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Green Synthesis Of Nanoparticles And Its Application

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Abstract: Even before the era of nanotechnology, people were utilizing nano-level procedures and inadvertently coming into contact with a wide range of nanosized objects. It was long believed that plant ingredients like henna were the source of the popular black hair dye used in ancient Egypt (Kharkin V etal). However, recent research on hair samples from Egyptian tombs has shown that a paste consisting of lime, lead oxide, and water was used to dye hair (Walter P etal 2006). During this dyeing process, galenite, or lead sulfide, PbS, nanoparticles, are produced. The ancient Egyptians were able to produce small PbS nanoparticles that allowed for uniform and even coloring by the reaction of the dyeing paste with sulfur, a component of hair keratin.

Key Words: nanotechnology, procedures, inadvertently, nanosized objects, ingredients, Egyptian, consisting.

Perhaps the most well-known instance of nanotechnology's application in antiquity is the Lycurgus Cup, which dates back to the fourth century CE. Due to its unique optical characteristics, this ancient Roman cup changes color depending on where the light source is. The cup is green in natural light, but turns red when lit from the inside (with a candle). According to a recent investigation, this cup includes 50-100 nm Au and Ag nanoparticles (Barber DJ et al., 1990). These nanoparticles provide the cup's distinctive coloring by excitation of electrons through plasmon effects (Atwater HA 2007). There is evidence that nanotechnology was used as early as Mesopotamia, Ancient India, and the Maya (Brill RH etal 1988; Sharon M. 2019). The scientific field known as nanotechnology studies materials at the nanoscale, which is generally between 1 and 100 nm. It is a science that functions at the nanoscale and offers a variety of focal points to pharmacology, dentistry, bioengineering, and other scientific fields (Rafique M, Sadaf I, Rafique MS, et al., 2017).

Green synthesis: The synthesis of a wide variety of nanoparticles can be accomplished consistently, sustainably, and environmentally friendly with "green" synthesis. Green synthesis is thought to be a crucial instrument for lessening the negative consequences of conventional nanoparticle synthesis techniques, which are frequently employed in labs and businesses. The distinct chemical and physical characteristics of nanoparticles are advantageous in a variety of applications. Because of their many uses, silver nanoparticles among metallic nanoparticles have emerged as a research hotspot.

Because of their extraordinary chemical, physical, and biological characteristics, silver nanoparticles are significant. Silver nanoparticles have several uses and are employed as antifungal, antiviral, and antibacterial agents due to their special qualities. They can be utilized to treat a variety of conditions and have a great catalytic effect on dye degradation. They are also effective antioxidants.

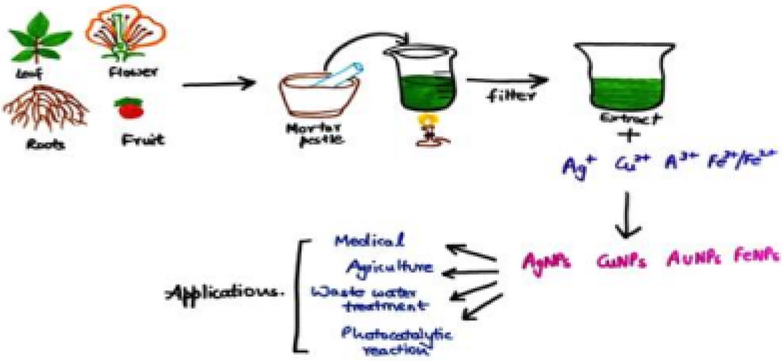

Figure: Green Synthesis of Nanoparticles

The science of the very small is called nanotechnology. It is the small-scale application and modification of matter. Atoms and molecules function differently at this size and have a wide range of intriguing and unexpected applications. Studies on nanotechnology and nanoscience have been increasingly popular in a variety of product categories in recent years. Whereas traditional methods might approach their limits, it offers prospects for the production of materials, particularly those for medical uses. It is incorrect to think of nanotechnology as a singular method that has limited use. Despite being

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dubbed the "tiny science," nanotechnology encompasses more than just extremely small objects and structures.

