Various synthesis methods to generate silver nanoparticles

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ABSTRACT

The use of nanoparticles is becoming widespread very quickly thus indicating their importance especially in the medical field. With advancements in the technological field, many nanoparticles of different types have been successfully formulated. In the current article, importance & production of silver nanoparticles have been discussed. The synthesis of even a single nanoparticle can be done by various methods. But every method has its limitations, which can be overcome with advancements.

INTRODUCTION

Nanoparticles are such entities that have particle size ranging up to 1-100 nanometers, they show attributes which are of great medical & technological significance[1]. Among them the metal nanoparticles have started being utilized due to their salient properties. Different nano-materials, inclusive of niosomal particles, nanoparticles which are polymeric, nano-emulsions, solid lipid nanoparticles, hybrid lipid polymer nanoparticles, dendrimers & liposomes, are currently used for manifold applications.

A diverse range of nano-materials have been used & their exploitation in multiple disciplines is now becoming frequent with an objective to obtain enhanced upshots, among these the present focus is on the production of silver nanoparticles. Silver nanoparticles have been eminent enough to prove their worth & gain attention due to their undeniable value. To obtain various size & shape of nano-particles, a variety of methods are being employed. Among these methods; the chemical, physical & green methods would be under discussion in the current article.

Silver NPs have been studied upon and enacted upon to produce many formulations in particular for the discipline of biomedical sciences. The utilization of silver NPs progressed over the time therefore it would not be wrong to assume that their importance will also be enhanced as time passes. Nanoparticles are known to be potential entities for appropriate delivery of drugs at cellular level, along

with ample functionality, increased availability, better biocompatibility, promising ability for targeted delivery (e.g. leaving normal tissues but killing tumor cells) and controlled pattern for release of nanoparticle loaded drugs. Due to these afore mentioned potential in nanoparticles, researchers have been supported to conduct research & development techniques at worldwide level. Nanoparticles also have marked their place in diverse range of fields, such as Raman spectroscopy, Anti-bacterial application, information storage, catalysis electronics and lubricating material. Silver nanoparticles which have very fine particle size of uniform distribution are of considerable use, particularly in the discipline of electronics and microelectronics, the reason behind them being used is as they possess potential to conduct thermally and electrically, and they demonstrate a good resistance to oxidation.

Section one in this article would be about the nanoparticles, their uses & significance. Then in the next section, the comparative study of various techniques applied for synthesis of different silver nano-particles. In the third section conclusion would be drawn.

1. Applications regarding silver Nanoparticles

Silver nanoparticle properties possess immense potential because of their diverse attributes which is why they may be used as biosensor material; have capacity of antimicrobial activity, as composite fibers, as cosmetic products, as cryogenic superconducting materials and electronic components, etc. A few of the applications are discussed as follows:

Biomedical applications: Silver nanoparticles have the margin to be used as a part of the formulations for the treatment of burns, coating stainless, dental materials, steel materials, water treatment etc[21].

Antibacterial applications: A supreme application of silver NPs in the discipline of biology is their use as antibacterial agents and to conduct DNA sequencing[20]. Silver has demonstrated a potent toxicity to various microorganisms. It has been in the understanding of scientists that the silver ions can be deadly to bacteria.

Catalytic applications: Lately nano-catalysis has proved to be a vastly progressing field inclusive of the usage of nanoparticles as catalysts. It was noticed that the chemi-luminescence emission from the luminal-H_2O_2 system was improved when the Ag colloid was incorporated[22]. Silver is also an extremely famous catalyst in order to conduct the oxidation of ethylene to ethylene oxide and methanol to formaldehyde. Silver nanoparticles immobilized on silica spheres have been tested for their ability to catalyze the reduction of dyes by sodium borohydride ($NaBH_4$)[22].

Optical applications: The metal nanoparticles are known to show exceptional optical approaches, thus have been used as optical biosensors and chemo-sensors. One of research subject focused on the measurement of biological binding signal between antigen and antibody using the triangular Ag-nanoparticles[23]. It has been made possible to observe the amount of chemical species inside along with

observing the dynamical processes that occur. Optical sensor of zeptomole sensitivity is another possible application using the potential of silver nanoparticles.

Electrochemical applications: Lastly, the electro-chemical properties of silver NPs when incorporated can offer quicker response duration and decreased detection limits[24].

2. Approaches for synthesis of silver NPs

A variety of nano-materials have been used in order to achieve better outcomes, among them the synthesis of silver nanoparticles have been discussed in this article.

