Silver Nanoparticles and its Applications

Poornasareena T, Sathya M , Keerthiga K , Dr. Anishkumar M
VSB ENGINEERING COLLEGE, KARUR

Abstract:- The recent development of nanotechnology helps in the effective synthesis and various applications of nanoparticles. Nanoparticles are present in a varying range of sizes from 1to 100nm. Nanoparticles of metals like silver, gold, selenium, and many others have applications in the medical field that can be used to treat specific lethal diseases like cancer. Especially, silver nanoparticles are used to treat cancer nowadays due to their effective anticancer activity. The effective and biological method of synthesis of. These silver nanoparticles have nanoparticles by using plant extracts has proved to be the best way to synthesize nanoparticles. Silver nanoparticles can also be synthesized by using the microbial method of extraction. Anticancer, antibacterial, antiviral, antifungal, and antioxidant characteristics of silver nanoparticles which help in the development of new treatment methods for treating different diseases are being studied. Researchers are satisfied with the applicable properties of silver nanoparticles and so they are used in medicinal creams to treat wounds and burns. Let's discuss the various applications of silver nanoparticles in this article.

***Keywords**:- Nanoparticles, Silver nanoparticles, Synthesis, Anticancer, Antibacterial, Antiviral, Antifungal, Antioxidant, Applications.*

I. INTRODUCTION

The field of nanotechnology in the recent research field deals with the synthesis and skillful handling of particles of varying sizes ranging from 1 to 100nm. The nanoparticles have their influence in every possible field because of their desired small size and structure[1-3]. Nanoparticles have high reactivity and these particles can easily vary their surface property[4]. The current field of research in nanoparticles uses silver nanoparticles due to their diverse application in fields like medical, agricultural, and various industrial applications[5,6].

Silver, a metal that has been in use for a long time ago due to its anti-bacterial property. They have been used to store water in portable silver vessels[18]. The synthesis of silver nanoparticles can be achieved through chemical, physical, and biological methods. The biological synthesis method produces the most significant silver nanoparticles with efficient solubility, yield, and biocompatibility [7]. The important application of silver nanoparticles is they are a good anti-diabetic agent and have wound-healing properties. Diabetics is the world's worst problem impacting the world population, thus silver nanoparticles can play a significant role as an anti-diabetic agent[8].

Cancer is the uncontrolled division of abnormal cells mainly caused due to external and genetic factors. Currently, silver nanoparticles are used as anti-cancerous substances. They are used in cancer diagnostics and probing studies[9]. Silver nanoparticles are known for their antiviral, antifungal, antibacterial, and anti-inflammatory properties. For the treatment of burns, wounds, and also bacterial infections silver is used in the form of silver nitrate or even as metallic silver[10]. Silver nitrate in the name of "Lunar caustic" has the best antimicrobial property. Different concentrations of silver nitrate can be used to treat venereal diseases and fresh burns. Silver in the form of silver nitrate can also be used to treat bone perianal abscesses.[11].

Moyer was the first to introduce that 0.5% of silver nitrate can be used to treat burns. He proposed that the antibacterial property of silver nitrate helps in treating burns and wounds without interfering the epidermal proliferation[12]. Silver is inert in its metallic form. Metallic silver has a significant antimicrobial property which helps in denaturing and inhibiting bacterial replication over wounded tissue by binding to the bacterial DNA and RNA. It also acts in bringing structural changes in the cell wall and nuclear membrane of the bacteria. Metallic silver gets ionized on the fluid of the wounded skin and becomes highly reactive helping in the distortion and death of the bacterial cells[13].In the method of synthesis of silver nanoparticles, the plant-mediated method of synthesis is most advantageous compared to other bio- synthesis methods. This is because the cell culture can be neglected and it is convenient for large-scale production in a non-aseptic condition. Since the cell cultures are omitted the plant-mediated synthesis method is easy to work on compared to other bio-synthesis methods[14].

In recent commercialization trends, out of all the nanoparticles silver nanoparticles applications are in the highest trade. These are used in cosmetics, textiles, disinfecting medical devices, and even in water treatment. These are all the recent applications of silver nanoparticles currently in the trend[15]. Nanosilver can be used in the treatment of HIV-1, due to its anti-viral activity. It is proved that silver nanoparticles have 98% anti-HIV activity which is higher compared to gold nanoparticles[16]. Silver nanoparticles being an effective fungicide can kill ordinary strains of fungi like *Aspergillus fumigatus, Aspergillus fumigatus, Mucor, Saccharomyces cerevisiae, and Candida tropicalis* [17]. Silver nanoparticles have a wide range of applications and properties. Let's discuss the various methods of synthesis and applications of silver nanoparticles.

