Chapter

Silver Nanoparticles: Properties, Synthesis, Characterization, Applications and Future Trends

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Abstract

Nanotechnology is an expanding area of research where we use to deal with the materials in Nano-dimension. The conventional procedures for synthesizing metal nanoparticles need to sophisticated and costly instruments or high-priced chemicals. Moreover, the techniques may not be environmentally safe. Therefore "green" technologies for synthesis of nanoparticles are always preferred which is simple, convenient, eco-friendly and cost effective. Green synthesis of nanoparticle is a novel way to synthesis nanoparticles by using biological sources. It is gaining attention due to its cost effective, ecofriendly and large scale production possibilities. Silver nanoparticles (AgNPs) are one of the most vital and fascinating nanomaterials among several metallic nanoparticles that are involved in biomedical applications. It has vital importance in nanoscience and naomedicines to treat and prevent vital disease in human beings especially in cancer treatment. In current work we discussed different methods for synthesis of AgNPs like biological, chemical and physical along with its characterization. We have also discussed vital importance of AgNPs to cure life threatnign diseases like cancer along with antidiabetic, antifungal, antiviral and antimicrobial alog with its molecular mode of action etc. Finally we conclude by discussing future prospects and possible applications of silver nano particles.

Keywords: green synthesis, silver nanoparticles, nonmaterials, anticancer and antidiabetic

1. Introduction

Currently, improving and protecting our environment using green chemistry have become important issues in many fields of research. The most promising approach for generating new fields in biomedical sciences is the pharmaceutical application of nanoparticles (NPs) [1]. Due to ascension of industrial era and explosion of world population large amount of hazardous chemicals and gases released in environment in which adversely affecting our nature. Due avoid this and to protect our nature currently we world is focusing on development of natural products nanoparaticles. Biomolecules are highly compatible with nanotechnology which makes unique assembly for development of metal nanoparticles of biological molecules which are authentic and coast effective [2]. From the ancient era noval medicinal potential of silver has been known and proven for its antimicrobial potential [3]. Silver nano particles (AgNPs) and its related products were tremendously venomous and showed broad spectrum antibacterial potential against sixteen bacterial species [4, 5]. Nanotechnology is future era in material science which develops and upgrades qulaites of particles such as size, and morphology which provide entry of nonmaterial in future quality material building in almost every field [6]. Nanotechnologies have been used to develop nanoparticles-based targeted drug carriers [7]. Metal nanoparticles have a high specific surface area and a high fraction of surface atoms because of the unique physicochemical characteristics of nanoparticles [8, 9]. In that they include catalytic activity, optical properties and electronic properties, antibacterial properties, and magnetic properties [10, 11]. The nanoscale materials have emerged as novel "antimicrobial agents" due to their high surface area to volume ratio and their unique chemical and physical properties [12, 13]. In recent years development of metallic nanoparicles is an emerging field of research in material science. Crystalline nanosilver gained prime importance and has superior applicability in detection of biomolecules, antibacterial, electronics, diagnostic applications in health care system etc. Apart from novel applicability of AgNPs researchers still in search of advance methods to synthesize eco-friendly and coast effective tools to develop AgNPs [14, 15]. As silver posse's broad spectrum potential against bacterial and microbial species which specially utilized in industries it has key role in healthcare systems [16]. Nitrate group of silver potentially responsible for its broad spectrum antibacterial potential and as it convert in to AgNPs surface area is drastically increased which improve microbial exposure time and area [17–19]. Different techniques are available to synthesize AgNPs such as physical, chemical and biological. Though chemical method is rapid it utilizes capping agents for synthesis which is costly and produces adverse and toxic effects. This demands development of safe, ecofriendly, coast effective tool for synthesis of AgNPs and focused on biological methods such as green synthesis which is non toxic and developed using plant origin materials and overcomes disadvantages of earlier approaches. Moreover, use of plant extracts also reduces the cost of microorganism's isolation and culture media enhancing the cost competitive feasibility over nanoparticles synthesis by microorganisms [20]. Applicability of AgNPs is primly due to its nanoscale size and shape as compared to bulk. Due to these unique properties researchers are hunting of novel methods to synthesize AgNPs with prissily controllable size and shape [21–24]. Apart from excellent inhibitory potential of AgNPs in recent years most of the pathogenic bacteria developed resistant against it which is major concern of health care system. Chemical and physical approaches consumes ample of time, energy, money and generate toxic side effects. Nowadays green synthesis utilize microbes, fungi and medicinal plants which are easily available, convenient to handle and wide source of metabolites to synthesize AgNPs gained prime importance due to its nontoxic and ecofriendly properties [25]. Currently AgNPs are synthesized from natural herbs having medicinal potential such as synthesis of various metal nanoparticles using fungi like *Aspergillus terreus*, *Paecilomyces lilacinus* and *Fusarium* [26]. *Penicillium* sp. [27] *Fusarium oxysporum* [28] and *Euphorbia hirata*, green tea, neem, starch aloevera, lemon etc. [29–32]. AgNPs mainly binds to cell wall and penetrate deep inside the cell wall which produces cellular damage by interacting with DNA, proteins inside the cell which leads to cell death [33–37].

