

Metallic Nanoparticles Fabrication Methods– A Brief Overview

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1. Abstract

With the advent of Nanotechnology, nanoparticle usage has increased tremendously in various applications because of their unique properties and enhanced functionalities. In order to meet the elevated demands for nanomaterials in the commercial market, industrial sector is involved in the mass production of different types of nanoparticles by using numerous fabrication methods such as physical/chemical techniques. But these methods are energy inefficient, costly, and uses hazardous chemicals. Therefore a novel green synthesis biological approach is being adopted for the fabrication of metallic nanoparticles that is much safer and effective in terms of cost, time and functionality.

2. Keywords: Lactobacillus, Escherichia coli, Bacillus cereus, Nitrate reductase, Yeast; Bioreduction.

3.Introduction

Metallic nanoparticles are sometimes also referred as inorganic nanoparticles that are made up of metals such as silver, gold, iron, zinc etc [1]. In 1875, Faraday was the first person to recognize metallic

nanoparticles as unique nanostructures with distinctive properties [2]. Effective methods for metallic nanoparticle synthesis require the use of non-toxic reagents, reaction parameters optimization for maximum product yield and desirable uniform morphology [3]. In addition, process should be inexpensive and reproducible [4]. Various fabrication procedures are utilized for the preparation of metallic nanoparticles using either top down or bottom up approach but each of these approaches comes with certain pros and cons [5,6]. Based on the fabrication strategy, synthesis of metallic nanoparticles is classified into two types namely top down and bottom up [7].

a. Top Down: Top down method is a technique in which the bulk material is transformed into small nano sized particles [8]. Preparation of nanoparticles is based on starting material size reduction by distinct chemical and physical treatments [9]. It

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comprises methods such as thermal milling mechanically and laser ablation [10, 11]. This method is not suitable for the synthesis of very small nano-sized particles with informal shapes [12]. The main challenge associated with this approach is the alteration of surface chemistry and physicochemical properties of the nanoparticles [13].

b. Bottom Up: This approach depends on the fabrication of nanoparticles from small molecules such as combining atoms, particles and molecules together [14]. Firstly the nanoparticle building blocks are structured to fabricate the final nanoparticle [15]. Methods such as spray pyrolysis, chemical vapor deposition, sol gel processes, laser pyrolysis, and molecular condensation are some examples of bottom up approach [16,17].

4. Limitations in Top Down/Bottom Up Approach

Both of these two approaches have certain limitations such as these methods are energy inefficient, cost ineffectiveness, hazardous chemical use and toxic end products formation [18]. To overcome or minimize these issues, a novel green synthesis biological approach is being adopted in material science and technology [19].

5. Biological Method (Green Synthesis)

In order to reduce the production and accumulation of unwanted/harmful byproducts, green synthesis method is the most suitable environmentally friendly and sustainable method for the synthesis of metallic nanoparticles [20]. Green synthesis of nanoparticles involves the use of biological organism such as fungi, bacteria, plant and algae extracts [21]. Use of plant extract for the synthesis of nanoparticle is a much easier and simple procedure relative to fungi and bacteria mediated synthesis because of availability of effective phytochemicals in plant extracts for bioreduction of metal ion [22]. The resulting synthesized nanoparticles are termed as biogenic metallic nanoparticles [23]. Fundamental

principle of green synthesis is to reduce accumulation of toxic waste, biodegradation of pollutants, and the use of renewable feedstock [24].

6. Biological Organisms for Green Synthesis:

a. Bacteria Mediated: Numerous bacterial species are broadly used for marketable biotechnological applications including bioremediation, bioleaching and genetic engineering [25, 26]. Bacteria possess the potential to reduce metal ions for nanoparticles synthesis such as silver nanoparticle fabricated from bacterial strains *Lactobacillus*, *Escherichia coli*, *Bacillus cereus* etc [27, 28].

b. Fungal Mediated: Fungi is capable of producing uniform sized nanoparticles with well-defined structures efficiently [29]. Variety of fungal intracellular enzymes such as nitrate reductase and protein complexes act as reduction agents for the synthesis of metallic nanoparticles [30]. Unlike bacteria, Fungal mediated synthesis can produce larger sums of nanoparticle [31]. Numerous fungal species are used to synthesize nanoparticles like silver, gold, titanium dioxide and zinc oxide [32, 33].

c. Yeast Mediated: Many studies revealed yeast as a potential producer of metallic nanoparticles such as silver-tolerant *Saccharomyces cerevisiae* is responsible for the biosynthesis of gold and silver nanoparticles [34]

d. Plants Mediated: This biosynthesis method gained increased consideration as compared to other ordinary preparation methods for the synthesis of nanoparticle because it is efficient, simple and cost effective [35]. Plants possess numerous biomolecules such as carbohydrates, enzymes, and coenzymes that act as reduction agents of metal ions [36]. Various plants such as tulsi, aloe vera, alfalfa, Oat, Coriander, lemon and neem etc have been used to manufacture gold and silver nanoparticles [37, 38, 39].

There are other biological organisms such as algae

and viruses e.g. tobacco mosaic virus is reported to be nanoparticle producers as well [40,41]

7. Applications

a. Metallic nanoparticle such as magnetic nanoparticle and semiconductor nanoparticle are employed in biomedical prospects such as in diagnostic, targeting cancer, treatment of disease, anti-microbial activity and tissue engineering etc [42,43].

b. Metallic nanoparticles have better penetration of therapeutic moieties and tracking within the body as compared to ordinary carriers [44].

c. Functionalized metallic nanoparticles are effectively utilized as therapeutics in cancer diagnosis as compared to ordinary chemotherapeutic agents [45].

d. Metallic nanoparticles along with their oxides i.e. Ti, Zn, Ag, Au and Cu are involved in the inhibition of growth of different disease causing viruses, fungi and bacteria [46]. This inhibition is caused by several factors such as the size of nanoparticles, their concentration used as well as their stability [47, 48].

e. Metallic nanoparticles serve as an important gene delivery vehicles for therapeutics purposes [49].

f. Presently silver nanoparticles are used in wound dressings because of their antiseptic and anti-microbial property [50].

g. Metallic nanoparticles can be used in the removal of heavy metals in drinking water and also be used in production of hydrogen fuel elements [51, 52].

8. Conclusion

The modern advancement in the structure and synthesis of metal-based nanoparticles proved that a number of different metallic nanoparticles can be prepared through various production routes now a days. Their preparation is so much important due to their novel and unique chemical, optical, magnetic and electrical properties.

9. References

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