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Green Synthesis of Magnesium Oxide Nanoparticles using Aloe Vera Plant

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بسم الله الرحمن الرحيم

ٱقْرَأْ بِٱسْمِ رَبِّكَ ٱلَّذِى خَلَقَ ١ خَلَقَ ٱلْإِنسَٰنَ مِنْ عَلَقٍ ٢ ٱقْرَأْ وَرَبُّكَ ٱلْأَكْرَمُ ٣
ٱلَّذِى عَلَّمَ بِٱلْقَلَمِ ٤ عَلَّمَ ٱلْإِنسَٰنَ مَا لَمْ يَعْلَمْ ٥ كَلَّآ إِنَّ ٱلْإِنسَٰنَ لَيَطْغَىٰٓ ٦ أَن
رَّءَاهُ ٱسْتَغْنَىٰٓ ٧ إِنَّ إِلَىٰ رَبِّكَ ٱلرُّجْعَىٰٓ ٨ أَرَءَيْتَ ٱلَّذِى يَنْهَىٰ ٩ عَبْدًا إِذَا صَلَّىٰٓ
١٠ أَرَءَيْتَ إِن كَانَ عَلَى ٱلْهُدَىٰٓ ١١ أَوْ أَمَرَ بِٱلتَّقْوَىٰٓ ١٢ أَرَءَيْتَ إِن كَذَّبَ
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وَٱسْجُدْ وَٱقْتَرِب ۩ ١٩

سورة العلق

الإهداء

إلى أبي الغالي، فطالما شجعني على المثابرة والجد

إلى القـلـب المعطاء والدتي الحبيبة التي بـها أعلو، وعليها أرتكز

إلى إخـو اني وأخو اتي الذين بذلوا جهدًا في مساعدتي وكانوا خيرَ سندٍ

إلى كل من ساهم ولـو بحرف في حياتي الدراسية

إلى كل هؤلاء: أهدي هذا العمل، الذي أسال الله تعالى أن يتقبله خالصًا

الباحث: فاطمة سهيل جاسم, زهراء حيدر جهاد, ضحى عباس فاضل

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Abstract

Numerous methodologies have historically been employed for the synthesis of nanoparticles (NPs). However, many of these approaches have proven to be expensive, yielding toxic byproducts and necessitating measures to mitigate chemical and physical contamination. Consequently, the adoption of green nanoparticle synthesis utilizing plant extracts has emerged as a sustainable alternative within nanotechnology, boasting applications across diverse fields.

In this study, Aloe vera extract was utilized for the synthesis of MgO nanoparticles. Through the utilization of scanning electron microscopy (SEM) and Fourier-transform infrared spectroscopy (FT-IR), we investigated and corroborated the presence of MgO nanoparticles. The findings of this investigation underscore the efficacy of Aloe vera extract in synthesizing MgO nanoparticles, as evidenced by SEM and FT-IR analysis.

In conclusion, our study demonstrates the feasibility and effectiveness of utilizing Aloe vera extract for the eco-friendly synthesis of MgO nanoparticles. By harnessing the power of nature, we pave the way for sustainable nanotechnology solutions with far-reaching implications across various scientific and industrial domains.

1.Introduction

In recent years, there has been a growing interest in the development of eco-friendly and sustainable methods for the synthesis of nanoparticles. Among these methods, green synthesis stands out as a promising approach that utilizes natural resources and minimizes the use of hazardous chemicals. One example is the green synthesis of Magnesium Oxide Nanoparticles (MgO NPs) using Aloe Vera. The synthesis of nanomaterials has emerged as a sub-discipline of modern science in recent years. Chemical methods that are being used involve hazardous chemicals and solvents.

On the other hand, green synthesis involves the usage of plants, bacteria, fungi, etc. This paper focuses on the synthesis of magnesium oxide nanoparticles using the aloe vera plant as the reducing agent [1].

Aloe vera is a well-known medicinal plant in the field of Ayurveda. It has been a part of various Ayurvedic preparations and is known for its antibacterial and antifungal properties. This synthesis avoids the usage of hazardous chemicals and solvents and is completely based on natural products. The aloe vera extract acts as a reducing as well as a capping agent. The magnesium oxide nanoparticles have been synthesized using magnesium nitrate and aloe vera extract. The filtrate is then dried in the oven. The dried powder is then annealed at a particular temperature.

Chemically, magnesium oxide is made of one central magnesium ion attached to two oxygen ions, giving it the chemical structure MgO. Magnesium is the ninth most abundant element in the universe. It is typically produced synthetically, usually using the hydrolysis of magnesium chloride. Magnesium oxide is typically produced by the burning of magnesium metal; however, there are other methods to go about it. Calcination is the process of heating a solid to rid it of water or other elements and involves the magnesium carbonate turning into MgO and CO2 [1].

