A general survey on Green synthesis and application of calcium oxide nanoparticles

Abhishek Kamboj, Mohd. Amjad, Waseem Ahmad, Ajay Singh*

Department of Chemistry ,Uttaranchal University, Dehradun, U.K., India

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Abstract

In this Survey we can study the synthesis of nanoparticles its application and properties. In this study our main focus on the green synthesis of CaO nanoparticles. Because in today's era green synthesis of nanoparticles gets a huge attention of many Researchers because it's a cheap, ecofriendly method and the Nanoparticles are formed by this method are superior in quality and contains a lot of advantages. In this study we found that CaO Nanoparticles is a precious material because it contains various applications in different fields like it is used as good catalyst for the production of Biodiesel, as an effective Drug Mediator, proves as a good chemisorbent for harmful gases and shows good photocatalytic and Antibacterial and Antifungal activities. The equipments and chemicals used in the green synthesis are cheap and easily available in the labs.

Keywords: Nanoparticles, Calcium oxide, Green synthesis, catalyst.

Introduction

In today's era nanotechnology plays an important role in various fields. The fundamental key in the nanotechnology is 'Nanoparticles'. According to ASTM and ISO standards Nanoparticles which have a ranging of size which varies from 1to 100nm and which contains more than one or one dimensions [1]. The nanoparticles are constituting of Metal, carbon, Organic matter and metal oxide. Each of the Nanoparticles shows a special property in terms of Chemical, Biological and Physical parameters in nanoscale if we match the comparative particles in highest dimensions [2-3]. The nanoparticles are different from several aspects such as shape and size apart from their material. The Nanoparticles can havevariousShape, Structure and size. It may aElliptic, spiral, flat, spherical, tubular, cone, conical etc. or irregular and differ in the range of 1nm to 100nm in size [4]. There is a variation in surface from particle to particle and these variations may be uniform or desultory.

**Correspondence*
Dr. Ajay Singh
Professor and Principal
Department of Applied and Life Sciences
Uttaranchal University, Dehradun, India.
Email: principal.ucals@uttaranchaluniversity.ac.in

Few of the nanoparticles are amorphous or crystalline contains double or multi crystal solid either aggregated or slack [5] Various methods have been made for the synthesis of nanoparticle and the synthesis process are modified to increase the properties and decrease the cost of Manufacturing of the nanoparticles [6]. Some of the synthesis method are improved to obtain a particular nanoparticle to enhance their physical, chemical, optical, and mechanical properties [7].Nanoparticles are synthesis by different process and these processes may be Physical, Chemical, and Mechanical process [8]. Nanoparticles are also used for commercial use. The Nanoparticles are applied in every object like in Aerospace industry, electronics, renewable energy, Cooking vessels etc. Nanoparticles are the basic source for a fair and sustainable future [9]. In recent years, due to their incredible properties nanoparticles have been used in various fields like energy, health care, environment, agriculture, etc. Nanoparticles technology have great ability to convert the poorly absorbed, poorly adsorbed, and labile biologically active substance into a superior and deliverable substance [10].

Classification of Nanoparticles

Organic, Inorganic and Carbon nanoparticle are the major forms of nanoparticles.

Organic-based nanoparticles

Nanoparticles like Liposomes, Micelles keeps gossipyvoid and can be called as Nano capsules and are very susceptive to thermal as well as electromagnetic radiation like light and heat [11]. These can be used as a drug delivery because they contain some unique characteristics which makes it suitable for drug [12]. The organic nanoparticles achieve advantages in the biomedical field. Apart from their common features like composition, size and surface morphology etc. the drug carrying delivery system, stability, and capacity either entangled or absorbed pharmaceutical system determines their usage and ability. For example, they used as a drug deliverybecause, these are very accomplished and can be injected on distinctbody partswhich is also called as drug delivery [13].

