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Review Article

Synthesis, Characterization and Biological Approach of Nano Oxides of Calcium by *Piper nigrum*

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Abstract: Spices are a natural source of antioxidants and hence play a vital role in the prevention of a variety diseases. The most extensively used spice in the world is piper nigrum. It is often referred to as the "King of Spices." Piperine ($C_{17}H_{19}NO_3$) is the main compound present in P. nigrum. Due to the presence of alkaloid piperine. piper Nigrum pungent, aromatic and warming in nature. It also has many pharmacological properties such as antioxidant, anti-viral, anti-diabetic and anti-inflammatory. The green synthesis of nanoparticles is an environmentally benign and appropriate technology, however there are numerous chemical and physical approaches for nanoparticle synthesis. The green synthesized CaO nanoparticles were characterized by using by FTIR, UV-Vis, SEM, XRD and EDX. CaO is particularly interest because it is regarded to be harmless for both people and animals. Many studies have shown that chemical processes can be used to make calcium oxide nanoparticles. CaO-NPs are a non-toxic, low-cost, and widely available raw material for catalysis in a variety of chemical processes. There are several other uses of CaO-NPs such as catalyst, bio-ceramics, refractory implants, biodiesel production, adsorbent, Cr (VI) removal, photocatalyst, trans ferrous oil extraction of palm and sunflower, to emit CO_2, to control pollutants and also to remove other toxic metal ions. It can exhibit greater and greater potency as a desorbent for many toxic chemicals.

Keywords: CaO Nanoparticles, Green Synthesis, *P. nigrum*, Nanomaterials

1. Introduction

The green chemistry is an emerging field in bio-nanotechnology and benefits economics and environment as an alternative to chemical and physical processes. They are needed to prevent production of harmful or unwanted products by building a process of trust, reliability, and environment friendly synthesis [1].

Metal nanoparticles synthesized by green methods are of immense importance as they are highly ecofriendly particles. Nanoparticles contain both chemical and physical characteristics such as conduction of electricity, thermal conductivity, congenital, solid, mechanical characteristics, melting point, and light absorption, in comparison to the larger size of the material structure. Nanoparticles can be synthesized as matter sizes from 1-100 nm because of to their size can vary from compact material. Nanoparticles (NPs) represent an active research area and a fully integrated technology field in many application domains [4]. Nanoparticles have features that differ greatly from huge particles of the same material [2]. Because the average atomic diameter is between 0.15 and 0.6 nm, a significant portion of the nanoparticle object is contained within a few atomic diameters. Therefore, the topmost layer's characteristics may take precedence over the bulk material. Because the contact between these substances at their boundary becomes significant, this impact is more effective for nanoparticles dispersed in a liquid of changing composition [3].

Nanoparticles are present broadly in environment and are the subject of many scientific studies such as chemistry, geology, biology, and physics. Being in transitions between many objects and structures of atoms or molecules, they often show things that cannot be seen on each scale. They are important pollutants in the atmosphere, as well as important ingredients in many industrial products such as paint, plastics, ceramics and magnetic materials. The production of structural nanoparticles is an important branch of nanotechnology. Usually, smaller the size of nanoparticles, lower the point defects in comparison to bulk complements, but they support a variety of displacements that can be seen using high-resolution microscopes. However, nanoparticles show the distinct dislocation mechanics, which, together with its unique structures, lead to different mechanical properties [4].

Nano materials (NMs) have gained excellence in technological advances due to their flexible physical, chemical and biological characteristics through the enhanced performance of many of their counterparts. Many methods such as hydrogen plasma-metal reaction method, biopolymer-assisted method, ultrasonic-assisted method, microwave-assisted method direct thermal decay, chemical degradation and two-step decay. Of all the tested methods, the biosynthesis methods have attracted a lot of interest because they are a natural and easy-to-use method. Instead of chemical assembly, biosynthesis uses bacteria, plant extracts, fungus, and pre-production nanoparticles for bioreduction and capping. The features of biosynthesized nanoparticles are unique and sophisticated, and they are used in biological applications [5].

1.1. Co-precipitation Method

Co-precipitation this is one of the most widely quoted process in the literature. It appears to be a simple, inexpensive and quick, flexible process with a high degree of industrial application Provides nanomaterials with high purity in an eco-friendly way, without the need for harmful organic solvents, or treatment under high pressure or heat [6].

