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PHYTOCONSTITUENTS FOR NANOPARTICLES SYNTHESIS: MINI REVIEW

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ABSTRACT

Green chemistry approach for synthesis of metal nanoparticles has received great response from researchers and many other researchers still contributing in the synthesis process to find cost-effective and eco-friendly methodologies for effective development of metal nanoparticles. Biological methods of metal nanoparticles synthesis are one such method which strongly follows the concept of green chemistry due to involvement of either plant biomass or microorganism. Among the biological methods, plant extract mediated synthesis of metal nanoparticles is considered to be the suitable for pilot scale synthesis with faster rate of reaction over the methods involves the use of microorganisms. plant mediated nanoparticles synthesis have also concerned many researchers to investigate the possible active organic compound present in plant extract which are responsible for reduction of metal ions to metal nanoparticles. Thus this review describe in details about the reported organic compound present in plant extract responsible for metal nanoparticle synthesis.

KEYWORDS: Phytoconstituents, Biosynthesis, Nanoparticles.

INTRODUCTION

Extensive research and development in nanoscale science and technology has derived new pathways to basic and applied research in the sector of materials science and engineering, biotechnology, applied microbiology, quantum dots, and surface-enhanced Raman scattering.[1–4] However, the nanotechnology find great importance in field of mechanics, optics, biomedical sciences, chemical industry, electronics, space industries, drug-gene delivery, energy science, catalysis, optoelectronic devices, andphoto–electrochemical applications.[5–8] The ability to tune the optical absorption/ emission properties of quantum dots (semiconductor nanoparticles) by simple variation in nanoparticle size is predominantly attractive in the facile band-gap engineering of materials[9], and the growth of quantum dot lasers.[10] Nanoparticles are of great interest due to their extremely small size and large surface to volume ratio, which lead to both chemical and physical differences in their properties compared to bulk of the same chemical composition.[11,12]

Nanoparticles exhibit size and shape-dependent properties which are of interest for applications ranging from bio sensing and catalysts to optics, antimicrobial activity, computer transistors, electrometers, chemical sensors, wireless electronic logic and memory schemes. These particles also have many applications in different fields such as medical imaging, nanocomposites, filters, drug delivery, and hyperthermia of tumors.[13–15]

Green Synthesis of Metallic Nanoparticles

Green synthesis of NPs is a cost-effective and eco-friendly technique that does not use toxic chemicals. This technique employs a number of reducing and stabilizing agents like microbes, plants and other natural resources to produce NPs for sustainable in manner.[16] Several studies have reported the production of NPs using plants and microorganisms. The green synthesis methods of NPs are diversified, but organisms or their extracts are simply reacted with a metallic salt and then biological reduction is carried out to convert the metal to NPs. The produced NPs are readily available to use after proper characterization.[17-19] Microbe-mediated synthesis of NPs is a green approach that utilizes bacteria, fungi, viruses and their products for the production of NPs. These microbes provide templates for synthesis and organization of well-defined, structured NPs.[20] In comparison to microbial synthesis as a potential technique, plants can be used in convenient manner for NPs production. The synthesis of NPs can be scaled up easily by using plant extracts. In addition, the plant extracts can reduce metallic ions more quickly than microbes and produce stable metallic NPs.[17] In plants extracts, many compounds like polysaccharides, proteins, amino acids, organic acids and phytochemicals like polyphenols, flavonoids, terpenoids, alkaloids, tannins, and alcoholic substances are present that can reduce and stabilize the NPs.[19,21]

The role and mechanism of phytoconstituents in nanoparticle synthesis

Flavonoids

Flavonoids are water-soluble plant secondary metabolites. Flavonoids comprise major subgroups: anthoxanthins, flavanones, flavanonols, flavans, anthocyanidins and isoflavonoid.

Flavonoids are supposed to be the key bioreducing constituents of aqueous plant extracts. The molecular oxygen scavenging potential of flavonoids is directly related to their electron or hydrogen atom donation ability.[22-23] The hydrogen and electron releasing capability of flavonoids is well exploited nowadays for fabrication of metallic nanoparticles by various researchers.[24-26] Hence, flavonoids contents of plant extracts are now being utilized as an important indicator for preliminary evaluation of unexploited plants for synthesis of metallic nanoparticles.[27] Ahmad *et al*., suggested that free hydrogen liberated during keto-enol conversion of flavonoids (luteolin and rosmarinic acid)are responsible for the reduction of metal ions to corresponding nanoparticles.[28]

