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Potential and Challenges in Green Synthesis of Nanoparticles: A Review

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Abstract- Nanoparticles have a wide range of potential to use in many fields which give advantages to human beings in daily life for instance agriculture, healthcare, food, textiles and many mores. There are several types of nanoparticles and their synthesis methods for example the green synthesis method, which is a convenient method to synthesis of nanoparticles (NPs) with desired properties. On the other hand the chemical methods are quite expensive and environmental unfriendly. Using living cells to create NPs is a novel and promising bio nanotechnology approach. Numerous living things, such as bacteria, fungus, yeast, algae, actinomycetes, and plant extracts, are capable of producing NPs either intra or extracellularly. Different methods, such as UV-vis spectroscopy, FT-IR, TEM, SEM, AFM, DLS, XRD, zeta potential studies, etc. are used to find and characterize biosynthesized NPs. In addition to being used in the food and textile industries, smart agriculture, and wastewater treatment, NPs created using the green approach can be incorporated into various biotechnological fields as antimicrobial, antitumor, and antioxidant agents, as a control for phytopathogens, and as bioremediative factors. In addition to uncountable advantages green synthesis method have some challenge's for instance lack of raw material and their specific time to harvest, mature and difficult to access the desired raw materials. This review will explain the potential to use the green synthesis NPs and the challenges face in synthesis.

Index Terms- Nanoparticles (NPs), Characterization, Green synthesis, TEM, SEM, FT-IR

BACKGROUND

Human imagination and innovation frequently result in new science and technology. The frontier of nanotechnology for the twenty-first century was born from these goals. Understanding and management of matter at scale between 1 and 100 nm, where special phenomena enable new applications, is called nanotechnology [1]. One thousand millionths of a meter (10-9 m) are represented by the Greek prefix "nano," which means "dwarf" or "very small". We ought to make a distinction between nanotechnology and nanoscience. Nanoscience is the science of structures and molecules at the nanometer scale (between 1 and 100 nm) and the technology that uses these structures and molecules in real-world applications like devices, among other things is known as nanotechnology [2]. The origins of nanoscience can be found in the 5th century B.C., during Democritus and the Greeks' time. At that time, scientists discussed whether the matter is continuous and thus extremely dividable into smaller pieces, or if it is composed of tiny, undividable, and unbreakable particles that scientists now call atoms [3]. The term "nanotechnology" was aptly defined by Professor Norio Taniguchi of Tokyo Science University as "the processing of separation, consolidation, and deformation of materials by one atom or by one molecule." He defined it as being the branch of science concerned with manipulating matter at the atomic or molecular level [4].

Nanobiotechnology, applied microbiology, surface-enhanced Raman scattering (SERS), and quantum dots, are just a few examples of the innovative applied and fundamental frontiers that nanotechnology's daily incredible growth has unbolted up in a new field of study called materials science and engineering [5]. In 1959 Richard Feynman, an American physicist who went on to win the Nobel Prize, introduced the idea of nanotechnology. Feynman gave a lecture at the California Institute of Technology (Caltech) titled "There's Plenty of Room at the Bottom" during the annual meeting of the American Physical Society. In this lecture, Feynman proposed the question, "Why can't we write the entire 24 volumes of the Encyclopedia Britannica on the head of a pin?" and gave a vision of how machines could be used to create smaller machines that could be made to the molecular level [6]. Feynman is regarded as the father of modern nanotechnology because this new idea demonstrated that his hypotheses were correct [6]. Nanoparticles are solid particles or dispersions of particles between 10 and 1000 nm in size [7]. Compared to most molecules with the same chemical composition, nanoparticles have a high surface-to-volume ratio and are extremely small (in nm), making them very interesting since their properties can be altered physically and chemically [8]. The delivery of drugs using nanoparticles (NPs) is a new field with promising outcomes [9]. The ability to circulate for long periods, target specific organs, act as a DNA carrier in gene therapy, and deliver proteins, peptides, and genes has made biodegradable polymeric nanoparticles, especially those coated with hydrophilic polymers, poly (Ethylene glycol)coated)(PEG) has recently been used as a potential drug-delivery device [10].

