IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Green Synthesis of MgO Nanoparticles Using Rose Petals Extract: Characterization and Photocatalytic Degradation of Methylene Blue

Priyal Kangane[1], Sandesh Jaybhaye[2] and Bhushan Langi[1]

Department of Chemistry, Satish Pradhan Dnyansadhana College, Kalyan, India

Nanotech Research Lab, Department of Chemistry, B. K. Birla College, Kalyan, India

Abstract:

This research demonstrates a sustainable green synthesis of magnesium oxide nanoparticles (MgO NPs) utilising *Rosa centifolia* rose petals extract as a natural reducing and capping agent from magnesium nitrate precursor, followed by calcination at 500°C. The resulting cubic-phase NPs, with crystallite sizes of 40–52 nm, were comprehensively characterized using XRD, FTIR, SEM-EDX, and UV-Vis, revealing spherical morphology, pure Mg-O bonding, and a wide bandgap of ~4.8 eV suitable for photocatalysis. Under visible light irradiation, the MgO NPs exhibited superior photocatalytic activity, achieving 98% degradation of methylene blue dye within 120 minutes at 1 g/L catalyst loading, outperforming unmodified counterparts due to enhanced charge separation and active surface sites from rose extract stabilisation.

Keywords

MgO nanoparticles, green synthesis *Rosa Centifolia*, rose petals extract, photocatalytic degradation, methylene blue dye, eco-friendly, wastewater treatment

1. Introduction

The nanotechnology field has attracted many researchers due to its broad range of applications. This field has technology combined in synthesis, characterization, and the creation of implementations from the manufactured particles, which is a minimum of one dimension on the nanoscale. Nanoparticles are structural constituents on the scale between 1- and 100-nm particles [1]

Magnesium oxide nanoparticles are attracting more interest compared with other metal oxide nanoparticles. They are effectively used in several areas, and they have interesting structural particles in biological applications because of their increased stability-to-weight ratio, less witness, better properties, are recyclable, nontoxic, and are hygroscopic in nature. These properties of MgO NPs enhance the activity and also have several applications like an increase in melting point, high cost, biocatalytic properties, and biocompatibility [2,3]

Water contamination by organic dye discharges from textile dyeing, paper making, paints, cosmetics, and food processing industries has attracted considerable attention recently owing to health hazards posed to humans and of other living organisms [4](Miao et al., 2020; Shang et al., 2021; Wang et al., 2020) Due to their colour and toxic products generated through hydrolysis and oxidation reactions in the wastewater phase, the discharge of effluents containing low biodegradable dyes into the water bodies is not desirable[5]. Among the various methods for treating dye-contaminated water, photocatalytic degradation of organic pollutants has received significant attention [6]. The traditional technologies for treating wastewater, in particular, coagulation, adsorption, flocculation, advanced oxidation, and precipitation do not only require

long operation times, but they also produce secondary sludge, which is expensive to dispose of [7]. Inorganic materials such as metal and metal oxides in nano-dimensions have received considerable attention in recent years owing to their potential use in several applications, including photocatalytic dye degradation [8].
Several methods have been explored to synthesise MgO nanoparticles, including the hydrothermal, sol–gel, co-precipitation, and chemical gas phase methods [8]. However, in general, these methods use several toxic reagents, strong acids and bases to synthesise MgO, which create environmental problems. Hence, it remains a challenge to synthesise MgO nanoparticles using safe, eco-friendly, and low-cost approaches. Recent efforts have turned towards the development of green synthesis approaches, where organisms such as yeast, bacteria, sugars, algae, polymers and plant extracts are used for the synthesis of nanoparticles
Magnesium oxide is a resourceful oxide material with numerous attributes such as high chemical and photo stability, large band gap, low dielectric constant and refractive finds many industrial applications and scientific applications in diverse fields of catalysis, antimicrobial and antibacterial materials, wastewater remediation, solar cells and supercapacitors.[9-10,14] To the best of our knowledge, the studies based on the employment of MgO nanoparticles for the wastewater remediation are quite limited[14]. Hence, from the environmental concern point of view, it is considerable to focus on the green synthesis of MgO nanoparticles for the degradation of hazardous organic contaminants as well as studying its antibacterial activity [11,12]
In the present work, the study focuses exclusively on the photocatalytic degradation of Methylene blue dye using MgO nanoparticles synthesised with *Rosa centifolia* (rose) petal extract. The rose extract acts as a green reducing and capping agent, helping to stabilize the MgO nanoparticles and providing a suitable surface for photocatalytic activity. Under UV light irradiation, these MgO nanoparticles generate electron–hole pairs and reactive oxygen species that promote the breakdown of Methylene blue dye molecules, leading to a measurable decrease in dye concentration over time. The study evaluates key parameters such as dye degradation efficiency, reaction kinetics, and the influence of nanoparticle concentration and irradiation time on the photocatalytic performance.