Inorganic-based nanoparticles

The particles which are synthesized from carbon called as inorganic nanoparticles. They are classified into two categories

1. Metal based nanoparticles
2. Metal oxide-based nanoparticles

Metal based nanoparticles: Metal based nanoparticles are the particles that are obtained from the metals to nanometric size either by constructive or destructive methods [14]. For the synthesis of nanoparticles, the metals which are generally used as Aluminum (Al), Iron (Fe), Cadmium (Cd), Cobalt (Co), Lead (Pb), Calcium (Ca), Silver (Ag), Gold (Au). These synthesized nanoparticlescontain specific characteristics like size 10 to 100nm surface spectrum such as pore size, surface charge surface and charge density, High surface area to volume ratio, response and susceptive to environmental causeslike Air, humidity, Heat and Sunshine etc., Amorphous and Crystalline structure, shapes like Cylindrical and Spherical and Colour [15].

Metal oxide-based nanoparticles: These are the particles which are formed to improve the characteristics of theirs related metal-based nanoparticles. These are synthesized basically due to their increasing activity and capacity. For example, if we oxidize the Iron (Fe) nanoparticles at room temperature with the existence of oxygen we get Iron oxide nanoparticle i.e. Fe_2O_3. After oxidize of Iron nanoparticle its reactivity increased as compared to simple Iron nanoparticles. The generallyformulated metal oxide-based nanoparticles are Iron oxide (Fe_2O_3), magnetite (Fe_3O_4), Aluminum oxide (Al_2O_3), Cerium oxide (CeO_2), Calcium oxide (CaO), Titanium oxide (TiO_2), Silicon dioxide (SiO_2) etc. As compared to their metal counterparts, these nanoparticles have possessed an exceptional property [16].

Carbon- based nanoparticles: These are the particles which are synthesis completely of carbon. They have been classified into Carbon nanotubes, Graphene, Fullerenes, Carbon black, and activated carbon in nanosized.

Carbon Nanotubes (CNT): Carbon nanotubes are formed when a graphene Nano foil having honeycomb lattice of carbon atom is sore into hollow cylinders to form nanotubes having diameter 0.7nm for single layered and for multi layered CNT it is 100nm. The length of CNT varying from some micrometers to few millimeters. There end can be closed or hollow by a half fullerene molecule [17].

Carbon nanofibers: For the formation of carbon nanofiber as CNT, the same graphene nanofoils were employed. Instead of regular cylindrical tubes, they are wound in the shape of cones and cups.

Graphene: It is an allotrope of carbon. It is a hexagonal network of honeycomb composed of carbon atoms, with 2-Dimensions planer surfaces. The obesity of the graphene sheet is generally about 1nm.

Fullerenes: It is a molecule of carbon that is constituted from carbon atoms which are capture to one another by Sp^2 hybridization. They contain globular in shape.

Carbon black: It is an amorphous material which is synthesized from carbon, having globular in shape and diameter varies in between 20 to 70nm. The interaction between carbon black particles are high and they are confined in aggregates.

Synthesis of nanoparticles

The Nanoparticles are synthesized with the help of different methods and are characterzied by Top-down and Bottom-up method.

These techniques are further classified as:

1. Physical Method
2.Chemical Method
3. Green synthesis Method
4. Microwave-assested Method

Bottom up method

It is a chemical method and called as creative method. In this system firstly, the materials are converted into clusters and then there is a formulation of nanocrystals. For the formation of Nanoparticles, the most general bottom-up methods are Sol-Gel, Spinning, Chemical Vapour Deposition (CVD), and pyrolysis.

Sol-Gel: Most of the nanoparticles can be produced by this method because it is an easyprocess to formulated the nanoparticles, due to its nature Sol-Gel is too preferential Bottom-Up method.

It is also known as wet chemical process because it contains a chemical solution that serves as a progenitor for the integrated system of individual particles. The

typically used progenitor in this method are Metal oxides and Chlorides. The progenitoris diffused in a liquid phase with continuous stirring and then sonicate the mixture after that we get a solution which have a solid and liquid phase in the form of resultant. With the help of various methods such as centrifugation, filteration, and sedimentation we can separate the resultant mixture and can get the required nanoparticles. After that we can drying the nanoparticles to remove the moisture contents in it [18].

