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Silver Nanoparticle for Disease Treatment: A Review

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ABSTRACT

Background: Since nanotechnology may be applied almost everywhere, it is a rapidly developing field of medical science. The need for silver nanoparticles (AgNPs) is rising quickly in numerous industries, including medicine, pharmaceuticals, healthcare, food and beverage, consumer goods, cosmetics, etc. Due to its many applications, including its antibacterial qualities, it has been utilized in home products, medical equipment, food industry, wound dressing, in diagnostic, orthopaedics, and as an anticancer agent. The use of Phyto-constituents in the synthesis of green silver nanoparticles (AgNPs), which have significant promise for treating a variety of ailments, is valuable and encouraging. The synthesis, characterization, and therapeutic potential of silver nanoparticles are discussed in general terms in this review.

Keywords: Silver Nanoparticles; Cytotoxicity; Antiviral Effect; Antibacterial Agent, Anticancer Agent

Introduction

The development of nanotechnology, which offers incredible ways to cope with life-threatening ailments, has boosted advancement in the field of medical science. Nanotechnology is a significant advancement that has numerous uses in a variety of industries, including electronics [1], textiles [2], and most significantly, healthcare [3], where it is used for targeted medication administration, diagnosis, treatment, and biosensing. An extremely appealing platform for a wide range of biological applications is provided by nanoparticles. Treatments using nanoparticles are more precise for diseases like cancer that are challenging to treat. Preventing the killing of non- cancerous cells while harming the tumor cells is the major problem in the treatment of cancer. Oral or parenteral treatments now used circulate throughout the body and are harmful [4].

Just the malignant cells that are actively growing will be targeted for cytotoxicity by targeted medication therapies using nanosized formulations. The use of nanosized formulations in the treatment of chronic diseases like cancer is absolutely astounding [5]. To create vaccinations against the virus, pharmaceutical corporations from across the world are working with researchers. But the world still struggles to accept it. This calls for urgent study and antiviral medicine development to protect human health from life-threatening viruses. Due to their distinctive characteristics and applications, metallic nanoparticles are receiving a lot of attention. The most researched silver nanoparticles are those that have incredibly broad- spectrum activity. Nanoscience research on AgNPs has advanced significantly, particularly in the areas of antimicrobial, antibacterial, antioxidant, antifungal, anti-inflammatory, anti-cancer, and anti-angiogenic properties [6-12]. As a result, the goal of this review paper is to provide an overview of silver nanoparticle therapy.

Synthesis Methods

To produce silver nanostructures, numerous methods have been developed. These approaches can be divided into three categories:

1. Chemical methods [13-16];
2. Physical methods [17-20]; and
3. Biological methods [21-23].

Chemical reduction [13], electrochemical approaches [14], irradiation-assisted chemical methods [15], and pyrolysis [16] are subcategories of chemical methods for the synthesis of silver nanostructures. Metal precursors, reducing agents, and stabilizing/capping agents are typically the three major components used in the production of silver nanostructures in solution. Boron hydride, sodium citrate, ascorbic acid, alcohol, and hydrazine compounds are some often used reducing agents. In the biological synthesis of AgNPs, benign molecules (proteins, carbohydrates, antioxidants, etc.) produced by living organisms, such as bacteria, fungi, yeasts,

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and plants, substitute the harmful reducing agents and stabilizers. Many reports have been made about biological techniques based on microorganisms such bacteria [21], fungus [22], and yeast [23]. For the synthesis of AgNP, the less expensive plant systems have been investigated, including lemongrass, Aloe vera, seaweed, alfalfa, tea, neem, mustard, safeda, lotus and tulsi. Enzymatic and nonenzymatic reduction are two possible methods for biological synthesis (e.g., NADPH reductase) [24]. The most popular ecologically friendly production method for AgNP is its synthesis from plant extracts.

Characterization Methods

Numerous characteristics and features of nanoparticles and nanocarriers, including size, shape, morphology, particle size distribution, ultraviolet-visible spectrum (UV-Vis), zeta potential, infrared spectrum, surface area, entrapment efficiency, and drug loading capacity, are frequently observed for characterization purposes [25].