Phenolic Acid

Phenolic acids belong to the family of polyphenols. Phenolic acid contains a phenolic ring and an organic carboxylic acid function. Antioxidant activities of these compounds are related to the metal chelating ability of highly nucleophilic aromatic rings ofphenolic acid.[29] Various type of plant phenolic acids namely, gallic acid[30], caffeic acid[31],bellagic acid[32], and protocatechuic acid[33], are reported as bioreducing agents for the fabrication of metallic nanoparticles. Supporting these conclusions, few researchers have directly utilized gallic acid for the reduction of metal ions and metal reducing potential of gallic acid has been proved in literature.[29,34] Edison and Sethuraman, have suggested that synthesis of Ag-NPs takes place due to the formation of an intermediate complex of silver ions with phenolichydroxyl groups of gallic acid, which consequently undergo oxidation to quinone with subsequent reduction of silver ions to AgNPs.[35]

Terpenoids

Terpenoids are a large and diverse class of naturally occurring small molecular weight organic compounds synthesized by plants, which belong to the category of terpenes. Terpenoids are responsible for the aroma, taste and color of various plant species. Shankar *et al*., has reported the ability of hydroxyl functional groups of terpenoids(citronellol and geraniol) present in *P. graveolens* leaf extract for the bioreduction of silver ions.[36] Later, Safaepour*et al*., has also proved the role of geraniol for the synthesis of AgNPs.[37] Similarly, terpenoid contents of *C. zeylanicum*bark extract such as linalool, eugenol and methyl chavicol are also reported for metal reducing potential.[38] Eugenol transforms itself to its anionic form due to proton releasing ability of the hydroxyl group of eugenol. Furthermore, the reducing power of eugenol is significantly improved due to the inductive effect induced by the electron withdrawing methoxy and allyl functional groups present at the para and ortho positions of the hydroxyl group. The two electrons released simultaneously during the reaction are responsible for the reduction of metal ions.

Proteins

Protein mediated bioreduction is complicated due to their complex structure. It is well known that nanoparticles can bind to proteins through their free amino or carboxylate groups.[27] Interaction of silver ions with arginine, cysteine, lysine and methionine residues was also reported earlier.[39] Tan *et al*., have tested the reducing and binding ability of twenty amino acids with metal ions.[40] Bioreducing and capping role of cyclic peptides present in the latex of *J. curcas* has also been proved for synthesis of AgNPs.[41] Recently described the reducing potential of tyrosine for metal ions of silver, through the ionization of the phenolic group in tyrosine. The metal reducing potential of tyrosine was also proved by other researchers.[42-43] Wangoo*et al*., has verified the single step synthesis of metallic nanoparticles by complex formation with glutamic acid.[44] One other amino acid tryptophan isalso reported to have reductive properties by the release of an electron during conversion of the tryptophan residue to a transient tryptophyl radical.[45-46]

Organic Acids

Plant systems are capable to produce a diverse range of secondary metabolites upon exposure to various metals. Various secondary metabolites such as organic acids and alkaloids are reported as bioreducing agents for the fabrication of different metallic nanoparticles. Tamuly*et al*., have stated the metal reducing potential of a plant alkaloid(pedicellamide) isolated from *P. pedicellatum.*[47] Pedicellamide exert metal reducing potential through the release of reactive hydrogen. The role of ascorbic acid of *C. sinensis* peel extract isalso reported as an effective reducing agent for the synthesis of Ag-NPs.[48] Jha*et al*., has reported the metal reducing potential of the different plant species from mesophyte, hydrophyte and xerophyte genera.[49] Tautomerization of benzoquinone derivativeshas been reported to contribute to the metal reducing capability of the *Cyperus sp.* of mesophytegenera. Similarly, in hydrophyte genera, compounds such as protocatecheuic acid, catechol and ascorbic acid of *Hydrilla sp.* have been reported to release reactive hydrogen. This reactive hydrogen contributed to the bioreduction of metallic silver ions. In xerophyte genera, pyruvicand malic acid produced during the redox reaction of glycolytic pathway in *Bryophyllum sp.*leads to the reduction of silver ions. The keto-enol tautomerization of emodin inxerophytes is also known for the reduction of metal ions.[50]

CONCLUSION

The present review describe the plant extract mediated green synthesis of nanoparticles. The nanoparticles fabrication using phytoconstituents presented a databased that could benefit researches on their future work regarding green synthesis of metal nanopaticles. Wide variety of plants traditionally used for nanoparticles synthesis as simple, cost-effective, ecofriendly and rapid technique. However this area is still dormant and more researches are required to explore the potentiality of phytoconstituents present in plants.

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