Large surfaces and bulk materials frequently contain nanoscale characteristics. In order to create novel nanosized materials, nanotechnology is the design, synthesis, and use of materials at the atomic, molecular, and macromolecular scales (Hahens et al., 2007). Pharmaceutical nanoparticles are defined as solid, potentially biodegradable drug carriers that are submicron-sized (less than 100 nm in diameter). Nanosphares and nanocapsules are united under the term nanoparticle. Whereas the medicine is encased in a distinct polymeric membrane in nanocapsules, nanospheres are matrix systems where the drug is evenly distributed. The classification, preparation technique, characterization, application, potential health effects, and pharmacological features of nanoparticles are the main topics of this systemic review (Couvreur P et al., 1995).

Types of Nanoparticles: Silver nanoparticles (Ag nanoparticles): Two essential components for the environmentally friendly production of silver nanoparticles are a reducing biological agent and a silver metal ion solution. Silver ion reduction and stabilization by a fusion of biomolecules such as polysaccharides, vitamins, amino acids, proteins, saponins, alkaloids, terpenes, and phenolics is the simplest and least expensive way to produce silver nanoparticles (Tolaymat et al. 2010). Numerous medicinal plants, including Saccharum ofcinarum (Chaudhari et al. 2012), Helianthus annus (Dubchak et al. 2010), Cinamomum camphora (Huang et al. 2008), Oryza sativa (Dar et al. 2016), Aloe vera (Chandran et al. 2006b), Capsicum annuum (Li et al. 2007), Medicago sativa (Lukman et al. 2011), Zea mays (Rajkumar et al. 2019), Magnolia Kobus (Lee et al. 2014) can all be extracted with silver nanoparticles.

Gold nanoparticles (Au nanoparticles): Out of all the metallic nanoparticles, gold nanoparticles have garnered a lot of attention because they are different. They have a strong potential for use in the fields of medicine and biology (Jain et al. 2006), are more biocompatible (Sperling et al. 2008), have tunable surface plasmon resonance (Huang and ElSayed 2010), are low toxicity (Jeong et al. 2011), are easy to synthesise, and are simple to surface functionalize (Ghosh et al. 2008), among other advantages. The production of gold nanoparticles involves the treatment of several chemical moieties in biogenic complexes as reducing agents, which then react with the gold metal ion to produce the reduction and nanoparticle formation. Platinum nanoparticles (Pt nanoparticles) and palladium nanoparticles (Pd nanoparticles): Platinum and palladium are both pricey, silvery-white metals with a high density. Because both types of plant-based nanoparticles are affordable, sustainable, and environmentally friendly, their biosynthesis has garnered the interest of numerous researchers. Many plant extracts, including those from Cinnamomum camphora, Gardenia jasminoides, Pinus resinosa, Anogeissus latifolia, Glycine max, Ocimun sanctum, Curcuma longa, Musa paradisica, Cinnamom zeylanicum, Pulicaria glutinosa, Doipyros kaki, and many more, have been used in the green synthesis of Pd and Pt nanoparticles (Siddiqi and Husen 2016).

Copper nanoparticles (Cu nanoparticles): By reducing aqueous copper ions, many plant extracts, including Aloe vera flower extract, can produce copper nanoparticles. A 578-nm peak at a UV-visible spectrometer confirmed the creation of Cu nanoparticles with an average size of 40 nm (Karimi and Mohsenzadeh 2015). Cuscuta refexa leaf extract, a rich source of numerous antioxidant phytochemicals including Myricetin, Myricetin glucoside, Kaempferol 3-Oglucoside (Astragalin), Kaempferol-3-O-galactoside, Kaempferol, Quercetin, Quercetin 3-O-glucoside, Cuscutin 3-O-galactoside, Oleic acid, Palmitic acid, Linoleic acid, Linolenic acid, Stearic acid, Isorhamnetol, Cuscutin, Cuscutalin, Azaleatin, Amarbelin, Dulcitol, Bergenine, Beta-sitosterol, Luteolin, Maragenin, and Coumarin. The aforementioned components are in charge of transforming plant extract into an abundant supply of antioxidants for the creation of nanoparticles.

