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EXPLORING THE CURRENT LANDSCAPE: UNVEILING THE POTENTIAL OF CAO-NPS AND PLANT EXTRACT-MEDIATED ECO-FRIENDLY SYNTHESIS

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ABSTRACT: Enhancing the safety and durability of the techniques used to generate nanoparticles (NPs) is an important component of green nanotechnology. Conventional techniques of creating nanoparticles are complex, dangerous, and expensive, putting both humans and the environment at risk. To avoid these risks, scientists created calcium oxide nanoparticles (CaO-NPs) using biopolymers produced from bacteria, plants, and mushrooms. For example, reaction circumstances have a major impact on the creation of CaO-NPs, which influences their dimensions, functionality, and morphology. Furthermore, it is possible to synthesis CaO-NPs in an environmentally friendly manner, which has shown promise in a variety of domains such as biofuel production, refractory additives, adsorption, antimicrobial characteristics, Cr(VI) removal, and oil trans esterification. Participants in this study looked at numerous plant species and their constituent parts that were used in the production of CaO-NPs. The book included a variety of CaO-NP topics, including as synthesis, functionality, description, and clean production techniques. It was mentioned that they are still in use.

***Keywords*: Green nanotechnology; Plant extracts; CaO-NPs; Mechanism; Applications**

1. INTRODUCTION

Nanotechnology is currently a large topic that covers various scientific and technological industries, providing unique potential in medicine, renewable energy, and healthcare. Nanoparticles (NPs) range in size from 1 to 100 nanometers. As a result, their chemical and biological properties are vastly different. Nanoparticles outperform bigger materials due to their small size, angular shape, extraordinary stability, and inclination for dispersion. Furthermore, the greater surface area to volume ratio of nanoparticles (NPs) is significant since it boosts their biological and catalytic activity significantly. Nanoparticles (NPs) have a variety of applications, including agriculture, health, electronics, water purification, and catalysis. Nanoparticles have a variety of other properties in addition to their durability, charge capacity, melting temperature, and strength when separated. In recent years, the use of "green nanotechnology" has increased significantly across various industries. The integrity of these sectors improves as more nanotechnology is included into their operations.

CaO is a chemical compound composed of oxygen and an alkaline earth metal. This material restricts the transmission of electricity due to its high energy requirements, broad band gap of 7.1 eV, and high dielectric constant of 11.8. Calcium oxide nanoparticles, or CaO-NPs, are a widely available, low-cost, and simple basic material that can be used for heterogeneous catalysis in a variety of chemical reactions. These nanoparticles are safe to use and have numerous applications. CaO-NPs can be used to absorb CO2, remove Cr(VI), and speed the transesterification of palm and sunflower oil, in addition to being photocatalysts, adsorbents, bio-ceramics, and biodiesel production aids. Furthermore, they have the potential to remove additional dangerous metal ions. CaO-NPs are also important in photothermal therapy, photodynamic therapy, drug delivery, tissue degradation, and chemotherapeutic drug transfer between synapses.

As a result, significant changes have been made to antibacterial and antifungal medications. Their consistent and efficient application in biology makes this possible.

There are now several generally accepted techniques for the simple synthesis of CaO-NPs. Solution combustion flame-assisted synthesis, co-precipitation, sonication, ball-milling, thermal breakdown, and the sol-gel method are examples of these. In contrast, the technologies described above are quite advantageous. On the other side, they are expensive, time-consuming and difficult to operate, use a lot of energy, have complicated processes, and produce undesired byproducts. As a result, it is critical that we address the concerns as soon as possible and develop "green nanotechnology" as a means of establishing a safer, more cost-effective, and environmentally sustainable alternative. As a result of its safety, cost-effectiveness, and lack of dangerous chemical components, the manufacturing of nanoparticles from plant extract has received widespread acceptance. By using natural capping and reducing agents, CaO-NPs can be synthesized more efficiently using plant extract-mediated nanoparticles (NPs).

The functionality of CaO-NPs generated from plant materials, their characterisation, and prospective innovative applications were the primary emphasis of this review.