1.1. Background

Magnesium oxide is an example of a material that is important to industry and has been the focus of much research due to its catalytic properties. It has been used as a support for metal catalysts and has been investigated as a catalyst in its own right. An example of a catalytic process that is of great industrial importance is the production of methanol from carbon monoxide and hydrogen. This is used to make a variety of chemicals. One active catalyst for this reaction is zinc oxide. It has been shown that MgO can be used to promote the methanol synthesis activity of ZnO. This is a sintered reaction between the CO and hydrogen with a low to moderate temperature [2].

A recent advance that is in part a response to environmental consciousness involves the use of biodiesel as a source of the hydrogen and CO2 from the sintering of methanol can be recycled to make more methanol. This is a perfect case of a catalytic process that has been improved by the design of the end materials [2].

There are a variety of methods that can be employed to generate nanoparticles of a given material. These can be broadly divided into two groups, those that generate particles from a bulk solid and those that build up particles from atomic or molecular scale species. Techniques such as ball milling or grinding may be used to make particles from a bulk material and processes such as chemical reduction or the use of plasma can be used to produce particles from atomic species. High temperatures and pressures are often required for these methods, which can make them energy intensive. Conversely, methods such as sol-gel or self-assembly techniques can be carried out in milder conditions. In recent times there has been a move towards greener methods of nanoparticle generation. This involves the use of less toxic chemicals and more energy-efficient processes, for example, heating by microwave or infrared radiation [3].

A general motivation for this has been that a love for the environment is embedded in the human consciousness. More specific to the generation of nanomaterials is a recent realization that the synthesis method can influence the properties of the final materials. This concept is often referred to as 'material by design'. A material that has improved catalytic ability can, in principle, allow a reaction to take place under more moderate conditions, lowering energy input and negating the need for toxic reagents [3].

The development of new nanomaterials is an area of particular interest to materials scientists. This is not only because they can be used in a variety of applications, ranging from catalysis to sensing to medical, but also because the properties of materials at the nanoscale can be very different from those at the microscale. Nanoparticles are of particular interest and have been the focus of much research as their small size and high surface area make them desirable for use as catalysts. The size and distribution of particles can have a significant effect on catalytic activity [4].

1.2. MgO nanoparticles concept

Magnesium oxide nanoparticles (MgONPs) have been attracting a lot of interest of late due to their noteworthy applications in different fields - be it in material science medicinal field or environmental science. Still, the fact that pulls back the extensive use of MgONPs in these areas is the process by which it is obtained. The chemical methods which are typically used for the synthesis of metal oxide nanoparticles involve high temperatures, pressures, and toxic solvents leading to energy consumption and the formation of noxious by-products. Hence, the focus is currently on methods that are cost-effective, eco-friendly, and non-toxic [5].

The ones that top the list amongst the green synthesis methods are the biological methods using plants or plant extracts. A wide variety of plant extracts have been used for the synthesis of metal oxide nanoparticles involving active components like alkaloids, terpenoids, phenolic compounds, and quinines. Bioactive molecules can act both as reducing and stabilizing agents, and the use of plants is within reach and quite practical. A recent study supported the use of Aloe vera, it is a succulent plant species of the genus Aloe [5].

It is cultivated for agricultural and medicinal uses. Aloe vera has been widely used to treat various ailments, and in the cosmetic industry, it has shown tremendous use. The clear gel which is obtained from the parenchymatous cells in the inner leaf has been shown to have a dual function and is an effective reducing and stabilizing agent. The water extract from the outer green leaf, known as aloe latex, has little or no reducing power. As an example in this study, the formation of MgONPs using aloe vera is projected for potential biomedical applications [5].

There are some key properties of MgO nanoparticles. The physical, chemical, and thermal properties of magnesium oxide nanoparticles are given in the following tables1,2,3 [6].

Table 1: physical properties of magnesium oxide nanoparticles

Properties	Metric	Imperial
Density	3.58 g/cm^3	0.129 Ib/in^3
Molar mass	40.30 g/mol	-

Table 2: chemical properties of magnesium oxide nanoparticles

Chemical Data	
Chemical Symbol	MgO
CAS No.	1309-48-4
Group	Magnesium 2 Oxygen 16
Electronic confirmation	Magnesium [Ne] $3s^2$ Oxygen [He] $2s^2$ $2p^4$
Chemical Composition	
Element	Content (%)
Magnesium	60.29
Oxygen	39.67

Table 3: Thermal properties of magnesium oxide nanoparticles

Properties	Metric	Imperial
Melting point	2852 ^oC	5166 ^oF
Boiling point	3600 ^oC	6512 ^oF

In addition, MgO nanoparticles possess several advantageous physicochemical characteristics, such as enhanced ionic character, substantial specific surface area, distinctive crystal structures, as well as oxygen vacancies, enabling seamless interaction with various biological systems [7]. These nanoparticles have found widespread utility in diverse areas, including toxic waste remediation, paints, antiseptics, catalysis, superconductors, catalytic devices, semiconductors, additives in heavy fuel oils, refractory materials, adsorbents, reflective coatings, lithium-ion batteries, and more [8].