Spinning: The nanoparticles can be synthesis by this process with the help of spinning disc reactor (SDR). This disc is placed internally a reactor where the physical parameters like temperature may be manage. To isolate oxygen and avoid chemical reactions inside the reactor, the reactor is then filled by using inert gases or nitrogen. The disc is moving at different speedand the liquid which acts as a precursor and water are pumped in. Various operating parameters can determine the characteristics of nanoparticles synthesized from SDR. And these parameters are Disc rotation speed, Location of feed, Liquid flow rate, Liquid/Precursor rate, Disc surfaceetc [19].

Chemical vapour deposition (CVD): In this method a fine membrane of gaseous reactant is deposited on the substrate. By combining gas molecules, the deposition is achieved in a reaction chamber at extensive temperature. And the chemical reaction take place if a heated substrate is in connection with combined gas. When the reaction completes, a fine membrane of the product is produced on the substrate surface and then this film is recovered from the substrate surface, and can be used in various fields. The factor which can influence the CVD is substrate temperature. The nanoparticles which are formed by this process are pure, uniform, strong and hard. This method also hasadisadvantage in this formation of gaseous by-product which are highly toxic and second is the requirements of special equipments [20].

Pyrolysis: This method is widely used for the synthesis of nanoparticles in largescale. In this process the precursor is burnt with flame. The precursor is then burnt into the furnace at a high temperature. The precursor may be liquid or vapour which is then put into the furnace with the help of a small whole in the furnace. To produce high temperature for simplevolatilization, fewfurnacesare used laser and plasma instead of flame. The advantages of this process are efficient, cost effective, simple, and continuous process with high yields.

Top- down method:This is also known as destructive method. In this process, the bulk material is converted into the nanometric scale size particles. The commonly used method for the production of nanoparticles by using this method are Mechanical Milling, Nanolithography, Laser Ablation, Sputtering, and thermal decomposition [21].

Mechanical Milling: It is the commonlyadopted process for the synthesis of nanoparticles from all the Top-down methods. In this process, during synthesis of nanoparticles Milling and Post Annealing take place where different types of elements are milled in an inert atmosphere. The causes which influence the mechanical milling is plastic deformation which gives direction to molecules shape, fracture which causes reducesthemolecules size and cold-wearing which increases the particle size.

Nanolithography: It is a process in which there is a synthesis of nanoparticles which contains one-dimensional structure and the particle size varies from 1 to 100nm. Different types of Nanolithographic process are occurring, for example: Electron-beam, Scanning probe lithography, Nanoimprint, Multiphoton. Mainly, Lithography is the process of printing an essential structure and shape on a photosensitive material that choicely eliminates a portion of material to fabricate the required structure and shape. The benefit of this process is to manufacture a single nanoparticle with required size and shape from the cluster. Whereas the main disadvantage of this method is that in this process there is a requirement of complicated instruments which is cost effective and cannot be easily available [22].

Laser Ablation: It is the static process for the s of nanoparticles in water and organic solvents. It is also called as a green process because on this process there is no requirement of any type of stabilizing representative or chemicals [23].

Sputtering: It is a physical method in which the nanoparticles are deposited on the surface when the particles are discarded from the surface when they are striking with certain ions. It is basically a deposition of fine membrane of nanoparticles with the of annealing. Various factors can determine the structure of the nanoparticles i.e. obesity of the membrane, temperature, time of annealing, substrate manner etc.

Thermal decomposition: It is a process in which the nanoparticles are synthesized by using an appropriate amount of temperature. In the thermal decomposition method the heat energy is required to break the chemical bond from which we synthesized the nanoparticles. The heat energy which is required to break the chemical bond of the desired material is known as decomposition temperature. It is also called as endothermic chemical decomposition because heat

energy is required to break the chemical bonds of the compound. The nanoparticles are synthesized, when the metals are decomposes at distinct temperature under a chemical reaction generate subsidiary products [24].

