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BIOSYNTHESIS OF GOLD AND SILVER NANOPARTICLES FOR ANTIMICROBIAL ACTIVITY: A REVIEW

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ABSTRACT

Nanotechnology is a field that is rapidly growing, making an impact in all spheres of human life. The development of biosynthesis of nanoparticles is evolving into a very important branch of nanotechnology. Green synthesized metallic nanoparticles usage, particularly silver and gold nanoparticles have been increased due to their advantages of high stability, loading capacity and cost effective method. Silver and gold nanoparticles play a vital role in nanotechnology as biomedicine against drug-resistant bacteria. Available published information on silver and gold nanoparticles synthesis, effects of various parameters, characterisation, applications and mechanism for antimicrobial activity are critically discussed in this review.

KEYWORDS

Nanotechnology, Silver, Gold and Nanoparticles.

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INTRODUCTION

Nanotechnology may be outlined as the manipulation of matter through certain processes to make materials with specific properties, which may be employed in specific applications. A nanoparticle is a microscopic particle that has at least one dimension less than a hundred nanometers in size[1]. Materials within the nano dimensions (1-100nm) have outstanding distinction in the properties compared to a similar material in the bulk. These distinction be the physical and structural properties of atoms, molecules and bulk materials of the component because of distinction in physico chemical properties and surface to volume quantitative relation[2]. Owing to the interest and importance of nanoparticles several researchers

have centered on the synthesis of nanoparticles using chemical and physicals ways, however unfortunately they are quite costly and probably dangerous to the surroundings that involve use of harmful and threatening chemicals that are liable for numerous biological risk[3]. A wide selection of biological resources like microorganisms (bacteria, yeast, fungi, algae, and viruses) and plants are often used for nanoparticle synthesis. The major drawback of microbe-mediated nanoparticle synthesis is that the obligatory constraint of antiseptic conditions, which requires trained workers and raises the scaling value. Of these reasons, at the side of the straight forward handiness of plants in nature, make them more preffered biological resources than microbes[1]. The synthesis of nanoparticles using plant extract provides advancement over different ways because it is easy, one step, price effective, surroundings friendly and comparatively reproducible results[3]. There are differing types of nanomaterials. Depending on dimensions they are being classified into 4 types: one dimensional, two dimensional, three dimensional nanostructures. Nanomaterials is a product of inorganic or carbon (fullerenes, nanotubes, etc.) based materials. The latter, embrace metal oxides (iron oxide, cerium oxide, zinc oxide, titanium oxide, etc.) metals (iron, silver, gold, etc.) and quantum dots (cadmium selenide and cadmium sulfide)[4]. The nanoparticles used for all same procedures, the metallic nanoparticles thought-about because the most promising as they contain exceptional antibacterial properties that is of interest for researchers because of growing microbial resistance against metal ions, antibiotics and also the development of resistant strains. Among all the metallic element particles, silver nanoparticles are an arch product as a result of their distinctive properties like chemical stability, sensible conduction, catalytic and most vital antibacterial, antiviral, antifungal additionally to anti-inflammatory properties[5]. Biogenesis of gold nanoparticles exploitation plant extracts have gotten additional widespread because of sturdy antibacterial action of nanoparticles and simple reduction of their salts[3].

DIFFERENT METHODS OF PREPARATION OF METALLIC NANOPARTICLES

Nanoparticles are often synthesized by either top-down or bottom-up approaches. Top-down approach relies on the mechanical ways of size reduction by breaking down the bulk materials bit by bit to nanosized structures. Bottom-up approaches are supported by the assembly of atoms or molecules to molecular structure in nanoscale range. In top-down synthesis, nanoparticles are created by their size reduction from an appropriate beginning material. This reduction in size is also achieved by varied physical and chemical treatments. In top down approaches, there will be imperfectness within the surface of the product and is found that may be a major limitation, as a result of the surface chemistry and therefore the alternative physical properties of nanoparticles primarily rely upon the surface structure. In bottom-up approach, nanoparticles are created of smaller molecules, for e.g., by connecting the atoms, molecules, and smaller structures. During this the nanostructure, building blocks of the nanoparticles are developed initially and so assembled to supply the ultimate particle. Each chemical and biological application of metal nanoparticles rely upon the bottom-up approaches. In bottom-to-top approaches, synthesis of metal nanoparticles is achieved by chemical reduction technique. Throughout this kind of synthesis method, chemicals concerned are harmful in nature and additionally led to non-eco-friendly by-products. Because of these disadvantages of synthesis method these are typically not utilized for the synthesis of metal nanoparticles. Ways usually used for the synthesis of nanoparticles are as follows:

Physical method of nanoparticle synthesis

Using physical approaches, we are able to get nanoparticles with high purity and definite form. However, these processes typically needed extremely refined instruments, chemicals and radiative heating and also high power consumption that result in high operating expense.

