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Review Article

Eletteria cardamomum and Greenly Synthesized MgO NPs: A Detailed Review of Their Properties and Applications

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Abstract: The use of live cells to synthesize green nanoparticles (NPs) is a promising and novel bio nanotechnology method. Chemical and physical methods are utilized to synthesize NPs; however, biological approaches are preferred because they are ecologically friendly, safe, healthful, cost-effective, accessible, and effective sources of high productivity and purity. Toxic and hazardous substances, as well as the use of external reducing, stabilizing, or capping agents, are not necessary for the green synthesis of NPs. Cardamom seeds, which are little Capsules (fruits) of *Elettaria cardamomum* (Family (Zingiberaceae)], have been used in herbal medicine to treat a wide range of ailments, including asthma, tooth and gum infections, cataracts, nausea, diarrhea, and cardiac, digestive, and kidney problems. Cardamom capsules have a number of additional health benefits that are important from both a traditional and current pharmacological perspective. MO-NPs (metal oxide nanoparticles) have caused quite a stir in recent years due to their diverse set of properties. *Elettaria cardamomum* is high in polyphenolic compounds and flavonoids, making it a viable green source for large-scale, low-cost, and environmentally friendly MgO-NP production. UV-Visible spectroscopy, X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FT-IR), and scanning electron microscopy (SEM) with EDS are used to investigate the phytoassisted synthesis of MgO. (Energy dispersive X-ray spectroscopy). Researchers have successfully disseminated suitable MO-NPs for obtaining significant results by leveraging their numerous desirable qualities, such as those found in the pharmaceutical, ceramics, textile, electronic, and fertilizer industries.

Keywords: *Eletteria cardamomum*, Nanotechnology, Miniaturization, Antioxidant, Nanoparticles, Ailments

1. Introduction

Nanotechnology advances and their implementation in the fields of neuropsychology and medicine have resurrected the twentieth century [1]. The analysis of extremely thin substances is known as Nano science [2]. The prefix "nano" is a Greek word that means "small thing." The word "nano" refers to a very small or extremely small scale. Nanotechnology is the practice of manipulating individual atoms, molecules, or compounds to produce materials and devices with specific properties [3]. Nanotechnology works with materials in terms of nanometer range (1-100 nm), and thus can be used for a wide range of applications and the manufacture of various types of nanomaterials and Nano devices. Nanotechnology deals with materials at the nanometer scale (1-100 nm) and can thus be used for a wide range of applications and the development of various forms of nanomaterials and Nano devices [4].

2. Classification of Nanoparticles Dimensionally

Nanoparticles can be divided into three categories: one-dimensional, two-dimensional, and three-dimensional nanoparticles. Thin films or surface coatings are common examples of one-dimensional nanomaterials. Thin films have been produced and utilised in a variety of applications for decades, including communications, data storage, chemical

and biological sensors, fibre optic networks, and magneto-optical and optical devices. Thin films can be generated in a controlled manner at the atomic level utilising a variety of techniques [5].

Nanotubes, dendrimers, nanowires, fibres, and fibrils, for example, are two-dimensional nanomaterials with two dimensions on the nanometer scale. In the Nanoscale range, free particles are 2D nanomaterials with a large aspect ratio. 2D structures have fewer well-understood characteristics and less advanced output capacities [6].

