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ASSESSING THE SYNTHESIS, MECHANISM AND PHARMACOKINETICS PROFILE OF SILVER NANOPARTICLES

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ABSTRACT

This study provides a comprehensive overview of silver nanoparticles (AgNPs) in medical applications, emphasizing diagnostic and therapeutic uses alongside their antimicrobial properties. Addressing nano toxicity concerns, the research explores AgNP mechanisms, synthesis methods, pharmacokinetics, formulations, and applications in infertility, antibacterial effects, skin damage, burns, and cancer treatment. The study delves into the potential toxicological challenges, presenting a nuanced perspective on the multifaceted role of AgNPs in medicine. The major applications of silver nanoparticles in the medical field include diagnostic applications and therapeutic applications, apart from its antimicrobial activity. Due to their Nano toxicity, AgNPs have a several drawbacks too. This study presents a complete view of the mechanism of action, synthesis, the pharmacokinetics of silver nanoparticles, different formulations of AgNPs used in biomedical applications, infertility management, antibacterial effects, skin damage, burns, cancer treatment, etc. and various applications of silver nanoparticles together with the possible toxicological challenge.

Keywords: - Applications, Mechanism, Silver, Nanoparticles, Liver.

I. INTRODUCTION

Nanotechnology has become a revolutionary approach in pharmaceutical research, providing exceptional prospects for the creation of novel treatment techniques in an ever-changing environment. Out of the many different nanomaterials, silver nanoparticles (AgNPs) have attracted significant interest because of their exceptional antibacterial characteristics. The unique physicochemical properties of AgNPs, including their size, shape, and surface charge, lead to their increased reactivity and prospective uses in the pharmaceutical industry. Silver nanoparticles, which generally have diameters between 1 and 100 nanometers, display unique features that set them apart from bulk silver due to their size-dependent nature. The production of AgNPs may be accomplished using many methods, each exerting an influence on their properties and possible uses. The main methods for AgNP synthesis include physical, chemical, and biological techniques. Physical approaches include procedures such as laser ablation or vapor condensation,

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which are used to reduce silver ions. Chemical procedures include reduction processes that use chemical agents such as citrate or sodium borohydride. In addition, the biological method employs microorganisms or plant extracts, demonstrating a more environmentally friendly and sustainable approach to the synthesis of AgNPs. The physicochemical characteristics of AgNPs are crucial in determining their effectiveness as medicinal agents. The nanoparticles' diminutive size enables easy infiltration into biological tissues, hence promoting heightened engagement with microbial cells. Furthermore, their significant ratio of surface area to volume enhances their responsiveness, allowing for efficient interactions with cellular components. The bioavailability and cellular absorption of AgNPs are affected by the surface charge, which is determined by the stabilizing agents used during synthesis. Comprehending and controlling these characteristics are essential for customizing AgNPs for particular pharmaceutical purposes, spanning from antibacterial substances to carriers for drug delivery. The primary pharmacological use of silver nanoparticles is their strong antibacterial effect. AgNPs possess a distinct capability to damage the cell membranes of microorganisms and hinder essential cellular functions. This characteristic makes them very viable contenders for addressing bacterial, viral, and fungal diseases. The increasing apprehension about antibiotic resistance has prompted the investigation of alternative antimicrobial agents, and AgNPs provide a feasible resolution to this worldwide health predicament. AgNPs possess a wide range of antibacterial properties and may effectively combat resistance mechanisms, making them very important in the field of pharmaceuticals.

Silver nanoparticles have shown great promise in drug delivery systems, in addition to their strong antibacterial properties. The adjustable physicochemical characteristics of AgNPs enable the containment and regulated discharge of medicinal substances. This feature is especially beneficial in improving the therapeutic effectiveness of traditional medications while reducing the occurrence of adverse effects. AgNPs has a wide range of applications in drug delivery, including their ability to deliver drugs to particular cells or tissues via surface changes that allow for targeted interactions. This focused strategy shows potential for strengthening the accuracy and effectiveness of medical treatments, decreasing overall harm to the body, and improving patient results. Moreover, the correlation between silver nanoparticles and biological systems has generated enthusiasm for their use in diagnostics and imaging. The optical characteristics of AgNPs, including their surface plasmon resonance, may be used for the advancement of biosensors and imaging probes. AgNPs' capacity to identify biomolecules with exceptional sensitivity and specificity establishes them as important instruments for the early detection of diseases and the monitoring of treatment reactions. Additionally, their ability to work well with several imaging techniques, such as fluorescence and surface-enhanced Raman scattering, broadens their usefulness in pharmacological research and clinical applications. As we explore the pharmacological properties of silver nanoparticles more extensively, it becomes clear that their potential goes beyond conventional therapeutic applications. The biocompatibility and minimal toxicity of AgNPs, when properly designed, provide opportunities for their use into medical devices and implants. Antimicrobial coatings containing silver nanoparticles may be used on surfaces in healthcare environments to reduce the likelihood of infections. This proactive strategy is consistent with the concepts of preventive medicine, which aims to tackle the issues presented by nosocomial infections and the transmission of antibiotic-resistant organisms.

