Journal of
Nano Drug Science

http://jnds.zbmu.ac.ir Review

2018, Volume 1, Issue 1, p. 18-21

Green Synthesis of Nano Silver: Review

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Abstract
The purpose of this study was to review previous studies on bioavailability of silver nanoparticles. In this regard, a comprehensive literature review was performed on papers published during 2004 to 2017. The most related data resources searched for the desired papers included NCBI, Sciencedirect, Springer, Web of Science as well as local databases such as Irandoc, Islamic science citation (ISC), and Magiran. The results of this study demonstrated the synthesis of nanoparticles in different plant extracts and its antimicrobial properties, which have been shown in studies.
Keyword: Biosynthesis, Antibacterial activity, Nano silver

Received: 20 July 2018, Accepted: 27 October 2018, ePublished: 17 December 2018

Introduction

Due to the new properties shown by nanoscale materials in industries, there is now a great deal of interest in the processing and application of such materials. Essentially, properties of the relationship between the surface area and the volume of matter on nanometer scale are significantly different. In other words, the surface and volume properties of matter on the nanometer scale are correlated with each other. Surface molecules can cause high hardness in metals and also make electronic tools and drugs highly efficient. Nanotechnology is one of the most promising areas in nanoscience and nanotechnology in the new era. This technology is emerging in various fields of science, including chemistry, biology, and materials science.

There are many methods for synthesizing nanoparticles. Many techniques are inefficient in terms of energy and material consumption.[1]

In most chemical methods, a chemical reducing agent (such as sodium borohydride) is used to reduce metal ions and stabilizers (e.g., polyvinylpyrrolidone) in order to control particle growth and prevent accumulation. In addition, in these chemical synthesis methods, particle stability is controversial and difficult to produce on a large scale. For this reason, there is a demand for production of nanoparticles through environmentally friendly methods. An alternative production method is the production of nanoparticles using biological techniques. For example, *Pseudomonas stutzeri* and *Plectonema boryamum* (cyanobacter) produce intracellular silver nanoparticles[2] and *Escherichia coli* produce cadmium sulfide nanoparticles.[3]

Another advantage of the biosynthesis of nanoparticles is the lack of using high pressure, energy, temperature, and toxic chemicals.[4]

Various secondary metabolites, enzymes, proteins, or other reducing agents are essential for the production of metal nanoparticles by plants. The bioaccumulation of nanoparticles is based on the presence of enzymes and proteins involved in their preparation. Recovering nanoparticles from plant tissues is boring and expensive and requires enzymes to degrade the cellulosic tissue of the plant.[5]

Therefore, it is easier to use plant extracts in the low process and large scale to produce various metal nanoparticles. In recent years, the use of plant extracts to prepare nanoparticles has been proposed as an easy and suitable alternative for chemical and physical methods. For the first time, the extract of the geranium plant was taken from leaves, stems, and roots to produce extracellular nanoparticles of gold.[6]

Shankar et al. reported a decrease in the gold ion into gold nanoparticles using leaf extract of geranium. They also produced triangular and spherical nanoparticles of gold using lemon extracts.[7] The purpose of this study was to review the previous studies on bioavailability of silver nanoparticles.

Methods

In this research, a comprehensive literature review was conducted on papers published during 2004 to 2017 with a special focus on those articles reporting native green nano silver. For this purpose, the most related data resources including NCBI, Sciencedirect, Springer, Web of Science, and local databases such as Irandoc, ISC, and Magiran were investigated for the desired papers. These papers were selected based on the following keywords:

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Biosynthesis, antibacterial activity, and nano silver

Results

Different studies were found reporting the green synthesis of nano silver.

Discussion

Shirmohammadi et al investigated the antimicrobial activity of nanoparticles synthesized in Savory (*Satureja hortensis* L.) extract on *Bacillus cereus* isolated from the soil. The results showed that the size of the silver nanoparticles was 17.58 nm. The maximum inhibitory concentration was 25 ppm and the minimum amount of which was 12.5, in that 2 strains were inhibited.[8]

In a study by Miri et al, synthesizing nanoparticles in the *Salvadora persica* plant, the minimum inhibitory concentration against *E. coli* was 200 µg/mL, while no effect was observed on *Staphylococcus aureus.*[9]

In a study by Taghavizadeh Yazdi, silver nanoparticles (Ag-NPs) were synthesized through a facile and "green" method, which uses the aqueous shoots extract of *Rheum turkestanicum* at room temperature. The formation of Ag-NPs at 1.0 mM concentration of silver nitrate resulted in nanoparticles with spherical shapes and a mean diameter of 26 nm. In addition, the biosynthesized Ag-NPs were found to illustrate stronger antibacterial activities against human pathogenic bacteria.[10]