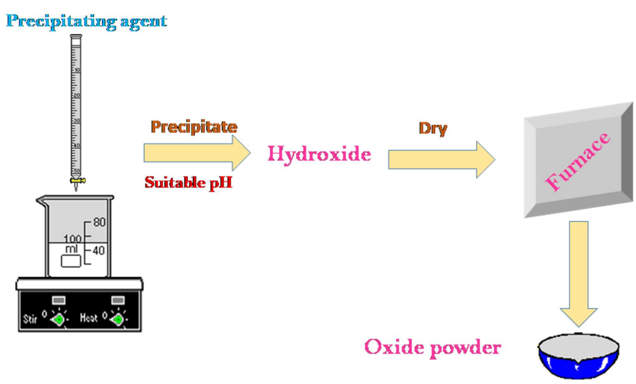

Figure 1. *Co-precipitation Methods of Nanoparticle.*

From a physical point of view, there are three main processes in the co-precipitation method: Surface Adsorption at surface: The charge on surface of the precipitate attract the opposite charge in solution. Inclusion: The sample can replace isomorphically ion in the crystal structure of the precipitates (mixed crystal), also can incorporate non-isomorphically (solid solution). Occlusion: Ions are engulfed physically in the precipitate forming before being dispersed or taken away. CaO-NPs were prepared using calcium chloride as a precursor for calcium and extracts of Piper Nigrum were used as a reducing agent and stabilizer. Also, the impact of the various volumes of Piper Nigrum powder water extract on controlling the size of Ca-NPs was studied. Calcium oxide nanoparticles with their nano-structures are most likely in the use of Drug Delivery Systems. It is also used in industry as an agent in dehydrating in creating steel, a water-absorbing agent, as a water softener, as a potential hydrogen control for wastewater and fertilizers [7].

1.2. Calcium Nanoparticles

Ca^{2+} can be reduced by many ways; for example, by adding a surface active agent in the early reactants, thus obtaining very small particles easily and greatly reducing the time required for preparation, using a certain sorbent, ethylene glycol, $HAuCl_4$, N-Cetyl-N, N, N-trimethylammonium bromide (CTAB) and diethyl ether (DE), ethanol, triethoxyvinyl silane (TEVS), N, N - dimethylformamide (DMF) etc. CaO is particularly interest because it is regarded to be harmless for both people and animals. Many studies have shown that chemical processes can be used to make calcium oxide nanoparticles. CaO-NPs are a non-toxic, low-cost, and widely available raw material for catalysis in a variety of chemical processes. There are several other uses of CaO-NPs such as catalyst, bio-ceramics, refractory implants, biodiesel production, adsorbent, Cr (VI) removal, photocatalyst, trans ferrous oil extraction of palm and sunflower, to emit CO_2, to control pollutants and also to remove other toxic metal ions. It can exhibit greater and greater potency as a desorbent for many toxic chemicals [8].

In addition, CaO-NPs play a major role in the domain of antibacterial agent, antifungal agent, drug delivery agent, tissue elimination, photothermal therapy, photodynamic therapy and synaptic delivery of chemotherapeutic agents due to of their reliable medical applications. The CaO-NPs synthesised by green methods involves three major steps, which should be tested depend on green synthesis perceptions, involves the selecting solvent medium, reducing agent, and non-toxic stabilising agent for CaO-NPs [9].

Figure 2. *Powder form of Piper nigrum.*

1.3. Piper Nigrum

Piper Nigrum, often known as the kaali Mirch, is a member of the piperaceae family. Piper Nigrum is known as the "King of Spices" because of the nutrients it contains, which are utilised in a variety of cuisines. Drugs, pesticides, insecticides, and larvicidal control agents are all made from Piper nigrum components, including secondary metabolites. Piper nigrum is a very significant element in biology. Antiapoptotic, antibacterial, anti-Colon toxin, antidepressant, antifungal, antidiarrheal, anti-inflammatory, antimutagenic, anti-metastatic activity, antioxidative, antispasmodic, antispermatogenic, antitumor, antithyroid activity can be found in peppercorn and the second metabolites of Piper nigrum [10].

Other roles of this type include protection against the oxidative stress caused by diabetes; Piperine protects against various oxidation reactions, decreases mitochondrial lipid peroxidation, inhibits aryl hydroxylation, increases the availability of vaccines and sparteine, increases the availability of active chemicals, delays in the elimination of antidepressants, orocecal time of transit, orocecal piperine induced and activated by the bio membrane to absorb a variety of active ingredients, increase serum concentration, reduce mutation events, tumor inhibition activity, Piperine inhibite mitochondrial oxidative phosphorylation, growth regenerative function and immune effect [11]. Nigrum is a tall climbing tree with pointed branches, and roots are present in the nodes. In the piper Nigrum round seeds are present. The popular spice is also well known and is also known as the king of spices. The height of the black pepper plant is 4 m (13 ft) and is a perennial vine [12].