In the realm of biomedicine, magnesium oxide nanoparticles have been employed for stomach relief, heartburn alleviation, and bone regeneration, as well as for therapeutic applications, such as coated capsules, biological labeling, band-aids, blood collecting vessels, etc. [7]. Additionally, MgO nanoparticles have exhibited potential as antibacterial [9], fungicidal, anticancer, antioxidant, and antidiabetic agents, as well as in applications such as tissue engineering [7, 8], bioimaging, and drug delivery.

Hence, the pursuit of novel synthetic methods for producing magnesium oxide nanoparticles becomes imperative owing to their escalating usage in biomedicine [8].

Moreover, Magnesium oxide nanoparticles can be applied in several fields, including electronics, catalysis, ceramics, and petrochemical products. When combined with natural materials such as wood chips and shavings, they can be used to produce lightweight, heat-insulating, sound-proofing materials, refractory fiber boards, and metallic ceramics [8].

Furthermore, several medical applications of magnesium oxide (MgO) nanoparticles have garnered significant interest for their potential applications in various biomedical fields. Due to their biocompatibility, low toxicity, and high surface area, MgO nanoparticles hold promise for drug delivery systems, where they can serve as carriers for therapeutic agents, facilitating targeted delivery to specific tissues or cells. Additionally, MgO nanoparticles have been explored for their antimicrobial properties, offering a potential solution to combat drug-resistant bacterial infections [9].

Moreover, their use in bioimaging and biosensing applications has been investigated, with MgO nanoparticles showing promise as contrast agents for magnetic resonance imaging (MRI) and fluorescent probes for cellular imaging [9].

Furthermore, MgO nanoparticles hold potential in tissue engineering and regenerative medicine, where their properties could be harnessed to enhance biocompatibility and promote tissue regeneration. Overall, the versatile properties of MgO nanoparticles position them as promising candidates for advancing medical technologies and improving healthcare outcomes [10]. One of the main advantages of magnesium oxide nanoparticles in biomedical and agricultural applications is their non-toxicity to plants and animals. This makes them interesting targets for research into their antibacterial properties to fight pathogens [10].

A study found that the main toxicity mechanism of magnesium oxide nanoparticles against Ralstonia.solanacearum was the physical disruption of bacterial cells via attachment of nanoparticles, which leads to drastically reduced motility and biofilm formation [5].

Another possible reason for the antibacterial activity of magnesium oxide nanoparticles is the accumulation of reactive oxygen species, which causes actions such as damage to bacterial DNA, amongst other effects. Physical disruption to bacterial cells was observed and confirmed using Transmission Electron Microscopy (TEM) and Scanning Electron Microscope (SEM). In addition, the Greenhouse experiments on tobacco crops infected with R. solanacearum confirmed the reduction of bacterial wilt index due to the significant antibacterial activity of magnesium oxide nanoparticles [5].

Thus, magnesium oxide nanoparticles could be used as alternative, eco-friendly, and non-toxic antibacterial agents in the future [5]. However, MgO Nanoparticles displayed a hemolytic activity, releasing their hemoglobin content. Being of a high positive charge, MgO nanoparticles produce an increment of the blood level of $K+$ as a progression for their hemolytic effect [4]. Using alcohols such as ethanol during MgO nanoparticle preparation can radically eliminate the risks of MgO nanoparticles in terms of being biocompatible with the components of the human blood [4].

1.3. Aloe Vera impacts

Aloe Vera, known for its medicinal properties and abundance in various bioactive compounds, has gained attention as a potential reducing and stabilizing agent in nanotechnology [11]. This versatile plant offers numerous advantages such as being readily available, cost-effective, non-toxic, and easily biodegradable. Additionally, Aloe vera is a medicinal plant with antioxidant and antibacterial properties. Several benefits of this plant include reducing dental plaque, accelerating wound healing, preventing wrinkles, and managing blood sugar [11].

1.4. Green synthesis of MgO NPs using Aloe Vera

Green synthesis refers to the environmentally friendly methods of synthesizing nanoparticles without the use of hazardous chemicals. Aloe vera, a commonly available plant known for its medicinal properties, has been utilized in the green synthesis of various nanoparticles, including magnesium oxide (MgO) nanoparticles. The green synthesis of MgO NPs using Aloe Vera presents several benefits over conventional methods [12].

It eliminates the need for harmful chemicals and reduces energy consumption during the production process [13]. Furthermore, it offers an alternative to traditional approaches without compromising the quality or functionality of the nanoparticles [14, 15].

The green synthesis of magnesium oxide nanoparticles using Aloe Vera is an innovative and sustainable approach in the field of nanotechnology. This method utilizes the natural properties of Aloe Vera to produce nanoparticles with reduced environmental impact. However, green synthesis is limited by time and place of production as well as issues with low purity and poor yield. However, considering current environmental problems and pollution associated with chemical synthesis, green synthesis offers alternative development prospects and potential applications [15].

