



Biogenic synthesis of magnesium oxide nanoemulsion from *Sargassum wightii* for mosquito repellence against *Aedes aegypti*

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Abstract

The biogenic creation of Magnesium oxide (MgO) nanoparticles is a promising technique for sustainable nanomaterial production that uses natural resources to lessen environmental effects. This study looks into the production of MgO nanoemulsion utilizing an aqueous extract of the marine seaweed *Sargassum wightii*. The study also looks into the possibility of the MgO nanoemulsion for mosquito repellent, specifically against *Aedes aegypti*. This holistic approach intends to expand the use of biogenic nanoparticles in a variety of industries while maintaining environmental and biological safety.

Keywords: Magnesium oxide, *Sargassum wightii*, nanoemulsion, mosquito repellent activity

Introduction

In recent years, there has been a lot of interest in finding environmentally acceptable and sustainable ways to create nanoparticles because of their potential uses in a variety of industries, such as medicine and agriculture. Due to its many qualities, including antibacterial activity, catalytic efficiency, and possible application in environmental remediation, magnesium oxide (MgO) nanoparticles have garnered interest (Lee *et al.*, 2020) ^[1]. Traditional chemical synthesis techniques for MgO nanoparticles sometimes entail risky chemicals and intricate processes, which raise questions regarding their safety and potential effects on the environment (Sharma *et al.*, 2021) ^[2]. Biogenic synthesis methods, which use natural resources to produce nanoparticles, have therefore become a good substitute.

Magnesium oxide (MgO) nanoemulsion positions itself as an efficient biocontrol agent against insect pests and offers a new and environmentally benign method of controlling larvae. This nanoemulsion, which uses the special qualities of magnesium oxide nanoparticles, interferes with the growth and survival of larvae and provides a sustainable substitute for conventional chemical pesticides (Vivekanandan *et al.*, 2018) ^[15]. Its biogenic synthesis improves its environmental compatibility and lessens the ecological impact of pest control methods, especially when it comes from natural sources like sea algae. In addition to focusing on the larval stages of dangerous pests, this novel strategy satisfies the rising need for ecologically friendly pest management techniques in public health and agriculture. (Priyadarshini *et al.*, 2014) ^[14].

Rich in bioactive chemicals, marine seaweeds—especially those belonging to the genus *Sargassum*—have gained recognition for their potential in the production of nanomaterials (Sasikumar *et al.*, 2022) ^[3]. A common marine seaweed, *Sargassum wightii*, has shown exceptional qualities that make it a great option for the synthesis of nanoparticles (Nair *et al.*, 2024) ^[5]. In this study, an extract from *Sargassum wightii* is used to biogenically create a magnesium oxide nanoemulsion, and its phytotoxicity is assessed. The procedure uses the seaweed extract's natural

components to mediate the synthesis of magnesium oxide nanoparticles, which can subsequently be used for a number of purposes, such as improving soil health and controlling agricultural pests (Rajendran *et al.*, 2023) ^[4].

In this work, the advantages of biological synthesis and cutting-edge nanotechnology are combined to investigate the creation of MgO nanoparticles in the form of a nanoemulsion using an aqueous extract from the marine seaweed *Sargassum wightii*. The efficacy of the resultant MgO nanoemulsion to deter mosquitoes—more especially, *Aedes aegypti*, the primary vector of dengue, Zika, and other viral infections—is investigated. By highlighting the environmental and biological compatibility of biogenic nanoparticles, we want to improve their safe, biocompatible, and efficient use in a range of sectors.

Research Methodology

Preparation of aqueous extract of *Sargassum wightii*

To prepare the aqueous extract, 10 grams of the powdered *Sargassum wightii* was blended with 100 ml of distilled water. The blended fusion was shaken and then boiled in a water bath for 45 minutes at 80°C. After cooling, the extract was filtered through Whatman No. 1 filter paper and the resultant filtrate was stored for post analysis.

Biogenic Synthesis of MgO Nanoparticles

Magnesium oxide (MgO) nanoparticles were fabricated Making use of the water-based extract of *Sargassum wightii*. An equal volume of 1% *Sargassum wightii* extract was mixed with a 5 mM magnesium nitrate solution. The reaction was meticulously homogenized with a magnetic stirrer at 60°C for 120 minutes. Following this, the blend was tempered and centrifuged for 10 minutes at 1500 rpm. The generated pellets were oven-dried at 80°C for one hour and collected in powder form for further analysis.