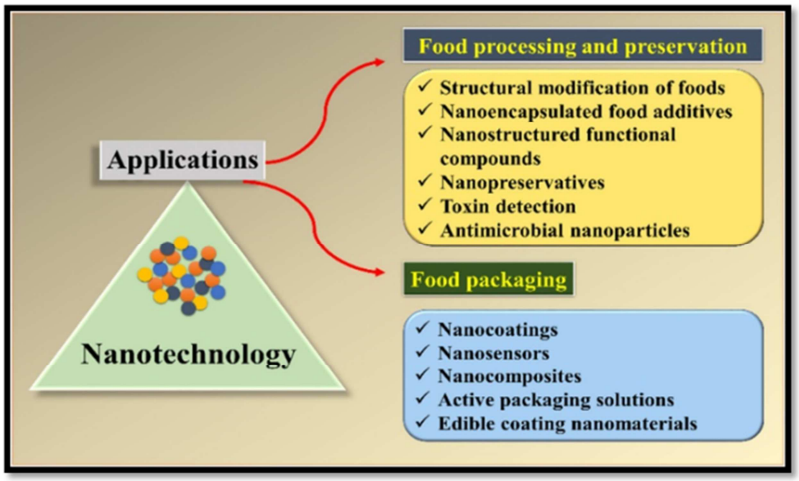

Figure 1. *Applications of Nanotechnology.*

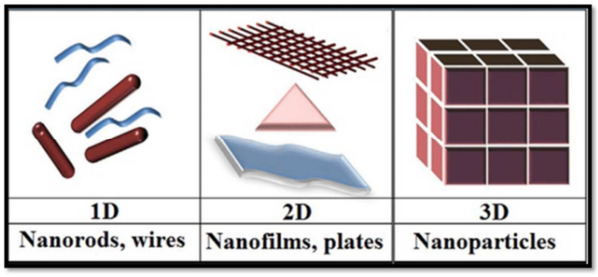

Figure 2. *One, Two and three dimentional nanoparticles.*

2D Nano size materials are considered 3D nanornaterials in all three dimensions. Examples include quantum dots, fullerenes, ions, precipitates, colloids, and Nano crystals. Natural nanomaterials and combustion components, metal oxides, black carbon, titanium oxide (TiO_2), and zinc oxide (ZnO) are examples of well-known 3D structures, while others, such as fullerenes, dendrimers, and quantum dots, present the greatest problems in property depiction. [7].

3. Synthesis of Nanoparticles

Two forms can be classified in the general synthesis of nanomaterials,

1. Bottom-u p approach
2. Approach Top-down

Bottom-up methods combine the miniaturisation of material components (down to the atomic level) with more self-assembly processes that contribute to the creation of nanostructures. During self-assembly, nanoscale physical forces are used to assemble units into larger, more robust structures, such as the quantum dot configuration during colloidal dispersion of nanoparticles. Top-down methods, such as ball milling and plastic deformation, use larger initial structures that can be manipulated externally in nanostructure manufacturing [8].

Following are the advantages and disadvantages of Bottom up approach listed in the table below.

Table 1. *Advantages and disadvantages of Bottom up approach.*

S. No	Advantages	Disadvantages
1	Obtained nanoparticles, nanotubes	Large scale production is difficult
2	The deposit parameters can be controlled	
3	It is possible to distribute the narrow size (1-20nm)	Chemical purification of nanoparticles is required
4	Cheaper technique	

Following are the advantages and disadvantages of Top down approach.

Table 2. *Merits and Demerits of Top down approach.*

S. No	Merits	Demerits
1	Large scale production	Size distribution (10-100nm)
2	It is possible to deposite on a large substarte	Expensive
3	No chemical purification is required	Various particle shapes
4		Conrolling the deposit parameters is difficult to achieve

Different chemical concentrations and reaction conditions can modulate the morphological constraints of nanoparticles (e.g., shape and size) (e.g., temperature and pH). However, if unique applications are applied to these synthesized nanomaterials, they can be very useful. The following drawbacks or challenges can arise:

1. lack of understanding of basic mechanisms and modeling factors,
2. bioaccumulation/toxicity characteristics,
3. need for a comprehensive examination need for qualified operators,
4. the challenge of deviation/toxicity,
5. resistibility in hostile environments.