2. Need for green synthesis and silver nanoparticles

Silver is a basic element which is non-toxic belonging thermal and electrical potential [38]. Silver demand will likely to rise as silver find new uses, particularly in textiles, plastics and medical industries, surgical, dental resigns, coated water filters, sanitizers, detergents, soap and wound dressings. Applicability in healthcare for treatment of mental illness, convulsions, de addiction of narcotic products along with sexually transmitted diseases like syphilis and gonorrhea leads to changing the pattern of silver emission as these technologies and products diffuse through the global economy [39–41]. Green synthesis is an emerging approach which overcomes demerits of physiochemical approaches by utilization of natural herbs which are nontoxic [42, 43]. Green synthesized nanosilver offer many advantages like utilization of phytochemicals, antioxidants acts as naturally occurring reducing agents, coast efficient, large scale manufacturing highly beneficial and usage of toxic chemicals, high pressure, energy are avoided. Nanosilver can be engineered by different techniques such as irradiation, reduction, electrochemical and chryochemical synthesis. Nanosilver can be molded in to desired shapes and bear unique properties like permeability by pH and dissolved ions as compare to routine metals [44, 45]. As AgNPs generate larger surface area per unit mass which improves contact time nanosilver customer market an demand drastically raised in wide verity of industries along with healthcare, food packing, textiles, cosmetics etc. [46].

3. Silver nano particles

Generally AgNPs are nanoparticles of silver having size range between 1 and 100 nm in size having unique properties such as electrical, optical and magnetic having wide range of applicability [47]. Green chemistry is and encouraging approach mainly utilize nanosilver along with natural biomolecules such as polysaccharides, tollens which overcomes drawbacks of conventional methods and produce AgNPs which are ecofriedly, nontoxic and coast effective [48, 49]. Metallic silver ions are inactive but once it come contact with reducing agent ionization occurs and it get converted in its active form. Ionic silver is active form of silver which binds to cell wall of bacteria leading to major structural changes in cell morphology. AgNPs causes de-naturation of RNA and DNA replication which further leads to cell death [50]. Silver is also called as oligodynamic due to its bactericidal potential at minimum concentration. That's why it has been largely used in medical products [51, 52].

4. Methods for synthesis of silver nanoparticle

4.1 Physical approaches

In physical approach of synthesis of AgNPs evaporation and condensation has major importance. Temperature gradient play important role in cooling of vapors at desired rate. A chance of contamination by solvent has been removed by physical approach as no solvent has been used in physical method and uniform distribution of particle size precisely obtained [53, 54]. Minimum inhibitory concentration in toxicity studies can be easily achieved by production of nano scale nanoparticles in high concentration [55]. AgNPs also synthesized by laser ablation of metallic particles [56]. One important advantage of laser ablation technique compared to other methods for production of metal colloids is the absence of chemical reagents in solutions. Therefore, pure and uncontaminated metal colloids for further applications can be prepared by this technique [57]. Wide range of material can be synthesized in nanoparticels by physical method such as Au, Au and PbS etc. Synthesis of AgNPs by tube furnace has ample of disadvantages such as require larger space, high power, rapid rise of environmental temperature etc. AgNPs synthesized by laser ablation strongly depend on laser wavelength, time of laser pulse, laser fluence, the ablation time duration and the effective liquid medium. Ejection of AgNPs synthesized by laser ablation requires little power and particle size is precisely depends on laser fluence. However morphology, size and shape of AgNPs mainly depend on contact of laser light passing. Also, the formation of nanoparticles by laser ablation is terminated by the surfactant coating. The nanoparticles formed in a solution of high surfactant concentration are smaller than those formed in a solution of low surfactant concentration. One advantage of laser ablation compared to other conventional method for preparing metal colloids is the absence of chemical reagents in solutions. Therefore, pure colloids, which will be useful for further applications, can be produced by this method [58, 59].