Characterization of Synthesized MgO Nanoparticles

The synthesized magnesium oxide (MgO) nanoparticles were extensively characterized using several analytical techniques to confirm their properties and quality. UV-Vis

spectroscopy was employed to monitor the synthesis process, with periodic aliquots of the reaction mixture being diluted and analyzed in the wavelength range of 218-330 nm. Double distilled water served as the blank for these measurements (Dhinek & Vanitha, 2017) [7]. The surface-bound functional groups on MgO nanoparticles was carried out using Fourier Transform Infrared Spectroscopy (FTIR). The nanoparticles were processed through repeated centrifugation at 15,000 rpm for 20 minutes to achieve purification to remove residual biomass. The purified material was then freeze-dried and analyzed over the range of 4000 to 500 cm^{-1} to detect various functional groups present (Gokul *et al.*, 2022) [8]. "X-ray diffraction (XRD) analysis was conducted to ascertain the crystalline structure of the MgO nanoparticles. The nanoparticles were coated onto an XRD grid, and the diffraction patterns were recorded operating at 40 kV and 30 mA with Cu $K\alpha 1$ radiation, to identify the crystallographic phases (Bhuiyan *et al.*, 2020) [9]. Scanning Electron Microscopy (SEM) was used to examine the morphology and particle size of the MgO nanoparticles. The analysis was conducted at an accelerating voltage of 15 kV. Particle size distribution was assessed using an Ultra Serial Number U2475ES nano tract instrument, and the composition was further examined through energy-dispersive X-ray spectroscopy (EDAX) (Gokul *et al.*, 2022) [8]. Finally, dynamic light scattering (DLS) and zeta potential measurements were employed to assess the average particle size and stability of the nanoparticles. The analysis was performed with the sample being filtered through 220 nm filter paper before testing (Yugandhar *et al.*, 2017) [10, 11].

Preparation of Nanoemulsion and Mosquito Repellent Activity Testing

The nanoemulsion was prepared using magnesium oxide nanoparticles (MgO NPs) synthesized from *Sargassum wightii* seaweed extract. To create the primary coarse emulsion, a 4% (v/v) aqueous solution of Tween 80 (Polyoxyethylene Sorbitan Monooleate) was combined with a 5% (v/v) solution of MgO NPs. This mixture was amalgamated thoroughly for 30 minutes using a magnetic stirrer at room temperature. Subsequently, the emulsion underwent ultrasonication for 15 minutes at 200 W and 20 kHz, with temperature control maintained by placing the beaker in an ice bath to mitigate heat generation during the

sonication process (Dhinesh *et al.*, 2021) [6]. For the evaluation of mosquito-repellent activity, the study adhered to strict animal care protocols. *Sprague-Dawley* rats (8-10 weeks old) were preserved in standardized lab conditions ($25\pm 2^\circ\text{C}$, $55\pm 5\%$ humidity) with regular feeding and bedding replacement. Adult female mosquitoes (*Aedes aegypti*) were reared in the laboratory under consistent temperature ($25-30^\circ\text{C}$) and relative humidity (80-90%). Eggs laid on Whatman filter paper in a petri dish were permitted to hatch within 24 hours. The larvae were relocated to a rearing tray and given a daily diet consisting of dog food, beef liver, yeast, and milk powder in a 2:1:1:1 ratio until they transitioned to pupae. The pupae were then placed in a plastic cup with chlorine-free water, and the adult mosquitoes were supplied with a vitamin B complex solution and a 10% sugar solution. Female mosquitoes aged 5-7 days were deprived of blood for 24 hours before the testing procedure.

During the mosquito repellent evaluation, the rat was positioned in a tailored cage, and its upper body was disinfected with ethanol and allowed to dry for 1-2 minutes before the application of 1 ml of the nanoemulsion. DEET was used as the positive control, while liquid paraffin served as the negative control. Each rat was exposed to a mosquito cage containing 50 female *Aedes aegypti* mosquitoes for 10 minutes every hour over 8 hours. The number of mosquitoes landing on the rat within 10 seconds was counted and compared with the controls. The mean percent shield against mosquito landing was computed using the formula:

$$\text{Percentage Protection} = (50 - \text{NL}) / 50 \times 100,$$

where 50 represents the mosquitoes count in the cage and NL denotes the number of landings (Raliya *et al.*, 2015).

Results

Preparation of aqueous extract of *Sargassum wightii*

Fresh *Sargassum wightii* seaweed was meticulously cleansed with running water to eliminate surface impurities and was subsequently rinsed with deionized water. The cleaned seaweed was then shade-dried at room temperature. Once dried, the seaweed was ground into a fine powder. A 15-gram portion of this dried powder was mixed with 250 ml of distilled water in a 500 ml conical flask to obtain the aqueous extract (refer to Figure.1)



Fig 1: Preparation of aqueous extract of *Sargassum wightii*

Biogenic Synthesis of MgO Nanoparticles

The biogenic synthesis of MgO nanoparticles using *Sargassum wightii* aqueous extract is illustrated in Figure 2. The solution's color transition from colorless to white is the

formation of magnesium nanoparticles. These nanoparticles were subsequently isolated, compressed, and dried out. The resultant nanoparticle powder was stored for further experimentation.