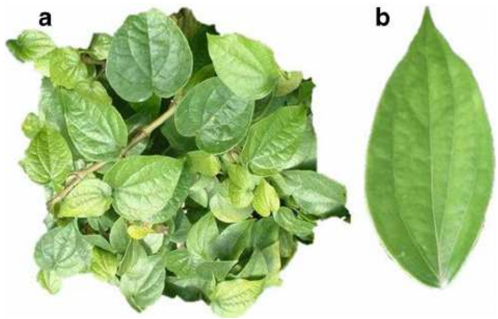

Figure 3. *(a) Whole plant, (b) Single leaf of Piper nigrum.*

Figure 4. *Benefits of Piper nigrum.*

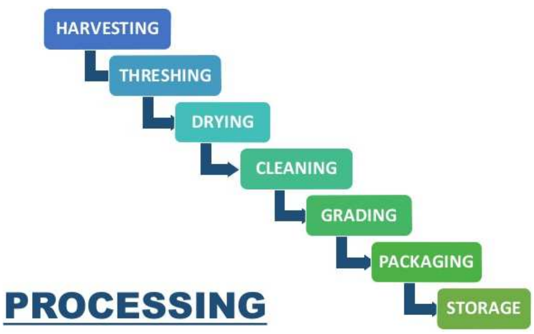

Figure 5. *Flow diagram of Piper nigrum processing.*

In traditional medicine, peppers are used for occasional fevers and intestinal disorders, epilepsy, pain relief, muscle aches and fevers [13].

Blanching allows the oxidation of phenols by phenolase enzymes, which leads to the formation of brown color on the fruit, and also allows the fruit to shrink by reducing their small load [14]. However, the blanching time should be as low as possible to avoid the denaturation of the enzyme and the loss of the evaporating flavored compounds. The dried fruit is then separated from chaff (vegetable seeds, leaves, sand, dust, small stones and outdoor light, etc.). When pepper is exposed to light, it loses its flavour, turning piperine into an unpleasant isochavicine [15].

2. Taxonomical Classification of *P. nigrum*

Table 1. *Nomenclature of Piper nigrum.*

Kingdom	Plantae
Class:	Equisetopsida
Family	Piperaceae
Order	Piperales
Super order	Magnolianae
Species	*Nigrum*
Kingdom	Plantae
Sub class	Magnolianae
Genus	*Piper* (Martinez, 2014).

A variety of phytochemicals found in piper Nigrum such as alkaloids, amide steroids, phenolics, lignans, chalcones, tarpenes, and flavonoids etc. and some other compounds are N-formyl piperidine, brachy-amide-dihydro-pipericide, trichostachine, isobutyl-octadienamide and retro fract amide. But their involvement in the spiciness of the piper Nigrum is very low [16].

2.1. Derivative of Black P. nigrum

In the family Piperaceae there are various chemicals present but piperine is the first bioactive compound pharmacologically isolated from the phytochemical analysis of black pepper and its taste is mild. The chemical formula for piperine is $C_{17}H_{19}O_3N$. Piperine contains anti-inflammatory qualities and has been shown to aid with nausea, migraines, and poor digestion. With a little more white pepper, P. Nigrum contains between 4.6 and 9.7% piperine in size. By weight, prepared piperine is about 1% as spicy as capsaicin found in pepper [17].