Many scientists and researchers have shown great interest in the distinctive properties of nanoparticle materials even though many of them have shown toxicity at the nanoscale size. These researchers and scientists have found that these properties have excellent applications in various fields To combat toxicity, green chemistry, and nanotechnology are combined to create eco-friendly nanoparticles using plants, microorganisms, and other living things [11,12]. It is important to point out that a material's nanoform can have very different properties than its bulk (heat of fusion, fluorescence, magnetic properties, melting temperature, catalytic activity, band energy gap, electronic structure, tensile strength, etc.) [11].

NPs can be broadly divided into organic and inorganic categories based on the core material. Inorganic NPs are divided into metals [nickel (Ni), aluminum (Al), gold (Au), tin (Sn), molybdenum (Mo), iron (Fe), cobalt (Co), copper (Cu), indium (In), lanthanum (La), cerium (Ce), selenium (Se), stannum (Sn), titanium (Ti), zirconium (Zr), silver (Ag), zinc (Zn)] and metal oxides (SiO_2, Al_2O_3, CeO_2, ZnO, MgO, Cu_2O, In_2O_3, CuO, La_2O_3, TiO_2, NiO, SnO_2, ZrO_2). Silver (Ag), zinc oxide (ZnO), titanium dioxide (TiO_2), Metal-based copper oxide (CuO), and iron oxide (Fe_3O_4) are extensively utilized and monitored for their toxic effects on flora and fauna activity, abundance, and diversity [12,13].

Properties and Applications of Green Synthesized Nanoparticles

A major global challenge is efficiently raising agricultural production without affecting the environment. Despite recent advancements in the agricultural and healthcare industries, food and healthcare insecurity remains a danger in many developing nations [14]. There are more and more commercial uses for nanoparticles, including medicine, fields of textiles, catalysis, environmental restoration water treatment, electronics, and optics [15-17]. Because of their wide range of applications in industries [18,19], biomedical fields [20], electronics [21], markets [22], energy [23], and especially chemistry [24], nanoparticles are currently in high demand on the commercial market. Gold nanoparticles have been utilized specifically in cancer therapy to identify protein assay, immunoassay, cancer cells, and capillary electrophoresis. Gold nanoparticles are of tremendous interest in the medical field. Biomarkers can be created using biological screening techniques. These are handled accurately and altered after cellular uptake to eradicate malignancy. They can also cause apoptosis in B-cell chronic lymphocytic leukemia in addition to these. When reducing 4-nitrophenol to 4-aminophenol, the gold nanoparticle extraction method of *Gymnocladus assamicus* demonstrated excellent catalytic activity [25].

Due to their numerous applications in cell electrodes, integrated circuits, biolabeling, sensors, antimicrobial activity, and other fields, Researchers and scientists have paid a lot of attention to silver nanoparticles. Numerous different industries can use these, including the military, cosmetics, animal husbandry, packaging, medicine, health, and accessories due to their antimicrobial activity. Potential antimicrobial effects against infectious organisms were demonstrated by nanoparticles like *Vibrio cholera*, *Staphylococcus aureus*, *Syphilis typhus*, *Pseudomonas aeruginosa*, *Bacillus subtilis* and *Escherichia coli*. TiO_2 nanoparticles derived from *Hibiscus rosa sinensis* exhibited excellent antimicrobial activity against both Gram-positive and Gram-negative strains of bacteria, making them useful for tissue engineering, sensing, imaging, disease diagnostics, the production of surgical tools, treatment, agriculture, and energy production [26].