II. METHODS OF SYNTHESIS

Synthesis of nanoparticles can be carried out by three different methods. This includes physical, chemical, and biological methods[19-22]. These are classified as Top-Down and Bottom -Up methods. The top-down approach includes the physical method while the chemical and biological methods come under the bottom-up approach[23].

In the physical method, the nanoparticles are mostly synthesized by evaporation-condensation, at atmospheric pressure using a tube furnace. Physical methods involve the synthesis of silver nanoparticles by this evaporation-condensation process[24]. Ball milling, sputtering, laser ablation, and ultrasonication are physical methods. The main advantages of physical methods involve no hazardous chemicals, speed, or radiation, and are used as reducing agents and the disadvantages are low yield, solvent contamination, high energy consumption, expensive instrumentation, and lack of uniform distribution[25-29].

In the chemical method, the silver nanoparticles are synthesized using electrochemical, sol-gel, and chemical reduction methods. These methods help in synthesizing nanoparticles in spherical size and are cost-effective methods. The chemical method involves the use of a reducing agent, stabilizing agent, and a metallic precursor which are easy to perform process but produce toxic reagents and hazardous polluting agents[30,31].

In the biological method, the silver nanoparticles can be synthesized using various biological systems like fungi, bacteria, plant extracts, and even biomolecules including vitamins and amino acids. This method is the alternative method for the chemical method. Biological methods are cost-effective and environment-friendly unlike chemical methods. The biological method gives a high yield of silver nanoparticles[32-36]. The advantages of the biological method involve the use of biological materials which is a non-hazardous, eco-friendly way to synthesize silver nanoparticles. This helps in obtaining defined particle size and shape thereby being used for various biomedical applications[37].

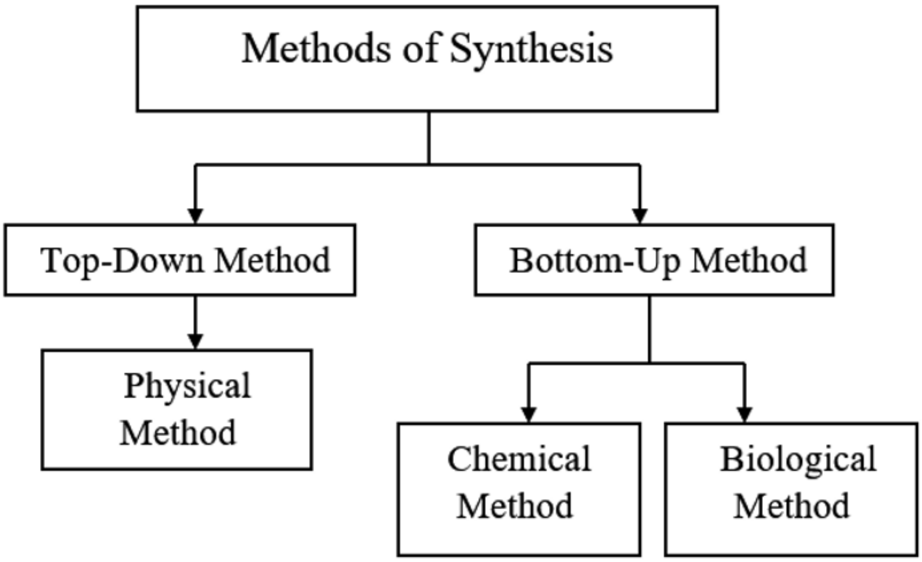

Fig Methods of Synthesis

III. APPLICATIONS OF SILVER NANOPARTICLES (AgNPs):

The applications of silver nanoparticles are widely studied based on their unique properties. These silver nanoparticles have a diverse range of applications with their antibacterial, antifungal, antiviral, anticancer, and antioxidant properties. The use of nanoparticles in the field of medicine, environmental studies, food packaging, bioengineering, electrochemistry, and catalysis have introduced silver nanoparticles as antiseptic agents[38].

