ISSN 2349-7203

IJPPR

INTERNATIONAL JOURNAL OF PHARMACY & PHARMACEUTICAL RESEARCH

An official Publication of Human Journals

Human Journals

Review Article

August 2020 Vol.:19, Issue:1

A Review on Pharmacological Applications of Silver Nanoparticles

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Submission:	24 July 2020
Accepted:	30 July 2020
Published:	30 August 2020

HUMAN JOURNALS

www.ijppr.humanjournals.com

Keywords: Green synthesis, Silver Nanoparticles (AgNPs), Characterization, Antimicrobial activity, Cytotoxic potential.

ABSTRACT

Green synthesis of nanoparticles is cost effective, easily available, eco-friendly, non-toxic, large scale production and act as reducing and capping agent in compared to the chemical method which is a very costly as well as it emits hazardous by-product which can have some deleterious effect on the environment. The biological synthesis of nanoparticle is a challenging concept which is very well known as green synthesis. Biological synthesis utilizes naturally occupying reducing agent such as plant extract, microorganism, enzyme, polysaccharide which are simple and viable which is the alternative to the complex and toxic chemical processes. Silver nanoparticles play a profound role in the field of biology and medicines due to their attractive physicochemical properties. Silver have long been known to have strong inhibitory and bactericidal effects, as well as a broad spectrum of antimicrobial activities which have been used for centuries to prevent and treat various diseases most notably infections. Biologically synthesized silver nanoparticles are known to have antioxidant and antimicrobial properties. Numerous researches have been done on the synthesis of nanoparticles from biological system of for their application in the field of biomedical and pharmaceutical field are briefly discussed in the present review.

INTRODUCTION

Nanobiotechnology is an amalgamation of the researches made in nanotechnology and biology. The specialty of this branch is the study of biological phenomenon at nanosized level. Nano is the Greek word which means "Dwarf", but nano is infinitely smaller than a dwarf. It is one billionth of a meter or 10-9m. Nanobiotechnology is a blend of nanotechnology and biotechnology comprises of nanoparticle synthesis using live organisms. Nano-pathogenic microorganisms, plants and different bio-excretory have found to be advantageous being non-carcinogenic, non-pathogenic and biocompatible during both synthesis and application. It includes methods of synthesis, characterization, pharmacological screening and the other possible applications of nanoparticles [1].

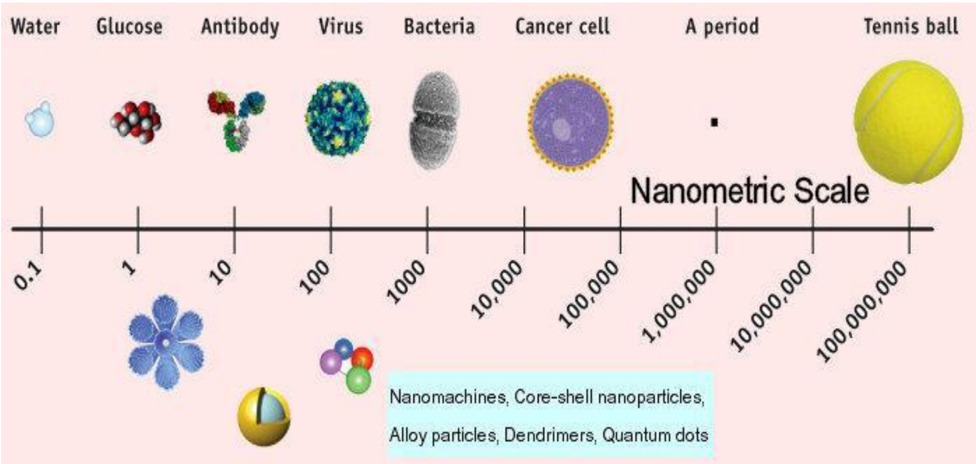

Figure No. 1: Nanometric scale

Biosynthesis of Nanoparticles

The green synthesis of silver nanoparticle are mainly three steps are considered: selection of solvent medium, selection of biological source related reducing agent, selection of nontoxic stabilizing agents. Silver nanoparticles have found tremendous applications in the areas of catalysis, optoelectronics, detection and diagnostic, antimicrobials and therapeutics [2]. Although chemical & physical methods are very successful to produce well defined nanoparticles, they have certain limitations such as increase cost of production, release of hazardous by-products, long time for synthesis and difficulty in purification. Use of biological organisms such as microorganism, plant extracts and biomass could be a best alternative method of physical and chemical method for synthesis of nanoparticles because the biological or green synthesis route is very spontaneous, economic, environmentally friendly and non-toxic [3].