Similarly, TiO_2 nanoparticles have numerous applications for reducing a variety of pollutants, such as toxic dyes and nitroarene compounds. These are certainly heterogeneous catalysts due to their recyclability and large surface area. The removal of chemical oxygen demand (COD) and chromium (Cr) from secondary treated tannery wastewater was also demonstrated using green-synthesized TiO_2 nanoparticles. The Parabolic Trough Reactor was able to remove approximately 76.48 % of Cr and 82.86 % of COD from tannery wastewater (TWW) by employing green-synthesized TiO_2 nanoparticles [27]. Without destroying the structure of deoxyribo nucleic acid (DNA). Numerous diagnostic procedures in the medical field make extensive use of palladium and platinum nanoparticles [28]. Phenol red dye could be broken down by some Pd nanoparticles with useful photocatalytic activity at pH 6. A catalyst called Pd nanoparticles drives the Suzuki-Miyaura coupling process. After the reaction is complete, the catalyst is easily removed from the mixture by centrifugation which reduced the process cost. The obtained catalyst was used successfully in four new runs with little loss of activity. The leaching phenomena were examined of the heterogeneity of the catalyst using inductively coupled plasma atomic emission spectroscopy. Only the total amount of 0.2% palladium disappeared during the reaction [29]. These Pd nanoparticles also function as nano-catalysts for environmental remediation by demonstrating catalytic activity in the reduction of dyes such as methylene blue, 4-nitrophenol methyl orange, and coomassie brilliant blue G-250 [30]. These Pd nanoparticles also demonstrated outstanding antioxidant properties at a lower nanoparticle dose. Four different types of cancer cells, including colon carcinoma cells (HCT-116), breast cells (MCF-7), and hepatocellular carcinoma (HePG-2), were used to test the anticancer activities of platinum nanoparticles. Ajwa extract produced promising results. Additionally, Barni extract had significant inhibitory effects on colon cancer cells (HCT), and breast cancer cells (MCF-7) as well as hepatocellular carcinoma cells (HepG-2). Doxorubicin HCl, a well-known cancer treatment, was the subject of this comparative study. These platinum nanoparticles inhibited the growth of both Gram-positive *Bacillus subtilis* (RCMB 010067) and Gram-negative *Escherichia coli* (RCMB 010052) bacteria [31].

Types of nanoparticles

The green method has been utilized in the creation of numerous nanoparticles that have been characterized by several different techniques, including Fourier transforms infrared spectroscopy (FTIR), Raman spectroscopy, ultraviolet-visible spectroscopy, attenuated total reflection (ATR), photoluminescence analysis (PL), transmission electron microscopy (TEM), X-ray diffractometer (XRD), atomic force microscopy (AFM), scanning electron microscopy (SEM), energy dispersion analysis of X-ray (EDAX), field emission scanning electron microscopy (FE-SEM), thermal-gravimetric differential thermal analysis (TG-DTA), X-ray photoelectron microscopy (XPS), UV–visible diffuse reflectance spectroscopy (UV-DRS) and dynamic light scattering (DLS)

Ag nanoparticles

A silver metal ion solution and biological reducing agent are the two most important prerequisites for the production of eco-friendly silver nanoparticles. Reduction and stabilization of silver ions by fusion of biomolecules like amino acids, phenolics polysaccharides, vitamins, saponins, terpenes, proteins, and alkaloids, are the simplest and least expensive ways to produce silver nanoparticles [32]. In the biological and pharmaceutical industries. Many medicinal plants can be used to extract silver nanoparticles, including *Helianthus annus* [33], *Cinnamomum camphora* [34], *Oryza sativa* [35], *Aloe vera* [36], *Zea mays* [37]. Eco-friendly bio-organisms found in plant extract contain protein treated as a reducing and capping agent for the synthesis of stable and shape-controlled silver nanoparticles. Silver nanoparticles were altered by surfactants and polymers to have high microbial activity against both Gram-positive and Gram-negative bacteria [38].

Au nanoparticles

Among all metallic nanoparticles, gold nanoparticles stand out as they have a lot of potential for use in biology and medicine [39]. More biocompatible nature [40], tunable surface plasmon resonance [41], low toxicity [42], absorption and strong scattering [43], simple synthesis methods, easy surface functionalization [44], and other characteristics. When various chemical moieties in the biogenic complexes react with gold metal ions as reducing agents, the gold metal ions are reduced to form nanoparticles. This is how gold nanoparticles are made. According to a few studies, certain biomolecules found in plant extract, including phenols, protein, flavonoids, etc. act significantly in the reduction of metal ions and topping of gold nanoparticles. Using geranium leaf extract as a reducing and capping agent, Shankar and his group 2003 performed an initial study on the synthesis of gold nanoparticles. This reaction was performed with triterpenoid extracts for 48 hours, converting the gold ions into gold nanoparticles. According to morphological research, these nanoparticles could have various shapes, including spherical, triangular, decahedral, and icosahedral [45]. In addition, in a reaction time of 2.5 hours, they produced gold nanoparticles from *Azadirachta indica* leaf extract. The nanoparticles were likely stabilized for four weeks by the Neem extract, which contains a lot of flavanones and terpenoids. Morphological studies revealed that the majority of nanoparticles had mostly planar shape, and were spherical with some hexagonal and some triangular [46].