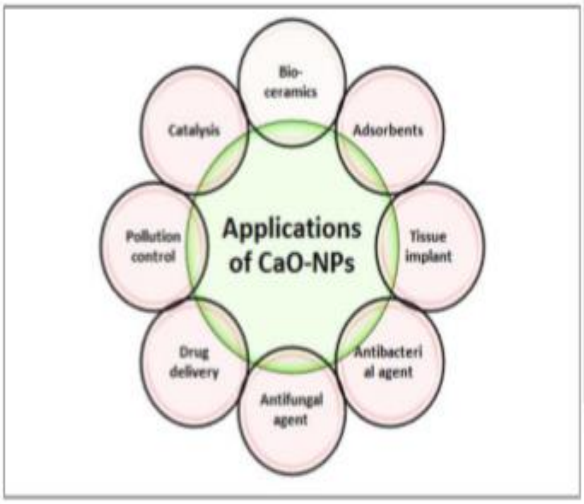

Figure 1. Calcium oxide nanoparticles have numerous practical applications.

Scope Of This Review:

Despite a few anecdotal examples, no extensive examination into the possible applications of plant-based CaO-NPs has been conducted. The medicinal and catalytic applications of CaO-NPs are discussed in this review. After describing the CaO-NPs synthesis process, the particles were thoroughly examined using XRD, other spectroscopic techniques, and microscopic approaches. An in-depth analysis of the time-tested techniques for manufacturing CaO-NPs from plant extracts, as well as the many applications for which they can be used, could aid researchers in nanotechnology, agriculture, biomedicine, and environmental remediation.

plant material assisted eco-benign synthesis of cao-nps:

Because of their constant nature and environmental safety, extracts obtained from diverse plant components (e.g., stems, roots, bulbs, foliage, flowers, or fruits) are preferred over alternative biomaterials when making metal oxide nanoparticles. Biomolecules in the plant broth, such as proteins, amino acids, vitamins, polysaccharides, enzymes, and flavonoids, produce the required nanoparticles.

Plant extract-mediated biosynthesis has various advantages (Figure 2), including plant safety, low cost, user-friendliness, quick production, and environmental friendliness. Numerous studies have been conducted to investigate the ability of various plant species to synthesize CaO-NPs, as shown in Table 1. Because the procedure offers several benefits.

CaO-NPs can be synthesized from a plant's stem, leaves, and spores. The water-soluble phytochemical components are principally responsible for CaO-NPs' stability. CaO-NPs must be evaluated using a number of complicated techniques after they have been manufactured in a laboratory.

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Research Paper , Journal Volume 10, Iss 11, 2021

Figure 2. Metal oxide nanoparticle production is significant.

2. METHODOLOGY FOR PLANT MEDIATED GREENSYNTHESIS OF CAO-NPS

Various plant parts, including fruits, foliage, and roots, are rinsed with distilled water to create CaO-NPs using the plant extract method. After chopping them with a household mixer, they are reduced to an aqueous bouillon by boiling them in double-distilled water.

Table 1. CaO-NPs, or calcium oxide nanoparticles, are made from several plant sources. These can take on a variety of shapes and forms.

Entry	Name of Plants	Part	Precursors	Shape	Size (nm)	Reference
1	*Azadirechta indica*	Leaves	$Ca(NO_3)_2$	Star shaped	50-200	[42]
2	*Broccoli*	Leaves	$CaCl_2$	Cube, Spherical, Hexagonal	32-45	[36]
3	*Cissus quadrangularis*	Stem	$CaCl_2$	Hexagonal	58	[57]
4	*Cissus quadrangularis*	Leaves	Egg shell	-	-	[58]
5	*Acalypha indica*	Leaves	Egg shell	-	-	[58]
6	*Solanum nigrum*	Leaves	Egg shell	-	-	[58]
7	*Phyllanthus niruri*	Leaves	Egg shell	-	-	[58]
8	*Hylocereus polyrhizus*	Fruits	$CaCl_2.2H_2O$	Rod	18.98	[43]
9	*Mentha piperata*	Leaves	$CaCl_2$	Disc	-	[59]
10	*Oscimum Sanctum*	Leaves	Egg shell	-	40-70	[60]
11	*Rhododendron arboreun*	Leaves	$Ca(NO_3)_2$	Broad needle like shape	-	[61]
12	*Papaya*	Leaves	$Ca(NO_3)_2.4H_2O$	Agglomerated	86-117	[62]
13	*Tea*	Leaves	$Ca(NO_3)_2.4H_2O$	Agglomerated	89-180	[62]