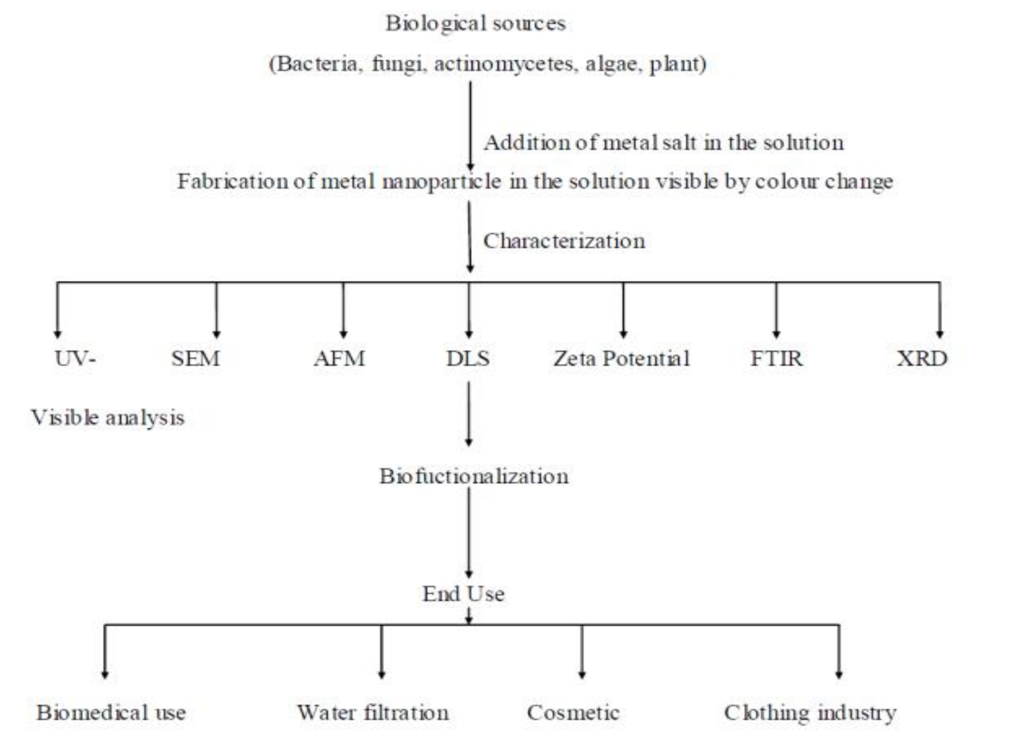

Figure No. 2: General procedure for Synthesis of nanoparticles and its applications

SILVER NANOPARTICLES

Silver nanoparticles have attracted and demandable research of interest in the field of nanotechnology, due to its distinct properties such as good conductivity, chemically stable, catalytic activity, surface enhanced Raman scattering and antimicrobial activity. Silver is widely used as catalyst for the oxidation of methanol to formaldehyde and ethylene oxide. Due to colloidal nature, it uses as substrate for surface enhanced spectroscopy, as it partly requires electrical conducting surface [4].

Synthesis of Silver Nanoparticles

There is still need for economic, commercially doable in addition environment friendly synthesis route to synthesize silver nanoparticles. Several approaches are out there for the synthesis of silver nanoparticles for example, chemical reduction, photochemical, reverse micelles, thermal decomposition, radiation assisted, electrochemical, and recently via green chemistry method. Plants like biological sources (bacteria, fungus, algae, yeast) are used for synthesis of silver nanoparticle by using chemical silver nitrate [5]. The green synthesis of silver nanoparticle are mainly three steps are considered: selection of solvent medium, selection of biological source related reducing agent, selection of nontoxic stabilizing agents. Silver nanoparticles have found tremendous applications in the areas of catalysis, optoelectronics, detection and diagnostic, antimicrobials and therapeutics [6].

Characterization of Silver Nanoparticles

Electron microscopy is the most basic and widely used technique giving a direct measurement of particle size, size distribution and morphology by image analysis. Sometimes, transmission electron microscopes are equipped with energy dispersive X-ray spectroscopy devices (EDS), which acquire the elemental analysis of nanoparticles. X-ray absorption spectroscopy techniques, such as X-ray absorption fine structure, are specifically designed for determining three dimensional structures. Furthermore, atomic force microscopy (AFM) is employed simultaneously to measure the particle surface morphology in three dimensions with high resolution [7]. Other techniques widely used to determine the nanoparticles phase and the size is X-ray powder diffraction (XRD), and small-angle X-ray scattering (SAXS). These techniques apply the Scherrer method to calculate the particle size and the inter-planar spacing d, to obtain lattice parameters of nanoparticles. Using these analytical techniques is necessary part of bio-adsorbed novel metal nanoparticle biosynthesis and gives very essential information on the size, shape, texture, dispersity, bio adsorption, biocompatibility and further direction for their usefulness [8].