Therapeutic Effect of Silver Nanoparticle

Antibacterial Effect

Antibacterial activity is defined as the removal of bacteria from the body or the slowing of their growth without harming neighboring cells. Silver is preferred as a nanoparticle because it is non- toxic to humans and possesses antibacterial properties. Ag-NPs can overcome the antibiotic resistance that has existed. AgNPs have been shown to have the potential to operate as an antibacterial agent due to their large surface-to-volume ratio and crystalline surface structure [26]. Several drug-resistant strains can be eliminated by AgNPs, proving that these Ag-NPs have the potential to function as an antibacterial agent [27]. Gram-negative bacteria are known to exhibit greater antibacterial activity than Gram-positive bacteria. It is caused by the presence of a cell wall, or peptidoglycan layer, which is reported to be thick in gram-positive bacteria, measuring 30 nm, whereas it is relatively thin in gram-negative bacteria, measuring only 3-4 nm [28]. Another factor is that cellular membranes are negatively charged, possibly because of the presence of carboxyl, phosphate, and amino groups, as opposed to bacteria, which have positive charges that attract negatively charged objects like AgNPs. This attachment to the cellular membrane will change the antibacterial activity of AgNP [28]. The antibacterial activity of the chitosan-Ag-nanoparticle composite was shown to be stronger than that of its components at their respective concentrations because one-pot synthesis favored the creation of tiny AgNPs connected to the polymer, which can be disseminated in solutions with pH 6.3.

Antiviral Activity

Since viral infections and diseases are widespread throughout the world, it is crucial to develop antiviral medications that have noticeable results. Due to their extremely small size and distinctive shape, AgNPs are seen to be particularly conspicuous in displaying such findings. It has been noted that silver is efficient against viruses and is shown to be largely non-toxic to both humans and animals [29]. HIV AgNPs were discovered to produce acceptable results. In this instance, AgNP functions as an anti-viral at an early stage of viral replication, primarily acting as virucidal or maybe inhibiting viral entry. AgNPs will attach to gp120 and stop CD-4 dependent virion binding and infectivity, acting as a powerful virucidal agent against cell free viruses. In addition to this, AgNPs block the HIV-1 life cycle after entrance [29].

Antifungal Activity

Those with weaker immune systems are more vulnerable to fungus infections. This technique is proven to be particularly time-consuming in nature when trying to treat fungus-related disorders. The number of antiviral medications on the market is extremely small [30]. Antiviral medications must be non-toxic, biocompatible, and environmentally friendly. Several disorders that are brought on by fungi are discovered to be particularly susceptible to AgNPs [31]. Bipolaris sorokiniana was effectively combatted by biologically produced AgNPs by preventing conidial germination. AgNPs also suppress indoor fungal species, including those grown on agar media such as Penicillium brevicompactum, Aspergillus fumigatus, Cladosporium cladosporoides, Chaetomium globosum, Stachybotrys chartarum, and Mortierella alpine.

Anticancer Activity

Cancer is essentially an unchecked cell proliferation in a specific bodily location. Almost one in three people worldwide have some form of cancer. For cancer patients, there are numerous therapies available, such as chemotherapy and radiation therapy, but they all have severe side effects and a painful recovery period. It is commonly known that chemotherapy, surgery, and radiation therapy are all used in the treatment of cancer. Targeted therapy is also quite costly and uncomfortable [31]. Finding efficient, affordable, and sensitive molecules is therefore necessary for the therapy of cancer. Several studies have been conducted to learn more about the promising outcomes of AgNPs [32]. It is seen to be the best option for treating cancer and a substitute for other cancer therapies. Only by encapsulating the therapeutic ingredient in a nanoparticle and using it as a medication delivery system do they have the potential to target specific cells or tumors at that location. A549 cells displayed 21% and 73% viability after 6 hours of exposure to the produced AgNPs from Albizia adianthifolia leaf extract (AA-AgNPs), whereas normal peripheral lymphocytes displayed 117 and 109 percent viability.