4.2 Chemical approaches

Chemical reduction is the most frequently applied method for the preparation of AgNPs as stable, colloidal dispersions in water or organic solvents. Most commonly used reductant is citrate. In aqueous solution reduction of silver occurs and nanosize colloidal silver ions are generated. Stability of any colloidal dispersion has prime importance and which could be achieved by stabilizing agent (dodecanethiol) which adsorbed on surface and produce protective sheath. It can avoid agglomeration and crystal growth of the system. During the synthesis of AgNPs minute changes in parameters (Polymers) makes drastic changes in size, shape, morphology, polydispersibility index, self assembling and zeta potential (Stability). Frequently used ingredients in synthesis of AgNPs and AuNPs are glycol derivatives Polyvinyl pyrrolidone (PVP) and Polyethylene glycol (PEG). Polyacrylamide play dual function such as reducing and stabilizing agent in synthesis of AuNPs [59, 60]. Surfactants containing functional groups such as amines, thoils and acids play important role in stability of colloidal dispersion which protects the system from crystal growth, coaleseces and agglomeration. Currently AuNPs developed by modified tollens method utilize saccharides and silver hydrosols and reducing agent which yield AgNPs in the range of 50–200 nm and 20–50 nm respectively [61].

4.3 Biological approaches

Biotechnology is an emerging tool to develop biological synthesis of AgNPs. Besides this magnetic nanoparticles has great antibacterial potential due to improved surface area to treat raised microbial resistant against many antibiotics and medicines [62]. Currently green chemistry is rapidly growing technique utilized for synthesis of AgNPs with naturally occurring stabilizing, reducing and capping agents to synthesize AgNPs without toxic adverse effects [63]. Reduction of metal ions by combined efforts of herbs and certain enzymes, proteins, microorganisms, bacteria and fungi etc. in biological synthesis has been successfully reported [64].

4.4 Synthesis of silver nanoparticles by fungi

High production yield AgNPs synthesized by fungi obtained when compared to bacteria due to fungi secret higher amount of proteins that directly responsible for increased production [65]. Higher production rate is mainly due to silver ions entered in to fungal cell wall which leads to reduction of silver ions by fungal enzymes such as naphthoquinones and anthraquinones [66]. Slower rate and process is only disadvantage associated with fungal synthesis of AgNPs hence green synthesis approach is more preferred over the other techniques [67].

4.5 Synthesis of silver nanoparticles by bacteria

Pseudomonas stutzeri which is the first strain of bacteria form which AgNPs were synthesized and isolated form Ag amine [68]. Many of the bacterial strains and microorganism developing resistance to metal at lower concentration. Resistance mainly produced due to efflux, change in solubility, toxicity via oxidation/reduction and precipitation of metals [69]. There are evidences that at lower conc. Microorganisms are alive but once exposed to high conc. Metal ions leads to microbial death. In biosynthesis of silver enzyme nitrate reductase convert nitrate to nitrite [70].

4.6 Synthesis of silver nanoparticles by plants

Green synthesis is an excellent tool that can be utilized for synthesis of AgNPs as it uses natural origin medicinal herbs and its extracts which contain wide range of metabolites specifically water soluble flavones, quiones causes rapid rapid and quick reduction of silver when compared to fungi and microbes. Green chemistry approach is safe, cosat efficient, easily scalable to mass productions, easily availability of raw materials at cheaper coast. Phytochemicals directly take part in reduction process of the silver ions a during synthesis of AgNPs (**Figure 1**) [71].

