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Review Article

Advancement in Carbon Nanoparticle Synthesis and Their Application: A Comprehensive Review

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Abstract

The global population gradually increase at an alarming state, which would increase demand for food globally. This increasing use of pesticides and fertilizers. In order to meet this demand, an overview of the numerous applications of nanotechnology for agriculture. Various nanomaterials like nanofertilizers and pesticides enhance soil fertility and crop productivity. However, excessive chemical fertilizer use as per FAO, 2017. Among these, the nanotechnology has wide range of applications in healthcare and medicines, diagnosis etc. Recently, carbon nanoparticles (CNPs) play a significant role in various fields. Carbon nanoparticles (CNPs) represent innovative nanostructures. These can be synthesized by different methods, green synthesis as well as chemical synthesis such as arch discharge method, laser ablation method, chemical vapour deposition method etc. The advancement of CNPs entails the exploration of diverse synthetic techniques and exploration of various application due to their chemical and physical properties in healthcare, agriculture (for delivery of agrochemicals) etc. These are also used in plant growth enhancement and resistance to stresses. However, challenges related to precisely defining CNP structures and ensuring property uniformity remain inadequately addressed and lack detailed study. In this review article we emphasize methodologies for the synthesis of CNPs by various chemical methods and also include their applications in therapeutics, pharmaceuticles, sensing and agriculture.

Keywords

Nanoparticles, Nano-Sensors, Nanotubes, Carbon Nano-Particles**,** Carbon-Nanodots

1. Introduction

Nanotechnology term given by 'Taniguchi'. The term "Nano" was originated from "Nanos". It is a Greek word means "dwarf". Nanoparticles (NPs) are smaller than bacterial cell, its Particle size is 10^{-9}m [1]. NPs can be extracted from both biologically and chemically. From few decades, population will be increased so availability of food resource will be increased [2]. For more production of crops, used of pesticides and fungicides and insecticides. Recent studies have been proved that, nanotechnology play a significant role in agriculture such as crop improvement, diseases resistant crop production, in diseases control etc [3, 4]. In agriculture, different types of nanomaterials (NMs) are used like Nano fertilizers, Nano pesticides, Nanosensor. NMs improve soil phytoremediation through biotic and abiotic pathways [5]. Some NMs effect the soil fertility, soil health and some crops etc. NMs enhance the crop productivity [15]. For more demand of crop productivity, increase the use of chemical ertilizers, pesticides etc. According to FAO, 2017 increased the

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use of chemical fertilizers, affects the crop yield and production. Nano fertilizers also enhance plant metabolism and it absorbed nutrient by minute pore of plants and transport through small cuticle pores. NMs produced plant nutrient which respond some stimuli and increased plant growth [7].

However, wide range of NMs could also affect the unexpected environmental issues such as the toxic substance which effect whole environment [52, 53]. Although, we have many NPs products which is used in market. In future, we will have lots of product which manufacture by NPs. They affect our environment conditions also cause many diseases. That we will not able to act towards by this problem. They also exchange natural environment and also effect the technology and its products [11]. Nanotechnology, like many technologies, may have unwanted effects that can harmful effect in our ecosystem and also injurious to human body. While taking benefits to this new technology for human needs, continuous and liveable benefits and our environments, science require examine the environmental conditions and its involvements [6, 8]. On the other hand, Carbon nanoparticles (CNPs) have attracted strong interest from the scientific community. These CNPs has significant characteristics such as photoluminescence, chemo- and photostability, highly soluble in water, easilysynthesize, and biodegradability, low toxicity, and scarce environmental impact [82].

Among these they can be classified as carbon nanotube (CNT) (including single walled CNT(SWCNT) and multiwalled CNT (MWCNT), carbon nanofiber (CNF), carbon nanodots (CND) etc.CNPs can be synthesize chemically by chemical vapor deposition (CVD), laser ablation and electric arc discharge method [13, 14]. However, recently it has been reported that CNPs produced by these methods has wide range of impurities such as use of catalysts (Fe, Co, Ni). These impurities can reduce the functional role of CNT.CNPs has significant characteristics such as nanodaimonds and florescent carbon nanoparticles (FCNPs) [14]. Recent research of [24, 57] estimate that new europium-doped carbon nanoparticles showing long-lifetime photo luminescenceand play a significant role in determination of tetracycline in waters. Also, the earlier study was demonstrated FCNPs act as novel fluorescence probe quercetin determination [24]. It has also been examined that they have potential applications in the drug delivery of a number of biomolecules such as nucleic acid (DNA), antibodies, and proteins [18]. CNPs are considered the best material for metal-based sensor applications and rapid diagnostic assays due to their high fluorescence value. As such, they can displace gold, coloured latex, silica, quantum dots, or phosphorous nanoparticles, in relevant applications [20, 22].

Other than optical sensing, these CNPs have also seen use in applications such as photocatalysis, bioimaging and optoelectronics [15, 72, 87]. Thus, we can say CNPs have shown great impact in health and environmental applications as well as being promising building blocks for future nanodevices because of their fascinating photoluminescence and potential to serve as nontoxic replacements for traditional heavy-metals- based quantum dots [82, 61, 24]. Carbon allotropes such as fullerenes are extensively being used as conductive materials that can mediate the removal of biological contaminants, optical devices, and various medicines and also act as a carrier in drug delivery contaminants, optical devices, and various medicines and also act as a carrier in drug delivery [16, 17, 19]. Although, the same approaches are applicable in the plant system but have not attracted much more interest of research, especially in the field of agriculture [40]. However, the impacts of CNPs on plant system have started recently.