Filtration and centrifugation are two further methods for purifying plant broth. CaO-NPs can be created by varying the temperature, pH, egg shell powder-to-plant water ratio, and time between processes. The plant broth rapidly mixes with solutions containing egg shell powder or calcium metal compounds in different quantities at room temperature. This method rapidly manufactures CaO-NPs in an environmentally benign, sustainable, and practical manner. The use of dangerous external compounds for capping or stabilizing is unnecessary because the plant broth is rich in phytochemicals that act as natural stabilizers and reducers. The authors describe how to use broccoli leaf extract in the biogenic synthesis of CaO-NPs. Finally, the NPs can be isolated by rapidly rotating them and then thoroughly washing them in water or a suitable solvent. CaO-NPs were then cooked to a high temperature in a muffle furnace using a clay crucible. Calcium oxide nanoparticles (CaO-NPs) are processed and collected in powder form for future research and use.

3. CHARACTERIZATION TECHNIQUES FOR CAO-NPS

Following their biological creation, it is necessary to provide a description of the CaO-NPs. Dimensions, uniformity, shape, durability, and chemical composition are all characteristics of CaO-NPs. Each of these CaO-NPs features is important in a variety of situations. Several widely used procedures are used to determine and evaluate the properties of CaO-NPs. Among these techniques are powder X-ray diffraction (XRD), energy-dispersive spectroscopy (EDS), transmission electron microscopy (TEM), and Fourier transform infrared spectroscopy (FTIR).

UV-visible spectroscopy is a commonly used method. This method makes use of light with wavelengths ranging from 200 to 800 nanometers. The composition of the CaO-NPs was established by evaluating spectrophotometric absorption readings between 400-450 nm and 260-410 nm. The surface plasmon resonance of the CaO-NPs produced from Cissus quadrangularis is responsible for the UV-visible band peak detected at 400-450 nm. The XRD pattern (Figure 3) was used to investigate the CaO-NPs' structure, crystal planes, and average particle size. The strong and narrow diffraction spots suggest that the CaO-NPs

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have crystallized. The average size of the CaO-NPs was measured by looking at the broadening of the diffraction peaks associated with the strongest reflections on JCPDS (Joint Committee on Powder Diffraction Standards) standard cards. Scherrer's equation (Equation 1) was applied to the XRD diffraction pattern to determine the crystallite size of the CaO-NPs.

$$d = K\lambda / \beta COS\theta \ (1)$$

What is the exact location?

The length of an X-ray wave is indicated by, while the size of a crystallite is generally d nanometers.

The Scherrer constant, written as K, is widely assumed to be 0.94.

The full width at half maximum (FWHM) of is represented as radians.

The Bragg angle, or is important to Bragg's rule.

The scanning electron microscopy (SEM) scan revealed accurate information about the average size and morphology of the generated CaO-NPs (Figure 3). EDX spectroscopy is frequently used to determine the chemical composition of biosynthesized CaO-NPs (Figure 4). TEM, or transmission electron microscopy, is the method used to investigate the precise size and shape distribution of CaO-NPs. The physical and functional properties of nanoparticles (NPs) can be investigated using FTIR spectroscopy. This method is used to determine the degree of chemical connection between metal atoms on the surface of NPs and plant extract. The biomolecules contained in plant water extracts that serve to encapsulate and support CaO-NPs during their biogenesis process were identified using FTIR spectroscopic methods. Experts have used more significant approaches to describe metal oxide nanoparticles, as shown in Figure 5.