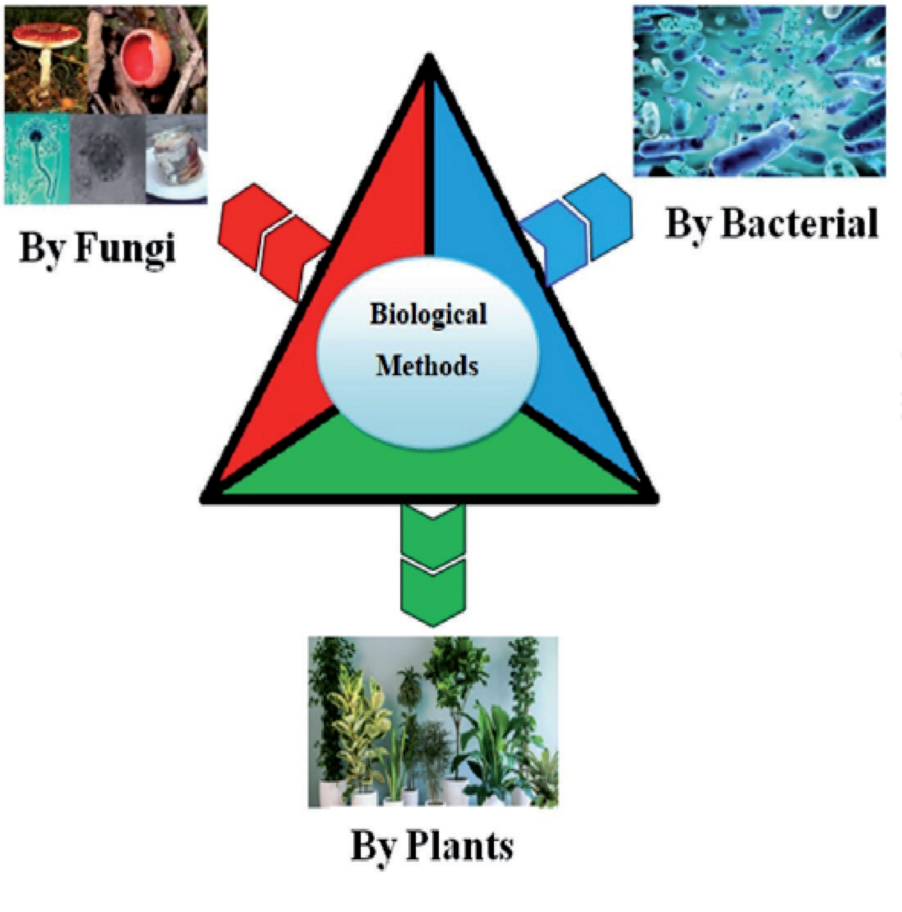

Figure 1.
Biological methods of silver nanoparticles.

5. Mechanism of action of silver nanoparticles

5.1 AgNP's antimicrobial MOA

When AgNP reaches toward cell they release Ag+ ions. These released ion then interact with sulfur and phosphorus containing compound present in cell wall. This lead to disarranged cell wall formation and small pits forms in the cell wall. Formed pit gives access to entry of ions and other foreign material to entry into cell. This increase intracellular osmotic pressure. As pressure built up in the cell, it begins to swell. Finally all these event lead to bursting of cell wall and cell lysis take place. This type of antimicrobial activity is more in gram –ve cell than gram +ve cell. As gram +ve cell have more cross linked peptidoglycan layer and teichic acid in their cell wall. The gram –ve cell have less or no peptidoglycane layer and have more lipopolysaccharide in their cell wall. So the AgNP's easily interact with gram –ve cell due less barrier [72].

5.2 AgNP's anticancer MOA

As described in above when pit formation takes place in the cell wall, the Ag+ ions released by AgNP's get entered into cell. Then they reaches to mitochondria where they interact with thiolgoups and bind to NADPH dehydrogenase enzyme and liberates ROS. These formed ROS in mitochondria interacted with respiratory enzymes damage ATP formation and respiratory cycle of cell. Formed ROS also interact with protein, sulfur and phosphorus containing cell constituent. Also these formed ROS also bind to phosphorus elements of DNA and RNA which lead to inhibit cell replication and protein synthesis. Due to binding with DNA aggregation of damage protein sysnthesis which lead to cell death. Another possible action is by autophagy. AgNP's have ability to induce autophagy by accumulation of autophagolysosmes in human ovarian cancer cell. This autophagy work by mainly 2 ways; at lower level they increases cell life i.e. surviving rate, but when its level increase it lead to cell death (**Figure 2**) [73].