The main objective of application of CNPs in the field of plant system is to improve crop yield [25]. Besides this, CNPs have wide range of applications in abiotic stress tolerance such oxidative stress. In this review, we will discuss about synthesis of CNPs. We will also demonstrate the applications of CNPs.

2. Classification of CNMs

2.1. Carbon Nanotube (CNTs)

Carbon nanotube (CNTs) is carbon-based nanomaterial and first discovered by Japanese researcher S. Iijima in 1991. CNTs are cylindrical structure and different length, diameter and chirality [51, 56]. It consists by rolled of graphene sheets. It have open and close ends and further classified into single-wall carbon nanotube (SWCNTs) and multi-wall carbon nanotube (MWCNTs) [81]. Recently, some researcher is identified Double wall carbon nanotube DWCNTs. A SWCNTs diameter is 0.2- 2nm and MWCNTs diameter is 5-20nm [54, 87]. The SWCNTs further classified in arm chair, chiral and zigzag as well as MWCNTs formed by multi-layered carbon atom have great mechanical and electrical properties [81]. S. Ijima work on new carbon structure and found fullerene soot. They discovered CNTs it is also called tubular fullerenes and cylindrical graphenes [12, 74, 78].

2.2. Carbon Nanodots (CNDs)

Carbon nanodots (CNDs) are latest and photoluminescent carbon -based nanoparticle [Table 1]. Traditionally it is used in organic dye because it has inherent optical properties, highly stable and low toxicity [50, 70, 72]. It is also synthesis by silico technique. CNDs can be synthesized by two methods- 1. Top-down synthesis 2. Bottom-up synthesis. These two methods have low toxicity, industrial attractive and cost-effective. The bottom-up method starts from organic molecules. In these process, we synthesised CNDs, graphene quantum dot and carbonized polymer dot to use carbon material and molecular precursors. Carbon material is used in top-down synthesis and molecular precursors is used in bottom-up synthesis [50, 58]. CDs are prepared by Many organic molecules like cellulose, phenolic compound, reddish, coriander leaves, lotus root, grass, coffee bean shells, ginger, lignin, chitosan, durian and common water hyacinth etc. CDs are extractedby many fruit juice such as orange juice, grape juice, banana juice, apple juice etc by using of green synthesis [23].

2.3. Carbon Nanosheets (CNSs)

Carbon nanosheets (CNSs) could be utilized as biosensors, in field electron emission, as fuel cells due to their property such as ultra-high surface to volume ratio [21, 26]. The 2D carbon nanostructures, especially porous CNSs, are being increasingly researched for energy storage/conversion devices [50]. They offer significant improvements in power and energy density compared with bulk electrodes. CNSs can be synthesized by several methods such as chemical vapor deposition, solvothermal synthesis and chemical-physical exfoliation [26].

2.4. Carbon Nanohorns(CNHs)

Carbon nanohorns (CNHs) are also known as nanocones closed cages of sp^2 bound C-atom. It is a conical shape carbon nanostructure [42-44]. CNHs provide alternative of CNTs in wide range of applications such as energy conversion, drug delivery, gas storage and supercapacitors etc.in contrast to CNTs they differ in following ways such as absence of metallic catalyst in their synthesis and their mass production at room temperature [21, 63, 64]. CNHs can be synthesized by sufficient injection of energy to vaporize and differ from synthesis of CNTs. Chemical functionalization of CNHs enhances solubility and handling in common solvents. CNHs provides wide potential role such as adsorption of gases, to act as drug carrier, to construct effective biosensor etc. [37, 41].

2.5. Carbon Nanofibers (CNFs)

Carbon nanofibers (CNFs) (3-100nm in diameter and 0.1 -1000 µm in length) exhibits similarity with fullerenes and CNTs. CNFs are fibrous, cylindrical and cup-stacked structure. CNFs are most important material of carbon that have vast range of applications due to their specific chemical, physical and mechanical properties [31-33]. Recently, it has been shown that CNFs used as potential material in various fields, such as adsorbents [9], sensors [67], electrode material and electromagnetic shielding etc. (Suhdi & Wang, 2021). As a consequence, alternate approaches to producing low cost CNFs are identified. Several kinds of CNFs produced from a variety of methods. CNFs synthesized from biomass can be produced in different kinds of methods such as the electrospinning method. The result of Suhdi & Wang, 2021 has been reported that CNFs can be produced by rubber fruit shell (RFS) isrenewable source of CNFs [34-36].

2.6. Graphene

Graphene is the allotropic form of carbon. It is two dimensional and made by single chain of carbon atom. Graphene theory is given by physicist P.R Wallace in 1947. In 2004, physicist A. Geim and physicist K. Novoselov described first sample of graphene and won nobel prize in 2010 [87]. The structure of Graphite consists planer hexagonal honeycomb like structure which is SP^2 bonded carbon atom are called graphene layers. Carbon atom bonded with graphene plane by hardly covalent bond and bonded with two Graphene layers by weak bond [12]. Carbon atom of graphene usually present sp^2 hybridization and linked by σ and π bond. There are some carbon-based nanoparticles such as Graphene NPs that have used in agriculture application. Graphene oxide NPs declined Chl content in pea plant, also reduced light captivation in plants [46].