Leaf extract of *Aloe vera* is used to adjust the shape and size of gold nanoparticles [36]. It is concluded that the size and shape a triangle and 50–350 nm were correlated with the amount of leaf extract used. By increasing the amount of leaf extract, and reducing the quantity of leaf extract in the $HAuCl_4$ solution larger-sized nanogold triangles and spherical nanoparticles were produced with the ratio of nanotriangles to nano-spherical decreasing utilizing a small amount of mushroom extract. There are some anisotropic gold nanoparticles with maxima of triangles and prisms but very few hexagons and spheres were produced. The morphology of nanoparticles became more hexagonal and sphere-like the size of m nanoparticles decreased while the size of nanotriangles increased as the quantity of mushroom extract increased. The nanoparticles that were produced measured 25 nm in size when the concentration of the extracted quantity reached its highest level. The nanoparticles were also affected by temperature; the highest extract quantity produced hexagons at 313 K, while dendrite-shaped nanoparticles were produced at 353 K by the largest extract quantity.

Pd and Pt nanoparticle

Both platinum and palladium are expensive white metals with a high density. Green synthesis of both nanoparticles from plants has attracted much attention from researchers due to their environmentally friendly, sustainable, and low-cost properties. The use of various plant extracts, including *Gardenia jasminoides*, *Cinnamomum camphora*, *Anogeissus latifolia*, *Pulicaria glutinosa*, *Pinus resinosa*, *Musa paradisiaca*, *Glycine max*, *Curcuma longa*, *Cinnamom zeylanicum*, *Ocimun sanctum*, and *Doispyros kaki*, green synthesis of Pt and Pd nanoparticles have been reported [17]. Pt4+ ion was reduced into platinum nanoparticles with an average size of 5–50 nm using neem leaf extract [47,48]. Platinum nanoparticles were produced when the chloroplatinic ions were broken down by the protein [49]. The same synthesis at a reaction temperature of 100 C produced the same irregularly shaped aggregates of about 23 nm in size. Platinum ions were significantly reduced by tulsi leaf extract's gallic acid, terpenoids, certain proteins, amino acids, and ascorbic acid. Water electrolysis applications were made possible thanks to these nanoparticles [50]. Saudi dates extract (Barni and Ajwa) was used to create some platinum nanoparticles because they have a lot of antioxidants in them, have outstanding antifungal and antibacterial properties, and serve a great therapeutic function [31].

Cu nanoparticles

Copper nanoparticles are produced by reducing of aqueous copper ions in plant extracts like *Aloe vera* flower extract. A UV–A visible spectrometer detected a peak at 578 nm. This confirms the formation of Cu nanoparticles with an average size of 40 nm [51]. Cheirmadurai and his colleagues in the lab used henna leaf extract as a reductant to make copper nanoparticles on a large scale. These copper nanoparticles and collagen fibers, which are not used in leather industries, were used to make nano biocomposites that function as films. Numerous electronic device applications could use the film [52]. Barberry fruit extract was used as a stabilizer and reducing agent in the in situ synthesis of Cu nanoparticles on reduced graphene oxide/Fe_3O_4. It has proven useful as an active catalyst for the ligand-free reaction of phenols with aryl halides to generate O-arylations of phenols. It could be recovered and can use multiple times without losing any of its catalytic activity [53].