To summarize, the pharmacological properties of silver nanoparticles constitute a dynamic and promising frontier in the pursuit of breakthrough therapeutic treatments. AgNPs, with their distinct synthesis processes and physicochemical features, have a wide range of applications in antimicrobial treatment, drug administration, diagnostics, and medical devices. They provide a versatile solution to current healthcare concerns. As we mark the one-year anniversary of our exploration of knowledge, we discover the tremendous potential of silver nanoparticles in the field of pharmaceuticals. This opens up several opportunities for enhancing healthcare and enhancing the lives of people across the globe.

II. SYNTHESIS OF SILVER NANOPARTICLE

Silver nanoparticles are often produced using two methods: the "top to bottom" technique and the "bottom to top" approach. The top-down approach involves reducing the size of a bulk material by using techniques such as grinding, milling, sputtering, thermal/laser ablation, etc. This method involves mechanically grinding bulk metals and then stabilizing them using colloidal protecting agents. On the other hand, the bottom-up approach involves synthesizing nanoparticles through chemical and biological methods.

This is done by self-assembling atoms into new nuclei, which then grow into nano-sized particles. The bottom-up methods include chemical reduction, electrochemical methods, and sono-decomposition. The primary benefit of the "bottom to top" approach technique is the rapid generation of a substantial number of nanoparticles in a short timeframe. Chemical procedures provide a significant advantage in terms of high yield, in contrast to physical approaches that have a poor yield. When using a "top to bottom" strategy, nanoparticles are typically manufactured by the evaporation condensation procedure using a tube furnace under air pressure.

In this procedure, the main substance positioned in the core of the furnace is transformed into a gaseous state by use of a carrier gas, contained within a boat. A major drawback of this process is the presence of flaws in the surface structure of the product, which significantly affects the physical characteristics of nanoparticles, particularly in relation to surface chemistry. Therefore, it was necessary to develop a cost-effective and environmentally acceptable alternative method, which resulted in the creation of green syntheses.

III. GREEN SYNTHESIS

The field of nanotechnology is witnessing a growing trend towards green synthesis of nanoparticles. This involves using biological entities such as microorganisms, plant extracts, or plant biomass to produce nanoparticles. This approach offers an environmentally friendly alternative to chemical and physical methods.

The use of green synthesis is favored over physical and chemical procedures due to its environmentally benign nature, cost-effectiveness, scalability for large-scale syntheses, and absence of high temperature requirements, energy consumption, and harmful chemical usage.

The utilization of plant extracts offers prospective advantages over microorganisms owing to the simplicity of enhancement, the reduced biohazard, and the less demanding technique of sustaining cell cultures as compared to the microbe approach (Figure 1).