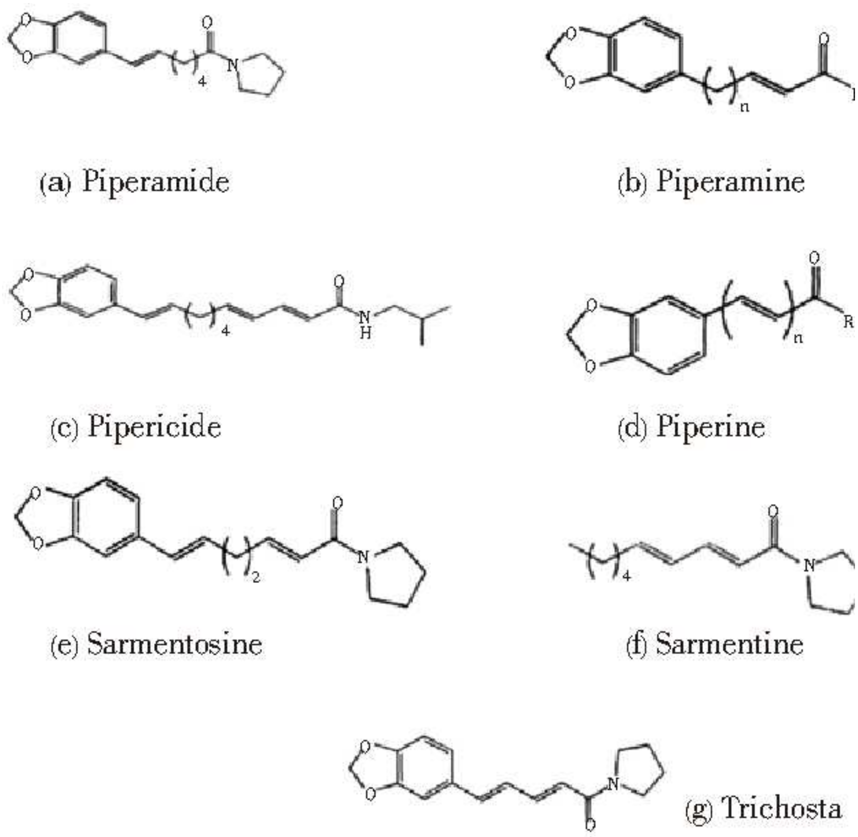

Figure 6. *phytochemical constituents of piper Nigrum.*

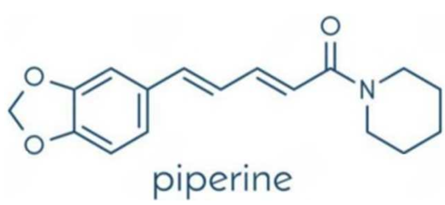

Figure 7. *Structure of piperine.*

Minerals such as potassium, calcium, zinc, manganese, iron, and magnesium are abundant in Piper nigrum. Potassium is a mineral found in cells and body fluids that aids in the regulation of heart rate and blood pressure. In the body, manganese serves as a cofactor for the antioxidant enzyme superoxide dismutase. Iron is necessary for cellular respiration and blood cell production. Vitamins like pyridoxine, riboflavin, thiamin, and niacin, which are all part of the B-complex, are also abundant [18]. They include a lot of anti-oxidant vitamins like vitamin C and vitamin A. Anti-oxidants such as carotenes, cryptoxanthin, zea-xanthin, and lycopene, which are flavonoids polyphenolic anti-oxidants, are also abundant. These substances aid in the removal of damaging free radicals from the body, as well as the prevention of cancer and disease [19].

2.2. Pharmacological Effects of Piperine

2.2.1. Antioxidant Activity

In chemistry, the "antioxidant" simply conceived a "compound that removes active species, especially those made of oxygen". Many active components, such as flavonoids, terpinoids, phyto estrogens, and minerals, are known to be present in numerous spices and herbs, including black piper. Piperine has been discovered to have antioxidant effects, which may help to reduce stress. In addition, piperine has also been shown to reduce thio-barbituric acid activity by catalase, glutathione peroxides, Glutathione-S-transferase, and the concentration of superoxide dismutase [20]. This can also improve the activity of enzymes that convert organic matter in the liver in a dose-dependent manner. The antioxidant activities of piperine are designed to eliminate the reduction of lung metastatic activity in B16F-10 melanoma cells by altering lipid per-oxidation and activation of antioxidant enzymes [21].

2.2.2. Anti-cancer and Hepato-protective Activity

Piperine, an anti-tumor human action used in the prevention or treatment of cancer, has been found to reduce the incidence of certain types of gastrointestinal cancer following its oral administration. Ken et al. Opiate from piperine-containing black pepper has been found to be effective against lung and lung cancer through lipid peroxidation, reducing free radical reactions and cellular damage. In addition, piperine regulates the cell cycle during the G1 / S phase, preventing the proliferation and migration of H1ECs (human umbilical endothelial cells). In animal models, piperine inhibits angiogenesis, suppresses tubular structure by endothelial cells, and phosphorylation of protein kinase B [22]. Piperine has been shown to induce apoptosis in both androgen-independent and independent prostate cancer cell types (LNCaP, 22RV1, PC-3, and DU-145) by activating PARP-1 and cospase-3 (MAO). Piperine reduces the detection of prostate-specific antigen in LNCaP prostate cancer cells via inhibiting androgen receptor expression [23].