4. Green Synthesis

To overcome these shortcomings, a revolutionary age of green approach is getting significant interest in the emerging scientific examination of material technology and research. In other words, the synthesis of green materials/nanomaterials, which is aided by the regulation, control, cleaning, and remediation processes, will directly contribute to their increased environmental friendliness. Therefore, several elements such as waste prevention/minimization, derivative/pollution reduction, and the usage of environmentally-friendly (or non-toxic) solvents and auxiliaries, as well as organic feedstock can explain some of the fundamental concepts of "green synthesis" [9].

By designing effective, safe, and environmentally sustainable synthesis procedures, 'green synthesis' is needed to evade the fabrication of unnecessary or dangerous side-products. To accomplish this goal, it is important to use epitome solvent processes and natural resources (such as organic systems) [10].

The number of research articles published in the subject of bio nanotechnology has increased dramatically during the previous decade. Green nanomaterials are essential for the advancement of nanotechnology in a variety of industries. Environmental friendly nanotechnology refers to the development and use, to promote sustainable growth, of green Nano-products. Green NPs were used in many drugs, pharmaceutical applications, and in- vitro diagnostics. Green synthesized NPs play an important role in medications, medical applications, and in vitro diagnostic applications. In the last decade, research publications in the area of nanotechnology have grown considerably. In the application of nanotechnology to various areas, green-synthesized nanomaterials play a significant role. Green nanotechnology speaks of the development and use of green Nano- products to achieve long-term growth. Drugs, pharmaceutical applications, and in vitro diagnostic applications all benefit from green synthesized NPs [11].

5. Spices

Rather than the leaves, the term spice refers to any dried part of a plant used in the culinary arts to season and flavor a recipe, but not as the main ingredient. Spices include dried bark, roots, berries, seeds, twigs, and anything else that isn't the herb's green leafy component. Today, India is the biggest buyer, manufacturer, and exporter of spices worldwide. The Indian Spices Research Institute has also been founded to research spices [12].

Figure 3. *Spices.*

6. *Eletteria cardamomum*

6.1. Types of Cardamom

Cardamom appears in two varieties:

1. small green cardamom (*Elettaria Cardamomum*) and,
2. big red/black cardamom (*Amomum suhulotum*).

Figure 4. *Elettaria cardamomum and Amomum suhulotum.*

Though large cardamom is mostly grown in India, with some in Nepal and Bhutan, the *Elettaria cardamomum* is the most common variety. They are also members of the Zingiberaceae plant family.

In the ginger tribe, cardamom is a spice produced from the seed pods of different plants. Cardamom purls have a triangular cross-section and are spindle-shaped. A variety of seeds are found in the Capsules, but whole or ground can be included in the whole cardamom pod. The seeds are tiny and black, while the color and size of the pods vary by species [13].

Elettaria cardamomum is a spice that has been used in cooking and as a material for years. lt was once a traditional ingredient in Middle Eastern and Arabic cuisines, has gained popularity in the West. lt is a seasoning that comes from the seeds of many various ginger plants. lt has a special taste that goes well in both sweetened and salty cuisines. Cardamom

seeds and pods can be used in curries, cakes, and meat based cuisines, also in drinks like coffee and chai tea. Cardamom should be taken as a substitute for its nutritional benefits. Eletteria is a term used to describe a form of Phytochemicals in Cardamom that have anti-inflammatory and antibacterial properties [14].

After flowering, *Elettaria cardamomum* capsules mature entirely in around 1 20 days. The fruits are non-dehiscent, corpulent, and tough when dry, with an ellipsoidal or nearly spherical shape. The fruit starts out green and turns golden yellow when it ripens, measuring 1-2 cm in length. Depending on the genotype, each pod encloses 12 to 32 seeds, which are black and covered with a white mucilaginous coating [15]. lt's a tall, annual herbaceous plant with a sheathing base of sub sessile, lanceolate leaves. The fruits are trilocular subglobose capsules with multiple longitudinal ribs, and the flowers are panicles with white and violet stripes. Every pod contains 15 -20 brownish-black seeds that are divided by a thin mucilaginous membrane [16].