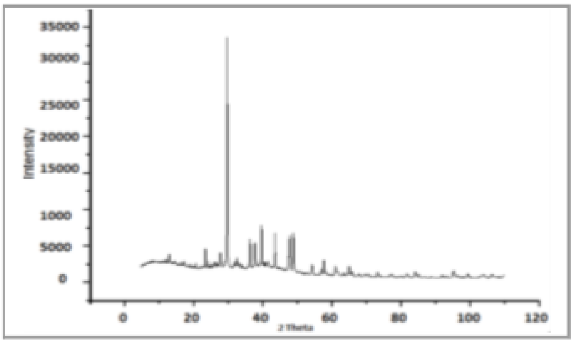

Figure 3. Figure 61 depicts the X-ray diffraction (XRD) pattern of biologically produced calcium oxide nanoparticles (CaO-NPs).

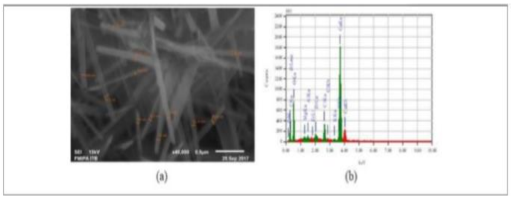

Figure 4. Figure 43 depicts the energy-dispersive X-ray (EDX) curve and scanning electron microscopy (SEM) picture of biologically produced calcium oxide nanoparticles (CaO-NPs).

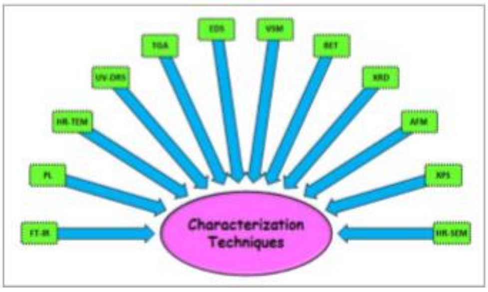

Figure 5. There are several ways to talk about nanoparticles.

Proposed Mechanism For Cao-Nps Formation Using Plant Extract

Phytoconstituents such as anthocyanins, flavonoids, coumarins, saponins, phenols, amino acids, steroids, and sugars are required for the production of nanoparticles (NPs). Metal oxide nanoparticles are manufactured using a variety of plant components. Plant extract synthesis is greatly influenced by phytochemicals. CaO-NPs were created by Onwudiwe et al. using a material obtained from broccoli leaves. According to his

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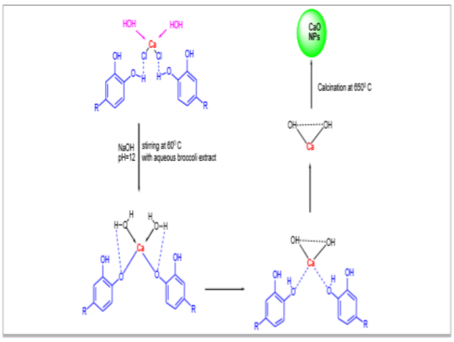
research findings, the flavonoid component, such as

The leaf extract contains quercetin, which acts as a stabilizer and a diuretic. When the aromatic hydroxyl groups of quercetin combine with calcium metal ions, a stable dyad is produced. His explanation of the CaO-NPs production process (Scheme 1) was basic and uncomplicated.



Scheme 1. The use of a byproduct of broccoli leaves in the manufacture of calcium oxide nanoparticles (CaO-NPs) appears reasonable.

4. APPLICATIONS OF BIOGENICALLY SYNTHESIZED CAO-NPS

Owing to their eclectic features and/or properties, CaO- NPs are especially used in several fields such as CaO-NPs are used in a variety of disciplines due to their unique properties, which include photocatalysis, antioxidant activities, bacterial eradication, and cancer therapy. Biogenerated CaO-NPs have a high value, especially for medical applications such as microbe elimination.

Table 2 summarizes the photocatalytic applications mentioned in the book. Prashantha et al. synthesized CaO-NPs and tested their activity against Bacillus bacteria using a chemical obtained from the leaves of Azadirechta indica. Onwudiwe et al. used a component generated from broccoli leaves to create calcium oxide nanoparticles (CaO-NPs). They then looked into the photocatalytic capabilities of the nanoparticles they created. CaO-NPs created range in size from 32 to 45 nm and have a variety of shapes, including cubes, spheres, and hexagons. The researchers assessed the degree of degradation of bromocrescol green dye. A reduction of 57.63% was achieved by using CaO-NPs as a photocatalyst and exposing it to UV light.