2.2.3. Anti-inflammatory Activity

The property of a substance or treatment that reduces inflammation or swelling is known as anti-inflammatory. Many therapeutic applications in contemporary medicine and pharmacy for diverse anti-inflammatory properties of plant components are known for many therapeutic uses in modern medicine and pharmacy to treat a variety of ailments. Some ethanolic and hexane extracts of black pepper have shown fundamental anti-inflammatory action in mice and rats using varied dosing methods. Piperine may also be viewed as a potent immune modulator, as it inhibited airway inflammation in a murine model of Asthma by increasing TGF-beta gene expression in the lungs. At concentrations of 10–100 g/ml, piperine was found to reduce the production of IL-6, MMP-13, and prostaglandin E. Piperine was combined with Curcumin from Curcuma longa in another study to suppress high fat diet-induced inflammation in C57BL/6 mice and to prevent metabolic syndrome [24].

2.2.4. Anti-thyroid Activity of P. nigrum

Piperine allows the thyroid gland's output to be suppressed. Piperine decreased the dilution of all thyroid hormones, thyroxin (T4) and triiodothyronine (T3) in the same manner as non-thyroid medications in a report on Swiss albino mice in which thyroid gland function was studied when piperine was given to them for 15 days. Piperine also decreases glucose levels by lowering the activity of the hepatic 5 D enzyme and glucose-6-phosphates (G-6-Pase). Antipyretics are medications that reduce high body temperatures. Yeast induces the release of prostaglandins, which causes the body temperature to rise, which is regulated by the thermoregulatory core of the hypothalamus. Antipyretic medications function by preventing the development of prostaglandins. The mice were then given piperine and indomethacin at doses of 20–30 mg/kg and 10 mg/kg, respectively. In the forced swim test and tail suspension test, mice treated with piperine displayed a drop in fever in the same way as normal medications did, as well as an improvement in motionlessness time. In these mice, the levels of neurotrophic factor protein and mRNA in the hippocampus area of mental capability were decreased. However, piperine therapy reduced corticosterone-induced effects, leading to the conclusion that piperine has antidepressant-like properties [25].

2.3. Health Benefits of P. nigrum

Weight reduction is helped by P. Nigrum, as well as relief from sinus, allergies, and nasal inflammation.

2.3.1. Improves Digestion

Pepper increases the release of hydrochloric acid in the intestine, which helps digestion. Proper digestion is important to stop complications with the intestines, such as diarrhoea and constipation. Black pepper is both a laxative and balanced seasoning [26].

2.3.2. Weight Loss

The outer layer of peppercorns is active in fat cell breakdown. As a result, eating peppery foods will help you lose weight naturally. Instead of settling in the body and rendering you overweight, fat cells are broken down into their constituent parts and quickly absorbed by the body, making them beneficial to other processes and enzymatic reactions [27].

2.3.3. Provides Respiratory Relief

Pepper is also applied to tonics in Ayurvedic medicine to cure colds and coughs. It also defends against sinusitis and nasal inflammation. It has an expectorant effect, which aids in the elimination of mucus and phlegm from the airway [28].

2.3.4. Enhances Nutrient Bioavailability

According to the researchers, P. Nigrum assists in the transfer of the medicinal properties of other herbs and compounds to various areas of the body, helping us to get the most out of the other foods we consume. As a result, applying it to food not only increases the flavor but also makes the nutrients more usable to our bodies [29].

2.3.5. Improves Memory

Piperine, one of the main components of pepper, has been found in several studies to assist with memory loss and psychiatric disorders. This organic compound helps to activate the brain's chemical pathways. Early research indicates that pepper can support Alzheimer's patients and those suffering from other age-related or free radical-related psychological problems. Potassium, zinc, calcium, iron, manganese, and magnesium are all found in significant concentrations in P. Nigrum. Potassium is a mineral contained in cells and body fluids that aids in pulse rate and blood pressure regulation. The antioxidant enzyme superoxide dismutase requires manganese as a co-factor. Iron is needed for the development of blood cells and cellular respiration. They're also rich in B-complex vitamins like pyridoxine, riboflavin, thiamin, and niacin. Antioxidant vitamins like vitamin C and A are also abundant. Antioxidants such as carotenes, cryptoxanthin, zea-xanthin, and lycopene, which are flavonoid polyphenolic anti-oxidants, are abundant in them. These compounds assist in the elimination of toxic free radicals from the body, as well as the prevention of cancer and disease [30].

