International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 09 Issue 11 ǁ 2021 ǁ PP. 12-16

A Short Review on Silver Nanoparticles: Synthesis and Properties

Lallianmawii and N. Mohondas Singh[1]
Department of Chemistry, Mizoram University, Aizawl-796004, Mizoram (India)
[1]Corresponding author E-mail: nmdas08@rediffmail.com

Abstract
Silver has been perceived as a secure inorganic antibacterial and antifungal agent which is also harmless and safe substance for centuries. Nanotechnology is capturing tremendous attention in the modern world due to its potential capability of regulating and modulating the metals into nanosized. The silver nanoparticles play a crucial role in the fields of medicinal nanotechnology and nanoparticles. They possessed unique chemical, biological, and physical properties and their size-dependent properties make their materials superior as compared to other nano compounds. Towards various pathogenic microbe silver nanoparticles are having antimicrobial activity. Since immemorial it is used for wound treatments, bacterial infections, it acts as an important antimicrobial agent.
Keywords: *Nanoparticles, Silver, Antimicrobial agents, Nanoparticles, Nanotechnology.*

Date of Submission: 18-10-2021 Date of acceptance: 02-11-2021

I. Introduction

Nanotechnology is a vast field in the area in field of researchers and the most interesting scientific area of inquiry, and one of the rapid-expanding areas in the world of science that made it easier in the scope of investigating and regulating different cell levels. The perception of Nanotechnology appeared in the 9th century Richard Feynman postulated the approach of small particles and started to introduce Nanoparticles of small size towards many fields of biology, electronics, optical imaging, information technology, etc. The noble metal nanoparticles have been known for more than 2,000 years. Nature has chosen Nanoparticles from different particles because of their tiny size they are easier to handle and earn attention due to their low cost-effective, environmentally friendly, and vast scale production processes[3]. They are unique due to their reduced size of Nanoparticles and have an important influence that the nano-size increased surface to volume ratio on their different unique properties. From the outburst of divergent disorder and diseases caused by pathogenic which is virus, fungi, and other bacteria, most researchers, and scientists are inquiring for more advanced antibacterial agents which are more improved. Novel application, applied frontiers, and growth physical of Nanomaterials and Nanoparticles are rising promptly in different fields including the manufacture of nanomaterials and exploration of their exotic physicochemical as well as their optoelectronic properties. Nanoparticles show brand-new and upgrade properties in size, morphology, and distribution of particles, etc. Different chemical, as well as physical methods, has been used for the synthesis. Due to the presence of many tiny particles, they promote miniaturization so the nanoparticles can be closely packed together and can be used for nanoelectronics. It may be useful for the vitro and in-vitro medical research and application.

Since antiquity, the bacterial effect of silver salts has been observed and much research has been taken. Nanoparticles also inhibit the growth of pathogens having an effective against both the gram negative and the positive bacteria, AgNP's has a crucial antimicrobial activity through electrostatic appeal between the two classified gram-positive bacteria and gram-negative bacteria. Thick layers made up the gram(positive) bacteria and gram(negative) bacteria are of thin layers[1]. From the morphological and structural alteration of certain bacteria found in nanoparticles, the demand for the mechanism of silver nanoparticles can be suggested. Silver is present in an ionized form to have antimicrobial properties which help to prevent various micro-organisms. Due to the antibacterial property which kills bacteria or inhibits them, they are used to control denture stomatitis, wound dressings, mental illness, and catheters. The anti-microbial activity has also shown a hostile effect in shampoo formulation. Shampoo that contains AgNP's improves the antimicrobial activity. From different plants like neem leaves, citrus lemon, curry leaf silver nanoparticles can be synthesized. Nanoparticles and the silver nanoparticles are mostly appealing to the researchers because they are safe, harmless to the human body. Nowadays, the necessity to spread non-toxic, eco-friendly, energy-saving approaches for the biosynthesis of nanoparticles has emerged in the world of modern nanoscience and nanotechnology[7]. Even though Physical and Chemical synthesis of nanoparticles are successful they are having some limitations such as the rate of the

cost of production is very costly, they reveal various harmful and dangerous by-products that affect human health and the environment, the duration for the production of silver nanoparticles taking a huge amount of time and purification of the nanomaterials is tough. In this regard, green methods of synthesizing nanoparticles have drawn attention since they are of low cost, environment friendly, and do not produce perilous substances that are harmful to human health and the atmosphere. Climate change and global warming have convinced the globe to minimize the perilous and poisonous waster particles the production of green and eco-friendly nanoparticles has elevated the field of science and industry. Biological methods produce silver nanoparticles without the involvement of the harmful chemical substance, toxic particles. Use of biological organisms that are from mother nature that uses aqueous or alcoholic extracts from fresh fruits or different plants and microorganisms such as bacteria, algae, fungi. They are spontaneous, eco-friendly, and non-toxic which are not harmful to mother nature. Due to this reason, they have created commercial importance due to the herbal nature, enzymatic reactions, and photochemical characteristics. The green (biological) production of nanoparticles is used in the field of pharmaceuticals, cosmetics, biomedical and environmental use. Mother nature has contributed to the development of a freshly unexplored area of biosynthesis of nanomaterials.