2. Materials and Method

2.1 Preparation of flower petals extract

Dried petals of *Rosa Centifolia* rose were collected from various temples in Kalyan flowers petals dried in sunlight in two days then grind in mortal pastel then it is powder from 10 gm of petals powder add in 100 ml DI water, the extract mixture was then filtered using filter paper and then filter mixture was then stored in refrigerator at 4^0C for further utilization in the experiments.

2.2 Green synthesis of MgO nanoparticles using Petals extract

Magnesium nitrate hexahydrate [$Mg(NO_3)_2 \cdot 6H_2O$] was dissolved in 50 mL of distilled water to prepare a 2 M solution. The solution was stirred magnetically for 90 minutes to ensure complete dissolution. Then, 50 mL of filtered petals extract was added dropwise (1:1 ratio with distilled water) into the $Mg(NO_3)_2$ solution under continuous stirring. Upon addition, the colour of the reaction mixture gradually changed to dark pinkish red, indicating the formation of Mg precursor complexes. The pH of the solution was adjusted to 9 using NaOH, and the mixture was allowed to react for 90 min under stirring to complete the reaction. The resulting mixture was poured into a petri dish and dried in a hot air oven at 100 °C for 12 h to remove the solvent and obtain a solid residue. The dried product was finely ground into powder and calcined in a muffle furnace at 500 °C for 3 h to obtain pure MgO nanoparticles. The calcined MgO Nano powder was obtained as a fine whitish powder and stored in a desiccator for further characterisation, as well as for evaluating its antibacterial and photocatalytic activity. Fig. 1 illustrates the schematic representation of the preparation process of MgO nanoparticles.