2.1 Considerable concentration has been thought about for various methods to synthesize silver nanoparticles with peculiar size and shape.

Physical approaches

During physical processes, metal nanoparticles are known to be formed by evaporation–condensation, which at atmospheric pressure may take place by using a tube furnace. In this method the basic substance is placed centrally at the furnace via which it is transformed into carrier gas. Many materials, such as Ag, Au, PbS and fullerene that are being used to form nanoparticles of varying types that have been lately synthesized using this condensation or evaporation technique[2]. However, the formation of silver NPs using a tube furnace has been found to have plenty of disadvantages, as a tube furnace covers up a lot of area, consumes huge amount of energy for increasing the surrounding temperature, and also quite much time to attain the desired thermal stability. Silver NPs have been formed with laser ablation of metallic materials in excess amounts in solution. One advantage of laser ablation in comparison to various other conventional methods is the lack of chemical reagents in solutions[3-8]. Thus, the pure colloids can be made by this method, which will be advantageous for further applications[7].

Chemical approaches

One of the customary approaches for forming silver nanoparticles is through the chemical reduction with the aid of reducing agents whether they are organic or inorganic & due to the noncomplex technical procedure, reaction conduction and device. Mainly, the various reducing agents like sodium citrate, ascorbate, sodium borohydride ($NaBH_4$), elemental hydrogen, polyol process, Tollens reagent, N, N-dimethylformamide (DMF) and poly (ethylene glycol)-block copolymers are being utilized for silver ions (Ag+) reduction in solutions; aqueous or non-aqueous[9,10].

In order to attain minute sized silver nanoparticles, a preliminary concentration of metal ion is usually not high, but when such circumstances were used to produce silver nanoparticles with strongly

controlled attributes, the industrial scale synthesis of nanoparticles was not found to be feasible. Moreover, it's a good possibility that the silver nanoparticles during the formation might get oxidized. The use of stabilizing agents is considered to be the foremost solution. A number of fatty acids and compounds have been utilized for the making of metal nanoparticles in an aqueous medium.

Tollens method

The Tollens synthesis method is a single step process that can generate silver NPs with a controlled size[11-14]. In the presence of an aldehyde the Ag(NH3)2+ (aq) get oxidized, this is the basic Tollens reaction[15]. In case the Tollens procedure is modified, Ag+ ions are reduced by saccharides in the presence of ammonia, generating varyingly shaped silver NP films having particle size ranging from 50 to 200 nm, Ag hydrosols with particles in the range of 20–50 nm. A stable complex ion $Ag(NH3)^{2+}$ is formed, resulting from ammonia's strong affinity for Ag+, therefore the size of silver NP may be regulated due to the ammonia strength and reductant nature[11].

Green synthesis

Biological method

The physic-chemical methods are used to formulate nanoparticles[16]; but it has a major shortcoming that a lot of the reagents consumed in these processes are potentially dangerous. So it's preferred that a secure & eco-friendly technique is adopted for the synthesis of such NPs. An alternative Green method by using plant-mediated can be due to natural sources. The establishment of experimental methods that are of biological origin for the development of nanoparticles is evolving into a vital discipline of nanotechnology[17, 18]. Silver nanoparticles formed via biological techniques could have many applications for instance they might be used as coatings for solar energy absorption and intercalation material for electrical batteries, as optical receptors, for bio-labeling and as antimicrobials. Silver nanoparticles (Ag-NPs) have been manufactured with aid of ultrasound irradiation in the sodium alginate media. AgNO3 and ultrasound irradiation have been used as silver precursor and physical reducing agent to catalyze the synthesis of Ag-NPs. The presence of Ag-NPs can be indicated by the altering color of the suspensions[19].

CONCLUSION

Precisely stated that various techniques may be employed to generate silver nanoparticles, whereas, each method adopted has its own benefits over the other. The stabilized minute silver nanoparticles possessing a narrow distribution from 2 nm to 15 nm were formulated by chemical reduction. A substantial dispersion of of silver nanoparticles with a variety of ionic liquids through the reduction of silver also exhibited a promising medium. Moreover, the sodium alginate/Ag-NPs have also promised a provision of stable particles and it can be used in a number of applications. This green method so

adopted helps achieve a scaled up production of Ag-NPs. The above mentioned methods emphasize that the silver nanoparticles can be delivered via different & better routes & the applications mentioned propose that their use in the various fields of life is becoming inevitable day by day.

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