ScienceDirect

Chemosphere

Volume 312, Part 1, January 2023, 137301

A critical review on the bio-mediated green synthesis and multiple applications of magnesium oxide nanoparticles

Ngoan Thi Thao Nguyen [a, b], Luan Minh Nguyen [a, b], Thuy Thi Thanh Nguyen [b, c], Uyen P.N. Tran [d], Duyen Thi Cam Nguyen [a, e], Thuan Van Tran [a, e]

Show more

Share Cite

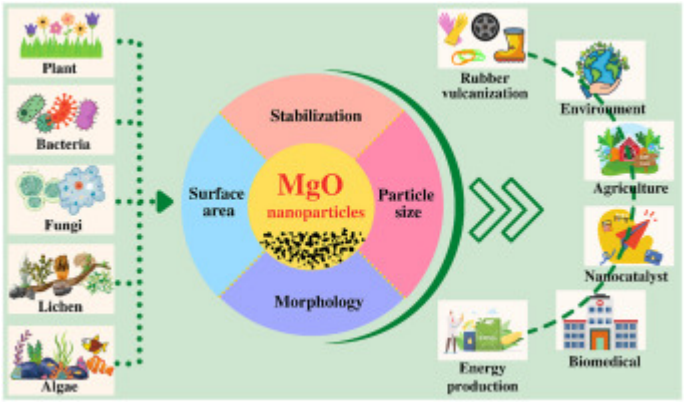
https://doi.org/10.1016/j.chemosphere.2022.137301 Get rights and content

Abstract

Nowadays, advancements in nanotechnology have efficiently solved many global problems, such as environmental pollution, climate change, and infectious diseases. Nano-scaled materials have played a central role in this evolution. Chemical synthesis of nanomaterials, however, required hazardous chemicals, unsafe, eco-unfriendly, and cost-ineffective, calling for green synthesis methods. Here, we review the green synthesis of MgO nanoparticles and their applications in biochemical, environmental remediation, catalysis, and energy production. Green MgO nanoparticles can be safely produced using biomolecules extracted from plants, fungus, bacteria, algae, and lichens. They exhibited fascinating and unique properties in morphology, surface area, particle size, and stabilization. Green MgO nanoparticles served as excellent antimicrobial agents, adsorbents, colorimetric sensors, and had enormous potential in biomedical therapies against cancers, oxidants, diseases, and the sensing detection of dopamine. In addition, green MgO nanoparticles are of great interests in plant pathogens, phytoremediation, plant cell and organ culture, and seed germination in the agricultural sector. This review also highlighted recent advances in using green MgO nanoparticles as nanocatalysts, nano-fertilizers, and nano-

pesticides. Thanks to many emerging applications, green MgO nanoparticles can become a promising platform for future studies.

Graphical abstract



Download : Download high-res image (396KB) Download : Download full-size image

Introduction

Nanotechnology concentrates mainly on a group of materials with the dimension of one unit lies within 100 nm, and prominent physical and chemical properties for a wide variety of fields. In recent years, nanomaterials have shown outstanding performance in multiple applications like catalysis (Astruc, 2020), biomedical technology (Canaparo et al., 2020), environmental science (Theophil Anand et al., 2021), anti-oxidation (Abdollahi et al., 2021), food packaging (Nikolic et al., 2021), agriculture (Fatima et al., 2021), sensing technology (Montes-García et al., 2021), etc. Among the different metal oxide nanoparticles, magnesium oxide (MgO) nanoparticles are economically viable, highly biocompatible, and stable under extreme conditions (Faisal et al., 2021; Saied et al., 2021). MgO has unique features such as superior refractive index (Jebur et al., 2019), excellent corrosion resistance (Lin et al., 2018), high thermal conductivity (Saranprabhu and Rajan, 2019), and low electrical conductivity (Giwa et al., 2021). These properties allow MgO nanoparticles to access to catalysis, electronics, ceramics, additives, photochemical products, and drugs production (Amina et al., 2020). As an example, MgO nanoparticles have not only been used as adsorbents for removing organic and inorganic contaminants from wastewater but also acted as electrochemical biosensors, photocatalysts, and refractories (Abinaya et al., 2021). Thanks to high ionic character, high crystalline and layered structure, and surface structural defects, MgO nanoparticles can be adopted in rubber vulcanization and energy production (Bindhu et al., 2016).

.

Conventional synthesis processes use toxic substrates that adversely affect both the environment and human health. Their secondary products generated during synthesis are also capable of life-

threatening. Meanwhile, physical synthesis requires expensive machinery and equipment, energy and time consumption (Aboyewa et al., 2021).. Therefore, green methods have been widely developed to synthesize MgO nanoparticles in eco-friendly, cost-effective, and energy-efficient manners (Jadoun et al., 2020). Natural sources like plants (Khan et al., 2021), bacteria (Ogunyemi et al., 2020), fungi (Fathy and Mahfouz, 2021), algae (Pachiyappan et al., 2020) and lichens (Alavi and Karimi, 2020)contain phytochemicals, biomolecules, amino acids, polysaccharides, polyphenols, and vitamins, which act as reducing agents and chemical stabilizers to replace harmful chemicals (David and Moldovan, 2020; Jeevanandam et al., 2022). Green MgO nanoparticles are also formed extracellularly or intracellularly by enzymes and proteins in microbial species of fungi and bacteria (Bandeira et al., 2020). For plants, MgO nanoparticles can be synthesized using natural compounds extracted from different parts, including leaves, flowers, roots, bark, fruits, stems, and sap. Algae and lichens are also potential precursors for the synthesis of MgO.