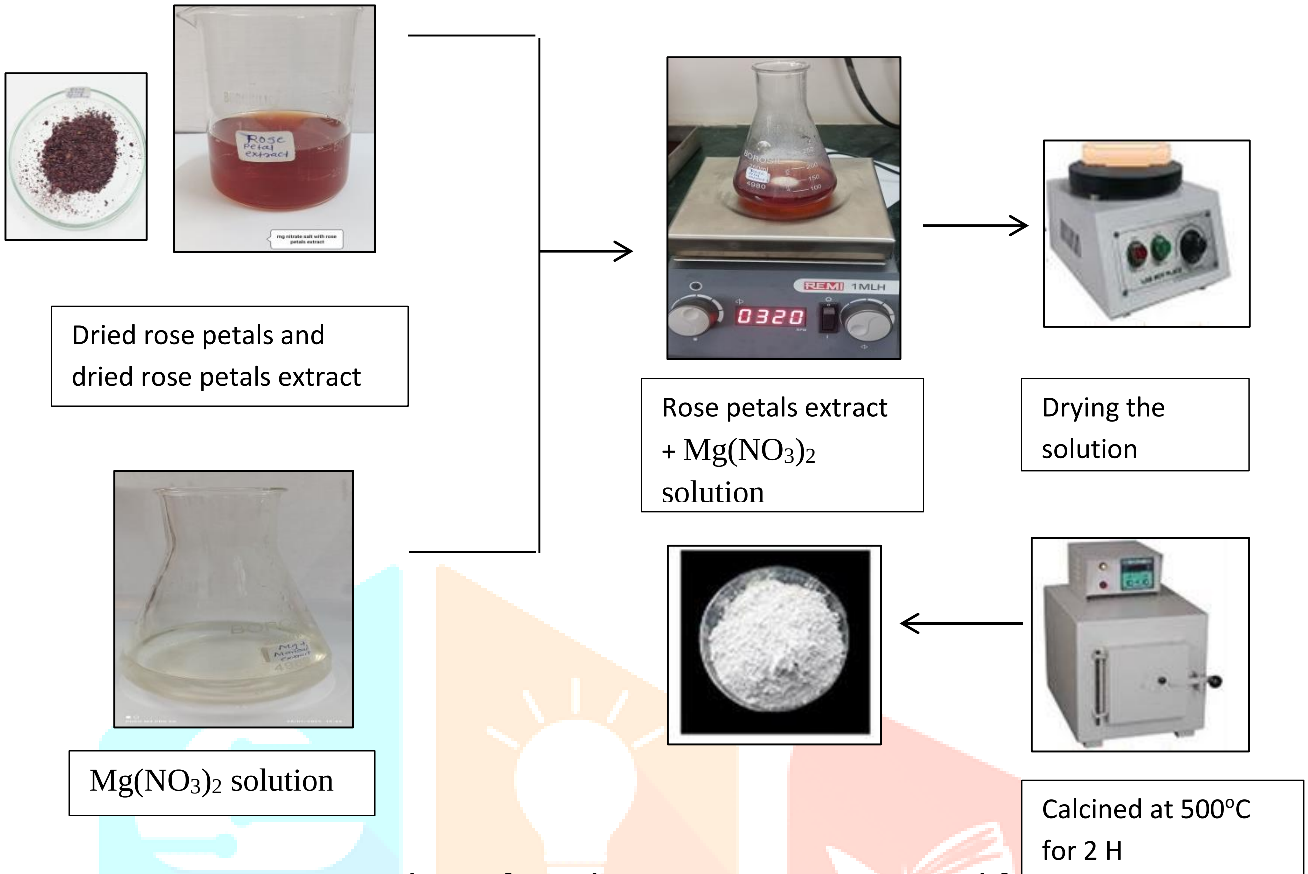


Fig. 1 Schematic to prepare MgO nanoparticles.

2.3 Characterisation of MgO nanoparticles.

The structural properties of MgO nanoparticles were analysed by X-ray diffraction (XRD; Bruker D2 PHASER (often designated in 2nd generation as A26-X1-A2B0B2B)) with Cu-Kα (λ=1.5418 Å) radiation at a grazing angle 1^{o} and a step size of 0.25 deg in the range of 10 ° to 80°. Fourier transform infrared spectroscopy **(**JASCO FT/IR-4X Series serial no. A150562111**)** at room temperature in the wavelength range of 400–4000 cm-1. The morphologies of the synthesised MgO nanoparticles were examined by scanning electron microscopy (SEM: Zeiss). The optical properties of MgO nanoparticles were estimated from

UV-vis. Spectroscopy

2.4 Photocatalytic activity

The photocatalytic performance of MgO nanoparticles was evaluated by monitoring the degradation of Methylene blue (MB) dye under zero bulb light irradiation from a 100 W bulb. First, a 100 ppm MB stock solution was prepared by dissolving 0.01 g of MB dye in 100 mL of distilled (DI) water. From this, a 10-ppm working solution (100 mL) was used for the experiment. Then, 0.05 g (50 mg) of MgO nanoparticles was added to 100 mL of 10 ppm MB solution under magnetic stirring. Before irradiation, the suspension was stirred in the dark for 30 min to establish adsorption/desorption equilibrium. The suspension was then irradiated with a 100 W bulb while stirring magnetically. During irradiation, 2 mL aliquots were withdrawn at 30 min intervals, centrifuged to remove catalyst particles, and analysed by UV-Vis spectrophotometer at λmax = 665 nm. Degradation efficiency was calculated as

$$\textbf{Degradation(\%)}=(C_0-C)/C_0\times100\%$$

where C_0 = initial MB concentration, C = concentration after time *t*. This setup aligns with standard photocatalysis protocols for dye degradation using metal oxide nanoparticles.

3. Results and discussion

2.3 Characterisations and properties of synthesised MgO nanoparticles

The structural properties of the synthesized MgO were examined by XRD and result is presented in Fig. 2. Fig. 2 exhibit the typical XRD pattern of synthesized MgO material which exhibited various diffraction peaks at 2θ= 36.91°, 42.88°, 62.25°, 74.62° and 78.55°, corresponding to the crystal planes of MgO (111), (200), (220), (311) and (222), respectively. The observed diffraction peaks are well matched with the face-centred cubic structure of MgO. The observed XRD results are well-matched with the JCPDS card no. 00-043-1022