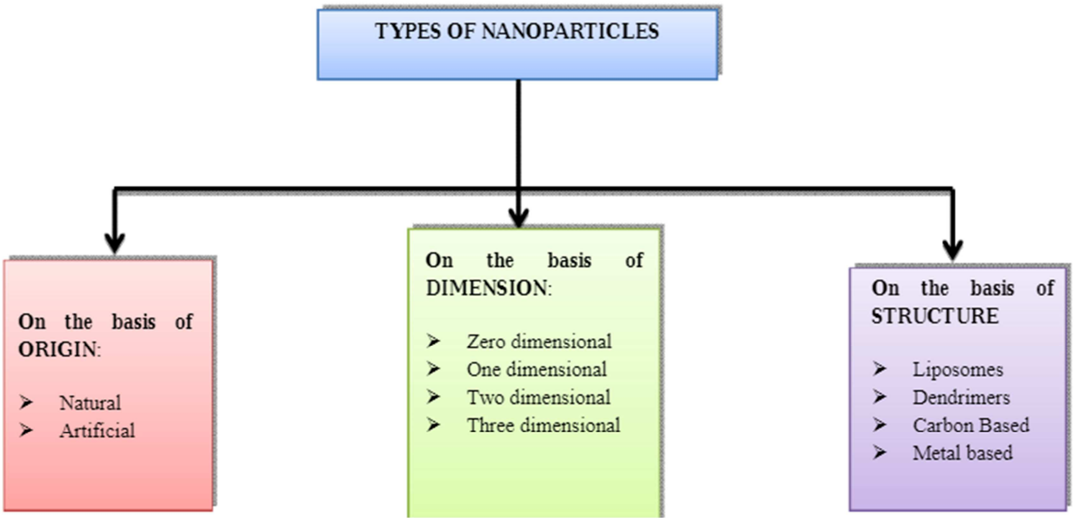

Figure 8. *Classification of nanoparticles based on their structure, Dimensions and origin.*

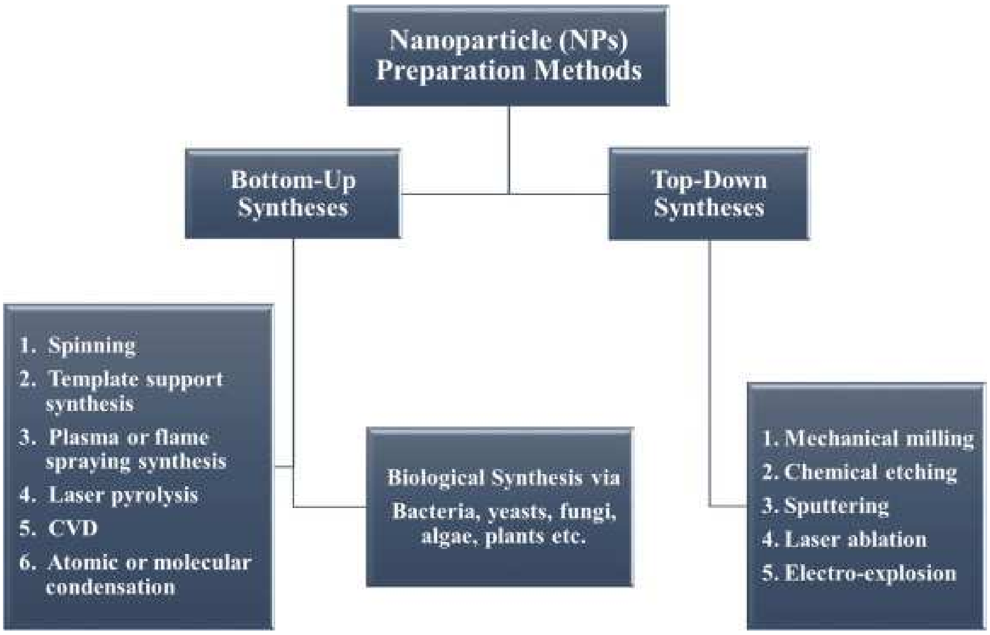

Figure 9. *Typical synthetic methods for NPs for the (a) top-down and (b) bottom-up approaches.*

2.4. Nanoparticles

Nanotechnology is a modern area of science that deals with the production and creation of nanomaterials. Nanoparticles are small structures ranging in size from 1-100 nm that differ from the bulk material due to their size.