2.7. Fullerenes

Some another type of carbon-based nanoparticles Fullerenols NPs it extended Chl content in wheat [29]. Carbon research in 1985, discovered a closed cage and spherical like crystalized structure which is largest family of all carbon atom are called fullerenes.For example – C_{60} [12]. In 1985, H.W Kroto, R.E Smalley and R.F Curl discovered Fullerene. In 1996, they won nobel prize in chemistry [87, 59]. According to buck ministersfullerene are used in CNDs in 1991 and graphene in 2004. [54, 60]. Multi-layered fullerenes are used in biomedical and electrochemical applications. This type of concentric and multi-layered fullerenes are called non anion [28]. Mixture of fullerenes and DDE treated with 40mg C_{60} 100mg DDE for 3 weeks have positive effect on soybean plant. Carbon atom of fullerene commonly present sp^2 hybrid and this atom is linked by covalent bond [86]. Carbon atom are mostly present on the vertices of pentagon and hexagon. Carbon atom are mostly present on twelve hexagon and twelve pentagons.Fullerene C_{60} diameter is 0.7nm [87].

3. Synthesis of CNPs

There are various types of methods for synthesis of carbon nanoparticles (CNPs) [Figure 1]. Here, we mentioned some important methods:

3.1. Green Synthesis of Carbon NPs

Green synthesis methodologies depend on several reaction parameters like (solvents, pressure, temperature, and acidic, basic, neutral, PH conditions). This methodology based on biological antecedent. [29]. Green synthesis is essential to save our nature, sustainable and eco-friendly synthesis producers by undesired consequence and its outcomes [74]. Sun *et al.* [45] synthesised CNDs by pomelo peel and willow bark and also synthesised carbon nitride dots by organic amine and N, N-dimethyl-formamide, CCl_4, etc. It is used for specialised catalytic applications and these were successfully synthesised. They described the optical, chemical, physical properties of carbon nanoparticles and this applications are spread at global level and found in the fields of bioimaging, photocatalysis and optical electronics [75].

In 2012, Yang *et al.,* synthesize CNDs by sucrose and citric acid. Carbon dots-based NPs has also been synthesized by using single sequence of polymeric NPs and studied their photoluminescence impact in natural solvent []. NPs are synthesised by plant extract because it very simple and cost-less process. At the large-scale NPs is synthesised by plants and also used of bacteria and fungi so its product is combinedly called biogenic NPs. It has been examined that, the FCNPs is produced by the hydrothermal treatment of pomelo peels and also observed that these NPs no further require any chemical modifications [77, 17, 73].

Using of food waste, CNTs, candle soot, [75] carbohydrates, active carbon, orange juice and honey. It has been observed that, the green synthesis of tea could synthesis tunable and safe drug delivery nanocarrier with successful biological compatibility properties. From few decades, [10] described that the structure of pollen grain of *Hibiscus sassiness* (china rose) are similar the symmetry of fullerene C_{60}.

3.2. Chemical Synthesis of Carbon NPs

At present, CNPs is prepared by the use of simple alkyne source. Metal-catalysed polycondensation dispersion by using this, they polymerized 1,4-bis(trimethylsilyl)-1,3-butadiyne and 1,2-bis(-trimethylsilylbutadiynyl) benzene and form metastable polyyne intermediate. This metastable polyyne intermediate extended for decomposition into carbon nanoparticles (CNPs). In 2012, published by Kuehne and co-workers, using of Suzuki-Miyaura dispersion polymerization and formation of conjugate-polymer based nanoparticle [35].

3.2.1. Arc Discharge Method

An arc discharge method has device which consist a chamber filled with a vacuum it is called vacuum chamber. The flow of current and temperature are discontinuous and non-homogeneous electric field [Figure 2].. When the increase the speed rotation of anode and collector are closer to plasma than increase the yield of nanotube. It is not a continuous and stable process so it cannot synthesis large amount of CNTs. This method is simple, direct and there is no need of pumps, vacuum chamber and sealed [12]. Apart from two graphite electrodes are present at short distance. Inert gas is released from chamber at specific pressure. DC discharge power source are present so voltage is applied at graphite electrode that is called arc discharge method. The adjustable rode is becoming closer than start formation of plasma. At the presence of discharge the small carbon electrode became vaporized and the carbon deposition started at the larger electrode. The mixture of this deposition has present SWCNTs, MWCNTs and some other carbon nanoparticle. Disadvantage of this method it is high growth temperature process [77].

3.2.2. Laser Ablation Method

Laser ablation method, is high growth temperature method for formation of CNMs [Figure 3].. There is placed a graphite rode under deposition chamber and heated with furnace tube at ~1200 ℃ in an inert atmosphere. This method is same as arc discharge method. It is the best method for obtained a mixture of nickel and cobalt [12].

In this method at the position of graphite target pointed a high-power laser which produced a vaporized material in cooling chamber these vapours became condense which is transported by gas. The mixture of these condense material have include highly ordered NTs and SWCNTs. Growth, temperature, pressure and gas flow rate control the size and diameter. Demerits of this method is it utilised high amount of energy and produced low yield [77, 87, 12, 35]. The easier and direct method for synthesis of CNMs are called pulse laser ablation method. It is used as synthesis or several fabric CNMs and semiconductor etc. when graphite target is used than MWCNT were found.

By using of two straight laser pulse, minimized the deposit carbon quantity on the soot. The first laser pulse are separate the combination of a carbon and metal and the second laser pulse are crake the large in size separated particles and provide these particle in structure of developing nanotube [12]. At few decades, [24]. Described that the sub picosecond laser are able to synthesis large quantity of SWNTs.