II. The synthesis of silver nanoparticles

The physical, biological, chemical synthesis of the nano compounds are divergent from each other. Although the chemical process requires a transient period for the synthesis of nanoparticles, they are poisonous, harmful, injurious to the environment. Due to the lethal effect caused by the chemical synthesis of nanoparticles, a great demand for the synthesis of nanoparticles which is non-toxic, non-flammable for the environment guides the developing interest in biological approaches that are eco-friendly in nature. Then there is a great demand for "Green technology" using plants, microorganisms[1]. Since plant extract is raw and present in our mother nature it reduces the cost of microorganism isolation, they are free from harmful chemicals, as well as their agents are natural that come from the earth.

2.1 Biosynthesis of Silver Nanoparticles

Even though the synthesis of nanoparticles in chemical and physical processes are successful they are having some limitations such as the rate of the cost of production is very costly, they reveal various harmful and dangerous by-products that affect human health and the environment, the duration for the production of silver nanoparticles taking a huge amount of time and purification of the nanomaterials is tough. In this regard, green methods of synthesizing nanoparticles have drawn attention since they are of low cost, environment friendly, and do not produce perilous substances that are harmful to human health and the atmosphere. Climate change and global warming have convinced the globe to minimize the perilous and poisonous waster particles this green synthesis of nanoparticles has elevated the field of science and industry[1]. Biological methods can produce silver nanoparticles without the use of any harmful chemical substance, toxic particles. Use of biological organisms that are from mother nature that uses aqueous or alcoholic extracts from fresh fruits or different plants and microorganisms such as bacteria, algae, fungi. They are spontaneous, eco-friendly, and non-toxic which are not harmful to mother nature. Due to this reason, they have created commercial importance due to the herbal nature, enzymatic reactions, and photochemical characteristics. Various investigations have been done on the synthesis of nanoparticles from a biological system. Biological nanoparticles are used in the field of pharmaceuticals, cosmetics, biomedical and environmental use. Mother nature has contributed to the development of a freshly unexplored area of biosynthesis of nanomaterials.

2.2 Synthesis of Silver Nanoparticles by microorganisms (bacteria, fungi, actinomycetes, plants)

In microbes the silver nanoparticles attach to the cell walls, disturbing the cellular respiration and permeability of the cell wall causing cellular damage by interlinking with compounds like phosphorus, sulfur-contained compounds such as protein, their DNA present in the cell. Microorganisms like bacteria, algae, fungi yeast that produced inorganic materials through the biological processes either taking place outside the cells or taking place inside the cells made the nanoparticles more biocompatible[6].

Bacteria: Silver and Gold can synthesize nanoparticles due to their distinctive properties but silver is commonly used rather than gold. One of the most accepted mechanisms for the synthesis of silver nanoparticles using bacteria is Nitrate reductase. It is a cycle in which the enzyme converts nitrate into nitrite with the presence of NADPH (nicotinamide adenine dinucleotide phosphate) causing the silver ion to be reduced to silver. In bacteria synthesis Microwave reduction is used to provide heat and it prevents the nanoparticles from aggregating. Nitrate-reductase has to be present to obtain silver. UV emission can enhance the production of silver nanocompounds, after the production of silver nanoparticles the bacteria grows continuously. Due to the resistance to the metal (gold or silver) microorganisms like bacteria, algae, fungi can survive the concentration of metal ions. Bacteria can also cultivate at low concentration and high concentration, it can persuade toxicity. In the presence of bio-reduction, the enzymes of bacteria play an important role, electron transfer also takes place in the process of reduction. Inorganic materials are produced mainly by bacteria (intra or extracellular)[4].

Due to biocidal properties, silver is acknowledged some of the bacteria can assemble silver on their cell wall up to 25% of their biomass due to this bacterium are important for industrial use. Based on the type of broth used during the period of incubation of bacteria (extracellular or intracellular) it can be promoted. This kind of opportunity made bacteria having ductile, eco-friendly, and can be used over a large production scale.