Green synthesis of nanoparticles: Green synthesis plays an important role in the field of nanotechnology. First of all, we know that how's the green synthesis of nanoparticles is going to trending for the formation of nanoparticles, so to know that first of all we known that chemical synthesis of nanoparticle**s-** In chemical formulation of nanoparticles there is a use of chemicals which acts as a reducing and stabilizing agent in the organic, Inorganic and metal salts. Different types of reducing agents like Ascorbate, Sodium citrate, elemental hydrogen etc, are used. For this synthesis the reaction will be carried out at room temperature [25]. The nanoparticle which are formed by the chemical synthesis have a definite shape, size, structure and composition and are used in various research fields like, in drug delivery, catalysts, data storage, sensors etc. and the working principles of these nanoparticles are simply to be known, but the disadvantages of this method are numerous and they are very harmful to living organisms as well as environment. This method is costly and requires toxic and harmful chemicals for the synthesis of nanoparticles. We know that the size of nanoparticles is microscopic and when these nanoparticles are expose to air or environment and inhale by living organisms can cause Inhalation problems and many other Malignant diseases. If we inhale the contaminated air only for 6 seconds, it can harm to our Lungs, Heart, Vascular functions and digestive system. If these nanoparticles transfer in our body with the help of any media, it creates free radicals and cause damaging of cells as well as damaging of DNA. It also causes pollution like water and air pollution, and the pollution which are caused by nanoparticles are known as Nanopollution. And it is very Hazardous for living organism. [26].Therefore, to overcome these adverse effects in the chemical method there is aincreasing interest in the field of green synthesis of nanoparticles because it is cheaper and ecofriendly method for the production of nanoparticles [27].

Green synthesis of nanoparticles: This method takes a wide interest in the field of nanotechnology. It offers many environmental and economical advantages and produce ourselves as a substrate to other conventional methods like physical and chemical methods. This method proves as a progressive method, because it is a simple, cheaper and environmentally friendly method. In today's era there is a huge interest in the field of green chemistry and every researcher are trying that they synthesis the nanoparticles which is simple, cheaper and environmentally friendly. There are many advantages for this method like there is no need of high pressure, temperature and poisonous and harmful chemicals for the synthesis of nanoparticles. These nanoparticles are used in many biological activities as compared as compared to chemical synthesis [28].In this method we use plant extract for the synthesis of nanoparticles, here plant extract is works as a reducing agent because plant contains appropriate reducing and stabilizing agent. The nanoparticles which are formed by using plant extract are more stable and have low toxicity. The reagent used are non-poisonous, ecofriendly and biosafe, instead of other methods for the formation of nanoparticles. So, it is better option for the formation of nanoparticles with the help of several plant species and their parts. Various metal and metal oxide nanoparticles are synthesis using plant extract. In past years metal oxide takes a huge attention in the field of nanotechnology due to its several applications, and many researchers are trying to synthesis the metal oxide nanoparticles with the help of plant extract. Various types of plant extract as well as fruits peels extracts are used for the synthesis of nanoparticles like Neem leaves, Tea leaves, Pomegranates peel, orange peel etc Many bacteria, fungi are also used for the synthesis of nanoparticles. Microorganisms are also be used for the formulation of nanoparticles, but the rate of reaction is slow and only a limited number of shape and sizes are formed by this method. So, the nanoparticles formed by this method contains a unique and enhanced properties, and also contains various applications in the various fields [29][Table 1]

Table 1:Green synthesis of CaO Nanoparticles by different Plants and Other Bio-products