3.2.3. Chemical Vapour Deposition

Chemical vapour deposition is the process where solid material is convert into gaseous state [77]. Chemical vapour deposition (CVD) is also called thin film deposition method. It is commonly used for synthesis of CNTs. Many methods are used for synthesis of CNTs such as electric arc method and laser vaporization method [Figure 4].. Earlier CVD is not satisfied technology but from 1998, it is highly controlled technology for CNTs synthesis [67]. At present, it is used to build high quality multi walled carbon nanotube (MWNTs) and single walled carbon nanotube (SWNTs).

It is directly produced in mass as a primary material. In this method, CNTs used without any purification and filtration and it is removed by catalyst particles. In CVD method, the decomposition of organic gas on the surface of substrate. This substrate is covered by metallic catalyst particle and synthesis high quality carbon nanotube (CNT) [12]. So, it is the standard technique to synthesized CNTs. Using this method, synthesis of CNMs at high temperature use of acetylene as a carbon source [35]. The growth of CNT are dependent upon preparation of catalyst, temperature, carbon source and feeding rate [77]. CVD synthesis based on decay of hydrocarbon to carbon and CNMs are convert in several substrate such as CNTs.

In this method, reaction chamber and tubes are filled with hydrocarbon and inert gas. SWCNTs production Methane is used as well as production of MWCNTs ethylene and acetylene is used. At last, removal of catalyst at the tip of NTs for making a high quality of CNTs [78]. The merits of this deposition method lower growth temperature than arc discharge and laser ablation method and demerits of this method is necessary to formed a catalyst for deposition [12, 35, 77].

(i). Thermal Chemical Vapour Deposition

A thermal chemical vapour deposition is simple and low-cost to build of a quartz tube surround in a boiler. In this method the deposition of material is depend upon several parameter such as catalytic metal nature, temperature, flow of gas [75], source of hydrocarbon and reaction time. This parameter controls the deposition of material. Silica, mica, silica quartz and alumina are a surface material. Recently, by physically and chemically condition synthesis of CNT. The physical properties are length of CNT, Diameter of CNT and its shape and the chemical properties are any deficiency and conversion of substance in graphite [35]. IN thermal CVD method synthesis of SWCNTs by using of methane and MWCNTs is synthesized by ethylene and acetylene. Fe, Ni and cobalt work as catalyst and other element like Cu and Mn are used in very low amount for synthesis of CNT [28].

All the metal is useful for their specialization such as Co is useful for production of large amount of MWCNT and Fe is necessary for thickness of tube. Other combination is also useful for production of large quantity yield. Many unsaturated hydrocarbons are used for large amount of yield such as C_2H_2, CH_4 and CO etc. Hydrocarbon CH_4 and CO is used for synthesis of SWCNTs in high amount and C_2H_2, C_2H_4 and C_6H_6 hydrocarbon is used for synthesis of MWCNTs in larger amount. THE intermediate structure of MWCNT and SWCNT is DWCNT and it consist two concentric graphene cylinders [77].

A very low amount of Mo is enhanced the productivity of DWCNTs [12]. By the using of alcohol, we synthesis high quality of SWCNTs and alcohol act as a CNMs, this method is used only for better mass production of SWCNTs. By this process, increase the 40 percent yield weight. Another method is deep coat method which is inexpensive, unique and simple method. In this method the pieces of material is pour on the solution of metal acetate in continuous speed [49].

(ii). Plasma Enhance Chemical Vapour Deposition

Plasma enhance chemical vapour deposition PECVD is used for synthesis of vertical alignment of CNT (Thesis, 2012). Recently it is used in field of flat panel display. In this method, where is plasma is used for processing and the primary substrate is breakdown in several energy electrons and its temperature is low while thermal CVD temperature is high [61]. Various technique such as hot filament PECVD, microwave PECVD, glow discharge PECVD, and inductively coupled PECVD are plasma processing technique are used for deposition of CNT in large amount and it is also control the vertical alignment of CNT [12].

(iii). Catalytic Pyrosis of Hydrocarbon

Catalytic pyrolysis of hydrocarbon method is used for well mass synthesis of CNT. In this method inject the catalyst nanoparticle directly in CVD chamber in the form of colloidal suspension and organic metal precursor. Iron phthalocyanine and iron pentacarbonyl are used for precursor for the catalyst. The solid precursor is heated and formed a catalyst particle. In this process different type of temperature is needed for growth of nanotube than also need the double stage boiler. Thus, sublimation is process control by the length and diameter. The double stage boiler/ furnace is act like syringe pump and convert into single stage furnace in the presence of benzene, toluene, xylene and n- hexane and growth of nanotube is increase. Carbon nanosphere is found when the absence of organic metal [12].

4. Application of CNPs

Carbon dots (CDs) were indicated to upgrade the productivity of microphytes species [12]. The main area of CNDs applications is sensing, photo electronics and optical electronics, supercapacitors, photocatalysis, solar cells, Bioimaging in the field of biomedicine CNMs are also produced by environmental application, biosensor, optics and nanomedicines. Today its applications are more useful and have increased interest in food and agriculture production. Now, CNM is widely exposures for studies purpose and also beneficial for demonstrated into cultural conditions.