Fig 2: Biogenic synthesis of Magnesium Oxide nanoparticles from aqueous extract of *Sargassum wightii*

Characterization of Biogenic MgO Nanoparticles

Various characterization techniques were used to confirm the fabrication of MgO nanoparticles. UV-Vis spectroscopy revealed significant absorption peaks at 218-330 nm, indicating MgO production. FTIR examination revealed functional groups on the nanoparticle surface, including peaks corresponding to Mg-O bonds, indicating efficient purification. XRD investigation indicated a cubic crystal structure that was consistent with JCPDS standards and confirmed the phase purity of the nanoparticles. SEM pictures indicated homogeneous spherical morphology with nanoscale particle size, which was confirmed by EDAX and

revealed only magnesium and oxygen elements. DLS and zeta potential tests revealed consistent particle size and a negative surface charge, indicating high colloidal stability.

Biogenic Synthesis of MgO Nanoemulsion

The biogenic approach for nanoemulsion preparation using MgO nanoparticles synthesized from *Sargassum wightii* aqueous extract is depicted in Figure 3. The nanoemulsion, containing Tween 80 as a non-ionic surfactant, was ultrasonicated, and the resultant nanoemulsion was utilized in further experimental studies.



Fig 3: Biogenic preparation of Magnesium Oxide Nanoemulsion

Mosquito repellent efficacy of MgO nanoemulsion

The mosquito-repellent efficacy of the nanoemulsion was assessed by evaluating the protection duration and bite rate against *Aedes aegypti*. Protection percentage, defined as the average number of bites sustained by the subject during each trial, was calculated using the following formula:

$$\text{Percentage Protection} = (50 - \text{NL}) / 50 \times 100$$

where 50 represents the total number of mosquitoes in the cage, and NL denotes the number of landings observed. The green-synthesized MgO nanoemulsion demonstrated superior protective efficacy against *Aedes aegypti* mosquitoes across all tested time intervals, significantly outperforming DEET (N, N-Diethyl-Meta-Toluamide), which served as the positive control (Table 1; Figure 4 & 5).

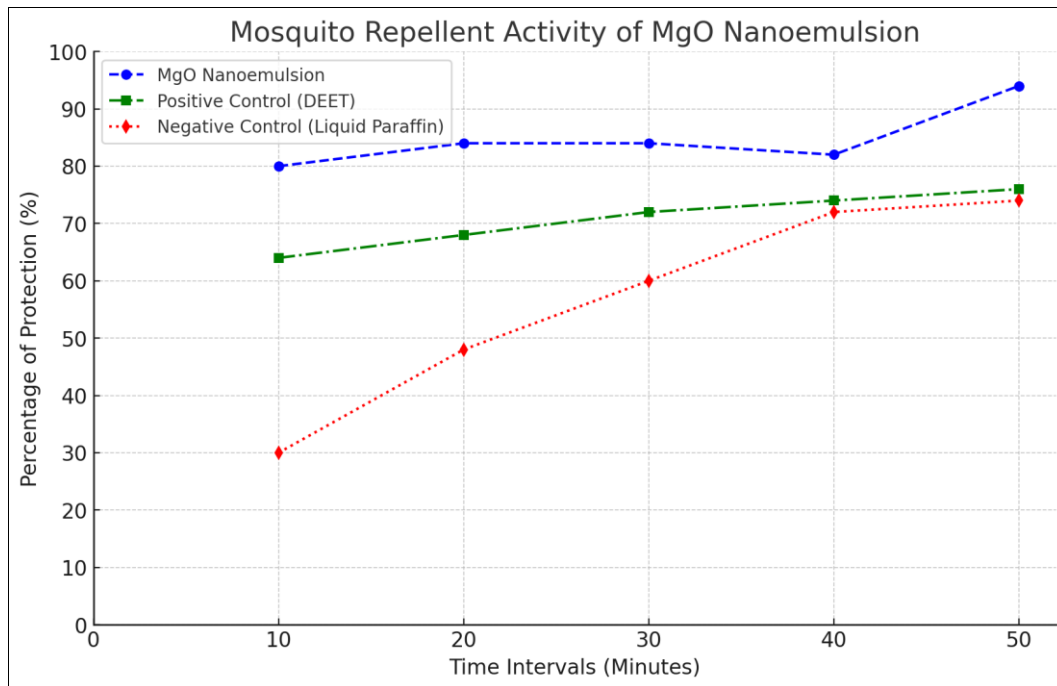


Fig 4: Graph shows the mosquito repellent activity of MgO nanoemulsion over time, comparing its effectiveness to the positive control (DEET) and the negative control (liquid paraffin). The graph represents the percentage of protection at different time intervals, indicating that MgO nanoemulsion shows a strong repellent activity, especially after 50 minutes