Ayyasami et al. discovered that using Cissus quadrangularis stem extract in the manufacture of CaO-NP was safe for the environment. They also discussed the nanoparticles' possible antibacterial properties. The CaO-NPs are barely 58 nm in diameter. CaO-NPs strongly suppressed the growth of Salmonella typhi, Escherichia coli, Klebsiella pneumoniae, Pseudomonas aeruginosa, Vibrio cholera, and Staphylococcus aureus, according to scientific findings.

According to Pasupathi et al., CaO-NPs can be created spontaneously using leaf samples from Phyllanthus niruri, Acalypha indica, Solanum nigrum, and Cissus quadrangularis. The agar well diffusion method was used to assess the efficiency of these nanoparticles in eradicating Bacillus subtilis, Staphylococcus aureus, and Escherichia coli infections. Ramli et al. created CaO-NPs, which are rod-shaped calcium oxide particles, using a fruit sample from Hylocereus polyrhizus. Turbidimetry was used to assess the efficiency of different concentrations of these nanoparticles against Candida albicans.

Mirza et al. identified antibacterial disk-shaped CaO-NPs after extracting Mentha piperata leaves from a liquid solution. Gurav et al. published their approach for synthesizing calcium oxide nanoparticles (CaO-NPs) utilizing an extract produced from Oscimum sanctum leaves. The experts also documented the antimicrobial characteristics of the 40-70 nm nanoparticles.

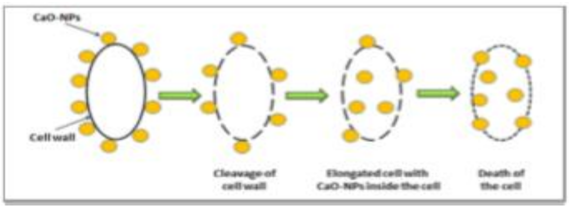


Figure 5. The most plausible method by which CaO-NPs destroy infections.

Joshi et al. investigated the biogenic synthesis of CaO-NPs using a substance isolated from the leaves of Rhododendron arboreum. They also looked into the effectiveness of CaO-NPs in destroying bacteria. According to the study, CaO-NPs had remarkable bactericidal action against Proteus vulgaris, Streptococcus mutans, and Escherichia coli. George and his colleagues used a mixture of tea leaves and pineapple to depict the green color of CaO-NPs. The researchers also tested the CaO-NPs for their ability to eliminate bacteria and function as a photocatalyst. The CaO-NPs produced via biosynthesis ranged in size from 86 to 148 nanometers. The photocatalytic study shows that the biosynthesized CaO-NPs are effective at degrading the Congo red pigment. The antibacterial investigations indicate that CaO-NPs have the potential to be used in the food packaging business. This is because CaO-NPs have been shown to effectively interact with the cell membrane, consequently suppressing bacterial action (Figure 5).

Table 2 CaO-NPs generated from various plant sources have numerous applications.

Entry	Name of Plants	Applications	References
1	*Azadirechta indica*	Antimicrobial activity	[42]
2	*Broccoli*	Photocatalytic activity	[36]
3	*Cissus quadrangularis*	Antibacterial activity	[57]
4	*Cissus quadrangularis*	Antibacterial activity	[58]
5	*Acalypha indica*	Antibacterial activity	[58]
6	*Solanum nigrum*	Antibacterial activity	[58]
7	*Phyllanthus niruri*	Antibacterial activity	[58]
8	*Hylocereus polyrhizus*	Antifungal activity	[43]
9	*Mentha piperata*	Antibacterial activity	[59]
10	*Oscimum Sanctum*	Antimicrobial activity	[60]
11	*Rhododendron arboreum*	Antimicrobial activity	[61]
12	*Papaya*	Antibacterial and photocatalytic activity	[62]
13	*Tea*	Antibacterial and photocatalytic activity	[62]

Future Prospects

- The utilization of plant extracts to produce varied amounts of calcium oxide nanoparticles is a quick and environmentally safe method. This approach is well-known and useful in a variety of situations. Several CaO-NPs have been produced using a variety of plant species. Nonetheless, some research areas still demand attention. Some instances are as follows:
- The lack of precise stoichiometric ratios of precursors and plant extracts hampers understanding the product's synthesis and achieving precise control over its structure.
- The specific process by which the plant extract is used in CaO-NP production is unknown.
- A thorough investigation of the used plants or plant materials is required for a detailed understanding of the working mechanisms.
- It has been established that certain plant species can naturally manufacture calcium oxide nanoparticles (CaO-NPs). As a result, the manufacture of CaO-NPs necessitates the utilization of a large number of medicinal plants.
- Green CaO-NPs created have a wide range of applications, including pharmaceutical conveyance, biosensor creation, agricultural help, and hydrogen production.