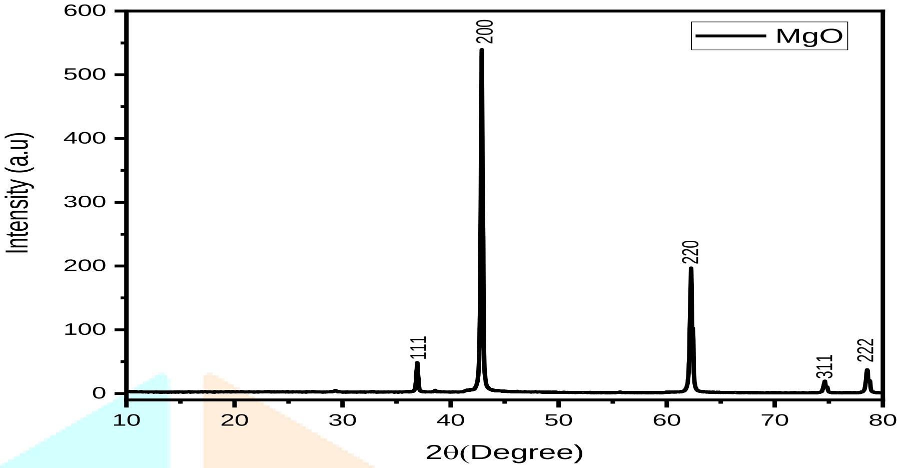
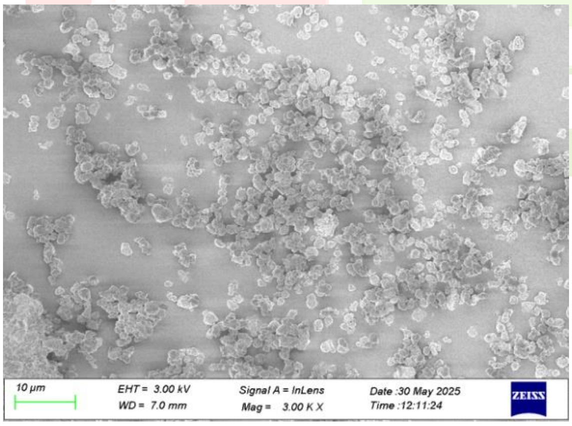


Fig. 2 Typical XRD pattern of synthesised MgO nanoparticles.

The general morphologies of the synthesised MgO material were characterised by scanning electron microscopy (SEM), and the results are demonstrated in Fig. 3, which exhibits the typical SEM images which exhibited that show the particle-shaped morphologies of the synthesised MgO material. The MgO nanoparticles are found to be uniform, dense, agglomerated and spherical cubic in shape. The typical sizes of the nanoparticles are in the range of 1 μm and the average particle size is 52nm



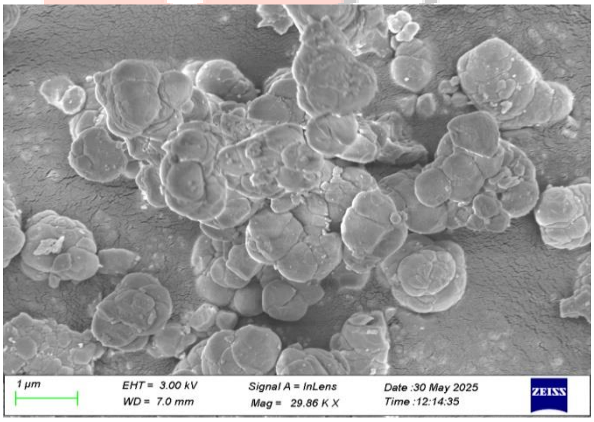


Fig. 3 Typical SEM images of synthesized MgO nanoparticles.

The material was further characterised by FTIR spectroscopy. Fig.4 shows the FTIR spectrum of synthesised MgO nanoparticles. The FTIR spectrum of the prepared sample shows a nearly flat transmittance pattern in the higher wavenumber region and a strong absorption at the lower end, which is typical of magnesium oxide nanoparticles. The characteristics Mg-O Stretching vibration is generally reported in the range of about 500-700 cm^{-1} and Mg-O bonds near 420,560,594,602,655 and 678 $cm^{-1,}$ depending on synthesis condition he strong low—wavenumber feature is consistent with Mg-O bond formation and confirms the synthesis of MgO nanoparticles.