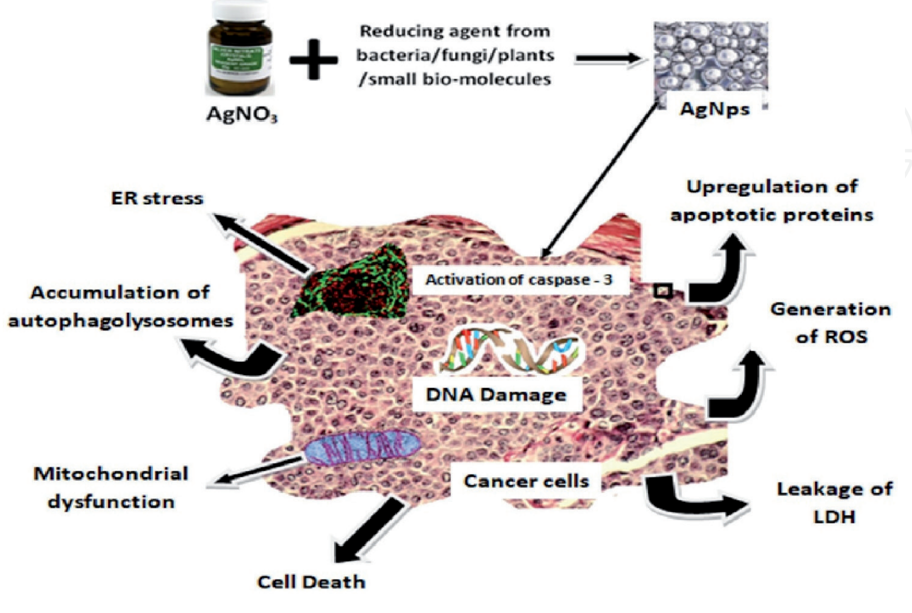

Figure 2.
Anticancer mechanism of action of silver nano particles.

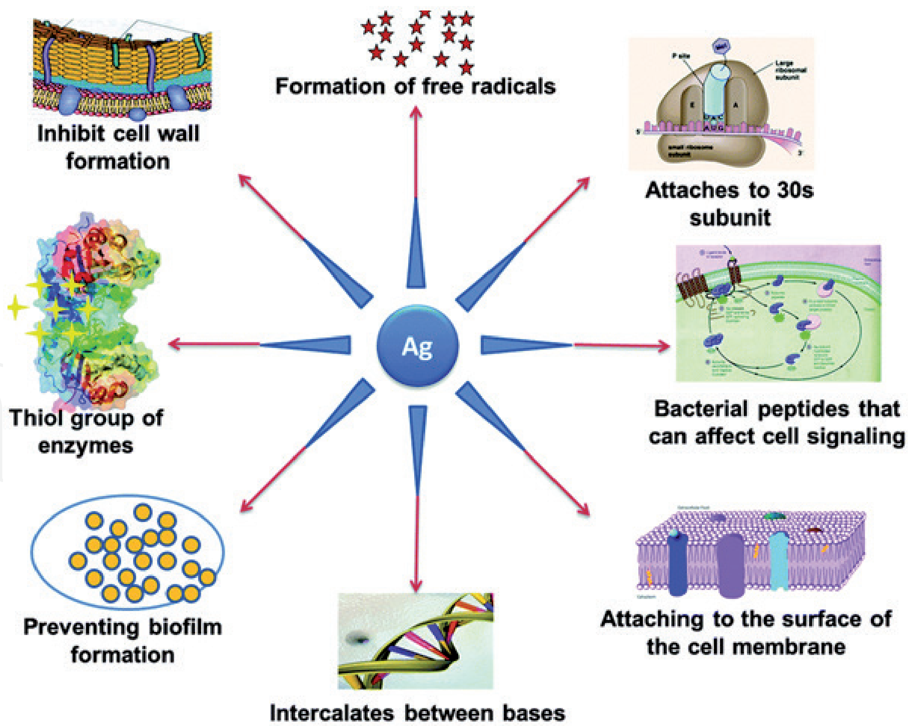

Figure 3.
Factors affecting to the bactericidal effect of silver nanoparticles.

6. Factors affecting bactericidal potential of AgNP's

Primarily morphology i.e. size and shape along with reactivity of AgNP's were responsible for bactericidal potential of AgNP's. Size and surface are inversely proportional to each other as size decreases area increases leads of rapid rise in surface-area to volume ratio. Bactericidal potential inhibit cell wall and free radicals Ag-thiol groups of enzymes Preventing biofilm formation Intercalates between bases Attaching to the surface of the cell membrane Bacterial peptides that can affect cell signaling Attaches to 30 s subunit (**Figure 3**). Silver nanoparticles showing multiple bactericidal actions [74].

7. Charactrisation of AgNP's

7.1 Visual and UV: Visible study

To ascertain either AgNPs are developed or not visual and calorimetric appearance of samples checked by UV–Visible spectrophotometer before and after formulation of AgNPs at different time intervals. Before synthesis of AgNPs silver nitrate is colorless and herbal extract has definite color. Once AgNPs synthesized silver nitrate solution develop yellowish brown color after interacting with herbal extract which is confirmed by surface Plasmon resonance SPR and UV visible absorption in the specific range of 400–475 nm [75].

7.2 FTIR analysis

FTIR spectroscopy is an investigational tool to determine/conform functional groups priesnt in the moiety which is characteristic of that compound. Major functional moieties present in AgNPs and herbal extract were identified by scanning the samples in the range of 4000 to 400 cm−1 [76].