Nanoparticles have the following characteristics:

a. Advanced reproducibility.
b. Maintenance of physical characteristics.
c. Lowering impurities of nanoparticles.
d. Monitor aggregation.
e. Crystal, structure and composition distribution.

Metal oxide NPs can be synthesised using a variety of ways, but they may be categorised into two categories: (1) bottom-up approaches and (2) top-down approaches. These methods are further divided into subcategories based on the operation, reaction, condition, and adopted protocols [31].

2.5. Top-Down Synthesis

This process starts with a large molecule that is broken down into small units, which are then repeated into appropriate NPs. Any of the most popular NP synthesis methods include mechanical milling, laser ablation, and thermal decomposition [32].

2.5.1. Mechanical Milling

Mechanical milling is a top-down approach for making nanoparticles of varying sizes. During the manufacturing of nanoparticles, mechanical milling is employed for grinding and post-hardening, where various components are processed in an inert environment. Plastic deformation causes particle shape, fracture causes particle size reduction, and cold-welding causes particle size increase in mechanical milling [33].

2.5.2. Nanolithography

Nanolithography is the study of creating nanometric scale structures with a minimum of one dimension in the size range of 1 to 100 nm. Optical, multiphoton, nanoimprint electron-beam, and scanning probe lithography are examples of nanolithography methods. Lithography is the process of selectively removing a part of a substance from a light-sensitive substrate to create the desired form and structure [34].

2.5.3. Laser Ablation

The LASiS method (Laser Ablation Synthesis in Solution) is a prominent method for creating nanoparticles from a variety of solvents. It is a reliable top-down approach for synthesizing metal based nanomaterials by irradiating a metal submerged in a liquid with a laser beam, which condenses a plasma plume that generates nanoparticles, as opposed to typical chemical reduction of metals [35].

2.5.4. Sputtering

Sputtering is the process of colliding with ions to eject nanoparticles off a surface. Sputtering refers to the process of depositing a thin coating of nanoparticles and then annealing them. The film thickness, annealing procedure and period, substrate type, and particle size and morphology are all factors that influence particle size and morphology [36].

2.5.5. Thermal Decomposition

Thermal decomposition is a type of endothermal decomposition in which heat is utilised to dissolve a compound's bonds. The decomposition temperature is the temperature at which an element chemically decomposes. Decomposing metal at appropriate temperatures results in a chemical reaction that yields secondary chemicals, resulting in nanoparticles [37].

2.6. Bottom-Up Synthesis

This method is also known as the building up method since NPs are made from very simple ingredients. The most common bottom-up methods for nanoparticle formation are sol-gel, spinning, chemical vapour deposition (CVD), pyrolysis, and biosynthesis.

2.6.1. Sol-Gel

A sol is a colloidal suspension of particles in a liquid medium. A gel is a liquid that contains a stable macromolecule dispersed in it. Because of its simplicity and ability to examine a wide range of nanoparticles, sol-gel is the most widely utilised bottom-up technique. A chemical solution serves as a precursor for a system of distinct particles in this wet-chemical process. Metal oxides and chlorides are commonly utilised as precursors in the sol-gel phase. The precursor is diffused in a host liquid via shaking, stirring, or sonication, resulting in a device having a liquid and solid phase [38].

2.6.2. Spinning

Nanoparticles are made by spinning them in a rotating disc reactor (SDR). Within a chamber/reactor, it has a rotating disc that can adjust physical factors like temperature. To prevent chemical reactions, the reactor is usually filled with nitrogen or a variety of other inert gases to extract oxygen [39].

2.6.3. Chemical Vapour Deposition (CVD)

The material, such as substrate and water, is injected into the disc at varying rates. The rotating allows the atoms and molecules to bind together, resulting in a precipitate that is condensed, cleaned, and stored. This reaction forms a thin substance layer on the substrate surface that is cured and used. CVD is influenced by the temperature of the substrate [40].

2.6.4. Pyrolysis

Pyrolysis is the most extensively utilised industrial procedure for mass-producing nanoparticles. It entails employing a flame to heat a precursor. A liquid or a vapour is injected into the furnace through a tiny hole under high pressure and burned as a precursor. The combustion or by-product gases are air classified to recover the nanoparticles. To produce high temperatures for easy evaporation, some of the chambers use laser and plasma instead of flame. Pyrolysis has the advantage of being an easy, reliable, cost-effective, and ongoing process with a good yields. Biosynthesis methods have piqued researchers' interest because they are both environmentally friendly and simple to implement. The CaONPs were synthesised using co-precipitation technique in this study.

a. It's abundant in nature, cheap, and simple to make.