This proves that normal PLs cells are not harmed by AgNPs. A549 cells were 50% more inhibited at 43 g/mL of AA-AgNPs, and apoptosis, which is caused by the production of ROS, was also increased. Sesbania grandiflora-mediated AgNPs (20 g/mL)-treated MCF-7 cells exhibit nuclear condensation, cell shrinkage, and fragmentation after 48 hours of Hoechst staining. These modifications imply that the cleavage has made it possible to perform DNA repair [31,32-53] (Table 1 & Figure 1).

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Table 1: Medicinal value of silver nanoparticle as per published literature.

Findings/outcomes	Study type	Date of publication	Disease	Pharmacological action	Reference
Antidiabetic potential and high synergistic antibacterial activity	Animal Study	Dec,31 2020	Diabetes Mellitus	Anti-Bacterial Agents,	[33]
Treatment of cisplatin-induced cardiotoxicity	Animal Study	May,19 2020	Cisplatin	Cardioprotective	[34]
Ameliorative effect on mycoplasmal pneumonia	Animal Study	No,30 2019	Pneumonia	Anti-Bacterial Agents	[35]
Beneficial effects of Spirulina platensis	Animal Study	Oct 09 2022	Testicular Injury	Antioxidants	[36]
Antitumor activity	Animal Study	Apr 16, 2020	Bladder cancer	Antiproliferative	[37]
Anti-gout activity	Animal Study	Dec 31, 2021	Gout	Antioxidant	[38]
wound healing	Animal Study	Dec 10, 2019	Diabetic	Antidiabetic	[39]
Combat against dengue and filariasis	Insect study	Jan 31, 2018	Dengue	Insecticidal	[40]
Treat osteomyelitis	Animal Study	Dec 31, 2017	osteomyelitis	Antibacterial agent	[41]
Treat Giardia lamblia	Animal Study	Mar 06, 2012	Giardiasis	Antiparasitic Agents	[42]
Treat liver and kidney inflammation	Animal Study	Apr 30, 2021	Inflammation	Anti-Inflammatory Agent	[43]
Treat renal toxicity	Animal Study	Jun 30, 2020	Kidney damage	Reno protective	[44]
Antiviral activity	Animal Study	Aug 07, 2019	Viral infection	Antiviral Agents	[45]
Anthelmintic potential	Animal Study	Dec 31, 2015	Helminthiasis	Antiparasitic agent	[46]
Treat Multidrug resistant bacteria	Invitro study	Apr 14, 2020	Bacterial infection	Antimicrobial agent	[47]
To reduce mutation rates	Invitro study	Dec 31, 2014	Mutation	Antimutagenic Agents	[48]
Cytotoxic potential	Invitro study	Dec 31, 2019	Colorectal cancer	Antiproliferative	[49]
Regulates p53 and Bcl-2 expression	Invitro study	Mar 17, 2018	Breast cancer	Antiproliferative	[50]
Immunomodulatory activities	Invitro study	Oct 31, 2017	HIV-infection	NF-kappaB Inhibitor	[51]
ttTreat acute myelomonocytic leukemia cells	Invitro study	Jan 31, 2015	Leukemia	Antiproliferative	[52]

Figure 1: Biomedical applications of silver nanoparticles [53].

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Conclusion

As silver nanoparticles have so many applications across so many industries, they are now widely employed. In addition to its extensive use as an antibacterial, Ag-NPs also have applications in gene therapy, anti-inflammatory medicine, anti-fungal medicine, diagnostic imaging, and many other fields. AgNPs are currently being researched as a potential cancer therapy alternative to other traditional treatments like chemotherapy, radiation therapy, etc. One of the intriguing methods for treating cancer is the use of these AgNPs as an antiangiogenic. There are three ways to make these AgNPs: physically, chemically, and biologically. The most popular method among the three is biological because it is safe for the environment, non-toxic, and eco-friendly. In the case of cancer treatment, it has been determined to be secure and site- specific. We can therefore conclude that these AgNPs are effective, simple, and safe treatments for a variety of disorders.

Data Availability

All of the required data will be available upon request to the corresponding author.

Authors' Contributions

The author wrote the paper alone.

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Conflicts of Interest

There are no conflicts of interest.

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