7.3 SEM/TEM analysis

Scanning electron microscopy/Transmission electron microscopy mainly used to study surface morphology of synthesized AgNPs. SEM/TEM plates were prepared by addition of silver nitrate to develop smear of solution on slides. Conductivity was incorporated in system by making thin film of platinum which was coated on slides. Once the slides were ready they were scanned at 20 KV accelerating voltage and high quality images were captured [77].

7.4 X-ray diffraction (XRD) analysis

X-ray diffraction is a modern technique mainly utilized to identify state of matter either it is crystalline or amorphous in nature at different radiation angles. X-ray diffraction determines phases either crystalline/amorphous and cell dimension [78].

8. Application of silver nanoparticles

8.1 Antimicrobial activity

Products prepared with silver nanoparticles have been permitted by no. of accredited bodies including USFDA, USEPA, Korea's testing body and SIAA of japan institute of research. Antimicrobial and antimicrobial potential potential of AgNPs containing silver sulfadiazine is incorporated in to medicines and used in burns to avoid infections. Nowadays AgNPs involved in extending field of nanotechnology and appears in many consumer products that include acne vulgaris cream and for deodorizing sprays. The antimicrobial properties of silver nanoparticles depend on size, environmental conditions (size, Ph, tonic strength) and capping agent. Recently an improvement in antimicrobial activity synergistic effect has been reported when silver naqnoparticles combined with ampicillin, amoxicillin and chloramphenicol on the contrary reports showed antagonistic interaction between silver nanoparticles and amoxicillin or oxacillin antibiotic combined with silver nanoparticles have suggested improve therapeutic activity (**Figure 4**) [79, 80].

8.2 Antiviral activity

Antiviral activity of silver nanoparticles have proven to exert antiviral activity against HIV-1 at non cytotoxic concentration but the mechanism underlying their HIV inhibitory activity has not been fully elucidated. The study from intranasal silver nano particles administration in mice increased survical, lower lung viral titer levels, minor pathologic lesions in lung disease, and remarkable survival benefit after infection with the H3N2 influenza virus, suggesting that AgNPs had significant role in mice survival. Biologically prepared silver nano particles inhibited the viability in herpes simplex virus (HSV) types 1 and 2 and human para influenza virus type 3 based on size and zeta potential. The treatment of vero cells with non-cytotoxic concentrations of silver nanoparticles significantly inhibited by the replication of paste des petits ruminants virus (PPRV). The mechanisms of viral replication are due to the interaction of silver

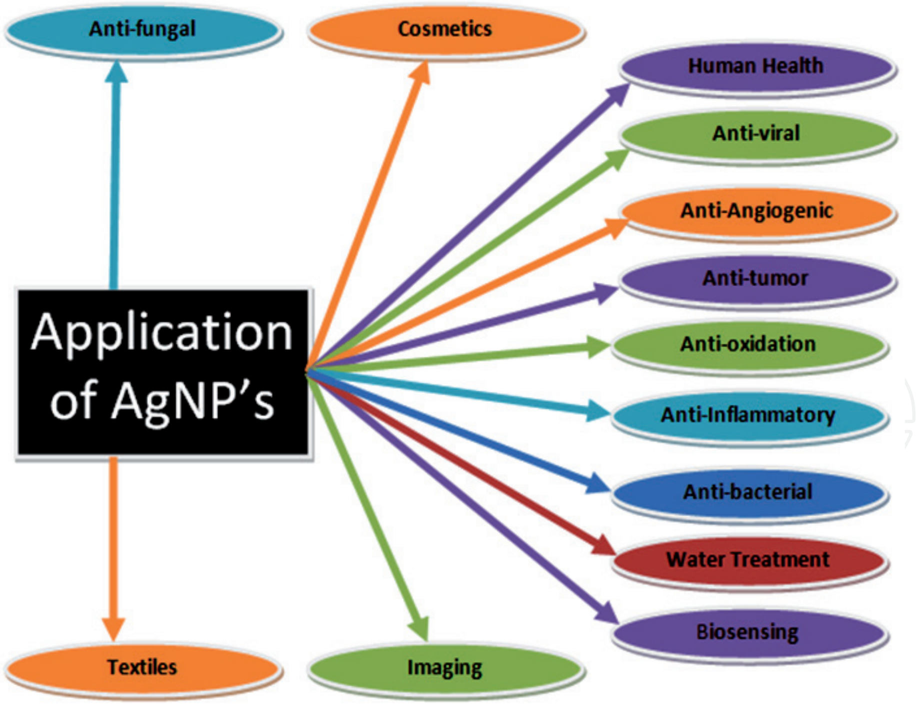

Figure 4.
Applications of silver nanoparticles.

nanoparticles with the virion core. Tannic acid mediated synthesis of various various sizes of silver nanoparticles capable of reducing HSV-2 infectivity both in in-vitro and in-vivo through direct interaction, blocked virus attachment, penetration and further spread [81, 82].