Nanoparticles	Plants/ Other bioproducts used	Reference
CaO	Ocimum Sanctum (Tulsi)	Vijay Gurav et al 2019
CaO	Azadirachta Indica (Neem)	Dani Jagadeesh et al 2016
CaO	Hylocereus Polyrhizus (Red Dragan fruits peels)	Muliadi Ramli et al 2019
CaO	Green Tea and Papaya leaves	Ashwini Anantharaman et al 2016
CaO	Rhododendron Arboreum (Burans or Laligurans)	Naveen Chandra joshi et al 2019
CaO	Broccoli	Jajenija Osuntokon et al 2017

CaO	Honey	E. Aruli et al 2018
CaO	Egg Shells	Lulit Habte et al 2019
CaO	Shrimp Shells	Gangarajun Gedda et al 2015
CaO	Natural Calcined	Nuni Widiarti et al 2019

Microwave Assisted Synthesis:It is founded on the Accomplished heating of the Accessories by Microwave dielectric heating effects. This phenomenon is based on the capability of a particular material that (reagent or solvent) absorbs microwave energy and converts it into heat. Microwave may be defined as an electromagnetic wave with vaccum wavelength between 0.1 to 100cm with frequencies ranging between 0.3 to 300GHz. Heat energy in the microwave can be applied directly to thesample/reaction not to the vessel. In microwave heating can be stopped or started immediately and according to the requirements. Microwaves dielectric heating is a non-quantum mechanical effects which gives direction to major heating of sample [30].In recent years there is a growing scope in the microwave assisted organic synthesis. In this process the heat energy is directly applied to sample not to the vessel, and time required is less for complete the reaction as compared to conventional methods in which a lot of expenditure of time. It is based on dielectric heating that will have a permanent dipole moment in the molecules that will be able to align the applied electromagnetic field causes friction, rotation, collision, and heat is generated. Some of the major advantages of the microwave assisted method are decrease the reaction time and increase the rate of reaction, clean product formation, improved conversions and there is a huge scope for the development of new reactions conditions [31].

Properties of nanoparticles

Physical properties: Physical properties includes colour of the nanoparticles, absorption, reflection, capabilities, its light penetration, the capability of UV absorption and reflection when coated in a solution or on a surface. Some of the mechanical properties plays aimportant role in their application and these properties are tensile strength, flexibility, elasticity and ductile strength. (Mark T. Swihart). Other properties like suspension, hydrophilicity, diffusion, hydrophobicity, and setting characteristics has found their way into several modern everyday things.

Chemical properties: The chemical properties such as stability, reliability, activity of the nanoparticles to the goal and sensibility to humidity, heat, atmosphere, and light shows its application. The Anti-fungal, Anti-bacterial, toxicity, and disinfections properties of the nanoparticles gives a crucial contribution role in the environmental and biomedical fields. Oxidation, reduction, corrosive, Anti-corrosive, and flammability properties of the nanoparticles determines theirs related usages.

Applications of Nanoparticles in various fields:

Cosmetics and Sunscreens: Large numbers of Nanoparticles are used for the manufacturing of sunscreens and cosmetics. Nanoparticles such as Zinc oxide and Titanium oxide are visible as well as transparent and reflect UV in their manner, so they are used in sunscreens as a better option to protect our skin from harmful UV rays. Some of the nanoparticles such as Iron oxide used in the Lipsticks as a pigment [32].

Electronics: Nanoparticles takes an advantage in the field of electronics. Nanoparticles are used in the display technology because in recent years there is a demand of large sizes and high brightness in the computer monitors and television and it can be achieved with the help of nanoparticles.For example-Nanocrystalline Lead telluride, Zinc selenide and sulphide, and Cadmium sulphide are used in LED (Light emitting diodes) of moderns displays. In today's era there is a huge there is a huge demand for intensive, ethereality and high ability batteries electronics such as mobile phone and laptop computers etc. Nanoparticles are the good alternative for separator plates in batteries. As compared to the traditional batteries these batteries contain more energy because they have foam like structure. Batteries which are built up with Nickle and metal hydride nanocrystals requires less charging and increase our utilization time because they contain larger surface area [33].Nanoparticles are helpful to find out gases like NO_2 and NH_3, this occurs because when charge shifting from nanoparticles to NO_2 it increases the pores of nanoparticles and the gas molecules will bindingside by side and produce a good gas sensor.