Fungi: As compared to bacteria they can produce a large amount of enzyme and lead to high-yielding nanoparticles. On solid fermentation, fungi can be easily cultured. During the culture of fungi, they can grow on the surface. The reduction of fungi is done by the enzyme present in it. The natural enzyme presents in fungi like naphthoquinone and anthraquinone helps in the reduction of silver ions. Nanoparticle production is a little slow as compared to plants. They can produce bacteria and antibodies which are known as secondary metabolites. A compared to bacteria they are much easier to handle and they secrete a large amount of protein and enzymes. The simplicity and eco-friendliness of fungi lead to the most feasible microorganism. $AgNO_3$ is exposed with fungi and reduction starts taking place. After reduction, enzymes attached to the cell wall reduced the silver ions. Fungi secrete a very large number of proteins that increase the biosynthetic approach. For developing nanomaterials fungi can be vastly used[5].

Plants: It is the most acceptable that is safe, non-toxic to the environment for the prediction of silver nanoparticles. It is preferable over the microorganism processes. They are easily available and easier to handle. Cell culture is introduced in plants that contain different molecules as capping and reducing agents that formed shape nanoparticles. The reduction of plants is due to the process of phytochemical the main compounds which affect reduction includes terpenoids, phenol, protein, enzyme, alcohol, amino acids, flavones, etc. Agglomeration is prevented by phenols and flavonoids that have unique properties. Leave, bark, root, stem has been used for the production of nanoparticles. Nature plants contain biomolecules that act as a capping agents. Therefore, plants are the most reliable for the producing of silver nanoparticles which is safe, stable, and safe for the environment.

III. Properties of Silver Nanoparticles

Nanoparticles have atoms of high specific surface area in the fields of nanotechnology. The property of nanomaterials that differentiate from those of bulk material. The antimicrobial and antifungal properties which inhibit the growth of microorganism, Nanoparticles has dominant properties. Because of its unique properties, it is serviceable on health issues, in the treatment of cancer, and for another purpose. Most nanoparticles are depended upon their shape and size. The higher the surface area of nanoparticles the smaller the size is. There are vast applications of Nanoparticles in different fields such as biomedical science, industries, drug-gene delivery, etc. Nanotechnology is also used in applied science and environmental fields in the fields of water treatment, solar energy, etc. Due to their unique properties, plasmonic nanoparticles of silver along with gold are some of the most commonly used nanoparticles. They are metallic nanoparticles. Silver has low toxicity and good compatibility as compared to other nanoparticles. Silver present in nanoparticles can kill microbes and it also possessed electrostatic attraction and can stick to the cell wall. It is enormously used in many different applications for cleaning swimming pools and purifying drinking water because the water source may be polluted due to different chemicals present in them. Some applications are mentioned below: they can be used for food and household packaging, for cosmetic and medical purposes, water purifying. Silver is vigorous than gold and it is strong and ductile. It also has divergent oxidation states mainly Ag^{3+},$Ag^{(0)}$, Ag^{2+}. To enhance the particle size of the material and improve their biocompatibility the particles are reduced from their size, to improve the looks of the particle. Towards bacterial strain and different microorganisms (in medical and industry) Silver has an inhibitory effect that prevents the growth of microorganisms and bacteria. It also has particular applications in the field of dermatology including skin ointments, oil, cream because it contains silver which can prevent infection to open wounds and skin burns. It has also an important role in the field of optometry $AgNO_3$ eye drops are used to prevent gonococcal ophthalmia neonatorum in newborns which are used since immemorial. The surgeon also used Silver Sulfadiazine (AgSd) cream as a topical treatment to heal open wounds, it is also used as disinfectants and antiseptics. The combination of silver and silver nanoparticles can change the entire polypeptide chain of protein of 3-D structure. Agglomeration of particles can be prevented in a liquid environment[2]. From electron spin resonance the free radical of silver on microorganisms can be investigated. Silver present in nanoparticles hurts the growth inhibitors in the various medical and anti-fungal control systems. For the stabilization of silver nanoparticles, various methods have been applied. Silver which is soluble in water can be used for the treatment of Mental illness, epilepsy, nicotine addiction, gastroenteritis, infectious disease including syphilis, and gonorrhea. It has a fascinating property and is of low cost and it is an abundant natural resource. Among certain noble metallic nanoparticles, silver nanoparticles (AgNP's) are enormously studied due to their Nontoxic (non-poisonous), Antifungal (prevent the growth of fungi), Antimicrobial (prevent the growth of microorganisms). It captivated worldwide research interest due to the distinctive physical-chemical property that makes them suitable for their countless potential applications like catalysts, sensors, biosensors, and antimicrobial agents. The superiority of nanoparticles is due to their shape and composition, size of the particles. It also depends upon the crystallinity and structure of silver nanoparticles.