4.1. CNPs in Agriculture

The applications of traditional fertilizers, pesticides etc. in agriculture negatively impacts the crop productivity and significantly dropped during green revolution [Table 2]. From few decades, nanoparticles attract new attention among scientific community [48]. In addition, climate change, land degradation and urbanization have posed more challenges to sustainable agriculture and a search for novel materials and technologies has become more urgent in modern agriculture [54]. Recent studies have shown that nanofertilizers or nanopesticides has great potential to improve crop productivity, to enhance seed germination, growth of plant etc [73].

CNPs composed of carbon which exhibit high stability, low toxicity and eco-friendly [72] Recent, investigation has been reported that CNPs have potential to improve crop productivity, soil properties and nutrient efficiency in soil such as in *Zea mays* [75], increase in total biomass yield in *Vigna radi-*

ate [71]. CNPs have wide range of applications in the field of agriculture for crop improvement [87]. Besides this, other carbon-based nanomaterials such SWCNTs, MWCNTs etc. also have potential application in crop improvement. In 2007 [79] examined that non-functionalized SWCNTs enhance remarkable root enhancement in *Allium cepa* and *Cucumis sativus whereas, Lycopersicum esculantum* showed seed germination and growth under influence of MWCNTs. Similarly, [75, 76] reported that MWCNTs showed seed germination and root growth in *Raphanus sativus, Loliumperenne, Brassica napus, Zea mays* and *Cucumis sativus*. In another reported it has been reported that exposure of CNTs on tomato exhibit seed germination and growth rate and potential in regulators of seed germination and culture of tobacco.Oxidized MWCNTs increased the germination of seed and also accumulate growth and development of root and stems [51].

It has been observed that pristine MWCNTs significantly enhanced growth and biomass of seedling of *Zea mays* by enhancing water absorption and concentration of essential nutrients. The CNPs act as the smart treatment delivery system in plant. It has been proposed that CNTs improve water retention capacity and biomass. [76] reported the response of *A. thaliana* to SWCNT exposure with two different types of surface chemistries commonly used for biosensing and nucleic acid delivery and proved that the importance of nanoparticles surface chemistry on their biocompatibility and will facilitate the use of functionalized nanomaterials for agricultural development.

Agriculture Management and production of food is improved by chemical sensing. Chemical sensing monitoring the ripening of fruit and prevent the spoilage of food and produce better quality of food. Using CNTs, detection of ethylene. Using the composition contain Cu metal centre and MWCNTs which is MOF-199 it absorb ethylene from blueberry, grapes, husk and wampee for the chromatography of gas. CNT sensor is also used for production of effective electric toung and nose for accurate and better taste of any food material.

4.2. CNPs in Pharmaceuticals

CDs have extensive advantages such as superior biocompatibility, optical property etc. due to tense properties CDs extensively employed in pharmaceuticals for diagnosis of various kinds of disease such as diabetes, cancer etc. [77]. It has been reported that CNPs have efficiency to remove pharmaceutical wastes from aquatic solutions. Further, it has been observed by [79] that MWCNT have efficiency to remove acetaminophen (AAP), carbamazepine (CBZ) and ibuprofen (IBP). [81] demonstrate the removal of sulfamethoxazole (SMX) by using MWCNTs ($CoFe_2O_4$). Functional PAni/ MCNT polyamine component was developed as an efficient absorbent material to remove meloxicam (MLX). Thus, all above the information shown that CNPs has significant importance in treatment and removal of pharmaceutical wastes from aquatic solutions.

4.3. CNPs in Detection and Sensing

Graphene incorporated CNSs are widely used as detector and sensor of metals and gases. Earlier, CNSs was used as electrochemical biosensor [47]. According to [82] CNSs with many graphene edges have efficiency to catalyse the oxidation of β nicotinamide adenine dinucleotide (NADH). It has been demonstrated that the original CNSs show lower selectivity than organo-silica, metal oxide and graphene coated CNSs]. [83], reported that CNSs with platinum constructed an electrochemical biosensor and showed high electrocatalytic activity toward the reduction of O_2. CNSs loaded with SnO_2 was produced by electrochemical exfoliation of a graphite pencil and exhibit high sensitivity and complete reversibility as ammonia sensor [89]. Due to excellent electrical conductivity of graphene, the graphene modified porous CNSs exhibit high electrochemical performance for Pb detection in an aqueous solution [80]. In another way CNPs provides vast range of potential in the detection of plant diseases. It has been proved that these CNPs can be used for the detection and quantification of antibodies, antigens etc. [65, 66].

4.4. CNPs in Bioimaging

Recently, CNPs provides wide variety of potential applications in biology due to their favourable biocompatibility, stable photoluminescence, chemical inertness etc. [72]. Most of the conventional organic dyes and semiconductor quantum dots are annoyed due to their negative impact on human health and environment. In [75] produced pH sensitive CNPs provide a promising possibility for serving as a proton sensor in the study of metabolite process of cell [10]. It has been demonstrated that fluorescent carbon nanoparticles (FCNPs) to be potential optical detection probe, light emitting diode material and bioimaging probes [76, 77]. The FCNPs has potential application in biomedical due to nontoxic element carbon. However, the FCNPs are unavailable in high quality so this potential is unexplored as compared to other carbon-based NPs [79].

4.5. CNPs in Therapeutics

Recently, CNPs have widely use in therapeutics application such as treatment of cancer and Diabetes mellitus. Diabetes mellitus is a metabolic disease it increases the level of glucose in blood known as hyperglycaemia. According to [76] in 2030, there will be more than 280 million people survive by diabetes and in 2050, more than 400 million adults survived in all over world. Many Researcher and scientist are developed glucose monitoring sensor, enhance glucose response and upgrade the efficiency of insulin therapy by employing carbon-based NPs [54].

