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Green Nanotechnology: Approaches for the Synthesis of Nanoparticles

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INTRODUCTION

Nanotechnology is a discipline of science concerned with the analysis of materials in the nanoscale, which ranges from 1 to 100 nanometers. It is a nanoscale science that provides multiple focal points to various branches of science such as dentistry, pharmacology, and biotechnology [1]. The importance of a green chemistry approach to nanomaterials' future prospects cannot be overstated. This field of nanoscience should lead to the production of safe, environmentally acceptable NPs and broad acceptance in nanotechnology [2]. Solvents and reducing operators used to reduce NPs have a significant impact on the morphology of integrated particles, such as size, physicochemical characteristics, and shape, and this morphology influences NP utilisation [3].

Different approaches for the synthesis of nanoparticles

Bottom-up and Top-down approaches for nanoparticle synthesis are the most common. The "bottom-up" method involves forming the nanostructure building blocks first, then putting them together to make the final material. Lithographic and nonlithographic fabrication technologies are used in the top–down approach. Lithography is a foundational technology for fabricating semiconductor chips and components [4].

Fabrication of micro- and nanosystem components, which range in size from micrometres to nanometers, is frequently done using a top–down approach. Many advanced materials synthesis processes, such as characterises chemical synthesis of nanostructured materials, combine both synthesis and assembly into a single process. Depending on the eventual materials application, the degree of control required over the sizes of the nanostructure components, as well as the nature of their distribution and bonding within the completely produced material varies substantially [5].

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In general, three approaches to nanoparticle synthesis were used: physical, chemical, and biological.

Physical method of nanoparticles

The most common physical method for synthesizing NPs is a "top-down" approach, in which the material is decreased in size using various physical methods such as ultrasonication, microwave (MW) irradiation, electrochemical treatment, and so on. In this method, a tube heater with a barometrical weight is used to integrate NPs through evaporation condensation. The most important physical approaches are evaporation condensation and laser removal. A carrier gas is created by vaporising the source material inside a pontoon that is focused on the heater. Various Ag, Au, PbS, and Cd NPs have been produced and described using this dissipation build-up technique [3].

Chemical method of nanoparticles

Metallic precursors, stabilising agents, and reducing agents are the primary components of the chemical method (inorganic and organic both). Sodium citrate, ascorbate, elemental hydrogen, sodium borohydride ($NaBH_4$), the polyol process, the tollens reagent, N, N-dimethylformamide (DMF), and poly(ethylene glycol)-block copolymers are all utilised as reducing agents [6].