ZnO nanoparticle

Due to their numerous applications in optics and electronics as well as the biomedical field, over the past four to five years, researchers and scientists have paid a lot of attention to zinc oxide nanoparticles. Nanoparticles of ZnO are of great interest because they can be made cheaply, safely, and easy mode of synthesis. Due to their high exciton binding energy of 60 meV and large band gap of 3.37 eV, these nanoparticles exhibit a variety of semiconducting properties, such as wound healing, high catalytic activity, anti-inflammatory properties, and ultraviolet filtering, and are widely used in sunscreen. The antifungal, antibacterial, drug delivery, diabetic, and cancer-fighting properties of these nanoparticles were also demonstrated to have biomedical applications. There has been much research on the synthesis and usage of ZnO by plants, bacteria, and other species. Parts of a plant, like a root, flower, seed, or leaf, are utilized in the process of producing ZnO nanoparticles. ZnO nanoparticles can be created by mixing a clear solution of plant extract with a 0.5 Mm solution of hydrated zinc sulfate zinc oxide, and zinc nitrate. Effective mixing can be achieved by boiling the mixture at the right time and temperature. Several parameters can be optimized at this point including time, temperature, pH and others. The presence of ZnO nanoparticles was confirmed by the color change in the reaction. Various techniques for spectral, thermal, and morphological analysis were used to define these nanoparticles. Compared to X-ray diffraction (XRD), studies using scanning electron microscopy and energy-dispersive X-ray analysis (EDAX) exposed distinct results. The synthesis of ZnO has greatly benefited from the use of the leaves of *Azadirachta indica* a member of the Meliaceae family [54].

Alcohol, alkane, carbonate, amide, carboxylic acid and amine functional groups are confirmed to be involved in the formation of nanoparticles by FTIR analyses. *B. licheniformis* produced some uniformly sized ZnO nanoflowers with enhanced photocatalytic and photostability activity for the degradation of methylene blue (MB) dye degradation. While self-degradation of methylene blue was nonexistent, these nanoflowers degraded the dye by 83% and at a different time three repeated cycles of the experiment revealed 74% degradation, demonstrating the photostability of the ZnO nanoflowers that were produced. Lactobacillus plantarum was used to create ZnO nanoparticles, which were discovered to be relatively stable with a 15.3 mV zeta potential [55].

TiO_2 nanoparticles

Due to their unique morphologies and surface chemistry, titanium oxide nanoparticles are of great interest. Textiles, cosmetics, papers, tints, foodstuffs, plastics and other products can all benefit greatly from the use of these nanoparticles. Colloid TiO_2 nanoparticles are extensively used to remove various lethal chemicals from water, including dyes and pollutants. For toxin-free synthesis, a better alternative is to create TiO_2 nanoparticles from plants using green synthesis. So far, numerous plants have been used for synthesis and application. An initial step in the synthesis is the reaction of a plant extract with the salt of TiO_2. Initially, the formation of nanoparticles can be confirmed by the color change of the reaction mixture, which was later confirmed by spectroscopic and morphological studies. The synthesis begins with the reaction of plant extracts with TiO_2 salts. The color change of the reaction mixture first indicates the formation of nanoparticles, and morphological and spectroscopic studies confirm the formation of nanoparticles. The reported color of these nanoparticles ranges from light to dark green. An aqueous solution of TiO_2 salt and leaf extract from *Annona squamosa* L. were combined at room temperature to produce spherical TiO_2 nanoparticles [56]. The fact that leaf extracts have always been a rich source of metabolites is the primary reason why we chose to primarily synthesize TiO_2 nanoparticles from leaf extracts. Gautam et al. [27] used leaf extract of *Jatropha curcas* to synthesize TiO_2 nanoparticles, which were confirmed by dynamic light scattering, scanning electron microscopy, energy-dispersive spectroscopy, X-ray diffraction, Brunauer–Emmett–Teller analysis, and ultraviolet-visible spectroscopy.

Methods use for nanoparticles synthesis

To make these materials, one of three methods is used particularly when using a bottom-up method: the Chemical, Physical, and Biosynthetic pathways [57] [58]. The selection of a green or environmentally friendly solvent, a good reducing agent, and a harmless material for stabilization are the three most important conditions for the synthesis of nanoparticles. The chemical methods used in most cases are too expensive and use toxic and hazardous chemicals that pose various hazards to the environment [59]. Using plants and microorganisms, the biosynthetic method is a safe, biocompatible, and environmentally friendly method for synthesizing nanoparticles for biomedical applications [60]. Fungi, algae, bacteria, plants and other organisms can all participate in this synthesis. Due to the presence of phytochemicals in their extract, that act as a reducing and stabilizing agent, certain parts of plants like leaves, fruits, roots, stem, and seeds have been used for the synthesis of various nanoparticles [61].