- *Anticancer Applications of AgNPs:*

Nanoparticles can be developed into therapeutic agents for labelling, targeting, and therapy for cancer treatment. In the case of cancer, early detection is a significant process to ensure the treatment of the disease[39]. Nanoparticles that are peripherally conjugated with targeted moieties give site specificity to therapeutics. Wang et al[40] displayed that AgNPs (15 nm) can help in inducing apoptosis and improve radiosensitivity in cancer cells. They experimented with this on the rat glioma C6 cells for hyperthermia treatment. AgNPs displayed dose-dependent cytotoxicity on the C6 cells. The uptake of AgNPs into the cells can be improved by heating the cells[40]. AgNPs have the ability to inhibit the development of acute myeloid leukemia, a type of cancer by DNA damage and apoptosis [41]. Recent studies show the therapeutic application of AgNPs in the treatment of cancers like breast cancer, lung cancer, and skin cancer[44].

- *Antibacterial Applications of AgNPs:*

Due to the antibacterial activity of silver, it has been used as a therapeutic agent since ancient times. This is because silver has the ability to treat open wounds and burns. It can act against both gram-positive and gram-negative bacteria. Bacteria that can be resistant to multiple antibiotics find it difficult to develop resistance against AgNPs[42]. Kim et al[43] researched the antibacterial activity of silver nanoparticles against *E.coli* and *Staphylococcus aureus*. It was explained that at low concentrations E.coli was inhibited and had moderate growth inhibitory effects on *S.aureus*[43]. Thus, the antibacterial property of silver nanoparticles is explained.

➢ *Antiviral Applications of AgNPs:*

The antiviral property of silver nanoparticles has been taken into study nowadays. The HIV-1 virus known as the human immunodeficiency virus is a real threat to humans as it attacks the immune system directly and because of this the immune system loses its ability to control the effects of other pathogens leading to exposure to the body to other diseases. HIV-1 can be inhibited with the help of silver nanoparticles. The antiviral properties of silver nanoparticles are under study. It is also effectively used against the dengue virus[45].

➢ *Antifungal Applications of AgNPs:*

Fungal infections occur due to the fungal spores that get attached to the surface of the wound. Usually, fungal infections are mostly caused by the *Candida* species. The antifungal properties of silver nanoparticles depend on their concentrations. Silver nanoparticles act as a good antifungal agent against the fungi *C.albicans* by inhibiting the cell division process and disturbing the cell membrane structure of the species. Due to this the fungi gradually destroy and the infection eventually gets cured[46]. Thus, many antifungal creams and ointments consist of silver nanoparticles in them due to their excellent antifungal properties.

➢ *Antioxidant Applications of AgNPs:*

The presence of oxidants otherwise known as oxidizing agents in cells leads to oxidation reactions which is the main reason for oxidative stress. Oxidative stress does not harm the human body and has an irreplaceable activity of free radicals and oxidants in cell functions but increased oxidative stress is not required for the body. Antioxidants help in preventing cell damage and premature cell death due to oxidation reactions[48]. Silver nanoparticles as an antioxidant agent help in reducing the oxidants and free radicals for preventing oxidation reactions. Oxidative stress may also lead to diseases like Alzheimer's disease, atherosclerosis, cardiovascular diseases, cancer, ADHD, and schizophrenia[49]. The antioxidant activity of silver nanoparticles helps in scavenging free radicals[47].

➢ *Other Applications of AgNPs:*

In the world of commercialization, silver nanoparticles have unique and attractive applications in various fields. Silver nanoparticles are used in disinfecting clinical equipment, and home appliances. In the food industry, they are used to prevent food spoilage. In the textile industry, they are used as a coating material. Nowadays, silver nanoparticles are used in electronic products as well. Nanocomposite fibres are also prepared using the applications of silver nanoparticles[50]. Silver nanoparticles have a significant role in the bone healing mechanism as they are used in bone cement. They play a significant role in dental applications too because of their antimicrobial property[51,52]. Silver nanoparticles have a wide range of applications in several fields because of their excellent properties.

IV. CONCLUSION

Since silver nanoparticles have good antimicrobial properties, these particles are used as antiseptic material in ancient times and even now. The biological method of synthesis is the significant method to synthesize silver nanoparticles because of their environmentally safe properties and it is the cost-effective method. Silver nanoparticles being used in the medicinal field is one of the clear ways to explain its clinical applications to treat diseases. Silver nanoparticles are also used in the field of water treatment which explains the various other applications of AgNPs. Thus, the antibacterial, antifungal, antiviral, antioxidant, and anticancer activities give the diverse properties of silver nanoparticles and their applications.

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