8.3 Antibacterial activity

Silver nano particles are one of the most attractive nonmaterial's for commercialization applications. As antibacterial agents silver nanoparticles were used for wide range of applications from disinfecting medical devices and home appliances to water treatment. AgNPs promisingly used in drastic fields such as healthcare products, food storage, textile and medicinal devices. In antibacterial potential AgNPs free silver ions are released at slower rate along with higher surface area which produces noxious environment and this is the main reason for broad spectrum antibacterial potential of AgNPs [83].

8.4 AgNP's in cancer control

AgNPs has prominent anticancer potential as it discourage mitochondrial respiratory chain, increase reactive oxygen species (ROS) rate of synthesis which finally leads to DNA damage and cancerous cell death. Yu-Guo Yuan in 2018 revealed that the combination of camptothecin and silver nanoparticles treatment significantly increases the levels of cancer cells. It increases oxidative stress markers and decrease ant oxidative stress markers compared to single treatment. Overall these results suggested that camptothecin and silver nanoparticles cause cell death by inducing the mitochondrial membrane permeability change and activation of caspase. The synergistic cytotoxicity and apoptosis effect seems to be associated with enhanced ROS formation and depletion of antioxidant. Certainly a combination of CPT and silver nano particles provide advantageous effect in treatment of cervical cancer compared to immunotherapy [84].

8.5 Antidiabetic activity of AgNP's

Tephrosiatinctoria stem extracts mediated silver nano particle synthesis was evaluated for control of blood suger levels. AgNP's scavenged free radicals, reduced the levels of enzymes that bring about hydrolysis of complex carbohydrates ($\alpha - glucosidase\alpha - amylase$) and as a result of which there is an increase in consumption ratr of glucose. The promising antidiabetic activity of shown by *Ananascomosus* (L.) silver nanoparticles. In dose dependent manner. AC-AgNP's inhibit α-glucosidase enzyme in stomach. Which is helpful in non-insulin diabetic patient. Also the silvernanoparticles synthesized with *Argyreia nervosa*leaf extract shown great antidiabetic activity. They inhibit mainly enzymes that digest the carbohydrates into monosaccharide and reduce blood glucose level [85, 86].

8.6 Different field application of AgNp's

Studies can contracting on the therapeutic applications of AgNP's in the gastrointestinal tract have displayed that gastric cells can be sensitized to radiation by the use of AgNP's and they may bypass the stomach and instead release the drug in small intestine. Apart from the health related applications; Silver Nanoparticles are act as a brilliant heterogeneous catalyst used for reduction of halogenated organic pollutants. Also it increases the bleaching power of organic dyes. The tubular shaped silver Nanoparticles have a very potent catalytic activity so they can used as a catalyst. In case of water treatment when the biosynthesized Silver Nanoparticles which are biologically synthesized on nitrocellulose membrane filters, can used for the promising inhibition and inactivation of microbes like *E. coli* and *Enterococcus faecalis*, etc. Rather as the silver Nanoparticles are the very good antimicrobial agents so they are used as the preservatives in various food and agricultural products [87].

8.7 Antifungal activity of AgNPs

AgNP's play important role as antifungal agents against various diseases caused by fungi. Biologically synthesized AgNP's shows enhanced antifungal activity with fluconazole against *phomaglomerata*, *Candida albicans* species. AgNP's stabilized by sodium dodecyl sulphate showed greater antifungal activity against *Candida albicans* compared to conventional antifungal agents. The AgNP's synthesized by bacillus species exhibit strong antifungal activity against the plant pathogenic fungus *fusariumoxysporum* at concentration of 8 μg/ml. AgNP's shown promising antifungal activity on *T. asahii* with MIC of 0.5ug/ml by damaging cell wall and components of cell. Due to size of nanoparticles they easily penetrate into cell. Where it binds to different cell components and inhibits cell functions. In combination with antimicrobial agents like ketoconazole shown great antifungal activity with MIC less than 0.5 mg/ml against the Malassezia where they give synergistic effect with ketoconazole it form pores in cell to show antifungal activity [88, 89].