Green synthesis of nanoparticles

The concept of environmentally benign "green chemistry" has been used in the biosynthesis of nanoparticles to produce pure and safe nanoparticles from, fungi, plants, bacteria actinomycetes, and other organisms. It's called "Green Synthesis" [62]. Plants are referred to as natural chemical factories because they are cost-effective and require little upkeep. Because even extremely low concentrations of these heavy metals are toxic, plants have demonstrated outstanding potential for both detoxification and accumulation of heavy metals, which can be used to address the issue of environmental pollutants [63]. The advantages of plant-mediated nanoparticle synthesis outweigh those of bacteria, algae, and fungi-mediated nanoparticle production, which takes a longer amount of time due to the need for constant sterile conditions and high-maintenance culture. Additionally, unlike the chemical method of synthesis [62, 64] the production of plant-assisted nanoparticles takes less time and is more readily available in usable forms. The plants leave and are used to make nanoparticles by thoroughly washing them with tap water, sterilizing them with double-distilled water, and then drying them at room temperature. On the dried sample, weighing and crushing are carried out. After that, Milli-Q H_2O is boiled with continuous stirring and mixed with the plant extract to the desired concentration. The resulting solution is next filtered through Whatman filter paper to remove the clear fraction that was suitable for the sample (plant extract) [65]. Using a green method, many nanoparticles like silver, iron gold and zinc oxide have been made easily [66].

Challenges and Limitations of Green Synthesis of Nanoparticles

Green synthesis of metals at the nanoscale has enormous potential. Selection of materials, synthesis conditions, product quality control, and application affect performance. These parameters impede industrial production and the widespread use of nanoscale metals synthesized under green conditions.

Materials

Many different plant materials are available for the green synthesis of NPs, and numerous studies have focused on locally accessible plants. Although these studies allow full utilization of native plants. Global production of green-synthesized nanoscale metals is challenging. Pd NPs, for instance, was produced from *Lithodora hispidula* (Sm.) Griseb. Leaf which can only be found in Cyprus, Cyrenaica, southern Turkey and the southern Aegean Sea [67]. *Sapium sebiferum* and Euphorbia plants are the two other materials that are used to make Pd NPs and are mostly found in the subtropics [67, 68]. Coconut, which is mostly found in India, Malaysia, Sri Lanka, Philippines and south China [69] and *Acacia*, which is mostly found in Africa, Arabia and mainland China [70] are two examples of plants used to synthesize Ag NPs. The green production of Cu NPs, Au NPs, NZVI and iron oxide nanoparticles has also made an effort to fully utilize nearby plants. While fenugreek, which is employed in the synthesis of Au NPs, is widely cultivated in China and along the eastern Mediterranean coast, peppermint is a native of Central Europe and West Asia [71]. While the *Acorus calamus* can be found in some regions of China, Galaxaura is elongated. However, at 2600 meters above sea level, the *Acorus calamus* grows on the coastline [72,73]. Principally grown in Fujian Province, oolong tea is a unique form of tea used in the manufacturing of nanoscale zero-valent iron (NZVI), a substance with a zero Valentity smaller than that of iron [74]. On the other hand, Taiwan and Hainan [75] are the primary locations where the bases for the production of nano-sized iron oxide are concentrated. Iron oxide nanoparticles can also be made with other substances, like psoralen, but they are mostly found in Sri Lanka, India and Myanmar [76]. Andean blackberry (*Rubus glucus* Benth.) which is used in the synthesis of Cu NPs, primarily found in Colombia, Ecuador and the Andes of Central and South America [77] has been used. As a result, when selecting synthetic materials, it is important to investigate the possibilities of using nearby plants to produce nanoscale metals on a big scale Lack of time also makes it difficult to use raw materials for production. The ingredients needed to make Ag NPs must be taken from cotton leaves during the flowering season [78] or *Sargassum fusiforme*, whose growing season varies greatly from region to region [79]. Also used is Arabica coffee, which grows at an altitude of 1500 meters and takes seven years to fully mature [80]. Peach blossoms are only available during their flowering season, so they must be carefully collected. *Trigonella trif*oliata seeds are utilized for Au NPs, however, the fruiting season which lasts from July to September is the only time the seeds can be gathered. The white willow has a relatively short flowering and fruiting season only lasting from April to May as a result, the time required to harvest leaves is longer. This is the same for *Cymodocea serrulata* and Pelargonium [81, 82]. Additionally, some raw materials are classified as secondary products that require further processing before being used in environmentally safe nanoscale metal synthesis, increasing the complexity and cost of the technology. As a result, it is necessary to verify these materials' economic feasibility, practicability, and cost-effectiveness. This is especially true when it comes to the coffee powder that is used to make CuO NPs [83]. Another example is tea extract. Wang and co. directly used pure tea polyphenols to make NZVI, but the methods for extracting and purifying them were too expensive [84]. Carboxymethyl cellulose which is used to make Pd NPs, is another example. Carboxymethyl cellulose must be obtained through the carboxymethylation process, which makes use of material extracted from other natural plants (such as sago pulp), even though an environmentally favorable raw material is cellulose. Cellulose methyl carboxylate, which is used to make Pd NPs is another example. Carboxymethyl cellulose must be obtained through the carboxymethylation process, which utilizes material extracted from various natural plants (such as sago pulp), even though cellulose is an eco-friendly raw material. Sodium hydroxide, sodium mono chloroacetate, and other reagents are used to improve the process, but these chemicals may not work with green synthesis.