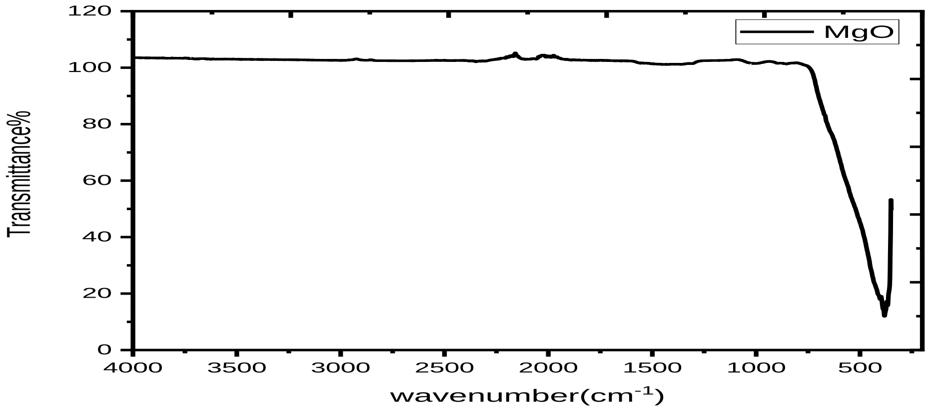


Fig. 4 Typical FTIR spectrum of synthesized MgO nanoparticles.

The optical properties and electronic structure of MgO nanoparticles can be characterized using UV-vis spectroscopy in the range of 200- 800 nm. Fig. 5 depicts the typical UV-vis. spectrum of synthesized MgO nanoparticles. The UV-vis spectrum shows a single absorption band at 264 nm.

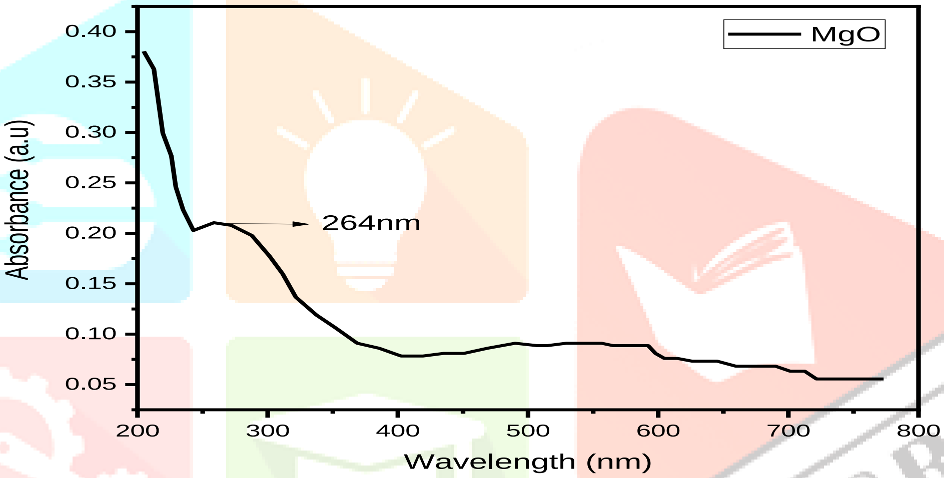


Fig. 5 Typical UV-Vis. spectrum of synthesized MgO nanoparticles.

3.3. Photocatalytic properties of MgO nanoparticles

The photocatalytic activity of MgO nanoparticles was monitored by degrading the Methylene blue blue dye under UV irradiation. Methylene blue dye is an important class of synthetic organic dyes used in the textile industries and is common industrial pollutants. Due to the interaction between the photocatalyst and the dye molecule, the efficiency of degradation was increased. The synthesized MgO nanoparticles exhibited 98% of decolourization of methylene blue dye in mere 120 min under UV irradiation, indicating the complete decomposition of dye molecules by MgO nanoparticles. The gradual disappearance of the absorption bands of Methylene blue dye suggested that the functional groups responsible for the characteristic colour of the dye are broken down. The time- dependent UV-vis absorption spectra of victoria blue dye in the presence of MgO nanoparticles

Conclusion

In summary, MgO nanoparticles were synthesised by a facile and green method using rose petals extract (*Rosa centifolia*). The synthesised MgO nanoparticles were characterised by several techniques, which confirmed the face-centred cubic structure. The nanoparticles exhibited smooth and clean surfaces with spherical morphologies. MgO nanoparticles showed appreciable photocatalytic activity against Methylene blue dye under UV irradiation and the degradation efficiency was estimated to be 98% in 120 min. Overall, it might be anticipated that the obtained outcomes can fasten the feasibility of employing MgO nanoparticles as a potential candidate for photocatalytic applications in addressing water contamination and environmental pollution.