8.8 Anti angiogenic activity of AgNP's

Antiangiogenic potential of green synthesized AgNP's in retinal endothelial cells model mainly produced by inhibition, proliferation and migration of BRECs at 500 nM concentration. In CAM model (chicken embryo chorioallantoic membrane) the silver nanoparticles inhibit angiogenesis approximately up to 73%. In comparison to other antiangiogenic molecules. They give dose dependent cytototoxic action on endothelial cell present in blood vessels to inhibit formation of new blood vessel in tumor region. Also the by using the same model i.e. by CAM assay the silver nanoparticle synthesized by *Rubinatinctorum* shown antigiogenic activity. Ru-AgNP's shown inhibitory action on blood vessels. In CAM model, there is decrease in length of embryo resulted out due to the antiangiogenic action of Ru-AgNP's [90, 91].

8.9 Diagnostic, biosensor and gene therapy applications of AgNP's

Nanoparticles have advantage over today's therapies because they can be engineered to have certain properties or to in certain way. They are helpful in cellular imaging. Silver plays an important role in imaging systems due to its stronger and sharper Plasmon resonance. Currently biosensor made with silver used as powerful tool to detect cytochrome P53 of squamous cell cancer of head and neck. Due to the colorimetric sensing property the silver Nanoparticles are applicable to detect the heavy metal ions of nickel, cobalt and mercury along with the sulfide traces. Among all the types of silver Nanoparticles, especially the triangular shaped silver Nanoparticles have higher anisotropy and lightening rod effect which leads to its wide use in manufacturing of Plasmon sensors or Plasmon detectors which are used to detect the mercurial ions in the solution. Also the silver Nanoparticles are used to develop the electrochemical sensor which is used to detect common herbicide atrazine. On the other hand the in situ growth and development of silver Nanoparticles on polydopamine traced filter paper is responsible for the quick collection and detection of green colored residue of malachite [92].

8.10 Anti-inflammatory activity of AgNP's

AgNPs have been known for its antimicrobial but the anti-inflammatory response is still limited. Rats treated intra colonic ally with 4 mg/kg or orally with 40 mg/kg of nanocrystalline silver (NP32101) showed significantly reduced colonic inflammation. AgNPs showed rapid healing and improved cosmetic appreance occurring in dose dependent manner. Silver Nanoparticles made by using the extraction method with petroleum ether and some small amount of ethyl acetate are having potent cyclooxigenase-2 inhibition property. So, as one can add the natural extract of anti-inflammatory activity to this silver Nanoparticles extracted with petroleum ether, the anti-inflammatory activity of the resulted silver Nanoparticles get increased. Recently some scientists were done the extraction of soft coral named nephthea sp. Which already possessing the anti-inflammatory activity and extracted the silver Nanoparticles with petroleum ethers then the produced silver Nanoparticles of nephthea sp. having very potent anti-inflammatory activity which were estimated by analysis and molecular docking methods [93].

9. Future prospects

AgNPs has potential applications in healthcare system and treating infectious diseases and it is emerging as remedies for large no of resistant bacteria infections along with it is known for its anti-inflammatory potential. Apart from it has numerous application in biological and research fields such as electrochemistry, biochemistry, nanoprism synthesis, garments, detergents and soap industry, involved in devising water purification system, and surgical instrument. Nowadays Ag-NPs opened new era as it has used in artificial implants which decreeing dependency on antibiotics. Studies have been revealed that Ag-NPs have novel potential in development of new pharmaceutical dosage forms and AgNPs cures inflammation of bladder which tremendous application in healthcare systems. AgNPs useful in animal models for detection of biosensors [94]. A reliable mechanism responsible for the impressive biological activity of AgNPs is considered to be a key factor in future research. Wide scope to aware control the release of silver and improving the stability of AgNPs used in medical and mechanical devices.

10. Concslusion

Over the past few decades, nanoparticles of noble metals such as silver exhibited significantly distinct physical, chemical and biological properties from their bulk counterparts. Current chapter specifically encounters synthesis, characterization, and bio-applications of silver nanoparticles, with special emphasis on anticancer, antimicrobial activity and its mechanisms. Green chemistry is being exploited for developing silver nanoparticles. Several methods utilized to create silver nanoparticles utilizing plant extracts as reducing or capping agents. Current chapter represents different methods of preparation silver nanoparticles and application of these nanoparticles in different fields.

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Conflict of interest

The authors declare no conflict of interest.

Notes/thanks/other declarations

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Abbreviations

AgNP’s	Silver Nano Particles
NPs	Nanoparticles
nm	nanometer
$AgNO_3$	Silver Nitrate
PVP	polyvinyl pyrrolidone
PEG	poly ethylene glycol
PMAA	poly methacrylic acid
SPR	surface plasmon resonance
ROS	Reactive oxygen species

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