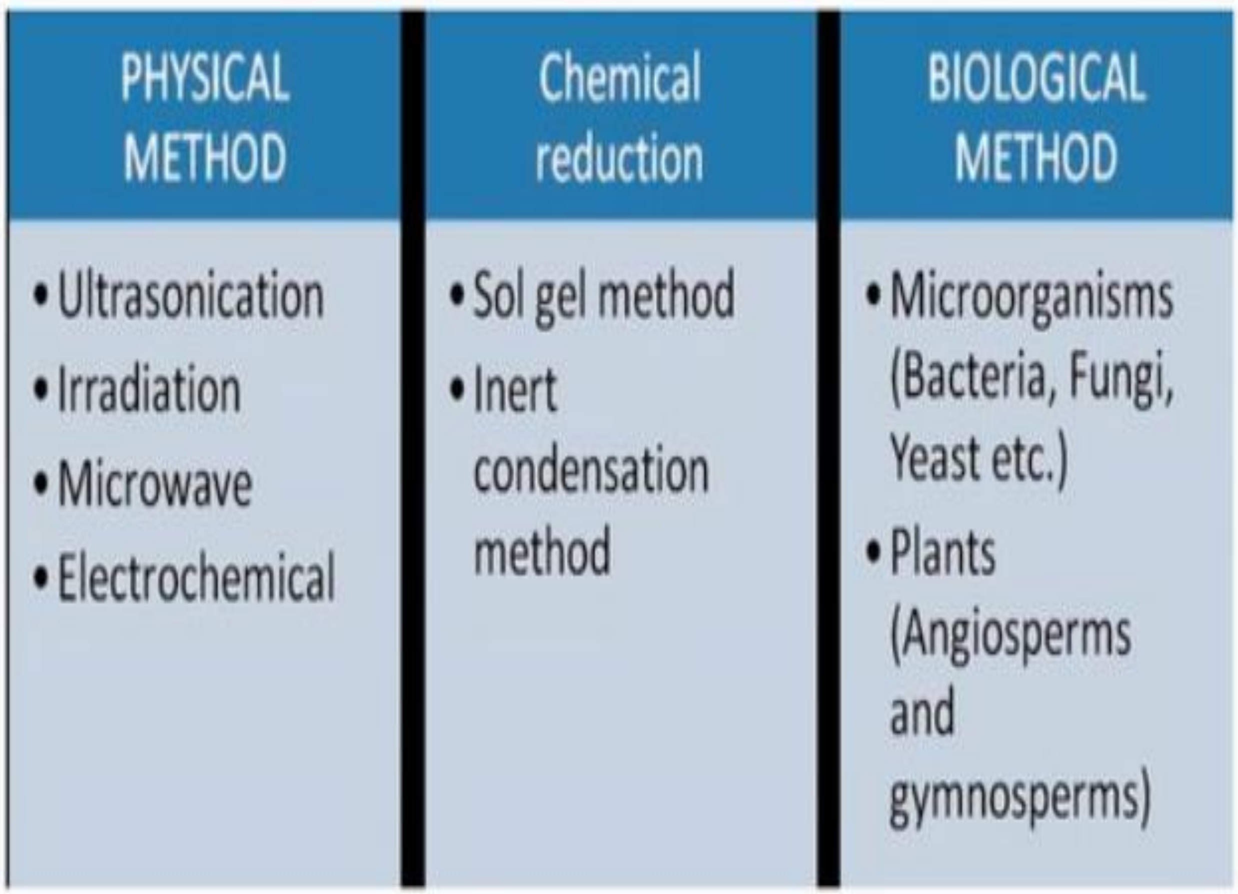

Figure 1. Different method of synthesis of nanoparticles.

IV. MECHANISM OF ACTION OF SILVER NANOPARTICLES

The precise mechanism behind the antibacterial effects of silver nanoparticles remains undetermined, despite the existence of different ideas. Silver nanoparticles adhere to the bacterial cell wall and infiltrate it, inducing changes in the structure of the cell membrane, such as increased permeability and ultimately leading to cell death.

Another method of action of silver nanoparticles is the generation of free radicals, which leads to cell death. The presence of free radicals is verified using electron spin resonance investigations.

Upon encountering bacteria, free radicals has the capacity to impair the integrity of the cell membrane, rendering it permeable and eventually resulting in the demise of the cell.

Compared to other salts, silver nanoparticles have effective antibacterial characteristics due to their extensive surface area, which enables enhanced interaction with microbes. Figure 2 demonstrates that the bactericidal activity of bacterial cells is enhanced by the discharge of silver ions from nanoparticles.