CNPs is used in specific application such as cardiovascular, dental, orthopaedic medicine also useful in Magnetic resonance imaging (MRI) and magneto photothermal therapy (MPT). Many CNM such as graphene, graphene oxides and carbon quantum dots are widely used in therapeutics because it has better physiochemical properties. By using of CNPs many drugs are applied for treatment of diabetes mellitus such as pulmonary delivery of drugs which encourage the level of insulin [40]. CNPs is applicable in both type of diabetes such as insulin dependent diabetes and insulin non-dependent diabetes [12]. α proton, β proton, neuton and magnetic waves are radionuclides emitting particulate radiation which is diagnosis in treatment of cancer in nuclear medicines fields. It works as therapeutics agent which eliminate the tumour of cancerous cells. α, β radionuclides and Auger electron emitter act as therapeutics agent when it localized by cancerous cells while the gamma ray emitters and pistron emitters are act as diagnostic agent when it localized by cancerous cells. Nuclear medicine and therapeutics are very hot research area for production and formation of newly agent [54, 55].

Classification of radionuclides on the basis of use of diagnostics, therapeutics and theragnostic. The unstable nuclide is convert into stable nuclide are radioactive decay. It has physical and chemical characteristics which is used in biomedical purpose. Effective half-life, decay mode and emission properties are physical characters as well as toxicity and in vivo stability etc. [62]. are biochemical characters. Some physiological characters are also play a very important role in clinical application of radionuclides such as targeted tumour type, radioactivity affinity, vascularity and heterogenicity [65].

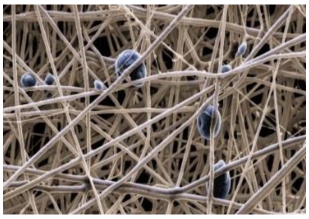
5. Future Aspect and Conclusion

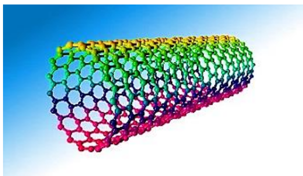
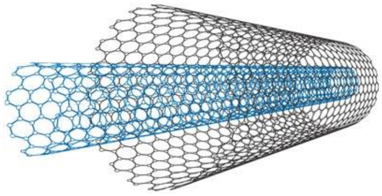
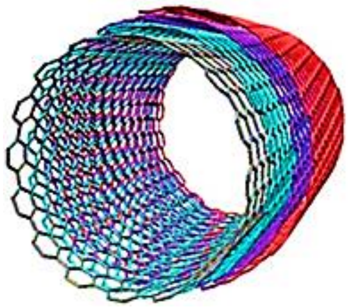
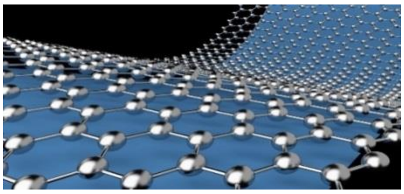
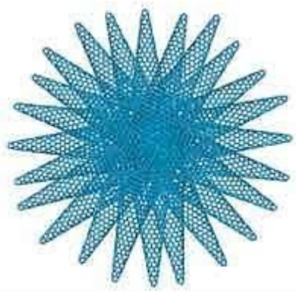
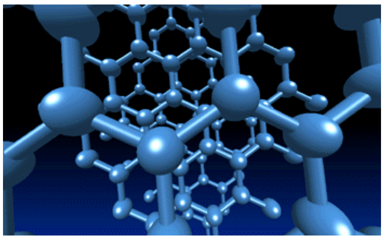
From this review, it is concluded that CNPs can be synthesized by different kinds of biological and chemical methods. Nanotechnology play potential applications in agriculture, therapeutics [88]. The focus of this review paper is based on the basic knowledge of CNPs, their synthesis method and application in agriculture and therapeutics for the human welfare and sustainable environment. CNPs which has unique physicochemical properties can be synthesized by chemical methods such as arc discharge method, laser ablation method and CVD method. From the above discussion, it is clear that CNPs has potential role in agriculture for faster seed germination, shoot elongation and increase in biomass. Lots of studies have been proved potential application in agriculture for growth and development [84]. Among all these CNPs, CNHs are interesting and neglected CNMs for a bright future.

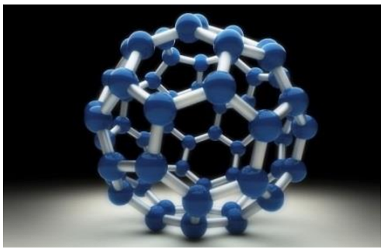
Table 2. *Application of carbon nanoparticles in various food crops.*

Name of plant species	Application	References
Zea mays	Increased shoot and root biomass yield	[6]
Vigna radiata	Increased in total biomass yield	[71]
Triticum aestivum	Increased shoot length and germinate seed faster	[13]
Lycopersicum esculantum	Seed germination and growth	[32]
Alium cepa	Root enhancement	[29]
Momordica_charantia	enhanced the medicinal property	[7]
Lolium perenne	increase the length of roots	[17]
Solanum lycopersicum	enhance the biomass mixture	[46]
Cucumis sativus	enhance the root growth and seed germination	[37]

Table 1. *Classification of Carbon nanomaterials.*

Category of nanomaterials	Description	Figure
Carbon nanofibers (CNF)	Carbon nanofibers (CNFs) (3-100nm in diameter and 0.1 - 1000 µm in length) exhibits similarity with fullerenes and CNTs.	