Calcium oxide is used to purify compounds and substances like citric acid, glucose, and certain dyes before they are refined further.

b. Calcium oxide is a high-volume substance that is used in a variety of industries.
c. Calcium oxide is used in regions where precipitation washes calcium out of the soil to balance out acidic soil.
d. It's abundant in nature, cheap, and simple to make. Calcium oxide is used to purify compounds and substances like citric acid, glucose, and certain dyes before they are refined further.
e. Calcium oxide is a high-volume substance that is used in a variety of industries. Calcium oxide is used in regions where precipitation washes calcium out of the soil to balance out acidic soil.
f. It is also used industrially as a dehydrating agent in the creation of steel, an absorbent, as a water softener, as a potential hydrogen regulator for waste water and in fertilizers.

Calcium oxide (CaO) is a widely used chemical substance that is also known as quicklime or burnt lime. At ambient temperature, it is a corrosive, white, alkaline, crystalline solid. Calcium oxide is typically produced in a lime kiln by the decomposition of calcium carbonate ($CaCO_3$; mineral calcite)-containing materials such as limestone or seashells.

$$CaCO_3(s) \rightarrow CaO(s) + CO_2\ (g)$$

Calcium is an alkaline mineral that can be found all over the world. It is the fifth most common element (by mass) and can be present in the mineral types of calcite, dolomite, and gypsum in igneous rocks. Calcium oxide nanoparticles (CaO NPs) have a high reputation across all elements because of their stability. They are used in storage systems and their biocompatibility makes them useful in drug delivery and gene transfection [40].

Calcium oxide (CaO) is a likely metal oxide with a wide range of applications, including catalyst, dopant introduced to alter electric and dielectric properties, toxic waste remediation, CO_2 capture, flue gas desulfurization and emission control agent in pollution, cleansing of hot gases, and so on. Green synthesis of metal oxide nanoparticles is gaining prominence due to the usage of earth cordial reagents and a room temperature mix. This is the most common method of arrangement since it uses contamination-free synthetic materials and promotes the use of non-harmful solvents including water and plant separates. Calcium Oxide (CaO) nanoparticles have a broad variety of uses, including catalysis, adsorption, water disinfection, and antibacterial professionals [41].

Without the use of a surfactant, Roy et al. (2010) established a method for generating and analysing $Ca(OH)_2$ nanoparticles. $Ca(OH)_2$ is also utilised as an adsorbent, as well as a precipitant, catalyst, paint, and hazardous material remediation operator. With $Ca(NO_3)_2{\cdot}4H_2O$ as the precursor, liquid NaOH as the precipitant, and ethane-1, 2-diol (ED) as the media, a simple hydrolysis approach was employed to create stable $Ca(OH)_2$ nanoparticles. The findings showed that the nanoparticles had a diameter of about 47 nm and a P3 ml hexagonal form. The technique is simple and efficient, with nanoparticles staying stable for up to 45 days, according to the XRD design [42]. In this study, Ijaz et al. (2017) examined the antibacterial efficacy of green combined calcium oxide nanoparticles using Mentha piperita leaf concentrate. Using scanning electron microscopy (SEM), Fourier change infrared spectroscopy (FTIR), and vitality dispersive x-beam spectroscopy [43], the mixed nonmaterial was portrayed (EDX). SEM images revealed agglomeration of circle-shaped nanoparticles [44], while FTIR and EDX spectroscopy revealed substantial tops for calcium particles and oxygen. Because of the advanced reaction, the CaO nanoparticle's most serious antimicrobial file was 6 mm. The results showed that CaO nanocomposites containing green course were a successful candidate for the expulsion of E. coli from drinking water at room temperature [45]. Using various techniques, sample chromatography is achieved. XRD, SEM, and TEM are three techniques used to study materials. Calcium oxide nanoparticles (CaO NPs) had a nanoscale morphology, as seen by SEM photos. According to TEM images, the CaO nanoparticles with a diameter of around 100 nm and a length of 500 nm are generated. Calcium oxide nanoparticles are both inexpensive and safe. It is used to cure skin infections as an antimicrobial agent [46].

3. Conclusion

Piper nigrum is known as the "King of Spices" because of the nutrients it contains, which are utilised in a variety of cuisines. Drugs, pesticides, insecticides, and larvicidal control agents are all made from Piper nigrum components, including secondary metabolites.

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