Catalysts: Nanoparticles are used as a catalyst in many reactions because they contain high surface area which gives suitability to reactions. They also contain large surface to volume ratio, so that the nanoparticles work efficiently in the production of chemicals. Other most important advantage is that the utilization of platinum nanoparticles in the automative catalysts convertor, it reduces the cost and improving performance because the platinum contains large surface area so not so much platinum is used. Some chemical reactions are also

performed with the help of nanoparticles. For example- reduction of Nickle oxide to metal nickle. Cao nanoparticles is used as a good catalyst in some chemical reactions [34].

Medicines: Nanotechnology are also used in medical field. nanoparticles are used as a drug delivery which can give major improvement in the medical field. with the help of nanoparticles, the drug can deliver to specific cells. The side effects and total drug consumption are fall short by using the drug in the requisite area in the needed dosage and also decrease the expenses of production. With the help of nanoparticles, the repair of damaged tissue and reproduction are to be done. The traditionarymedication like artificial implants and organ transplants will changed by tissue engineering. In Indian methodology, gold is used in medicines and memory enhancement. Similarly, calcium oxide nanoparticles are used as a potential drug delivery agent.

Food: Nanotechnology are also used in the processing, production, maintenance and stuffing of food materials. For example- in the food packing process, a nanocomposite can introduce the Anti-microbial substance on the coated film surface, similarly the canold oil manufacturing industry includes nanodrops designed to transferals vitamins and minerals to food.

Constructions: Nanotechnology is widely used in the construction field nanotechnology improves the construction process by making it inexpensive, quicker and safer. For example- when the SiO_2 nanoparticles is combinedby general concrete, then it enhances the concrete durability as well as concrete Mechanical properties. Also, when Hematite (Fe_2O_3) nanoparticles is mixed with concrete it increases it strength.

On the other hand, steel is widely used in the constructions. The properties of steel will be increased by using nanosized steel offers strong steel cables. Similarly, the nanotechnology is widely used in other fields of constructions like glass, paints etc.

Environmental Remediation: The nanoparticles are helpful for the treatment surface water by purification, desalination, and disinfection, and some other contamination like heavy metals, pathogens and organic contamination. The nanoparticles are also be used for the treatment of municipal and industrial wastewater and similarly the slime products. The substitution of chemicals from nanoparticles is a better option because they are lower expenditure, supreme competency and less amount are required for treatments. (Tiwari D K 2008). In some food and dairy industries, Nanofiltration is widely recent membrane filteration technique for sanctification of water [35].