Category of nanomaterials	Description	Figure
Carbon nanotubes (CNT) SWCNT	CNTs are classified into single wall carbon nanotube SWCNT. The SWCNTs diameter is 0.2- 2nm. The SWCNTs further classified in arm chair, chiral and zigzag.	
DWCNT	CNTs classified into Double wall carbon nanotube DWCNTs. Its diameter is 2-25nm. It is composed by two coiled cylinders.	
MWCNT	It is the type of CNTs, more than two cylinders are coiled and formed multiwall carbon nanotube. Its diameter is 5-20nm. MWCNTs formed by multi-layered carbon atom have great mechanical and electrical properties.	
Carbon nanosheets (CNS)	Carbon nanosheets (CNSs) could be utilized as biosensors, in field electron emission, as fuel cells due to their property such as ultra-high surface to volume ratio.	
Carbon nanohorns (CNHs)	Carbon nanohorns (CNHs) are also known as nanocones closed cages of sp^2 bound C-atom. It is a conical shape carbon nanostructure.	
Carbon nanodots (CNDs)	Photoluminescent carbon -based nanoparticle. CNDs can be synthesized by two methods- 1. Top-down synthesis 2. Bottom-up synthesis.	
Graphene	Graphene is the allotropic form of carbon. It is two dimensional and made by single chain of carbon atom.	

Category of nanomaterials	Description	Figure
Fullerene	It spherical like crystalized structure which is largest family of all carbon atom.	