Zinc oxide nanoparticles (ZnO nanoparticles): Over the past four to five years, scientists and researchers have paid close attention to zinc oxide nanoparticles because of its numerous applications in the biological field as well as in optics and electronics. ZnO nanoparticles are highly desirable because of their simple, safe, and low-cost fabrication method. Due to their large bandgap of 3.37 eV and high exciton binding energy of 60 meV, these nanoparticles exhibit a variety of semiconducting properties, including high catalytic activity, wound healing, anti-inflammatory, and UV filtering capabilities. They are also widely used in cosmetic products like sunscreen.

Titanium oxide nanoparticles (TiO2 nanoparticles): Due to their unique morphologies and surface chemistry, titanium oxide nanoparticles are quite interesting. When preparing fabrics, plastics, papers, colors, cosmetics, foodstuffs, etc., these nanoparticles are quite helpful. Colloid TiO2 nanoparticles are widely employed in the removal of water-borne contaminants and dyes, among other harmful substances. For a toxic-free synthesis, green synthesis of TiO2 nanoparticles from plants is a preferable option. Many plants have been employed thus far for both its synthesis and uses. The reaction of a plant extract with TiO2 salt initiates the synthesis. The first indication that a nanoparticle has been generated is a change in hue in the reaction mixture. Later, morphological and spectroscopic investigations confirmed the production of the particles. There have been reports of light green to dark green nanoparticles.

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Applications: Anti-Cancer Potential: Nanomedicine is the use of nanotechnology in the treatment, screening, and diagnosis of a variety of diseases, including cancer. It adds complete procedures and effective approaches against cancer through cancer prediction and diagnostics, prevention and medication, as well as possible individualized therapy.

Many plant-derived NPs have shown some potential against cancer cells. ZnONPs produced from a Cassia auriculata leaf extract, in particular, has shown tumoricidal activity against MCF-7 breast cancer cells while having no detrimental effect on normal MCF-12A human breast cells.

Similarly, green AuNPs produced from a Trachyspermum ammi seed extract inhibited cellular growth in HepG2 cancer cell lines in a concentration-dependent manner, which was linked to a reactive oxygen species (ROS)-driven apoptosis. This mechanism has recently been reported to be potentially connected to mitochondrial action via ROS-induced Caspase-3 gene expression and enzyme activity following mitochondrial membrane potential disruption caused by plant-based NPs.

However, in addition to a deeper understanding of the molecular mechanism of action of NPs against cancer cells, there is also a need to properly understand the fate of NPs. These questions include how long NPs stay in the body, what conditions influence the duration of NP degradation, how to make NPs stay for longer or shorter periods, what are the long-term and short-term effects of NPs, how the body behaves towards these outsider entities on a micro and macro level, and how we can standardize NPs to ensure experiment reproducibility. These should be solved before introducing nanotechnologies into the healthcare industry. Aside from this, there are several questions that require further research and testing. In order to avoid any unanticipated consequences, we must also determine the possible risks linked with these nanomaterials. Furthermore, in order to obtain the safest and most successful therapy regimen, the numerous nanomedicines and nanoformulations targeting specific cancer cells must be thoroughly constructed. We conclude with the hope that nanotechnology will propel the development of more viable medicines to treat cancer, as well as offer researchers with powerful tools to overcome several bottlenecks in this health sector.