6.2. Chemical Structures of Major Constituents of Elettaria cardamomum

Elettaria cardamomum is composed of α-pinene (1.5%), β-pinene (0.2%), sabinene (2.8%), myrcene (1.6%), α-phellandrene (0.2%), limonene (11.6%), 1,8-cineole (36.3%), γ-terpinolene (0.5%), linalool (3.0%), linalyl acetate (2.5%), terpinen-4-ol (0.9%), α-terpineol (2.6%), α-terpinyl acetate (31.3%), citronellol (0.3%), nerol (0.5%), geraniol (0.5%), methyl eugenol (0.2%), and trans-nerolidol (2.7%) [17].

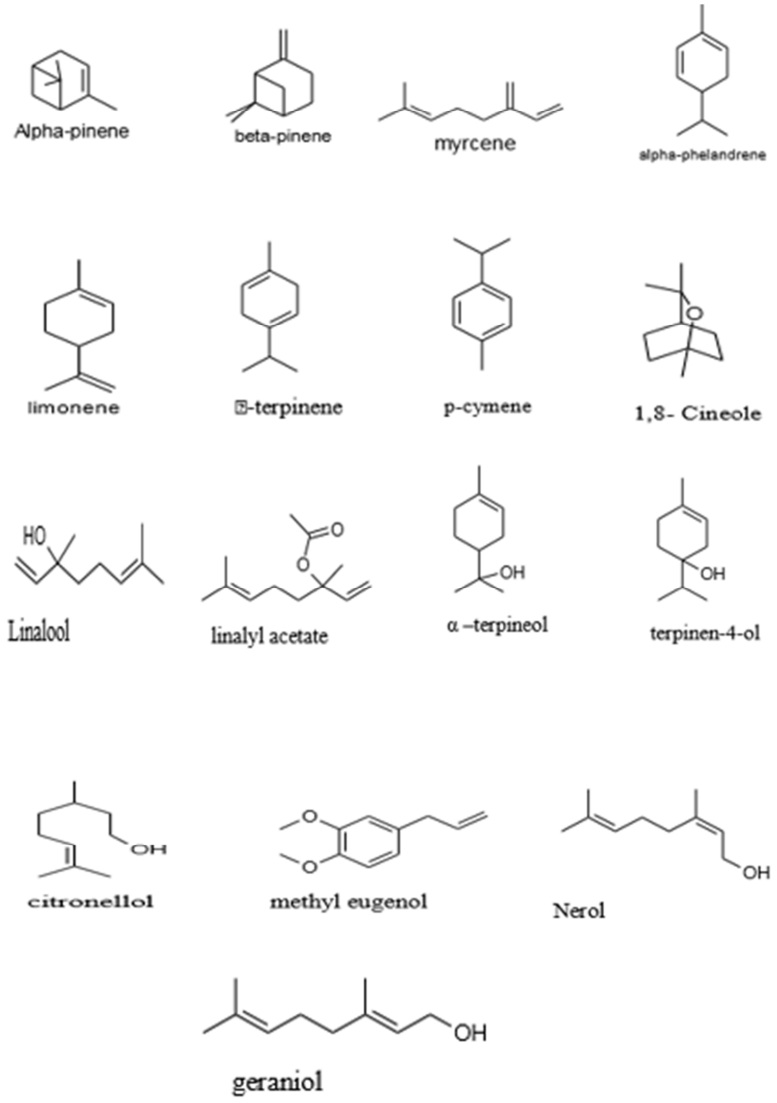

Figure 5. *Chemical Structures of major constituents of cardamom.*

7. Medicinal Uses of Elettaria Cardamomum

Elettaria Cardamomum possesses various medicinal properties [18-20]. To prevent bad breath, vomiting, and indigestion, *Elettaria cardamomum* seeds may be usedCardamom capsules reduce the caffeine content of coffee, and the combination of cardamom and coffee is known as 'gavah,' which is used in Arabian culture to cure headaches

and tension. Add two drops of cardamom oil and two drops of lavender oil to the water in your normal bath to maintain healthy skin [21].