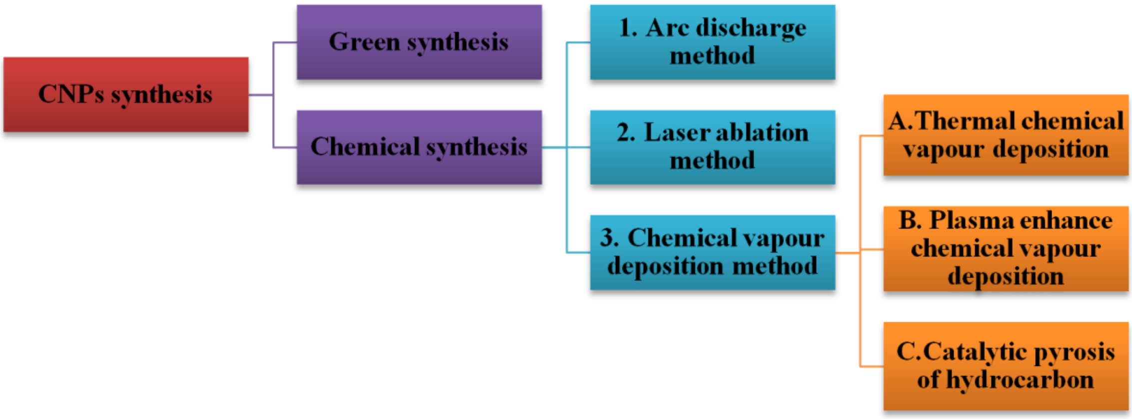


Figure 1. *Schematic representation various methods of CNPs.*

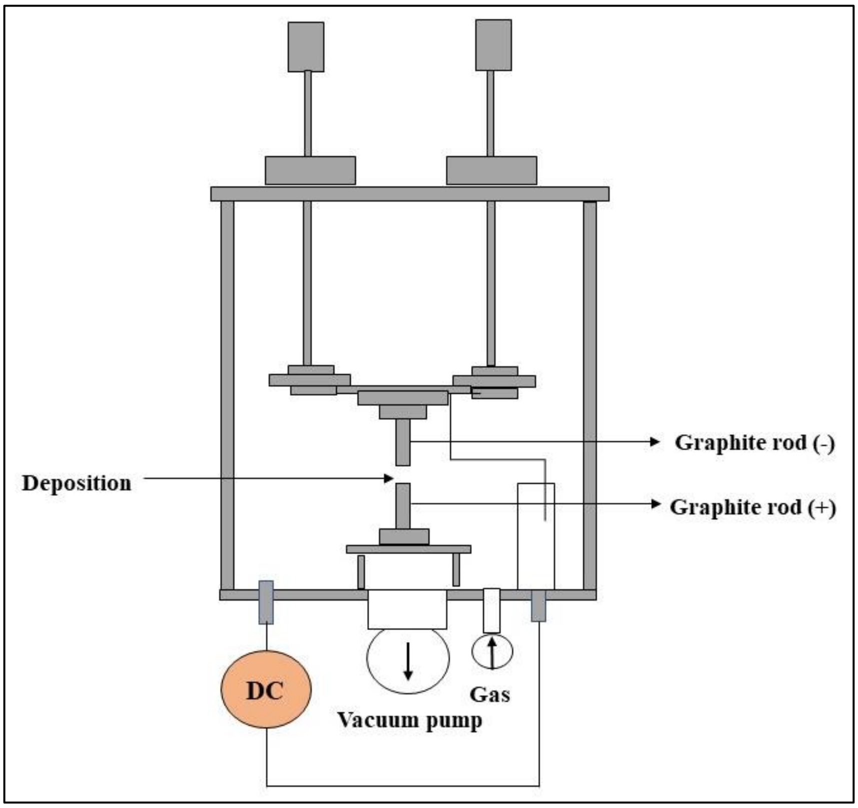


Figure 2. *Schematic presentation of arc discharge method of CNPs synthesis.*

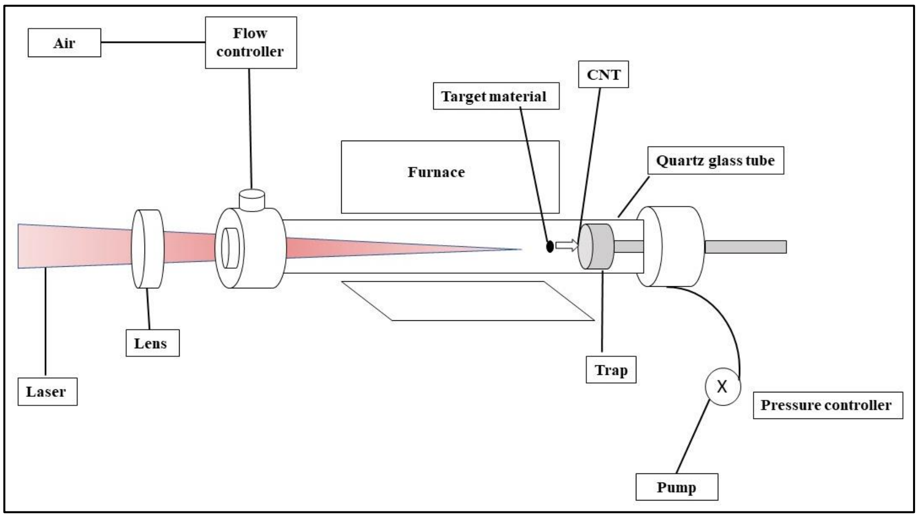


Figure 3. Schematic diagram of laser furnace apparatus.

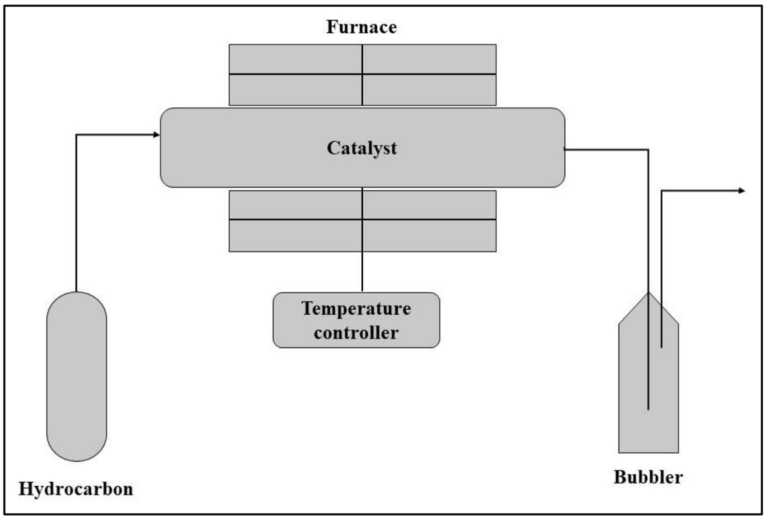


Figure 4. Schematic diagram of a CVD method.

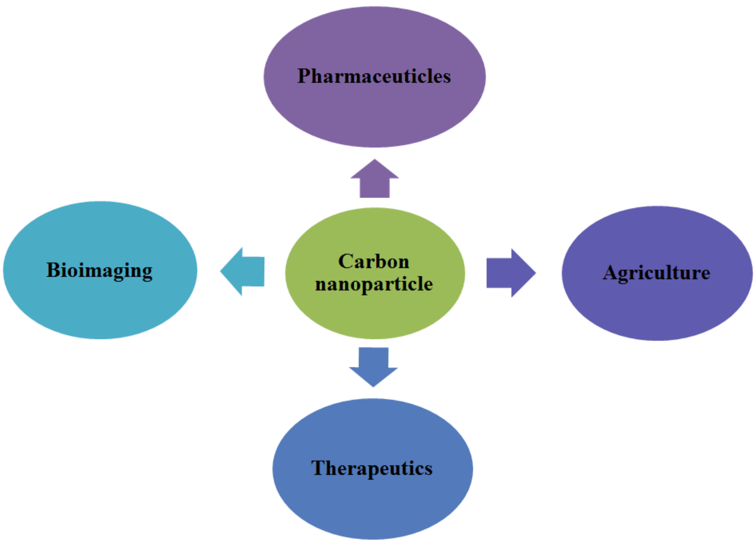


Figure 5. Applications of CNPs.

Abbreviations

CNPs: Carbon Nanoparticles
CNF: Carbon Nanofiber
CNT: Carbon Nanofiber
CND: Carbon Nanodot
CNS: Carbon Nanosheet
FCNPs: Fluorescence Carbon Nanoparticles
MWCNTs: Multiwalled Carbon Nanotubes
DWCNTs: Double Walled Carbon Nanotubes
CVD: Carbon Vapour Deposition

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Author’s Contribution

Vanshika Sharma conceived the idea; Vanshika Sharma wrote the whole manuscript. The complete manuscript was revised and edited by Vanshika Sharma and VanditaSoni.

Availability of Data and Materials

The data and materials that support the findings of the study are available from the corresponding author upon request.

Consent to Publication

All authors are agreeing for publication.

Consent to Participate

All authors are participated in this review work.

Conflicts of Interest

The authors declare no conflicts of interest.

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