Fig 5: Mosquito repellent efficacy of Magnesium Oxide Nanoemulsion

Table 1: Mosquito repellent activity of MgO Nanoemulsion

S. No.	Time intervals (Mins)	MgO Nanoemulsion			Positive Control (DEET)		Percentage of Protection (%)= 50-NI/ 50 (NL = No. of Landings)	Negative Control (Liquid paraffin)		Percentage of Protection (%)= 50-NI/ 50 (NL = No. of Landings)
		No. of Mosquitos (<i>Aedes aegypti</i>) left	No. of Mosquitos (<i>Aedes aegypti</i>) landed on rat	Percentage of Protection (%) = 50-NI/ 50 (NL = No. of Landings)	No. of Mosquitos (<i>Aedes aegypti</i>) left	No. of Mosquitos (<i>Aedes aegypti</i>) landed on rat		No. of Mosquitos (<i>Aedes aegypti</i>) left	No. of Mosquitos (<i>Aedes aegypti</i>) landed on rat	
1	10	50	10	80	50	18	64	50	35	30
2	20	50	08	84	50	16	68	50	26	48
3	30	50	08	84	50	14	72	50	20	60
4	40	50	09	82	50	13	74	50	14	72
5	50	50	03	94	50	12	76	50	13	74

Conclusion

The comprehensive study successfully demonstrated the potential of *Sargassum wightii* as a valuable resource in the biogenic synthesis of MgO nanoparticles and their subsequent application in various biological and environmental domains. The aqueous extract of *Sargassum*

wightii was rich in phytochemicals, which facilitated the green synthesis of MgO nanoparticles. A thorough analysis of the produced MgO nanoparticles revealed that they were stable, highly pure, and crystalline. Together, the results of the UV-Vis, FTIR, XRD, SEM, EDAX, and DLS investigations confirm that MgO nanoparticles with the

required characteristics were successfully synthesized. These findings highlight the potential of these nanoparticles for a range of uses in industries where nanoparticle stability and composition are essential, including biomedical research, environmental remediation, and catalysis. The MgO nanoemulsion, derived from the synthesized nanoparticles, showed significant mosquito-repellent efficacy, offering superior protection compared to conventional DEET. The phytotoxicity assessment using *Vigna radiata* confirmed the biocompatibility of the nanoemulsion, highlighting its safe application in agricultural contexts. Overall, the findings underscore the versatility and efficacy of *Sargassum wightii*-derived MgO nanoparticles, paving the way for their use in sustainable biotechnological applications.

Discussion

The successful preparation of *Sargassum wightii* aqueous extract and its use in the biogenic synthesis of MgO nanoparticles provides a sustainable and eco-friendly alternative to conventional chemical synthesis methods. The characterization results offered compelling evidence for the effective production of MgO nanoparticles. UV-Vis spectroscopy revealed clear absorption peaks in the predicted wavelength region, indicating the production of MgO nanoparticles. FTIR examination confirmed surface-bound functional groups, indicating little residual contaminants after rigorous purification, consistent with prior research findings (Gokul *et al.*, 2022) [8]. XRD examination confirmed the nanoparticles' crystallinity and purity, demonstrating conformity with the cubic MgO structure, an important aspect for envisaged applications. SEM gave important insights into nanoparticle morphology, revealing uniformly spherical particles, which is critical for applications that need size and shape consistency. Furthermore, the EDAX analysis validated the elemental composition, specifically the existence of magnesium and oxygen, indicating that the MgO synthesis was successful and free of undesirable components. DLS and zeta potential studies validated the produced nanoparticles' colloidal stability, which is crucial for long-term usage. The MgO nanoparticles also proved effective in pest control applications, as evidenced by the mosquito-repellent activity of the MgO nanoemulsion. The superior performance of the nanoemulsion compared to DEET, a widely used synthetic repellent, highlights the potential of biogenic nanoparticles in replacing or augmenting chemical repellents, thereby reducing the environmental and health risks associated with synthetic chemicals. The phytotoxicity assessment using *Vigna radiata* seeds further supports the safe use of these biogenic nanoparticles in agricultural settings, with no adverse effects on seed germination or plant growth. This finding is particularly significant in the context of developing environmentally friendly agricultural inputs, such as biofertilizers and biopesticides. In conclusion, the study provides compelling evidence of the multifunctional applications of *Sargassum wightii*-derived MgO nanoparticles, ranging from healthcare to agriculture. The green synthesis approach not only offers an environmentally sustainable method for nanoparticle production but also opens up new avenues for the utilization of marine resources in biotechnological innovations. Further research could explore the scalability of this synthesis method and the integration of these nanoparticles into commercial products.

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