Chemical method of nanoparticle synthesis

Another technique for the synthesis of nanoparticle is reduction of metal ions in solution using chemicals. These chemicals are toxic in nature and

are non-biodegradable, that limit the production scale. Together with this, a number of the toxic chemicals may contaminate the surface of nanoparticles and make them unsuitable for many biomedical applications.

Biological method of nanoparticle synthesis

In biogenic synthesis method, the synthesis of nanoparticles is achieved through microorganisms and plants. It is found that microbe-mediated synthesis is not applicable for large scale production, because they need high sterile condition and special maintenance, because of this the utilization of plants for the synthesis of nanoparticles is a lot useful over microorganisms because of the straight forward scale-up method, no extra demand of maintaining of cell culture. Use of plant extract for nanoparticle synthesis together reduces the additional demand of organism isolation and matter preparation that may increase the price competitive quality over nanoparticle synthesis by microorganisms. Plant mediated synthesis may be a one-step method towards synthesis, whereas microorganisms during the cause of time might lose their ability to synthesize nanoparticles because of mutation, therefore, research on plant is increasing speedily[6].

FACTORS AFFECTING THE SYNTHESIS OF METALLIC NANOPARTICLES

Hydrogen ion concentration

The different hydrogen ion concentration results in various sizes and shapes of nanoparticles formation.

Temperature

Temperature is additionally one in all the stimulating factors for the nanoparticle synthesis with completely different size and shapes.

Salt solution

The distinction in morphology is especially because of the percentage/amount of the salt solution within the reaction mixture. The concentration of salt may be altered with the reduction ability and sizes.

Environmental factors

Some environmental factors like physical and chemical parameters controlled metallic crystal structure by exploiting the plants biomass as substrates. Additionally, the reduction time interval (minutes-hours) is one in all the factors to reduce the ions into bulk metal with variant shapes. The optimum time period produces high absorbance peak value to spot the higher concentration NPs within the medium[7].

GREEN SYNTHESIS OF NANOPARTICLES

The physical and chemical synthesis is cost effective, thus green synthesis of nanoparticles arose. The low cost pathways of nanoparticles are synthesized using plants. The most reaction happens is oxidation or reduction in biosynthesized nanoparticles, that is bottom up approach.

Preparation of nanoparticles

There are three major steps for green chemistry

The selection of the solvent medium to synthesize.

The selection of the setting for reducing agent.

The selection of non-toxic materials for stabilization.

Principle of green chemistry

In green chemistry principle the bio-organisms are used and is compatible to synthesize. The bio-organism

Acts as reductant

Eco-friendly

In reaction it is used as capping agent

Chemical synthesis carries some harmful chemicals and result in adverse effects in application of medicines, this is not observed within the synthesis method of nanoparticles as they are biocompatible and eco-friendly for pharmaceutical applications.

Biosynthesis is a better method

Biosynthesis are higher considered over chemical and physical methodology because

High production, low cost, within the reduction it is giant saving, and is higher in business viability while employing biological nanoparticles.

The production of little nanoparticles in giant scale within the biogenesis method where as in physical and chemical methodology the dimensions of the particles is large in large scale process.

It is eco-friendly, clean and non-toxic

For physical ways hot temperature is needed and for chemical methods high pressure is required it is hard to produce this situation[4].

PROPERTIES OF SILVER AND GOLD NANOPARTICLES

Silver nanoparticles

Silver nanoparticles own novel biological, chemical and physical characteristics as compared to their solid silver bulk type. Silver nanoparticles have special chemical and physical properties, like surface increased Raman scattering and optical behavior, electrical conduction, high thermal, chemical stability, non-linear and catalytic activity. These properties of silver nanoparticles obtained in physical science, and for medical application. Silver nanoparticles are ordinarily utilized in the antimicrobial field to treatment microbes like fungi, virus and bacteria.

Gold nanoparticles

The gold nanoparticles properties are wine-red solution. There are completely different sizes of gold nanoparticles begin from one nano-meter to eight micro-meter, and varied shapes, for example, spherical ring, sub-octahedron, polyhedron tetrahedral, decahedral, octahedral and nanorods. The gold nanoparticles are non-toxic particles with giant surface area and may be changed with alternative molecules, and utilized in medical speciality fields. The importance of gold nanoparticles in biochemistry field is because of the compatibility, and optical properties. Nanoparticles are sensible therapeutic agents because of their ease transport within the pathological cell and carrier-loading drug. Gold nanorods are widely utilized in the vivo cell imaging attributable to resonance absorption Plasmon and scatter of light in IR. Additionally, colloidal gold nanoparticles have the terribly tiny size to introduce within the tissues and cells of biological molecules like proteins and deoxyribonucleic acid. Attributable to their electronic properties, gold nanoparticles are normally utilized in associate analytical ways and used as an electrode detector of various samples[8].

APPLICATIONS OF NANOPARTICLES

Silver nanoparticles

Antimicrobial agents

Several industries have started exploiting silver for its use as an antibacterial drug agent, and silver is commonly added to wound dressings, topical creams, antiseptic sprays, and fabrics. Silver nanoparticles conjointly exert their antibacterial drug activity by acting as antibacterial enhances to antibiotics. Thus, silver nanoparticles is employed in the case of development of resistance to standard antibiotics.