Figure 6. *Applications of E. cardamomum.*

Elettaria cardamomum seeds are fragrant, acrid, sweet, cooling, stimulant, carminative, stomachic, diuretic, cardiotonic, and abortifacient, and can help with bronchitis, haemorrhoids, stangury, renal and vesical calculi, anorexia, dyspepsia, gastropathy, and vitiated vata [22].

7.1. Antioxidant Activity

A significant cause in the stimulation of many prolonged and deteriorating disorders which includes diabetes, cancer, immune deficiency and Parkinson's disease is oxidative stress [23, 24]. Elettaria cardamomum has a broad antioxidant profile. Antioxidants are natural or synthetic compounds that can be used to avoid the creation of free radicals by scavenging them. Natural antioxidants obtained from herbal sources are currently attracting a lot of interest [25, 26]. The pods and spores of Elettaria cardamomum are richly supplied with antioxidant compounds that neutralize free radicals while stopping other components from being oxidized. lt is known that natural antioxidants are more stable than synthetic types [27].

7.2. Antimicrobial and Antibacterial Activity

Elettaria cardamomum essential oils have vigorous antibacterial effects against innumerable food borne microorganisms [28]. Morgenella morganii growth was moderately inhibited when *Elettaria Cardamomum* oil was applied [29].

Elettaria cardamomum antibacterial capabilities range beyond countering bad breath. ln laboratory studies, the Elettaria cardamomum extract was shown to inhibit the growth of many cultures of candida yeast. Elettaria cardamomum essential oil was also extraordinarily successful against the production of many microbial and mycological species [30, 31]. While the contrivance is not well known, it is suspected that active constituents present in essential cardamom oils interact with proteins inside bacteriological membranes, contributing to the inactivity and death of the organism [32, 33]. *Elettaria Cardamomum* oil could play a vital role in developing safe and novel antibiotics in modern medicine [34].

E. cardamomum oil has possible antiseptic and antifungal broad-spectrum properties that may be cast-off to deter harm from frond-borne infections and microbes [35]. The multiple metabolic reactions create free radicals spontaneously and emit toxins that can destroy other internal chemicals, substances, and cells. Besides, our free-radical development contributing to oxidative stress is intensified by a variety of eco-friendly causes, such as nourishment, smoking, air quality and others. Increases in oxidative stress have lately been linked to many significant and lethal illnesses, including causes of cancer, dementia and diabetes. This is where antioxidants play an imperative role in responding to and neutralizing free radicals [36].

7.3. Natural Breath Freshener

As a natural air freshener, Elettaria cardamomum is widely used. 1n Southeast Asia, locals chew the seeds in cardarnom pods, collecting essential oils along with a fragrant scent. Several studies have revealed antibacterial effects against traditional oral strains of Elettaria cardamomum extracts. Cardamom oil's active ingredient cineole is a potent antiseptic, inhibiting bacterial growth. Both forms of cardamom (green and black) were found to have antibacterial properties against cavity-causing microorganisms found in the human mouth [37].

7.4. Anti-inflammatory

Cardamom is widely used in India to combat diseases in the teeth and gums, to avoid and treat throat conditions, lungs and consumption congestion, irritation of the eyelids, and biological process diseases. Species from the genus Amomum were also used in ancient Indian medicine. *Eettaria cardamomum* extract improves overall metabolism while avoiding multiple duct problems such as acid reflux, heartburn, abdominal cramps, and diarrhea, due to a combination of inhibitor and anti-inflammatory compounds present in the genus *Elettaria cardamomum's* extract. Indigestion, also known as dyspepsia, is a disease in which digestion is hindered in some way. Upper stomach pain, fullness of the belly, heartburn, fatigue, itching, and it may be uncomfortable at times are some of the symptoms. Indigestion may also be a sign of stomach ulcers, which are bloated stomach lining. Cardamom's anti-inflammatory properties were found to limit the formation of ulcers induced by aspirin and alcohol by reducing inflammatory protein levels, according to researchers. (TNF-alpha) and the operation of TNF-alpha [38].

