 2017.1390512

29. Singh K, Kukkar D, Singh R, Kukkar P, Bajaj N, Singh J, Rawat M, Kumar A, Kim K-H (2020) In situ green synthesis of Au/Ag nanostructures on a metalorganic framework surface for photocatalytic reduction of p-nitrophenol. J Industr Eng Chem 81:196–205. https://doi.org/10.1016/j.jiec.2019.09.008

30. Rawat M, Singh J, Singh J, Singh C, Singh A, Kukkar D, Kumar S (2017) Synthesis of Cu and Ce-doped ZnO nanoparticles: crystallographic, optical, molecular, morphological and magnetic studies. Mater Sci 35(2). https://doi. org/10.1515/msp-2017-0040

31. Kaur S, Singh J, Rawat R et al (2018) A smart LPG sensor based on chemobio synthesized MgO nanostructure. J Mater Sci 29:11679–11687. https://doi. org/10.1007/s10854-018-9266-y

32. Stoimenov PK, Klinger RL, Marchin GL, Klabunde KJ (2002) Metal oxide nanoparticles as bacterial agents. Langmuir 18:6679–6686

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 10, Iss 2, 2021

33. Lin ST, Klabunde JK (1985) Thermally activated magnesium oxide surface chemistry. Adsorption and decomposition of phosphorus compounds. Langmuir 1(5):600–605

34. Moorthy SK, Ashok CH, Venkateswara Rao K, Viswanathan C (2015) Synthesis and characterization of MgO nanoparticles by Neem leaves through green method. Mater Today Proc 2:4360–4368