Anti-Leishmanial Potential: Leishmaniasis is a protozoan vector-borne illness that affects almost 350 million people worldwide. Chemotherapeutic medicines were initially used to treat leishmaniasis, but they had adverse side effects. Due to their unique properties, such as bioavailability, reduced toxicity, targeted drug delivery, and biodegradability, a variety of nanotechnology-based techniques and products have emerged as anti-leishmanial drugs, including liposomes, lipid nano-capsules, metal and metallic oxide nanoparticles, polymeric nanoparticles, nanotubes, and nanovaccines. AgNPs containing xylan (also known as nanoxylan) synthesized in a green synthesis route with corncob xylan as a reducing and stabilizing agent demonstrated effective inhibitory activity against Leishmania amazonensis promastigote viability, whereas xylan alone had no effect. This work nicely illustrates the potential of the nanoxylan as a promising new type of antiparasitic agent.

Antimicrobial Potential: Antibiotic resistance is one of the most pressing issues of recent years, and it is only going to become worse. Bacteria have developed resistance to antimicrobial agents as a result of the rapid evolution of the bacterial genome. Thus, in the search for a new therapy, biogenic NPs have shown encouraging results in the treatment of multidrug-resistant bacteria and might be a potential choice in the fight against such resistant pathogenesis. To improve the antimicrobial response, NPs and other conjugates have been combined with different organic and inorganic compounds.

Ag has long been known for its antibacterial properties against a variety of bacterial strains. In particular, green AgNPs prepared from a Carissa carandas leaf extract demonstrated antibacterial efficacy against a variety of human pathogenic bacteria, with Gram-negative bacteria, particularly Shigella flexineri responsible for shigellosis, being more likely to be inhibited. Similarly, bimetallic nanostructures coated with reduced graphene oxide generated from a stevia leaf extract, such as Pd-Ag nanostructures, can limit the development of Gram-negative bacteria Escherichia coli. AgNPs obtained from the Saudi Arabian desert plant Sisymbrium irio showed potent inhibition potential against multidrug-resistant Pseudomonas aeruginosa and Acinetobacter baumanii that are responsible for ventilator-associated pneumonia. Furthermore, antifungal activity of nanoxylan derived from corncob xylan against Candida albicans, Candida parapsilosis, and Cryptococcus neoformans has been described, whereas AgNPs obtained from the leaf extract of Clerodendrum inerme showed a dual antibacterial and antifungal actions against a wide range of human pathogenic strains.

Interestingly, AuNPs produced from the same C. inerme extract also showed very similar inhibition capacity. The authors concluded that these NPs may have improved antimicrobial activity due to the synergistic effect of biologically active absorbed phytochemicals from this plant. Antibiofilm action of AuNPs produced from a T. amni seed extract was also observed against Listeria monocytogenes and Serratia marcescens, most likely as a result of intracellular ROS production.

ZnONPs also showed potential antimicrobial activity as evidenced by the action of ZnONPs derived from a Cinnamomum verum bark extract against E. coli and Staphylococcus aureus. Similarly, ZnONPs derived from a C. auriculata leaf extract

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exhibited antibacterial activity due to direct cell contact, which disrupted bacterial cell integrity.

Other metallic NPs, such as CuONPs derived from Cymbopogon citratus, can exhibit significant antimicrobial activity, including antibiofilm properties. Interestingly, these authors noted a variation in antibiofilm activity, which they suspect is due to differences in the cell wall compositions of the examined bacterial strains. MnONPs derived from an Abutilon indicum leaf extract demonstrated potent antibacterial activity against both Gram-negative and Gram-positive bacteria, whereas NiONPs deriving from stevia leaf extract were more effective against Gram-negative bacteria. This shows that antimicrobial activity is influenced by the type of NPs produced, but also the composition of the coated phytochemicals on their surfaces, which is affected by the plant extract used for NPs synthesis.