1.5. Affecting Factors of Green Nanoparticles Synthesis

Several factors affect the synthesis, characterization, and application of nanoparticles. including pH of the solution, temperature, concentration of the extracts used, concentration of the raw materials used, size, and above all the protocols that are followed for the synthesis process as shown in figure 1[16].

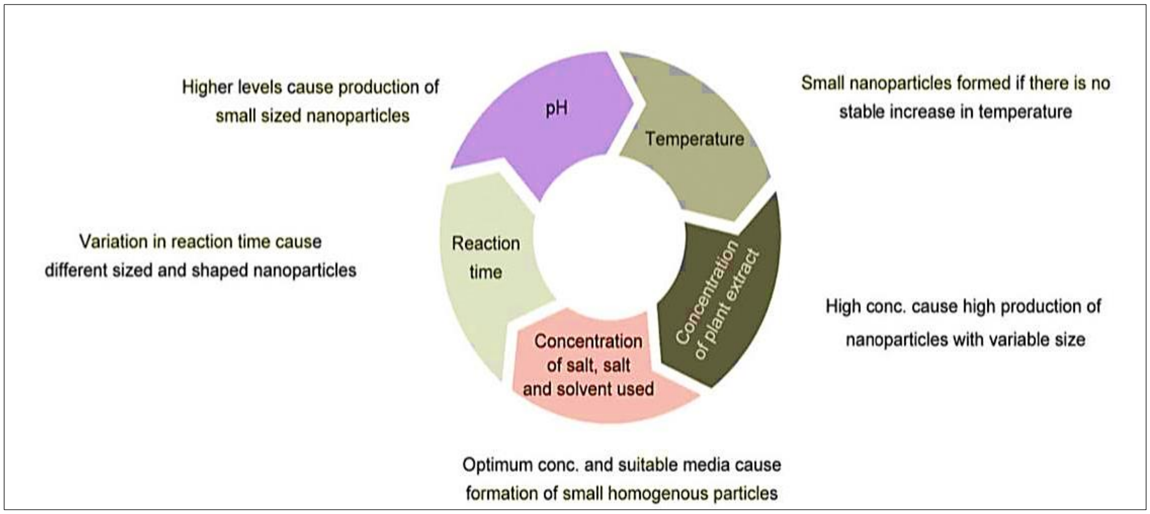

Figure 1 Factors affecting the green synthesis of metallic NPs. Specifically, pH, temperature, reaction time, the concentration of metallic salt, solvent medium, and concentration of plant extracts need to be optimized. NPs, nanoparticles

So, pH, temperature, reaction time, concentration of metallic salt, solvent medium, and concentration of plant extracts are among the critical parameters that must be carefully optimized. pH affects the ionization state of functional groups in the plant extract, influencing the reduction and stabilization of metal ions. Temperature plays a crucial role in controlling the rate of nucleation and growth of nanoparticles, while reaction time determines the extent of particle formation and maturation [16]. The concentration of metallic salt dictates the availability of metal ions for nucleation and particle growth, while the solvent medium affects the solubility and reactivity of reactants. The concentration of plant extracts provides reducing agents and stabilizing agents essential for nanoparticle synthesis. Optimization of these parameters is essential to achieve reproducible and tunable synthesis of metallic nanoparticles with desired properties for various applications [16].

2.Materials and Method

2.1. Required Materials

The following document delves into the intricacies of the Green Synthesis of Magnesium Oxide Nanoparticles using Aloe Vera and its Applications, designed to create Magnesium Oxide Nanoparticles using Aloe Vera.

Through a meticulous examination of STM and FT-IR, this report endeavors to shed light on the Synthesis of Magnesium Oxide Nanoparticles by using some materials which include aloe vera leaves, deionized water, magnesium nitrate, Sodium hydroxide, and Distilled water with specific quantities as listed in Table 4.

Table 4: Project Materials

materials	Amount
aloe vera leaves	50 g
deionized water	50 ml
magnesium nitrate (con.)	256.41g/ml
Sodium hydroxide (con.)	40g/ml
Distilled water	1000 ml

2.2. Project Equipment

The equipments used in this project are listed below:

- Sensitive Balance
- PH meter
- Filter paper
- air oven

- Magnetic Stirrer
- Heater plate
- SEM
- FT-IR Spectrum

2.3. Methods

The techniques that we used in our project as the following:

2.3.1. 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 as shown in Figure 2.

Figure 2 The solution on the magnetic stirrer

Boiling the leaves helps rupture the plant's cell walls, releasing the intracellular contents into the surrounding water. This allows the bioactive compounds to be leached out and dissolved in the aqueous medium.

