A Brief Profile of Techniques Applied for Synthesis of Nanoparticles

Prof.(Dr.)H.R.Chharang
Department of Chemistry
S.B.R.M.Govt.College,Nagaur(Raj.)

Abstract

The interdisciplinary field of science and innovation known as nanotechnology, which unites biology and material science, has recently gained power. As new avenues for research are opened up by nanoscience and nanotechnology, it becomes easier to create novel nanomaterials with amazing uses. Engineered nanomaterials have attracted a lot of interest recently due to their noteworthy characteristics, leading to considerable technical and financial progress across numerous industrial sectors. Additionally, a number of industries, including microelectronics, materials, textiles, energy, healthcare, and cosmetics, are anticipated to benefit from the use of nanomaterials. Applications of nanotechnology will result in the creation of stronger, lighter, and cleaner materials as well as intelligent drugs and medical diagnostics. This article outlines some of the popular techniques for creating silver and other nanomaterials.

Keywords: Nanotechnology, Silver Nanoparticles, Nanoparticle, Nano-techniques, Green methods

Introduction

Due to the future potential of nanotechnology, the use of nanomaterials can aid in upgrading products and industrial processes with improved features or new functions. Future predictions predict that practically all industrial sectors will be considerably impacted by nanotechnology-based products, which will also be widely available on the consumer market [1, 2]. In the world of nanotechnology, a particle with lengths in two or three dimensions greater than 1 nm and less than 100 nm that may or may not exhibit a size-related intensive feature is referred to as a nanoparticle. NPs are also categorised as zero-dimensional nanomaterials to distinguish them from one- and two-dimensional nanomaterials, which have dimensions that are one or two orders of magnitude larger than nanoscale, respectively [3, 4]. Recent technological advancements have shown that evolution in nanotechnology and nanoscience is a crucial component. Practically every field of science and technology is finding uses for nanotechnology [5]. The great functions of silver nanoparticles, including their use in photoelectricity [6], catalysis [7], antibacterial [8, 9], biosensors [10], and surface-enhanced Raman scattering (SERS), have recently been the subject of a thorough study by researchers. As of yet, chemical reduction [12– 16], light reduction [17– 18], laser synthesis [19], and other methods have all been successful in producing AgNPs. However, these techniques typically require a lot of time and effort. They also have the drawbacks of having tight preparation requirements and AgNPs that are not uniform in size.

Therefore, it is urgently necessary to develop simple and affordable methods that can be used to finely control the size, shape, and size distribution of AgNPs. AgNPs can be effectively produced with good stability and dispersibility by using protecting agents. While this is happening, a protective agent can prevent particle agglomeration. Therefore, it is crucial to use protective agents when synthesising AgNPs [20]. We have outlined the synthetic processes used to create silver nanoparticles in this review study.

Synthetic Methods of Nanoparticles

The following three techniques can be utilised to produce nanoparticles (NPs): The three techniques are biological, physical, and chemical.

Biological technique

The biological method is straightforward, usually only requiring one step, and advantageous for the environment. In this sense, microbes and various plant components can be used to create nanomaterials [21].

Using of microorganisms

Numerous organisms, including algae, fungi, and bacteria, can be used to produce a variety of nanomaterials from an aqueous solution of metal salts.

Using of bacteria

Living beings will take part in biomineralization, which produces nanoparticles, by using a protein. For example, at the bottom of the sea in anaerobic conditions, magnetotactic bacteria use magnetosomes, which are protein-coated for the production of nanosized magnetic iron oxide crystals, to create the magnetic particles as a compass to the direction of their chosen home [22]. Pseudomonas cells from the alpine region were employed to make extracellular palladium nanoparticles, according to Schluter et al. [23].

Using of fungus Extracellular

Using the fungus Fusarium oxysporum, Ag NPs were produced. These nanoparticles remain stable for a long time because of the activity of NADH-enzymatic reductase. Fungal cells release more protein compared to bacterial cells [24].

Using of algae

Singaravelu et al. proposed extracellular Au NPs produced from Sargassum wightii algae. Only 12 hours of incubation were necessary to produce 95% of the output [24]. There hasn't been enough research done on how algae produce NPs. In this procedure, some bacteria, fungi, and algae can be toxic. Therefore, measures should be taken to avoid them.