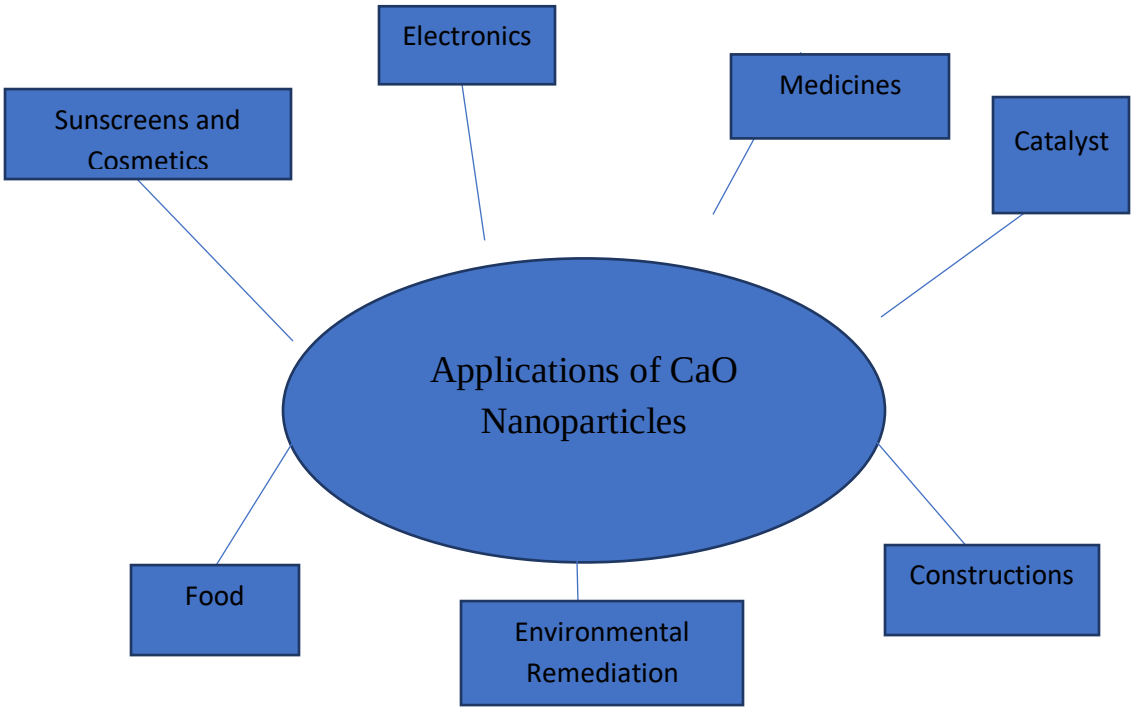

Fig 1:Applications of CaO Nanoparticles

Overview of calcium oxide (CaO) Nanoparticles: CaO is a crucial industrial compound because it is employed as a catalyst, poisonous waste treatment, an effective chemisorbent for toxic gases, and used in calcitrant, in paints, ceramics and other elementary applications.Metal oxide such as MgO, ZnO, TiO_2, and CaO are widely used in various in every fields and represent a category of nanoparticles with the highest global annual production. Amongst the metal oxide nanoparticles, CaO is an alkaline earth metal oxide and contains many applications in various fields like used as a gas sensor, in cosmetics, in solar cells, refractory material, catalysts, and varistors. In alkaline earth oxides barium and calcium-based oxides are helpful for the sanctification of hot gases. CaO nanoparticles are particularly cheap, has a high basicity, non-corrosive, economically kindly, and easy to handle. Whereas ultrafine metal oxides particles are applied as a bactericide and adsorbent. Particularly CaO is also used as a destructive adsorbent for poisonous chemicals agent .

According to Literature, there are mainly two methods for the preparation of CaO nanoparticles. First method is Sol-Gel, and other method is Thermal Decomposition. In sol-gel method the nanoparticles are formed about 14nm size, but the cost of production is high and the process of formation is complex and time consuming. So, it is very stiff to put sol-gel in industries. Other method is thermal decomposition, it is simple process, lower expenditure, comfort of gettingadvanced précised products. So, this method applied into industries. In this method the CaO formed directly through calcining $CaCO_3$ and High temperature is required for calcination. But with the help of this method, it is very difficult to obtained nanoscale CaO but find CaO above 100nm .The Green synthesis path is a different method for the formation of metal oxides and has been achieving significance in the formation of oxide nanoparticles. This method is generally cheaper, easy energy accomplished, eco-friendly, and lesser time consuming [36]. This method is used on the laboratory scale of only a few grams. And the nanoparticles are formed by the green synthesis are less-toxic.

Conclusion

The green synthesis of CaO nanoparticles takes a huge attention in this time. The Nanoparticles synthesized from this method are cheap, less-toxic and ecofriendly and required less cost of production. The nanoparticles formulated by the green synthesis method shows superior uses and application. The formulated CaO nanoparticles used in various fields like as a Catalyst, Drug delivery agent, and shows good Antibacterial and Photocatalytic activity. The green synthesis method of nanoparticles is a good alternative of chemical synthesis method. So many researchers take a huge attention in this field and synthesized various nanoparticles by using different plants and plants materials.

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