Synthesis process

The use of additional industrial chemical reagents, excessive energy consumption and a prolonged reaction time are the primary concerns in the synthesis process. Cu NP san was synthesized using guava fruit extract in an 800 °C water bath, while Ag NPs were synthesized from the roots and leaf extract of *Ferula persica* in a three-hour process at 600 °C [85,86]. Ultrasonic stirring for two hours at 80°C can synthesize CuO NPs which is superior to the chemical synthesis method [87]. Because of this some green synthesis procedures need to be carried out at extremely high temperatures and for an extended period which uses a lot of energy that can be hazardous to the atmosphere. Although we use environmentally friendly raw materials, the process does not necessarily follow the concept of "green synthesis". In other situations, the extracts of the plant must be kept in storage until needed [88] used the brown algae *Cystoseira baccata*, which consumes a lot of energy, to create Au NPs at a temperature of 24 degrees Celsius. Extracts from other plants should also be stored at low temperatures. *Azadirachta indica* leaf extract must be stored at 4°C and dry herb extract should be stored below 4°C [89]. Equipment that consumes a lot of energy, like a freezer, is required to operate in these low temperatures. As a result, producing nano-sized metals at room temperature is best because it saves energy as well as simplifies the process of synthesis. Because efficiency and production cost are linked, the appropriate time of reaction should be short. However, numerous studies demonstrated that a long-time reaction is necessary. For example, a mixed solution of $Fe(NO_3)_3$ and mint Place the leaf extract on a rotary shaker at 30 °C and 200 rpm in the dark for 72 hours [74]. In addition, the mixed alga and $FeCl_3$ solution must be shaken for 48 hours in an orbital shaker at 24 °C in the dark [90]. Black tea and $FeSO_4$ must be mixed for 24 hours to produce Fe NPs. The black tea should then be dried in an oven at 250 °C for 24 hours [91]. The synthesis of CuO NPs requires microwave radiation in coffee powder extract. It is boiled for 3 hours and dried in a hot air oven for 4-5 hours [49]. However, the sol-gel method for synthesizing nano-sized metal oxides requires only centrifugation, continuous heating at 60° C for 1 hour, stirring for additional 30 minutes and heating for an additional 1 hour [92]. Additionally, the lengthy extraction method is unsuitable. For instance, to extract mango peel, it must be boiled for 12 hours [93]. Pre-drying mulberry, oak leaf and cherry extracts at 50°C for 48 hours are recommended [94]. *Sargassum acinarium* and *Padina pavonica* are to be washed with distilled water and then freeze-dried at 20°C for 3 days to obtain the algae extract [95]. Air can easily oxidize metal nanoparticles. The high surface-to-volume ratio and the disruption of 3-D symmetry can have a major impact on surface coordination. Because of this, even chemically inert metals can oxidize in mild-stress situations [96, 97]. As a result, to stop metal nanoparticles from oxidizing, synthesis was described in some published reports under inert conditions. For instance, the Pd NPs were separated by centrifugation using Euphorbia granulate leaf extract in an argon-free atmosphere [98]. Under N_2, the NZVI synthesis was performed in one study [99]. The synthesis process becomes more complicated and costly as a result of this condition. Additional key obstacles to green biosynthesis include a lack of understanding of the biosynthesis mechanism and the challenge of finding accurate chemical reactions to explain the synthesis process. In the process of synthesizing Cu_2O/ZnO/CuO/Cu nanostructures, for instance, the pomegranate extract (*Punica granatum* L.) peels [100] can serve as an end-capping agent. Root extracts of *Zingiber officinale* (ginger) and *Sageretia thea* (Osbeck.) as occlusive and reducing agents can synthesize Ag NPs [30] being able to be utilized in the synthesis of Fe_2O_3 NPs as a chelating agent [101]. Alternatively, existing studies can only conclude that green extract contributes to the synthesis. However, deciphering the specific reaction mechanisms involved remains a challenge. Additionally in the green synthesis of nanoscale metals scale-up of the process becomes a significant engineering challenge due to the lack of production recommendations for mass balance and stoichiometric ratios. This is a problem in terms of industrial production. Non-green synthesis and green synthesis are compared using life cycle assessment. The manufacturing procedure for the non-green approach is high-energy consumption, with electricity accounting for a significant portion. Additionally, it will increase the environmental impact, particularly in the areas of greenhouse gas emissions and energy resources [102] [103].