Leishmanicidal agent

Leshmaniasis may be an unwellness caused by parasites of the genus Leishmania. Current drugs caused severe toxicity and also the parasites have developed resistance to the out there leishmanicidal agents. Methods to beat these problems include a combined therapy of leishmanicidal agents with silver nanoparticles.

Catalytic agents

Metal particles within the nm size vary exhibit physical properties that are different from both the ion and therefore the bulk material counterparts, as well as raised chemical process activity. Currently, nanocatalyst is employed to get rid of harmful chemicals that are wide applied in several merchandise, together with cosmetics and prescribed drugs.

Wound healing agents

Silver nanoparticles are used as glorious healing wound dressings as a result of accelerate reepithelialization and increase the microorganism clearance from the infected wounds.

Biosensors

The plasmonic properties of silver nanoparticles modify the detection of an outsized proteins that do not seem to be detected by normal biosensors.

Drug delivery

Nanoparticles have benefits like little particle size, high stability, and specific targeting ability through surface functionalisation, therefore, nanoparticles is used as versatile drug delivery systems.

Gold nanoparticles

Gold nanoparticles are extensively utilized in biomedicine owing to their properties like easy detection, high practicality and low toxicity.

Antimicrobial agents

Gold nanoparticles have wonderful antibacterial drug activities. They show germicidal effects on numerous microorganisms. A previous study has shown that gold nanoparticles are often effectively used as a vehicle for antibiotics. The mixture of

gold nanoparticles with another antibacterial drug agent like ciprofloxacin showed synergistic effects, and therefore the antibacterial drug activity of the mixture was more than that of gold nanoparticles alone.

Leishmanicidal agents

Leishmanial parasites multiply in host macrophages. Specific drug delivery to macrophage is so required in combating leishmanial parasite infections. Gold nanoparticles as drug delivery systems for leishmanicidal agents are reported antecedently.

Catalytic agents

Like silver nanoparticles, gold nanoparticles has been additionally developed as catalytic agents for numerous sorts of reactions, together with removal of harmful chemicals.

Diagnostic and imaging agents

Binding of the gold nanoparticles with the analytes alters the chemistry properties of the gold nanoparticles. For example, conduction, oxidation-reduction behavior, and SPR, and thus, forms detectable signals that modify their use as diagnostic agents. Gold nanoparticles are used as imaging agents in different techniques like dark field light scattering, computed tomography (CT), photothermal heterodyne imaging technique, optical coherence tomography (OCT), and Raman spectrometry, thanks to their electronic and optical properties.

Drug delivery

Nanoparticles as well as gold nanoparticles, are used as gene and drug delivery agents due to their capability of high surface loading. The high extent of gold nanoparticles acts as a platform for therapeutic agents and facilitates dense binding of multifunctional moieties like targeting agents and medicines. Gold nanoparticles are often delivered into the cells via active or passive targeting mechanisms[9].

CHARACTERISATION OF GOLD AND SILVER NANOPARTICLES

Characterization of nanoparticles is a very important task to grasp and management over nanoparticles synthesis and applications and may be done exploiting techniques like transmission and scattering microscopy (TEM, SEM), atomic force microscopy (AFM), dynamic light scattering (DLS), powder X-ray diffractometry (XRD), Fourier transform infrared spectroscopy (FTIR), and UV-Vis spectroscopy[10].

MECHANISM FOR ANTIMICROBIAL ACTIVITY

The interaction of nanoparticles with microorganisms starts with adhesion of nanoparticles on the microorganism cell wall and membrane, and it is supported by electrostatic attraction between negatively charged microorganism semi permeable membrane and absolutely or less negatively charged nanoparticles. The membrane structure are evoked by the nanoparticles, and thereby leading to disruption of the membrane porousness and metabolic process functions through membrane depolarization and ultimately disruption of the cell structure and death. As a result of the disruption of the cell structure, the cellular elements as well as enzymes, proteins, DNA, metabolites begin leaking into the surroundings. Therefore, this degeneration of the semi permeable membrane by the nanoparticle attachment is believed to be the primary mechanism of the antimicrobial action. Moreover, nanoparticles are reported to cause irregular pit on the semi permeable membrane, that further facilitate the nanoparticles to enter into the periplasmic area and eventually within the cell. Once the interaction of nanoparticles with microorganism cells, peripheral damages and dense cavities on the cell surface will be discovered by advanced imaging techniques like TEM, SEM, and AFM.

CONCLUSION

The present review focus towards the green chemistry particularly the use of gold and silver nanoparticles. The plant constituents have the capacity to produce the metallic nanoparticles in an environmental friendly manner. This review mainly focus in the gold and silver nanoparticles with it's application in the antimicrobial activity.

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CONFLICT OF INTEREST

We declare that we have no conflict of interest.

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