Fig. 6 Typical Photocatalytic Degradation using Methylene blue dye

Acknowledgments

We sincerely thank the Nanotech Research lab, Department of Chemistry, B.K. birla College, Kalyan, for providing essential lab facilities and equipment. Our heartfelt gratitude goes to our supervisors for their constant guidance and to our colleagues for their help during experiments.

Reference

1. Khan, I.; Saeed, K.; Khan, L. Nanoparticles: Properties, applications and toxicities. Arab. J. Chem. 2019, 12, 908–931.
2. Mihai, M.M.; Dima, M.B.; Dima, B.; Holban, A.M. Nanomaterials for wound healing and infection control. Materials 2019, 12, 2176.
3. Choudhary, S.; Kumar, R.; Dalal, U.; Tomar, S.; Reddy, S.N. Green synthesis of nanometal impregnated biomass–antiviral potential. Mater. Sci. Eng. C 2020, 112, 110934.
4. Miao, Y., Xu, X., Liu, K., Yu, S., Wang, Y., Yang, S., 2020. Preparation and activity evaluation of the novel Cu/TiO2 nanometer photocatalytic materials. Sci. Adv. Mater. 12, 1027–1033
5. Panimalar, S., Uthrakumar, R., Tamil Selvi, E., Gomathy, P., Inmozhi, C., Kaviyarasu, K., Kennedy, J., 2020. Studies of MnO2/g-C3N4 hetrostructure efficient of visible light photocatalyst for pollutants degradation by sol–gel technique. Surf. Interfaces 20, 100512.
6. Saini, Meenu, Dehiya, Brijnandan S., Umar, Ahmad, VO, 2020. Ceram. Int. 46 (1), 986–995
7. Wei, Y.X., Ma, M.G., Li, S.Y., Liu, F., Zhao, G.H., 2020. Visible light activity in phenol degradation of C60@P25 photocatalyst with Core–Shell structure. J. Nanoelectron. Optoelectron. 15, 189–196.
8. Kaviyarasu, K., Maria Magdalane, C., Jayakumar, D., Samson, Y., Bashir, A.K.H., Maaza, M., Letsholathebe, Douglas, Hossam Mahmoud, Ahmed, Kenned, J., 2020. High performance of pyrochlore like Sm2Ti2O7 heterojunctionphotocatalyst for efficient degradation of rhodamine-B dye with wastewater under visible light irradiation. J. King Saud Univ.-Sci. 32, 1516–1522.
9. K. Karthik, S. Dhanuskodi, S. Prabu Kumar, C. Gobinath, S. Sivaramakrishnan, Mater. Lett., 2017, 206, 217-220.
10. J. Y. Park, Y. J. Lee, K. W. Jun, J. O. Baeg, D. J. Yim, J. Ind. Eng. Chem., 2006, 12, 882-887.
11. S. Ashok Kumar[1], M. Jarvin[1], Shelja Sharma[2]Facile and Green Synthesis of MgO Nanoparticles for the Degradation of Victoria Blue Dye under UV Irradiation and their Antibacterial Activity ES Food Agrofor., 2021, 5, 14-19
12. S. Sagar Dhage [a], D. P. Biradar [a] Green Synthesis and Characterization of Magnesium Oxide Nanoparticles from Leaf Extracts of Amaranthus retroflexus and Azadirachta indica, International Journal of Environment and Climate Change Volume 13, Issue 9, Page 214-219, 2023; Article no.IJECC.101959
13. Saheb Ali 1, Kattakgoundar Govindaraj Sudha 2, Green Synthesis of Magnesium Oxide Nanoparticles by Using Abrus precatorius Bark Extract and Their Photocatalytic, Antioxidant,

Antibacterial, and Cytotoxicity Activities Bioengineering 2023, 10, 302. https://doi.org/10.3390/bioengineering10030302

14. S. Ashok Kumara, M. Jarvina, Facile green synthesis of magnesium oxide nanoparticles using tea(Camellia sinensis) extract for efficient photocatalytic degradation of methylene blue dye, Environmental Technology & Innovation 28 (2022) 102746