Antibacterial activity of Silver Nanoparticles

Bacteria, one celled, prokaryote microorganisms are a major group. Especially to a few micrometers, bacteria are a wide range of shapes. Environment and with these steps, depending on the organisms as nutrient cycling, nitrogen fixation bacteria fermentation, nutrient recycling is important. In recent years, antimicrobial resistance has emerged as a major public health problem. The metallic AgNP show lethal effect on the variety of microorganisms and do not allow the pathogens to develop resistance unlike conventional and narrow spectrum antibiotics. There lies a strong challenge to produce stable and safe AgNP to prevent bacterial growth significantly. Though the antibacterial activity of AgNP is being studied extensively, reports on the effect of these bio-functionalized nanoparticles in particular are rare. Free-radical involvement of AgNP surface in antimicrobial activity is discussed based on their zone of inhibition [9].

Biosynthesized AgNP can be used as an effective tool in the control of microorganisms at a very low concentration and as a preventive agent in deleterious infections. Although silver ions or silver salts are known to have antimicrobial effects but the AgNP mechanism of action is not well understood till today. The anti-pathogenic activity of AgNP was investigated against gram +ve, gram –ve microbes. Muller Hinton Agar (MHA) plates were used and AgNP at various concentrations were supplemented in liquid form for these examinations. At lower concentration of AgNP, *Staphylococcus aureus* and *Providencia* [10].

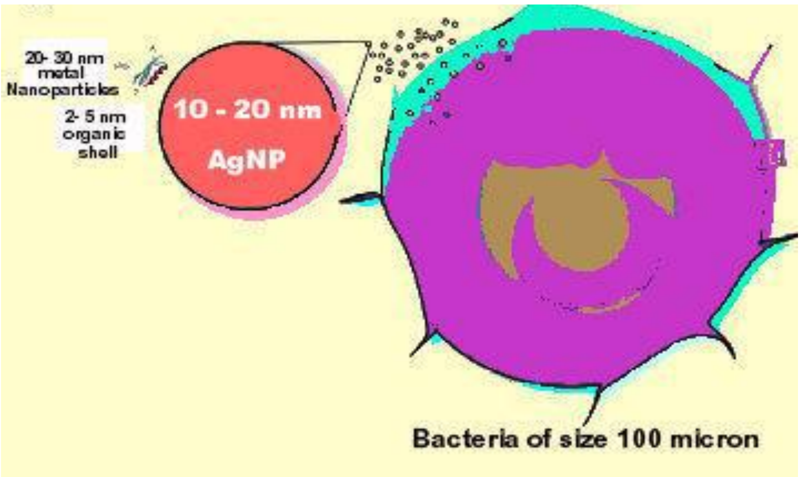

Figure No. 3: Action of silver nanoparticles on bacteria

Silver nanoparticle have capacity inactivates bacterial enzyme by releasing ionic silver which inactivates the thiol groups. This silver ion inhibits bacterial DNA replication, damage cell cytoplasm, depleting levels of adenosine triphosphate (ATP) and finally death of cell. As the nanoparticle distinct property surface to volume ratio silver nanoparticle increases surface to contact with bacterial cell which promote silver ion to dissolve and improving the bacteriocidic effectiveness [11].

Antifungal activity of Silver Nanoparticles

Mycology is the study of fungi. Including fungi, yeasts, molds, and fleshy, this is close to, live off organic matter obtain saprophytes, or nutrient Parasites; Fungus. They eukaryotic, a rigid cell wall, both chemoheterotrophs (organic carbon and energy sources) by the absorption of the nutrients that are necessary for the organic compounds of the organic matter. 100,000 species of fungi, only 100 species are pathogenic to animals. They decay and used by industry to produce a variety of useful products because by their ability to play a role in nutrient recycling a major. However, they also Waste and many undesirable economic effects, such as fruits, grains, and vegetables, as well as the destruction of wood, produces and unpreserved leather products.