It has different shapes of octahedral, rod, triangular or round shape. The uniqueness of their properties enables the different shapes of nanoparticles in nanomedicine, biosensing, biomedical engineering, etc.

There is certain scrutiny for silver nanoparticles which includes reduction of chemicals using reagents of organic and inorganic compounds, electrochemical techniques, physicochemical reductions, and radiolysis. It is one of the most captivating inquiries in the modern world so researchers and scientists also come up with an effort to produce particles that are eco-friendly to our nature. Green chemistry has an advantage over conventional methods, they are much cheaper and of low cost. Metallic silver cannot be dissolved in water while $AgNO_3$ and the present silver chloride are water-soluble. It has a fascinating property and is of low cost and it is an abundant natural resource. Among certain noble metallic nanoparticles, silver nanoparticles (AgNP's) are enormously studied due to their Nontoxic (non-poisonous), Antifungal (prevent the growth of fungi), Antimicrobial (prevent the growth of microorganisms). It captivated worldwide research interest due to the distinctive physical-chemical property that makes them suitable for their countless potential applications like catalysts, sensors, biosensors, and antimicrobial agents. The superiority of nanoparticles is due to their shape and composition, size of the particles. It also depends upon the crystallinity and structure of silver nanoparticles. It has different shapes of octahedral, rod, triangular or round shape. The uniqueness of their properties enables the different shapes of nanoparticles in nanomedicine, biosensing, biomedical engineering, etc. They are spontaneous, eco-friendly, and non-toxic which are not harmful to mother nature[1]. Due to this reason, they have created commercial importance due to the herbal nature, enzymatic reactions, and photochemical characteristics. Various investigations have been done on the synthesis of nanoparticles from a biological system. Biological nanoparticles are used in the field of pharmaceuticals, cosmetics, biomedical and environmental use. Mother nature has contributed to the development of a freshly unexplored area of biosynthesis of nanomaterials. Bacteria, algae, fungi are environmentally friendly materials, it is of low cost and affordable which is produced by nature can be used for the production of nanoparticles. The main perception of biogenic (the green chemistry) employs the biological entities in which production of silver nanoparticles are mainly the utilization of microorganisms and plant extract which is environment friendly, an eco-friendly agent which is not harmful to the environment.

3.1 Toxicity of silver nanoparticles:

Although the distinctive features of nanoparticles make an outstanding impact on our environment. Concerning the World Health Organization (WHO 2002), the toxicity in silver nanoparticles releases free silver ions Ag+ the concentrations are low to lead to harmful effects. There are some observations and revelations that show silver nanoparticles are harmful to our environment, because of the free silver ions released in the water phase from industrial and commercial waste. Metallic silver constitutes a minimal health risk, while silver compounds can produce adverse effects. The Nanoparticles can be attached to dissimilar tissues and due to this attachment, it can lead to harmful effects such as inflammation on mitochondria (the powerhouse of the cells), adhesive interactions. Shape and size are crucial for determining the toxicity of nanoparticles. It can cause minimal health problems and it can lead to harmful effects. Toxicity in various cells can be known by the surface charge of the silver nanocompounds and can affect the environment. The enlargement of nanotechnology and trading products has an alarming effect on the research potentiality on economic growth and human health. The waste or degradation product can be released into the environment[6]. The widely use of Nanosilver and Nanoparticles in industry and trading centers can cause wastewater effluent. The wastewater coming from industries can be polluted by chemicals that are elaborated for the synthesis and production of nanoparticles. It can also affect the aquatic environment groundwater but it is not confirmed that the toxicity comes from silver or particles the mechanism is not clearly understood. If it is present in bulk form, it is very harmful to the aqueous environment. Silver also affects soil that plays a crucial part in the mechanism of nitrogen fixation. DNA and proteins of sulfur and phosphorus compounds can be destroyed by silver ions and nanoparticles. The release of Ag^+ ions is a vital role in the destructivity of silver nanoparticles because it can release toxic chemicals that can affect health and the environment. Since the exact mechanism of Nanosilver is not yet confirmed but there are 3 probabilities:

1. It may be produced directly by silver (Ag+) that is linked with the particles.
2. Nanoparticles have a unique mechanism that may be appeared at the nanoscale.
3. Due to the high concentration of (Ag+) silver level up the exposure above the indicated point.