Cell wall disruption, cell membrane disintegration, massive free radical production, specific (targeted) and/or specific actions against proteins, DNA fragmentation, vital enzyme inhibition, loss of cellular fluids, and disruption in electron transport have all been proposed as possible mechanisms for NPs antibacterial activity. Bio-mediated NPs might also have an antifungal effect by causing excessive ROS generation. However, few studies have focused only on fungus as of yet. Despite advances in understanding of the antimicrobial efficacy of plant-based NPs, much remains unclear regarding their specific mechanism of action, toxicity, and possible environmental issues.

Agricultural Applications: When agricultural pathogens are targeted, the antimicrobial activity outlined in the previous Section may be effective for crop protection. In particular, ZnONPs have demonstrated their wide agricultural interest showing an anti-phytopathogenic action against both bacteria as evidenced by ZnONPs derived from lemon fruit against soft rot bacteria pathogen Dickeya dadantii, and fungi as illustrated by the fungicidal activity of ZnONPs produced using a Eucalyptus globules extract against major pathogens of apple orchards. It is noteworthy that TiO2NPs produced from lemon fruit showed antibacterial activity comparable to ZnONPs against D. dadantii.

Through modifying abscisic acid concentration, ion homeostasis, and defense mechanisms comprising both enzymatic and non-enzymatic antioxidants, AgNPs synthesized from a wheat extract significantly contributed to alleviate the negative effects of salinity stress in wheat. Interestingly, ZnONPs exhibited low toxicity and the capacity to stimulate the antioxidant response of flax seedlings as well.

Antioxidant Action: Excessive oxidative stress generated by the action of mitochondria and other internal or external sources may result in oxidative damages to various cell macromolecules (membrane lipids, proteins, and DNA), leading to functional declines, degenerative diseases, and aging [48]. Antioxidants may be able to reverse this detrimental process and may be used to treat aging and age-related diseases. Some green plant-derived NPs have been described for their antioxidant potential as shown for AgNPs produced from a C. carandas leaf extract, AuNPs and AgNPs deriving from a C. inerme leaf extract, or NiONPs prepared from a stevia leaf extract.

The phytochemicals coated on the NPs surface have certainly a prominent influence in the observed antioxidant action. Commonly, just one in vitro assay, such as the DPPH (2,2-diphenyl-1-picrylhydrazyl) assay, is performed. However, due to the complex nature of phytochemicals, and in particular, because the determination of antioxidant activity is significantly reliant on the reaction mechanism involved, antioxidant activity of should not be measured using a single approach. Therefore, the validity of the results from in vitro cell-free antioxidant tests must be restricted to the interpretation in terms of chemical reactivity, but in vivo (cellular) validation is strongly required.

Other Applications: Other potential applications, such as (photo)catalytic and/or absorption potential applications, are also described. AgNPs produced by Matricaria chamomilla showed effective catalytic activity against Rhodamine B under UV light, which could make it a promising material for wastewater treatment. MnONPs produced from an Abutilon indicum leaf extract has shown efficient absorption activity against the heavy metal CrVI as well as strong photocatalytic activity, indicating the potential to remediate various organic and inorganic contaminants. Finally, the photocatalytic H2 production, mediated by Pd-Ag bimetallic nanostructures coated with reduced graphene oxide produced from a stevia leaf extract, can be noted.

Conclusion- The utilization of plants in the production of nanoparticles is a quick, inexpensive, environmentally beneficial, and one-step procedure. The ions of metal reductions caused by leaf extract that result in the creation of synthesized nanoparticles are very stable in solution. An intriguing and newly developed component of nanotechnology that significantly affects the environment and advances the long-term sustainability and advancement of nanoscience is the utilization of plants for the manufacturing of green nanoparticles.

The creation of environmentally friendly methods for synthesizing nanoparticles is becoming into a significant area of nanotechnology. By removing the complex procedures required to maintain microbial cultures, the production of nanoparticles utilizing plants or components of plants can be advantageous over other biological techniques. The utilization of plants in the production of nanoparticles is a quick, inexpensive, environmentally beneficial, and one-step procedure.

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