The boiling process is typically carried out for a certain duration, often ranging from 20 minutes to an hour. Then we filter the liquid using filter paper as shown below.

Figure 3 Filtering process.

Figure 3 shows that the resulting extract was cooled and used as a gelling agent for the synthesis of magnesium oxide nanoparticles as shown below.

2.3.1.1. Preparations of MgO nanoparticles using Aloe-Vera

extract (MgA) Ten mL of magnesium nitrate solution was added to 10 mL of aloe vera extract as shown in Figure 4.

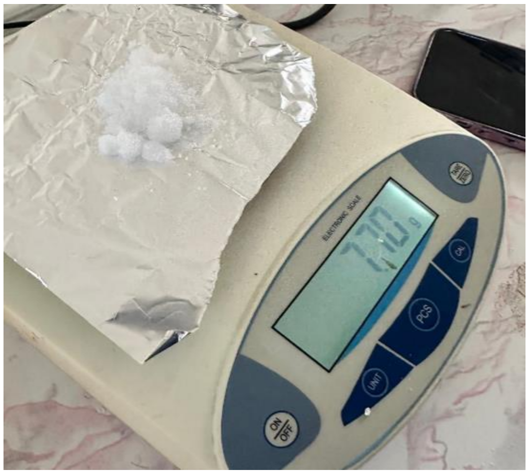

Figure 4 using the scale to measure NaOH

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 as shown in figure 5. Further, the calcination was done in the muffle furnace at 500°C for three hours.

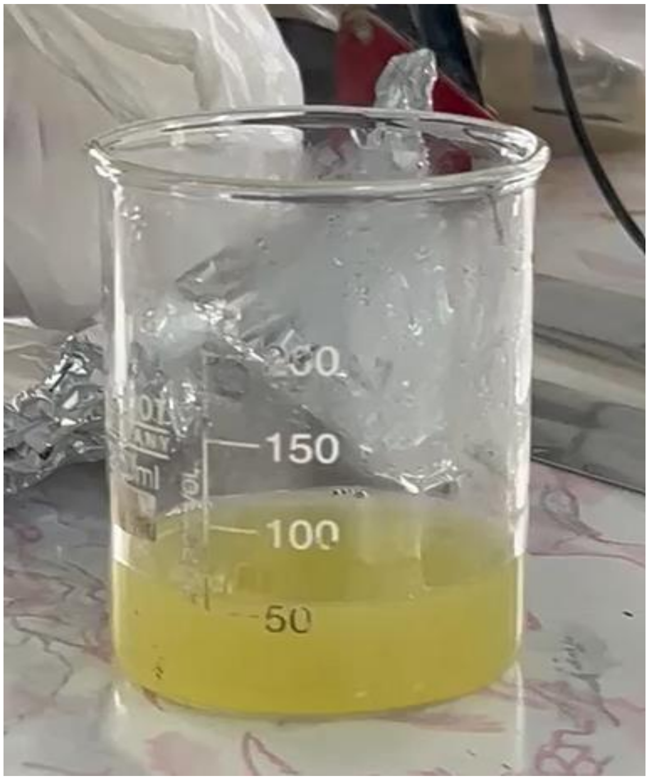

Figure 5 Extraction liquid.

Figure 5 shows the extraction liquid obtained after we boiled Aloe Vera leaves for MgO nanoparticle synthesis, it would contain a diverse array of bioactive compounds and phytochemicals with potential medicinal, cosmetic, or nutritional benefits. This liquid extract serves as a starting material for our further processing into nanoparticle synthesis protocols, contributing to the green synthesis approach using natural plant sources.

2.3.2. FT-IR Method

In our analyses, we have performed two methods, the first method is the FT-IR method.

To perform FT-IR spectroscopy on MgO nanoparticles synthesized using Aloe vera extract (MgA nanoparticles), several steps are involved:

- **Sample Preparation:** In this, we have prepared the synthesized MgA nanoparticles for analysis. Typically, that involves dispersing the nanoparticles in a suitable solvent or medium to form a uniform suspension or thin film. We have ensured that the sample preparation method does not alter the structural or chemical properties of the nanoparticles.
- **Instrument Setup:** We have configured the FT-IR spectrometer properly for the analysis, such as calibrating the instrument, setting the appropriate spectral range, and selecting the desired resolution and scan parameters.
- **Baseline Correction:** Before acquiring the spectrum of the MgA nanoparticles, we performed the following baseline correction to account for any contributions from the solvent or medium. This step ensures that the observed spectral features are primarily attributed to the nanoparticles and not interference from the surrounding environment.
  - $\frac{1000}{50} * \frac{w}{256.41} = 0.6$
- **Acquisition of Spectrum:** Once the instrument is calibrated and the baseline corrected, the FT-IR spectrum of the MgA nanoparticles can be acquired. This involves illuminating the sample with infrared radiation over a range of wavelengths and measuring the intensity of the transmitted or reflected light as a function of wavelength.
- **Interpretation of Spectrum:** After acquiring the spectrum, it needs to be analyzed to identify characteristic peaks and features. Peaks corresponding to specific molecular vibrations or functional groups are assigned based on known spectral patterns and literature references. Peaks in the fingerprint region are particularly

informative for identifying organic compounds from the Aloe vera extract and any surface functional groups on the MgA nanoparticles.