Many plants have also been utilized to produce colloidal Ag-NPs including *Ziziphora tenuior*,[11] *Althaea officinalis*,[12] *Tecomella undulate*,[13] *Pulicaria gnaphalodes*,[14] *Solanum indicum* L.,[15] *Brassica oleracea* L.,[16] *Quercus brantii*,[17] *Ceropegia thwaitesii*,[18] *Lavandula 9 intermedia*,[19] and *Withania somnifera*.[20]

The results of the study by Bokaeian et al, synthesizing nanoparticles in the *Sesamum indicum* extract, showed that synthetic nanoparticles that inhibit *E. coli* are multi-drug resistant.[21] Similarly, Amini et al synthesized Ag-NPs in the *Avena sativa* L. extract.[22]

Many studies have so far produced nanoparticles from microorganisms such as *Aspergillus flavius*,[23] *Aspergillus niger*,[24] *E. coli* (25), and *Bacillus subtilis*.[26]

In a study by Awwad et al, synthesizing Ag-NPs in the carob leaf extract (*Ceratonia silique*) and investigating the antimicrobial activity on *E. coli*, it was revealed that the inhibition zone diameter was 8-12 mm in different concentrations.[27]

Helianthus annuus, Basella alba, Oryza sativa, Saccharum officinarum, Sorghum bicolor, and *Zea mays*,[28] pine, persimmon, ginkgo, magnolia, and platanus leaves[29]; *Jatropha curcas* seeds,[30] Acalypha indica leaf[31]; banana peel[32]; *Chenopodium album* leaf[33]; *Rosa rugosa*[34]; *Trianthema decandra* roots[35]; *Ocimum sanctum* stems and roots[36]; *Sesuvium portulacastrum* leaves[37]; *Murraya koenigii* (curry) leaf,[38] *Macrotyloma uniflorum* seeds,[39] *Ocimum sanctum* (Tulsi) leaf,[40] *Garcinia mangostana* (mangosteen) leaf[41]; *Stevia rebaudiana* leaves[42]; *Nicotiana tobaccum* leaf,[43] *Ocimum tenuiflorum, Solanum trilobatum, Syzygium cumini, Centella asiatica,* and *Citrus sinensis* leaves[44]; *Arbutus unedo* leaf,[45] *Ficus benghalensis* leaf,[46] mulberry leaves[47] and *Olea europaea* leaves.[48]

In another study by Kavoosi and Yaghoobi who studied the synthesis of nanoparticles using European marjoram extract and its antimicrobial effects, the results showed that the average diameter was about 70-30 nm. Ag-NPs had antimicrobial activity against Gram-positive and Gram-negative bacteria. It seems that the green synthesis of nanoparticles using plant extracts can help increase their antibacterial properties.[49]

Gardea-Torresdey et al were the first to report the production of Ag-NPs by plants.[50]

Chenopodium album plants - *Camellia sinensis*, and *Rhus coriaria* (Sumac) also recovered silver ions in sizes below 50 nm.[51-53]

The Ag-NPs of *Garlic* and *Pinus*, with sizes of 10-40 and 20-20 nm, exhibited strong antimicrobial properties against some of the bacteria.[54,55]

In the same vein, Etemadi et al in their study, synthesized Ag-NPs in green tea and found that the average diameter of the nanoparticles was 18.23 ± 14.52 nm and that they were an inhibitor of *E. coli* and *S. aureus*.[56]

Moreover, Khalili et al. also synthesized nanoparticles of 10 to 30 nm in diameter using *Artemisia annua* extract.[57]

In their study on synthesizing nanoparticles in the Eucalyptus extract, Rashed Zadeh et al. observed that the size of the nanoparticles was between 30 and 70 nm.[58]

Similarly, Omrani et al, synthesized nanoparticles in licorice and mint extract and found that the average size of nanoparticles was 55 nm. The minimum inhibitory concentration for the biosynthesized nanoparticles with licorice extract versus *S. mutans*, *Actinomyces viscosus*, and *Lactobacillus rhamnosus* were 1.56-6.25 and 5 µg/mL, respectively. Besides, the minimum inhibitory concentration (MIC) for nanoparticles in the mint extract against these bacteria were 12.5-12.5 and 200 µg/mL.[59]

Conclusion???

Conflict of Interest

None.

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