As compared to chemical and physical approaches, the green synthesis of MgO nanoparticles has many advantages such as benignity, safety, effectiveness, and eco-friendliness. Although several reviews have mentioned narrow scopes of applications of green MgO, other promising areas such as biomedical, environmental, agricultural, bio-sensing and energy production were not still discussed yet. To the best of our knowledge, such potential areas of green MgO nanoparticles have been comprehensively reviewed for the first time in this study. We also hope the present review will provide a fascinating highlight on green MgO nanoparticles for future applications.

Section snippets

Fundamentals of green synthesis

Green routes to synthesize MgO nanoparticles have been published by a considerable amount of research groups in the last decades. Green synthesis minimizes the use of toxic chemicals and the release of secondary pollutants into the environment (Nguyen et al., 2021b). Another advantage of synthesis of MgO using green resources is to obtain low production and energy saving. Their approaches would go in agreement with the twelve principles of green chemistry. This section provides biological modes ...

Characterization techniques

Green MgO nanoparticles possess unique physicochemical properties that must be analyzed by various reliable characterization techniques. Most prioritized among these properties are morphology, particle size, surface area, and stability, which have implications for research and development in their later applications. In this section, we describe a combinatorial approach of

techniques required to characterize these four main characteristics. To be more specific, Fig. 5 illustrates some...

Background

In this section, objective assessments of MgO nanoparticles in each biomedical application are provided. An overview of each application type and approaching formation mechanism of MgO nanoparticles in each field of biomedicine are also elucidated. In addition, several studies documenting the biomedical advancements in nanotechnology, specifically MgO were collected and compared. These evidences demonstrate the special ability of MgO nanoparticles and their potential in future medical...

Detection of toxic chemicals

Metal ions are discharged from wastewater from factories or daily life is an urgent problem for the environmental ecosystem. Living organisms and even humans accidently consuming water contaminated with these metal ions can develop dangerous health problems (Chandraker et al., 2019). Therefore, determining the presence of metal ions in water helps the technology to treat tap water and wastewater increasingly develop (Roto et al., 2019). The metal ion detection methods include thermoelectric...

Plant pathogens

Bacterial diseases cause much damage to crops and directly affect the quality and quantity of agricultural products. In the worst-case scenario, plant diseases can even result in a complete failure to harvest seeds and thereby can have a disastrous impact on global food security. A typical example is the rice bacterial leaf blight, a common disease in rice-producing countries that is highly destructive and causes yield losses of up to 50% depending on rice variety, growth stage, and farming...

Nanocatalysts

Currently, the size and shape-selective synthesis of MgO nanoparticles and their diverse catalytic applications are attracting much interest in nanochemistry. The properties of MgO nanoparticles are good thermodynamic stability, low refractive index and dielectric constant (Aziz and Karim, 2019). One of the standard catalytic reaction models to test catalytic activities is the reduction of 4–nitrophenol to 4–aminophenol. 4–nitrophenol occurs as a crystalline solid, can cause severe skin and eye ...

Activators for rubber vulcanization

Natural rubber is converted into a more durable material through a chemical process called vulcanization. This process typically uses ZnO to improve the mechanical properties of the rubber by cross-linking unsaturated polymer chains (Maciejewska et al., 2021). It was recently discovered that MgO nanoparticles can act as an activator in the vulcanization process of rubber. Indeed, Silva et al. (2021) used MgO nanoparticles using *C. sinensis* leaf extract as an activator in nitrile rubber...

Energy production

Industrialization and modernization leading to high energy use, rapid increase in oil prices and other harmful effects leading to greenhouse effect have led people to turn their attention to alternative energy sources (Rizwanul Fattah et al., 2020). The challenge is to find potential energy sources that are renewable, biodegradable and especially non-toxic and environmentally friendly. Biodiesel is a renewable, clean-burning, domestically produced alternative with the potential to replace...

Challenges and solutions

Along with the presented results, green MgO nanoparticles still have many limitations to achieve higher efficiency in each application. First of all, the utilization of MgO photocatalysts under visible-light irradiation conditions to remove pollutants is still narrowed due to their large band gap. It recommends that green MgO should be doped with some semiconductor materials such as $ZnFe_2O_4$, CdS, and WO_3 with low band gap energy to enhance visible light absorption. Besides, the surface area and ...