- **Data Analysis:** Once the spectrum is interpreted, we performed the data analysis to quantify the intensity of specific peaks, assess peak shifts or changes compared to reference spectra, and extract relevant information about the composition and structure of the MgA nanoparticles.

Reporting and Interpretation: Finally, the results of the FT-IR analysis are reported and interpreted in the context of the synthesis process, the role of Aloe vera extract as a bio-template, and the potential implications for the properties and applications of the MgA nanoparticles as shown in the result section.

2.3.3. SEM of MgO nanoparticles Method

Here are the steps that are involved in acquiring Scanning Electron Micrographs (SEM) of MgO nanoparticles:

- **Sample Preparation:** In this step, we have prepared the MgO nanoparticles for SEM analysis. This typically involves dispersing the nanoparticles onto a suitable substrate. Depending on the specific requirements of the analysis, the nanoparticles may be dispersed in a solvent and drop-cast onto a conductive substrate such as a silicon wafer or a carbon-coated grid. Care should be taken to ensure that the nanoparticles are evenly distributed on the substrate to facilitate accurate imaging.
- **Instrument Setup:** In this step, we have adjusted parameters in the SEM instrument such as accelerating voltage, beam current, working distance, and aperture size to optimize imaging conditions for the specific sample being analyzed.
- **Sample Loading:** The prepared sample is then loaded into the SEM chamber and positioned on the sample stage.
- **Vacuum Pumping:** Before imaging, we evacuated the SEM chamber to create a high-vacuum environment, which helps us to minimize scattering of the electron beam by air molecules and ensures optimal imaging conditions.

- **Electron Beam Scanning:** Once the vacuum is established, the electron beam is scanned across the surface of the sample in a raster pattern. As the electron beam interacts with the sample, various signals are generated, including secondary electrons, backscattered electrons, and characteristic X-rays.
- **Image Formation:** The signals generated by the interaction of the electron beam with the sample are collected by detectors within the SEM chamber and used to form an image of the sample surface as shown in our result.
- **Image Analysis:** After acquiring the SEM images, they could be analyzed using specialized software to extract quantitative data such as particle size, shape, and distribution. Image analysis techniques such as particle counting, size measurement, and morphological characterization can provide valuable insights into the properties of the MgO nanoparticles.
- **Interpretation and Reporting:** Finally, the SEM images and analysis results are interpreted in the context of the synthesis process, sample preparation methods, and the properties of the MgO nanoparticles.

3.Results And Discussion

Scanning Electron micrographs (SEM) of MgO nanoparticles was done and the results show that the surface morphology of the SEM images depicts the nanoparticles as, aggregated and dense rock-shaped flakes. Figure 6 displays the scanning electron microscopy (SEM) images of the MgO NPs synthesized using the Aloe Vera herb extract where the scale bar is (A) 10 µm, (B) 20 µm, and (C) 30 µm. The figure shows that the nanoparticles are agglomerated and have a spherical shape with minor variations in size and shape. Furthermore, the MgO NPs were well dispersed. Locally, the synthesized MgO NPs were agglomerated and formed larger clusters.