The effect on the human body: Through the ingestion of the human body, silver can enter through it and it can cause various infections. From the pores present in our body (lungs, mucous membranes, respiratory tract) silver can also enter through it. From the wall of the alveolus which is present inside human beings, silver can be absorbed in it. It can also cause a severe effect in animals, it can also affect the male reproductive parts, studies suggested that silver nanocompounds cross the blood fencing and the silver is deposited in the male testis. A large concentration of Ag is also detected in nasal cavities mainly in lungs lymph nodes. Silver is also found in the blood, spleen, heart, and human brain[5]. The release of free silver ions can affect human health and mother nature. Some observations revealed that it can cause:

a. Argyria or Argyrosis: Long-period use of silver salts ($AgNO_3$) can infuse silver under human skin. When direct contact with silver particles and silver holding particles can lead to Argyria or Argyrosis. A tiny amount of silver particles can enter the body through pores or needle penetration into human skin. Eyes and our hands may be the area that can easily be infected. People that work in silver mining, jewelry making, metal manufacturing can be easily infected because their workplace includes silver and it cannot soak up to our skin and it causes discoloration to the skin.

b. It can affect the exchange in blood cells, it may produce toxicity to the liver kidney, eye, skin, and human intestine. However, there are only a few cases that conducted the toxicity of silver nanoparticles. The human dietary intake of silver is 90ug/day.

c. Silver nanoparticles with a size of less than 10nm were able to enter cell lungs and disrupt them.

d. Silver nanoparticles have a bad influence on soil communities it shows potential harmful effects leading to soil disruption.

e. Silver nanoparticles can link with the cell membrane and can produce highly toxic radicals and affect mitochondria.

IV. Conclusions:

The silver nanoparticle is one of the most crucial and captivating particles in the field of nanotechnology with its unique physical and chemical properties that can inhibit the growth of micro-organisms and bacteria which can affect human health and growth. Since immemorial it has been used as metallic silver, it has vast properties and applications on electrical and thermal conductivity. It belongs to the transition metals from the periodic table, it is also used to make human needs like jewelry, ornaments, coins, utensils, etc. The use of nanoparticles is vast in our day-to-day life. It is dissolved in a liquid environment. Due to their special feature scientist and researchers try to produce the easiest and effective ways of antimicrobial reagents which is eco-friendly to our environment from silver particles. There are vast applications of Nanoparticles in different fields of biomedical science, Nanotechnology is also used in applied science and environmental fields in the fields of water treatment, solar energy, etc. Silver nanoparticles are used to slow down the growth of bacteria, algae, fungi, and other microorganisms and it has a productive effect on positive and negative gram bacteria[4]. In order to have an anti-microbial property, it has to be present in an ionized form. Because of their good flexibility, it gained attention and has a growing interest among scientists and researchers.

References:

[1]. Haqq S, Chattree A. M. I. T. (2018) "A review: A green approach for the synthesis of silver nanoparticles and its antibacterial applications", *Asian J. Pharm. Clin. Res*, *11*, 74-78.

[2]. Lara H. H, Garza-Treviño E. N, Ixtepan-Turrent L, Singh D. K. (2011). "Silver nanoparticles are broad-spectrum bactericidal and virucidal compounds" *Journal of nanobiotechnology*, *9*(1), 1-8.

[3]. Moazeni M, Shahverdi A. R, Nabili M, Noorbakhsh F, Rezaie S. (2014)" Green synthesis of silver nanoparticles: The reasons for and against Aspergillus parasiticus" *Nanomedicine Journal*, *1*(4), 267-275.

[4]. Morones J. R, Elechiguerra J. L, Camacho A, Holt, K, Kouri J. B, Ramírez J. T, Yacaman, M. J. (2005) "The bactericidal effect of silver nanoparticles." *Nanotechnology*, *16*(10), 2346.

[5]. Panyala N. R, Peña-Méndez E. M, Havel J. (2008) "Silver or silver nanoparticles: a hazardous threat to the environment and human health" *Journal of applied biomedicine*, *6*(3).

[6]. Rai, M., Yadav, A., & Gade, A. (2009). Silver nanoparticles as a new generation of antimicrobials. *Biotechnology advances*, *27*(1), 76-83.

[7]. Zhang X. F, Liu Z. G, Shen W, Gurunathan S, (2016) "Silver nanoparticles: synthesis, characterization, properties, applications, and therapeutic approaches", *International journal of molecular sciences*, *17*(9), 1534.