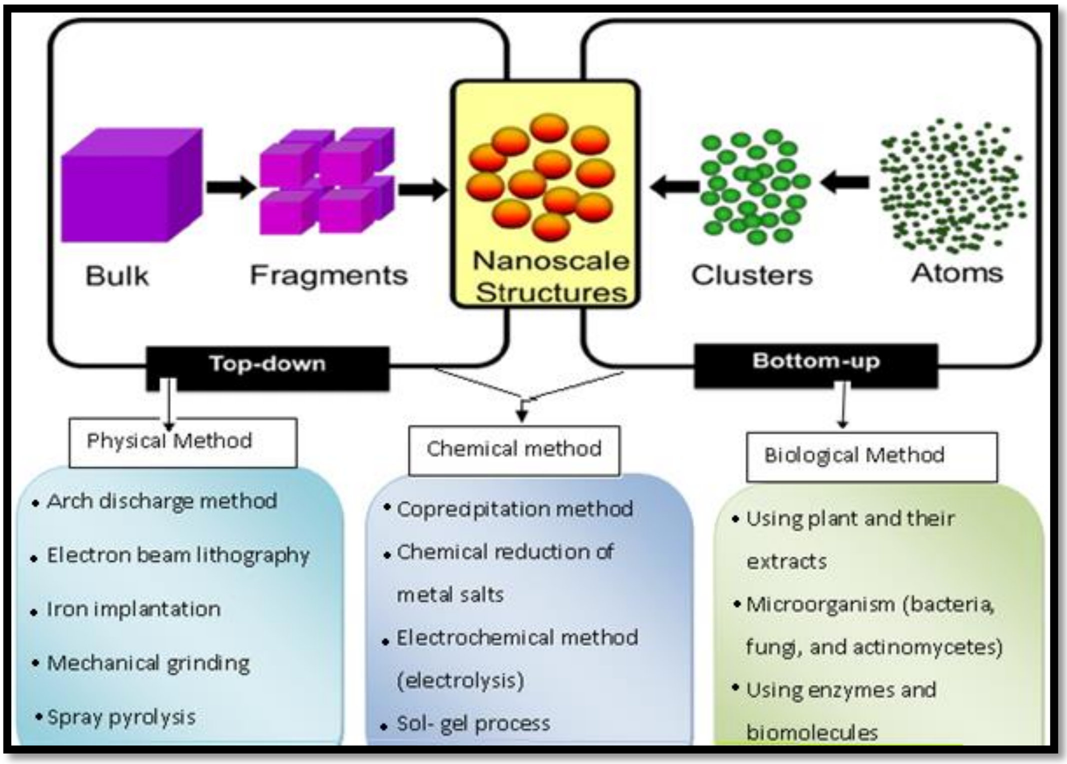

Figure: Approaches and method for synthesis of nanoparticles

Green method of nanoparticles

The syntheses of ecologically friendly nanoparticles that do not produce harmful waste products during the manufacturing process have attracted interest in recent years. This can only be accomplished through biologically benign synthesis procedures using biotechnological instruments that are regarded safe and environmentally friendly for nanomaterial fabrication as an alternative to traditional physical and chemical approaches [7]. The term "green technology" or "green nanobiotechnology" was coined as a result of this. In general, Green nanobiotechnology refers to the use of various biotechnological methods to synthesize nanoparticles or nanomaterials through biological routes such as those involving microbes, plants, and viruses, or their byproducts such as proteins and lipids. Bottom-up production of

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nanoparticles is more environmentally friendly because it uses a biological system or a derivative of one [8].

Factors on which Green Synthesis Depend

The green synthesis of nanoparticles mainly depends on three factor material used, reducing agent and solvent **[9].** Ostwald ripening and oriented attachment (OA) is two processes that cause a nanostructure to grow. The OA mechanism involves two particles self-organizing into a single crystal by having a shared crystallographic orientation. At the nanometer scale, this method is dominating. It has been noted that capping agents can have a significant impact on OA processes since they directly affect the nanoparticle surface. The capping ligand's molecular weight also has a significant impact on the nanoparticles' assembly behaviors [10].

One of the most significant parts of nanoparticle synthesis is surface functionalization, especially when nanoparticles or nanomaterials are generated for a specific application. The production of nanostructure materials, particularly metal (silver, gold, copper, platinum, and palladium) nanoparticles, is of tremendous interest due to their unique features that allow them to be used in a variety of sectors such as technology and research. It's about changing the way we touch, see, and feel things [11].

Benefits of Green synthesis

The advancement of green synthesis over physical and chemical methods are environment friendly, cost-effective, and easily scaled up for vast scale synthesis of NPs, while high-temperature, energy, pressure, and harmful chemicals are not required for green synthesis [12]. Previously, dangerous compounds that could be life-threatening were used in the creation of nanoparticles using chemical and physical processes. It was recently discovered that proteins found in plants may be used to reduce metal ions to nanoparticles in a single step. The biological manufacturing of nanoparticles is environmentally benign, cost-effective, and, most importantly, health-safe [13].

The remarkable optical, chemical, photo electrochemical, and electrical characteristics of nanoparticles synthesized with living entities have piqued researchers' interest. Nature has evolved a variety of techniques for the synthesis of nano- and micro-length sized inorganic materials, which have aided in the creation of a relatively new and mostly unexplored field of research centered on nanomaterial biosynthesis. The development of clean, nontoxic, and environmentally acceptable "green chemistry" processes, likely including species ranging from bacteria to fungus and even plants would help the synthesis and assembly of nanoparticles. Plant-derived nanoparticles are more stable, and their production is even faster than that of microbes [14].

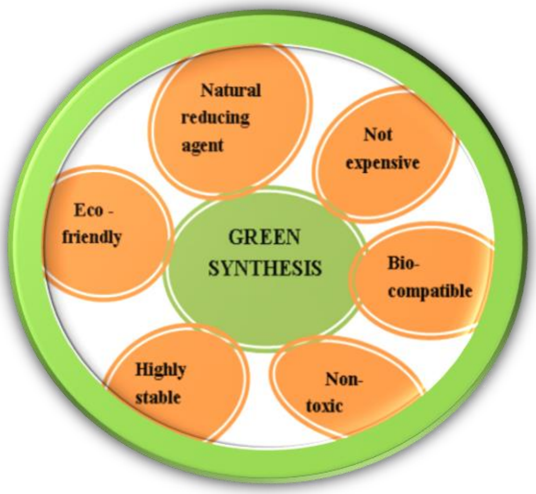

Figure: Importance of green nanoparticles

CONCLUSION

Scientists studied advanced novel methods of synthesizing NPs with the ideal size and morphology that would be advantageous for numerous fields since the commencement of NPs over half a century ago. A variety of physical, chemical, and biological approaches are available to engineer and create an optimum size and morphology of NPs, depending on their application/use. Synthesis of nanonoparticles selects a specific synthesis technique for creating desired NPs with certain material types, sizes, surface qualities, targeted applications, etc. Green synthesis has an advantage over chemical and physical processes since it is less expensive, more environmentally friendly, and more easily scaled up for large-scale synthesis. Nature has beautiful and imaginative ways of creating the most capable tiny functional materials. The desire to develop eco-friendly approaches arose from a growing knowledge of green chemistry and the use of green routes for the manufacture of metal NPs, particularly Ag-NPs. Because of the poor synthesis rate and small number of size and shape distributions created, the study focused on using plants.

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