Conclusion

This review comprehensively addressed the unique properties of MgO nanoparticles for a wide range of applications such as biomedical, environment, agriculture, and energy production. Green MgO nanoparticles could be produced using safe, sustainable and eco-friendly sources such as the extraction of plants, fungi, bacteria, algae, and lichens. Many factors including pH, temperature and extraction ratio profoundly affected the morphology, size, surface area, and stability of MgO nanoparticles....

Author contribution statement

Ngoan Thi Thao Nguyen: Conceptualization; Data curation; Investigation; Methodology; Writing - original draft. Luan Minh Nguyen: Data curation; Investigation; Validation; Writing - original

draft. Thuy Thi Thanh Nguyen: Writing - review & editing; Data curation; Validation; Validation. Uyen P. N. Tran: Writing - review & editing; Data curation; Validation. Duyen Thi Cam Nguyen: Conceptualization; Writing - review & editing; Validation; Data curation; Supervision. Thuan Van Tran:...

Funding information

There was no external funding for this study....

Conflicts of interest/Competing interests

The authors declare that there are no conflicts of interest....

Availability of data and material

The authors declare that all data and materials support their published claims and comply with field standards....

Compliance with ethical standards

The authors declare that.

- The manuscript has not been published anywhere nor submitted to another journal....
- The manuscript is not currently being considered for publication in any another journal....
- All authors have been personally and actively involved in substantive work leading to the manuscript, and will hold themselves jointly and individually responsible for its content....
- Research does not involve any Human Participants and/or Animals....

...

Code availability

The authors declare that software application or custom code supports their published claims and comply with field standards....

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper....

Acknowledgment

The authors would love to appreciate the effort of researchers all over the world in the fight against the COVID-19 pandemic. We also acknowledge Mina Rees Library, The Graduate Center of the City University of New York (CUNY) for granting access to databases, Freepik company projects at http://www.freepik.com, and Canva® graphic design platforms at http://www.canva.com for many graphic resources reproduced in this work....

References (232)

Kainat *et al.*
Exploring the therapeutic potential of Hibiscus rosa sinensis synthesized cobalt oxide (Co3O4-NPs) and magnesium oxide nanoparticles (MgO-NPs)
Saudi J. Biol. Sci. (2021)

B.H. Jume *et al.*
Biodiesel production from waste cooking oil using a novel heterogeneous catalyst based on graphene oxide doped metal oxide nanoparticles
Renew. Energy (2020)

R. Javaid *et al.*
Subcritical and supercritical water oxidation for dye decomposition
J. Environ. Manag. (2021)

H. Jan *et al.*
Biogenically proficient synthesis and characterization of silver nanoparticles (Ag-NPs) employing aqueous extract of Aquilegia pubiflora along with their in vitro antimicrobial, anti-cancer and other biological applications
J. Mater. Res. Technol. (2021)

M.S. Jameel *et al.*
Comparative analysis of platinum nanoparticles synthesized using sonochemical-assisted and conventional green methods
Nano-Structures & Nano-Objects (2020)

A. Jain *et al.*
Colorimetric sensing of Fe3+ ions in aqueous solution using magnesium oxide nanoparticles synthesized using green approach
Chem. Phys. Lett. (2018)

I. Ihsanullah *et al.*
Bioremediation of dyes: current status and prospects
J. Water Proc. Eng. (2020)

A. Husain *et al.*
DC electrical conductivity and liquefied petroleum gas sensing application of polythiophene/zinc oxide nanocomposite
Materialia (2020)

R. Gupta *et al.*
Clinical considerations for patients with diabetes in times of COVID-19 epidemic
Diabetes Metab. Syndr. Clin. Res. Rev. (2020)

G. Güney *et al.*
A look into Colorado potato beetle lipid metabolism through the lens of lipid storage droplet proteins
Insect Biochem. Mol. Biol. (2021)

View more references

Cited by (0)

Recommended articles (6)

Research article

WO_3/rGO nanocomposite-based sensor for the detection and degradation of 4-Chlorophenol

Chemosphere, Volume 312, Part 1, 2023, Article 137302

Show abstract

Research article

Oral administration of *Bacillus cereus* GW-01 alleviates the accumulation and detrimental effects of β-cypermethrin in mice

Chemosphere, Volume 312, Part 1, 2023, Article 137333

Show abstract

Research article

Urinary arsenic and health risk of the residents association in contaminated-groundwater area of the urbanized coastal aquifer, Thailand

Chemosphere, Volume 313, 2023, Article 137313

Show abstract

Research article

Selected dechlorination of triclosan by high-performance g-C_3N_4/Bi_2MoO_6 composites: Mechanisms and pathways

Chemosphere, Volume 312, Part 1, 2023, Article 137247

Show abstract

Research article

Nanocubic copper cobaltite for methyl orange degradation through photocatalytic process

Chemosphere, Volume 312, Part 2, 2023, Article 137311

Show abstract

Research article

Experimental evaluation on liquid area sources: Influence of wind velocity and temperature on the wind tunnel sampling of VOCs emissions from wastewater treatment plants

Chemosphere, Volume 312, Part 2, 2023, Article 137337

Show abstract

View full text