One of the primary cell signaling protein families for the body's defenses is tumor necrosis factor (or TNF for short). To battle foreign compromised cells or pathogens, TNF triggers the normal reaction that induces inflammation. Foreign invaders cause TNF levels to rise, causing an increase in the immune response to inflammation. However, excessive stress retains high levels of TN F, contributing to prolonged inflammation, resulting in hyperactivity and damage to healthy or uninfected soft tissue. Therefore, general inflammation also decreases by reducing TNF-alpha concentrations [39].

7.5. Reduces Anxiety

For decades, cardamom has been used to spice dishes and as a natural cure for its distinct scent and taste. However, it is

often believed that the heavy ingredients in the essential oils of Eettaria cardamomum contain anti-depressant properties and are extensively used in aromatherapy. The familiar, tried-and-true cure for depression for decades speaks of the strength of the seed of cardamom. Grinding the seeds of Eettaria cardamomum into powder and heating them with tea leaves in water creates a calming fragrance and a drink that is an important depression remedy.

Besides providing several therapeutic uses, clinical evidence confirms the remarkable anti- inflammatory effects of Elettaria Cardamomurn. ln nature, mental health disorders such as post-traumatic stress disorder (PTSD) are complex, with several distinct signs and causes. In the intimate, educational and social circles of people, such symptoms cause different problems. The idea that symptoms from person to person is what makes those disorders extremely complex Scientists are working with various potent antioxidants as part of their continuing quest for successful therapy.. Eettaria cardamomum contains a flavonoid compound called quercetin, which is considered to be responsible for its potent effects. In small animals, quercetin was shown to alleviate fear and depression. [40, 41].

7.6. Hepatoprotective Effect

Eettaria cardamomum contains ground-breaking cell reinforcement properties and have been utilized as normal detox specialists. Liver is the principle detoxification organ that utilizes various explicit proteins to measure, channel and eliminate body's results and poisons. In view of such exceptionally explicit and complex capacity, liver is frequently exposed to different degrees of stress, prompting more prominent creation of free revolutionaries. Stress can get persistent or oxidative in nature, metabolic unevenness between body's free extremists and cell reinforcement levels. In the liver, free revolutionaries assault and cause harm to cell proteins, lipids and DN A, obliterating these atoms and mixtures, just as upsetting or diminishing generally usefulness of the organ. The free extreme convergence makes an invulnerable reaction and arrival of a few flagging proteins called cytokines. These cytokines, for example, changing development factor-beta (TGF- beta), interleukin-6 (lL-6), and tumor rot factor-alpha (TNF-alpha) are significant pieces of the invulnerable framework be that as it may, in enormous amounts can prompt obliteration of sound tissue [42]. In the liver, this sort of invulnerable reaction that is persistent in nature can prompt a few illnesses. Henceforth different cell reinforcements found in food have reestablishing cancer prevention agent limit and improving liver sicknesses. [43].

8. Magnesium Oxide Nanoparticles

Magnesium oxide nanoparticles are both non-aromatic and are not poisonous. They have a high melting temperature, hardness, and potential purity. In a white powder shape, magnesium oxide nanoparticles emerge. The chemical, physical and thermal properties of MgO nanoparticles are shown below [44].

They can be used in several applications, including petrochemical materials, and coatings. Sound- proof, lightweight, heat-insulating, and refractory fiberboards and metallic ceramics can be made from magnesium oxide nanoparticles and wood chips and shavings [45].