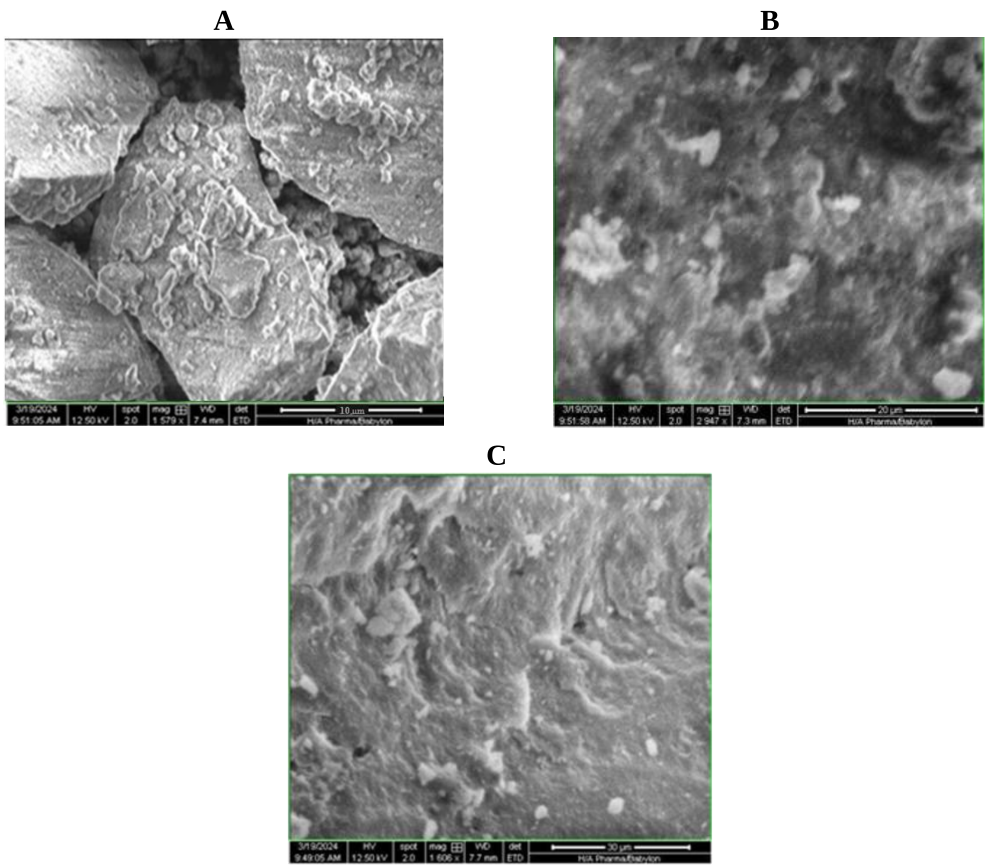

Figure 6 identifies A, B, and C SEM images

The uniform distribution of MgO nanoparticles was observed on the entire surface as shown in Figures 6 (A, B, and C). The Figure 6.A as observed from the scale bar indicating a length of 10 µm. The nanoparticles appear predominantly as small and uniform spheres, characterized by their smooth surfaces and relatively homogeneous size distribution. The nanoparticles in Figure 6.B appear to have a variety of shapes, including spherical, quasi-spherical, and irregular shapes. Moreover, a scale bar indicating a length of 30 μm, reveals a diverse array of morphologies and shapes. The nanoparticles exhibit predominantly spherical and quasi-spherical shapes, characterized by smooth surfaces and relatively uniform size distributions as shown in Figure 6.C. Therefore, that can be represented as an improvement in the ability of Aloe vera extraction to be a good method for MgO nanoparticle creation [17].

Moreover, the uniform distribution of particles over the whole surface can be observed. The aggregation could be due to the interactions and Van der Waals forces between the MgONPs [18]. Researchers also reported that larger grains could be attributed to the Oswald ripening process, with limited porosity and crystallinity [19].

Another result has been reported using the FT-IR method, Fourier transform infrared spectroscopy (FT-IR) was used to identify the possible biomolecules that are responsible for the reduction and capping of MgO NPs. Figure 7 presents the FT-IR spectra of MgO NPs synthesized using the Aloe Vera herb extract. The spectra show bands at 3415, 1458, 1063, 868, 667 and 438 cm−1. The strong infrared band near 3415 cm−1 was observed for the O–H bond vibrations of the hydroxy group, A study by Bindhu et al. (2014) on green synthesis of MgO nanoparticles using plant extracts reported similar absorption peaks associated with hydroxyl groups [20].

The most intense band at 1458 cm−1 represents vibrations C=O, The absorption peak at this wavenumber indicates C-H bending vibrations, particularly associated with alkyl groups. Organic compounds present in Aloe Vera extract may contribute to this peak, acting as stabilizing agents during nanoparticle synthesis. Some researchers on the synthesis of silver nanoparticles using Aloe vera extract reported similar absorption peaks at around 1460 cm-1, attributed to the stretching vibrations of C-H bonds in aromatic compounds present in the plant extract [21].

The band at 1063 cm-1 related to C–H bending vibrations of the aromatic tertiary amine group may correspond to stretching vibrations of Mg-O bonds in MgO nanoparticles.

Similar peaks have been reported in studies on the synthesis of metal oxide nanoparticles, confirming the presence of MgO. The absorption at 869cm-1 is due to C-N stretching in amines, potentially originating from organic compounds in the Aloe Vera extract. A study on green synthesis of MgO nanoparticles using plant extracts observed similar absorption peaks associated with organic functional groups [22].