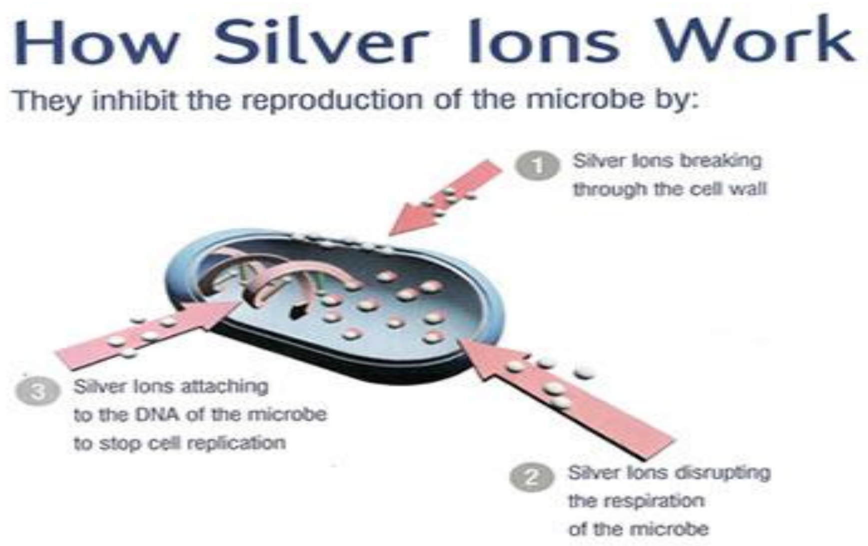

Figure No. 4: Activity of Silver Nanoparticles on Microorganisms

Silver nanoparticles breaks down the membrane permeability barrier of microorganisms, it is possible that nano-Ag perturbs the membrane lipid bilayers, causing the leakage of ions and other materials as well as forming pores and dissipating the electrical potential of the membrane [12].

Anti-cancer activity of Silver Nanoparticles

Cytotoxicity is the first step towards understanding how a foreign particle (Nanoparticles) or chemicals will react with the cells and alter the normal cellular function. Presence of Nanoparticles is possibly dangerous to human as well as the environment. High surface to volume ratio of nanoparticles makes them very reactive/catalytic. They are able to pass through cell membranes and interact with different cellular organs [13]. Many of cytotoxicity assays used in nanoparticle studies, regularly to *in vitro* toxicity testing of the 'conventional' chemicals, evaluate cell viability *via* methods that measure plasma membrane integrity. For example, the dyes neutral red and Trypan blue have been used in the cytotoxicity studies of silver nanoparticles in fish cells, human colon cells [14], human kidney cells, goldfish skin cells, human blood lymphocyte [15].

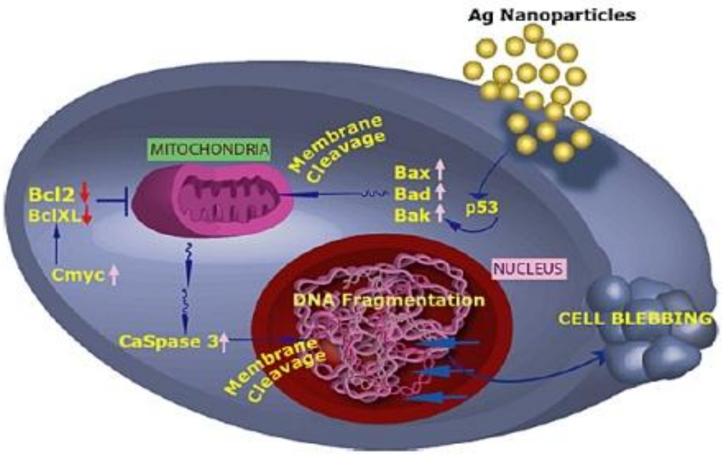

Figure No. 5: Role of Silver nanoparticles in apoptosis

For instance, membrane impermeable molecules ethidium homodimer used in human bronchial epithelial cells and propidium iodide in human colon cells and in mouse leukemic monocyte macrophage cells, which can only enter the cells with damaged membranes have been widely used for cytotoxicity assessment of silver nanoparticles [16]. Also, lactate dehydrogenase (LDH) release from the cells, a sign of membrane damage, which is another biochemical assay for cytotoxicity assessment, has been used in human epidermal cells (A431) [17] mouse fibroblast (L929) cells and rat kidney proximal cells for *in vitro* studies [18]. Many attempts have been made to use silver nanoparticles as an anti-cancer agent and they have all turned up positive. However, the role of silver nanoparticles as an anti-cancer agent should open new doors in the field of medicine.

CONCLUSION

On current literature review, Silver is known since ancient times for its potent antimicrobial properties. The applications of silver nanoparticles are thus imperative due to the beneficial effects of the noble metal. The biosynthesized silver nanoparticles proved to be potential candidates for medical applications where antioxidant, antimicrobial and, cytotoxic activities are highly essential. Hence, the synthesized nanoparticles are more efficient in the drug delivery process and it can be explored as a new source of alternative medicine for treating many human ailments.

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