Table 3. *Chemical, physical and thermal properties of MgO nanoparticles.*

Chemical Data	
Chemical symbol	MgO
Group	Magnesium 2 Oxygen 16
Electronic configuration	Magnesium [Ne] $3s^2$ Oxygen [He] $2s^2$ $2p^4$
Chemical Composition	
Element	Content %
Magnesium	60.29
Oxygen	39.67
Physical Properties	
Propertie Properties	Metric
Density	3.58 g/cm^3
Molar mass	40.30 g/mol

Magnesium oxide nanoparticles are used in the manufacturing of silicon steel tubing, high-grade ceramic glass, electronic industry material, adhesives, and chemical raw materials as a high- temperature dehydrating agent. MgO nanoparticles are typically used to produce crucible, seer, shielded tube, electrode bar, and electrical layer in electrically insulating material, as well as high- frequency magnetic rod antennas, magnetic unit filler, insulating material filler, and other radio industry carriers [46].

Following are the uses of MgONPs.

8.1. Refractory Applications

lt is an appreciated fireproofing constituent in construction materials. lt is also used in solicitations such as fissile, biochemical or super alloy industries where corrosion is not acceptable. [47].

8.2. Medical Applications

MgO nanoparticles are used as an antacid, magnesium supplement and a immediate laxative for the treatment of heartburn and sour stomach [48].

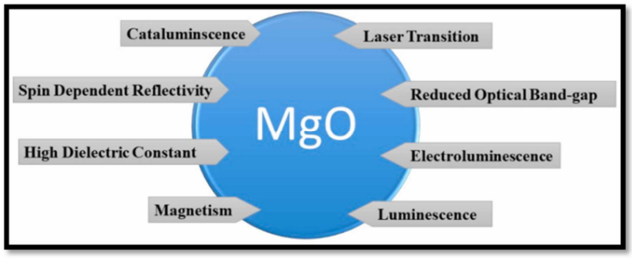

Figure 7. *Applications of MgONPs.*

8.3. Miscellaneous Applications

Following are the miscellaneous applications of MgO nanoparticles.

1. insulators [44],
2. fertilizers [49],
3. water treatment [45],

4. protective coating [50], etc.
5. Currently, there are trends to use nanoscale fillers [51].

The fabrication of functional structures in the range of 0.1–100 nm by various physical or chemical processes is referred to as nanotechnology [52]. This holds true for magnesium oxide nanoparticles as well. The sol-gel method [53] or the hydrothermal method [53] or hydrothermal technique [47] could be utilised to make nanoscale magnesium oxide. MgO nanoparticles are a potential filler for electrical applications, such as high voltage insulation. Because of the broad band gap (7.8 eV) and high volume resistivity (1017 Ω·m), it is very attractive. It has the highest volume resistivity of all the nanoscale oxides that are widely utilized [54].

MgO nanoparticles are an important inorganic material with a wide band-gap that has been used in a variety of applications, including catalysis, catalyst supports, toxic waste remediation, refractory materials and adsorbents, additive in heavy fuel oils, reflecting and anti-reflecting coatings, superconducting and ferroelectric thin films as substrates, superconductors and lithium ion batteries, and so on [55].

9. Conclusion

In this study, MgO Nanoparticles are synthesized using a simple, environmentally friendly green synthetic approach. Phytofabrication of MgO Nanoparticles without the use of harmful chemicals using E. cardamom seed extract. The reduction of metal ions happens relatively quickly, and the reduction of Mg ions will take 4 hours. Flavones, which are water soluble heterocyclic chemicals, were primarily responsible for the Nanoparticle's reduction and stabilization. The current study used E. cardamomom seeds as a source, which are readily available and have a wide range of biomedical applications. MgONPs produced using a green technique are low-cost, monodispersive, and can be used for a variety of biomedical applications thanks to their antibacterial, antifungal, and antiallergic capabilities.

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