Using of biological templates

Utilising biological processes allows for the production of nanomaterials inside the organism. Biological templates are the primary tools for doing this. They use biological building blocks like DNA and proteins to produce unique and complex nanostructures. These nanoparticles may be used to develop biosensors [25], bio NEMS, and bioelectronic systems [26]. Proteins make up the vast majority of the parts of nanocomposite materials. For instance, prokaryotes and eukaryotes both include the intracellular iron store protein ferritin. Iron oxide builds up and is progressively released from it. It acts as a buffer and regulates when there is a shortfall or excess of iron in humans. It features a protein shell surrounding an iron oxide core.

Using of plant components

Plant extracts have also been used in the Synthesis of the NPs. The metal NPs are reduced by plant phytochemicals. Organic acids, flavones, and quinones are examples of phytochemicals that naturally act as powerful reducing agents to produce NPs. Differently shaped Au NPs are made from the biomass of the Medicago sativa and Pelargonium graveolens plants [27]. Bimetallic Ag, Au, and bimetallic Au core-Ag shell nanoparticles are made from Azadirachta indica leaves. This plant has sugars and/or terpenoids that act as reducing agents [28]. Au NPs are produced using aloe vera leaf extract [29]. To make Ag, Co, Ni, Zn, and Cu NPs, a number of plants are employed, including Brassica juncea and Helianthus annuus.

Physical method

The physical pathway or mechanism incorporates a number of different techniques, including gas-phase deposition, electron beam lithography, pulsed laser ablation, laser-induced pyrolysis, powder ball milling, and aerosol[30]. When a strong laser beam contacts the target material during laser ablation synthesis, nanomaterials are created [31]. The original substance or precursor vaporises during the laser ablation process as a result of the intense laser irradiation, creating nanoparticles. This technique can be used to create a wide variety of additional nanomaterials, including oxide composites, metal nanoparticles, ceramics, and carbon nanomaterials [32].

Chemical Methods

Thermal breakdown, electrochemical deposition, coprecipitation, microemulsion, hydrothermal, and sonochemical deposition are only a few of the methods used by the chemical pathway. Some of the chemical procedures used to produce magnetic nanoparticles for medical imaging applications include microemulsions, sonochemical reactions, sol-gel syntheses, hydrothermal reactions, hydrolysis, flow injection syntheses, thermolysis of precursors, and electrospray syntheses[33, 34]. Methods of chemical vapour deposition are necessary for the synthesis of carbon-based nanomaterials. If a precursor has acceptable volatility, good evaporation stability, high chemical purity, low cost, and no risks, it is rated optimal for chemical vapour deposition. Furthermore, after it is broken down, no pollutants should remain [35].

Silver nanoparticles

Typically, chemical or physical methods such as the sol process, micelle, chemical precipitation, hydrothermal method, pyrolysis, and chemical vapour deposition are used to create nanomaterials. Some of these techniques are simple, and by resetting the reaction environment, they allow for control over crystallite size. However, there are still issues with the product's overall stability and the use of these techniques to produce monodisperse nanoparticles. Many common techniques have also been found to be capital-intensive and inefficient in terms of their use of resources and energy [36]. As a result, AgNPs were successfully produced using chemical reduction [37– 41], light reduction [42– 43], and laser synthesis [44], among other methods.

Photochemical Approach

Additionally, photo-induced synthetic techniques have been developed. For instance, Huang and Yang created AgNPs by photoreducing AgNO3 in suspensions of layered inorganic clay, which acts as a stabilising agent to stop nanoparticles from aggregating. The AgNPs were broken down by irradiation into smaller pieces with a single mode distribution until a size and diameter distribution that was mostly stable was attained [45]. However, this method calls for expensive equipment and an experimental setting.

Polysaccharide method

with water as an ecologically friendly solvent and polysaccharides as a capping agent, or in some circumstances, polysaccharides acting as both a reducing and a capping agent, AgNPs are created with this approach. For instance, starch was used as a capping agent and b-D-glucose as a reducing agent during the synthesis of starch-AgNPs in a gently heated environment [46]. By using starch in the solution, somewhat hazardous organic solvents were avoided [47].

Conclusion

It has been shown that nanomaterials differ from their bulk counterparts in a number of different ways. Nanomaterials have several properties, including a large surface area, magnetism, quantum effects, antimicrobial activity, and high thermal and electrical conductivities. Mixed-composition nanomaterials are also being developed for usage in a variety of industries. Although there is a lot of research being done in the fields of sensors, biomedicine, and electronic storage devices, there is still room for improvement. These benefits make the current approaches practically relevant and potentially adaptable to the large-scale commercial production of stable colloidal silver nanoparticles, which have numerous applications, particularly in the digital fabrication of electronic circuits and medical applications.

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