NPs quality

Specific properties are not sufficient, and the nanoparticles formed by different extracts vary greatly in shape and size. Large-scale production or managing particle size during production are not appropriate uses for green technology because current reports reveal significant differences. NZVI NPs produced by grape seeds ranged in size from 63 to 381 nm [104] whereas The Ag NPs produced by the leaf of *Nigella arvensis* ranged in size from 5 to 100 nm [105]. According to SEM analysis [106][107][72] the Au NPs made from aqueous *Elaeis guineensis* (oil palm), *Galaxaura elongata* and *Pistacia integerrima* gall also had very different sizes of particles. From 20 to 200 nm, 13 to 97 nm and 2 to 100 nm respectively were the sizes. Similar issues exist with other materials like the fruit of *Rosa canina* [108], citron juice [109], the flower of *Cassia alata* (83) and green tea [110]. Additionally nanoparticles made from green materials have a low conversion rate and yield. *Camellia sinensis* (green tea, GT), *Mentha spicata* (spearmint, SM) and *Syzygium aromaticum* (clove, CL) extract resulted in a modest iron reduction under all of the conditions examined. As a result, the conversion of Fe to Fe NPs was found to be less than 50% [111]. Similarly using *Melaleuca nesophila*, *Rosemarinus officinalis* and *Eucalyptus tereticornis* leaf extracts the iron content of Fe-P NPs was 0.24 %, 8.58 % and 0.53% respectively [112]. Physically synthesized nanoparticles, on the other hand may have uniform particle size distribution and high purity [113]. This phenomenon reflects the low conversion and utilization of metal ions, as only a few nanoparticles can be synthesized at high concentrations of metal ions. Economic benefits are correspondingly low.

Conclusion and Future Prospects

For nearly half a century, nanotechnology has been the basis for impressive industrial applications and exponential growth. For example, in the pharmaceutical industry, nanotechnology is having a major impact on medical devices such as diagnostic biosensors, imaging probe delivery systems, and drugs [114]. Nanomaterials are increasingly being used to improve production, packaging, shelf life and bioavailability in the food and cosmetics industry. Zinc oxide quantum dot nanoparticles were shown to have antimicrobial action against food-borne bacteria [115] and are currently used as food sensors to assess food quality and safety [116, 117].

Nanotechnology has a daily effect on the life of humans today. There is a wide range of potential benefits. However, there are significant concerns about risks to the environment and human health from widespread human exposure to nanoparticles. The emergence of new scientific disciplines was the result of these concerns including nanotoxicology and nanomedicine. Nanotoxicology is the study of the potentially harmful effects of nanoparticles on health [118]. The purpose of the field of nanomedicine which encompasses subfields such as biomaterials, bioimaging, biosensors and tissue engineering aims to look into the benefits and drawbacks of using nanomaterials in medical equipment and medicine. Enhanced medication delivery, antimicrobial coating for medical equipment, less inflammation, quicker tissue healing following surgery and detection of circulating cancer cells are potential benefits of medical nanomaterials. Because there aren't any reliable toxicity data available the possibility of causing harm to human health still warrants serious concern.

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