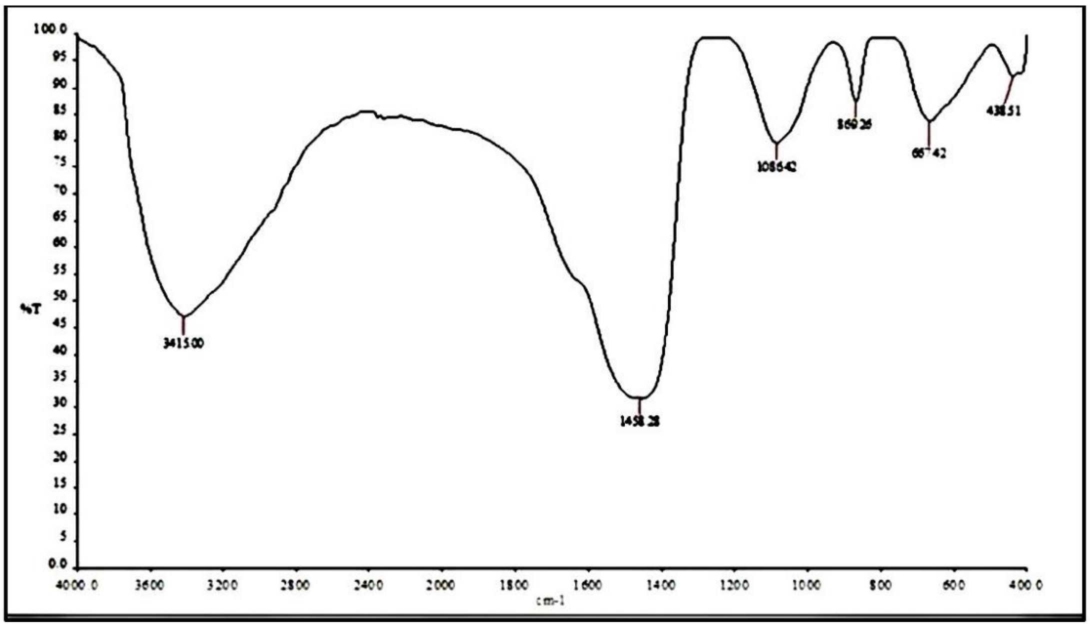

Figure 7 FT-IR Spectrum of MgO nanoparticles.

The peaks at 667 cm−1 and 438 cm−1 may correspond to additional vibrational modes of the MgO lattice or residual organic compounds from the Aloe Vera extract. Further characterization techniques such as Raman spectroscopy could provide additional insights. Additionally, we can confirm these observations that FT-IR spectroscopy is a powerful tool for characterizing MgO nanoparticles synthesized using Aloe Vera herb extract. The observed absorption bands reveal insights into the chemical composition and surface functionalization of the nanoparticles. Green synthesis methods utilizing plant extracts offer sustainable approaches for producing functional nanoparticles with diverse applications.

4.Conclusion

In conclusion, the findings of our study underscore the remarkable feasibility and efficacy of leveraging Aloe vera extract in the eco-friendly synthesis of magnesium oxide (MgO) nanoparticles. Through this innovative approach, we not only achieve successful nanoparticle synthesis but also significantly reduce the environmental footprint associated with traditional chemical methods. By harnessing the inherent properties of Aloe vera, a natural and renewable resource, we unlock a pathway towards sustainable nanotechnology solutions. This pioneering research not only showcases the potential of bio-inspired synthesis techniques but also highlights the importance of interdisciplinary collaboration between biology, chemistry, and materials science. The implications of our work extend far beyond the confines of the laboratory, offering promising avenues for applications in diverse scientific and industrial sectors. From biomedicine to environmental remediation, the utilization of Aloe vera for nanoparticle synthesis opens doors to environmentally conscious innovations with the potential to revolutionize numerous fields. Embracing nature's versatility and resilience, we chart a course towards a more sustainable future, where the principles of green chemistry intersect with cutting-edge nanotechnology to address pressing global challenges.

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الخلاصة

تم استخدام العديد من الطرق في تخليق الجسيمات النانوية .ومع ذلك، أثبتت العديد من هذه الطرق أنها مكلفة وتؤدي إلى إنتاج منتجات جانبية سامة وتستلزم اتخاذ تدابير للتخفيف من التلوث الكيميائي والفيزيائي.

ونتيجة لذلك، انتشر اعتماد تخليق الجسيمات النانوية الخضراء باستخدام مستخلصات النباتات كبديل مستدام ضمن تكنولوجيا النانو، مع تقديم تطبيقات عديدة عبر مجالات متنوعة .في هذه الدراسة، تم استخدام مستخلص الألوفيرا لتخليق جسيمات أكسيد المغنيسيوم .من خلال استخدام المجهر الإلكتروني الماسح والطيف الأشعة تحت الحمراء حيث قمنا بفحص وتأكيد وجود جسيمات أكسيد المغنيسيوم.تؤكد نتائج هذا التحقيق فعالية مستخلص الألوفيرا في تخليق جسيمات أكسيد المغنيسيوم، كما يظهر ذلك من خلال استخدام المجهر الإلكتروني الماسح والطيف الأشعة تحت الحمراء .في الختام، تظهر دراستنا جدوى وفعالية استخدام مستخلص الألوفيرا لتخليق جسيمات أكسيد المغنيسيوم بشكل صديق للبيئة. من خلال استغلال قوة الطبيعة، نمهد الطريق لحلول تكنولوجيا النانو المستدامة التي تطال مجالات علمية وصناعية متنوعة.