5. CONCLUSION

This study looks into the recent rise in interest in making CaO-NPs from diverse plant parts in a simple way, which has applications in a range of disciplines.

The catalyst has the potential to be used as a bio-ceramics adsorbent for medication delivery, tissue dissolution, and pollutant emission reduction. To generate nanoparticles using living organisms, innovative, cost-effective, and environmentally sustainable technologies have been developed, as compared to archaic, toxic, and more complex chemical and physical procedures. CaO-NPs are still used for environmental stabilization; consequently, fresh approaches are needed to define them and select suitable plant species so that the goal can be reached while preserving plant variety.

REFERENCES

1. Gawande, M. B., Goswami, A., Felpin, F. X., Asefa, T., Huang, X., Silva, R., ... & Varma, R. S. (**2016**). Cu and Cu-based nanoparticles:

ISSN PRINT 2319 1775 Online 2320 7876
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synthesis and applications in catalysis. Chemical reviews, 116(6),3722-3811.

2. Matussin, S., Harunsani, M. H., Tan, A. L., & Khan, M. M. (**2020**). Plant extract-mediated SnO2 nanoparticles: Synthesis and applications. ACS Sustainable Chemistry & Engineering, 8(8), 3040- 3054.
3. Gholamrezaei, S., Ghanbari, M., Amiri, O., Salavati-Niasari, M., & Foong, L. K. (**2020**). BaMnO3 nanostructures: Simple ultrasonic fabrication and novel catalytic agent toward oxygen evolution of water splitting reaction. Ultrasonics sonochemistry, 61,104829.
4. Ghotekar, S. (**2019**). A review on plant extract mediated biogenic synthesis of CdO nanoparticles and their recent applications. Asian J. Green Chem. 3(2), 187-200.
5. Pagar, T., Ghotekar, S., Pagar, K., Pansambal, S., Oza, R. (**2019**). A review on bio-synthesized Co3O4 nanoparticles using plant extracts and their diverse applications. Journal of Chemical Reviews, 1(4), 260- 270.
6. Nikam, A., Pagar, T., Ghotekar, S., Pagar, K., Pansambal, S. (**2019**). A review on plant extract mediated green synthesis of zirconia nanoparticles and their miscellaneous applications. Journal of Chemical Reviews, 1(3), 154-163.
7. Ghotekar, S. (**2019**). Plant extract mediated biosynthesis of Al2O3 nanoparticles- a review on plant parts involved, characterization and applications. Nanochem Res. 4(2):163-169.
8. Ghotekar, S., Pansambal, S., Pawar, S. P., Pagar, T., Oza, R., Bangale, S. (**2019**). Biological activities of biogenically synthesized fluorescent silver nanoparticles using Acanthospermum hispidum leaves extract. SN Applied Sciences, 1(11), 1342.
9. Aher, Y. B., Jain, G. H., Patil, G. E., Savale, A. R., Ghotekar, S. K., Pore, D. M., Pansambal, S. S., & Deshmukh, K. K. (**2017**). Biosynthesis of copper oxide nanoparticles using leaves extract of Leucaena leucocephala L. and their promising upshot against diverse pathogens. International Journal of Molecular and Clinical Microbiology, 7(1), 776-786.
10. Pagar, K., Ghotekar, S., Pagar, T., Nikam, A., Pansambal, S., Oza, R., Sanap, D., Dabhane, H. (**2020**). Antifungal activity of biosynthesized CuO nanoparticles using leaves extract of Moringa oleifera and their structural characterizations. Asian Journal of Nanosciences and Materials, 3(1), 15-23.