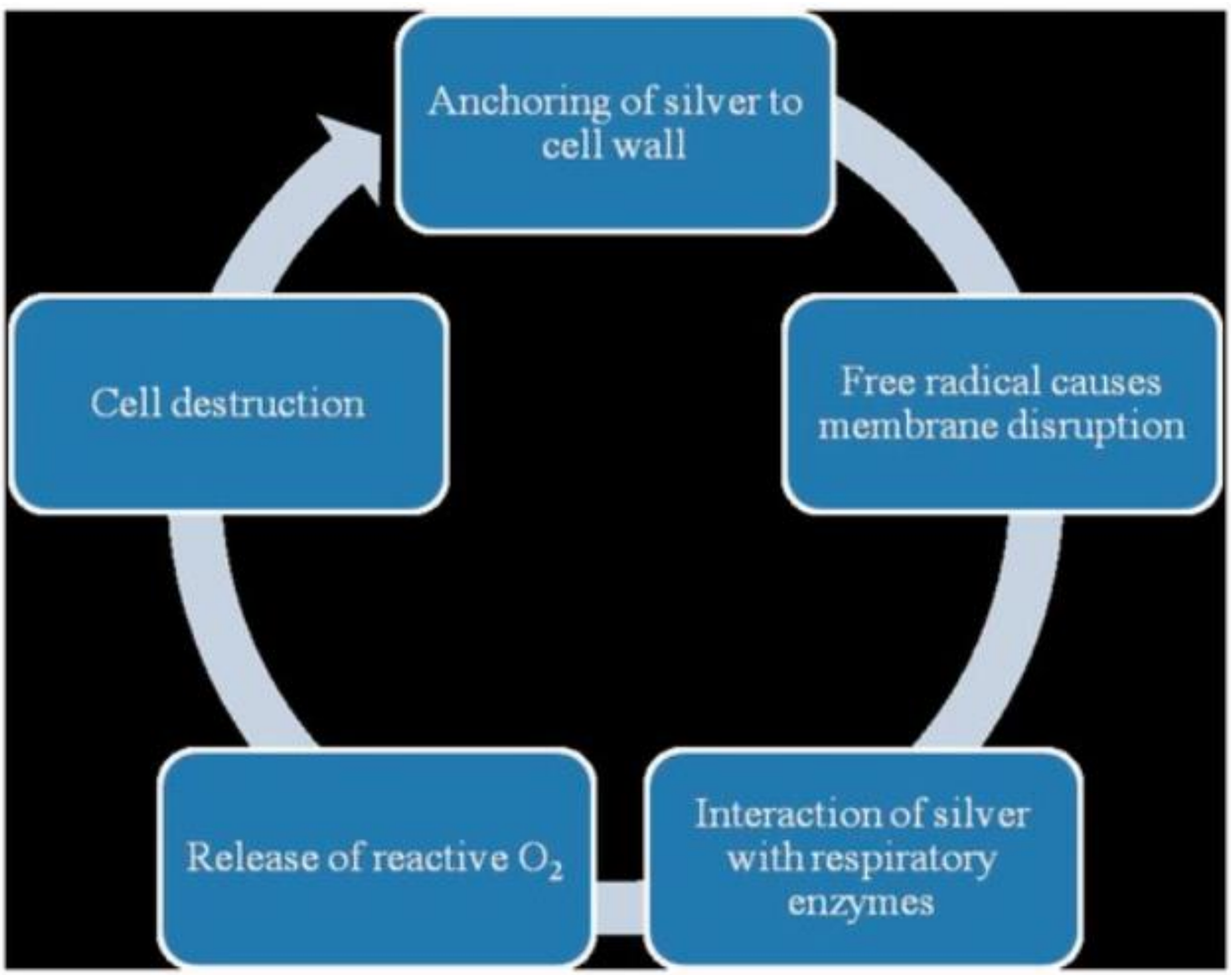

Figure 2. Mechanism of action of AgNPs.

V. PHARMACOKINETICS OF SILVER NANOPARTICLES

It is generally desired for medications or NPs to mostly accumulate in the target tissue in order to increase therapeutic benefits. Conversely, a high level of distribution to non-target tissues may lead to undesirable toxicity and should be prevented. Hence, it is important to get pharmacokinetic and tissue bio-distribution data in order to ensure the safe and effective use of NPs in biomedical applications.

Absorption

The process of nanoparticle absorption is more intricate than that of tiny molecules. Orally given nanoparticles may be absorbed by paracellular transport, transcytosis, and M cell uptake in the gastrointestinal system. On the other hand, macrophages and lymphatic absorption mostly absorb subcutaneous, intramuscular, or inhaled nanoparticles. Several studies have subjectively documented the absorption of orally administered substances in humans and other animals, but there is a limited amount of quantitative data available.

In 1980, East et al. examined the silver retention in a 47-year-old lady who had previously developed argyria. The study revealed that 18% of the orally delivered dosage was retained in the body, as determined by the use of a radioactive tracer. When comparing the oral administration of ionic silver with Nano particle silver, it was found that the Nano particulate silver had reduced bioavailability. This was determined by seeing greater amounts of excretion in feces and lower absolute quantities in organs during direct comparisons.

Distribution

The dispersion of nanoparticles in living organisms relies on many transport processes, including opsonization, protein corona formation, absorption by the mononuclear phagocyte system (MPS), the increased permeability and retention (EPR) effect, target-mediated disposal, and lymphatic transport. The liver has been identified as the main organ responsible for the dispersion of Ag, with the spleen and kidneys also playing a significant role. This applies to several routes of exposure, including oral, intravenous, subcutaneous, and inhalation. Silver deposition has been seen in many cell types inside the liver, including Kupffer cells, hepatocytes, and sinusoidal endothelial cells. Silver deposition was observed throughout the kidney, including the cortex, medulla, inner medulla, and cortical glomeruli. A gender-related difference was found in rats' kidneys regarding the accumulation of silver after repeated oral exposure, with females showing twice as much accumulation as males.

VI. CONCLUSION

The investigation of silver nanoparticles in pharmaceutical applications represents a significant advancement and potential in the medical area. AgNPs provide a versatile answer to current healthcare concerns due to their many synthesis techniques and wide range of applications in antimicrobial treatment, medication administration, diagnostics, and medical devices. On the one-year anniversary of our educational trip, we acknowledge the significant potential of silver nanoparticles in the field of pharmaceuticals. These nanoparticles provide several opportunities to transform healthcare and improve the overall health of people worldwide.

REFERENCES

1. Abderrhmane, Bouafia & Salah Eddine, Laouini & Ahmed, Abdelaal & Soldatov, Alexander & Algarni, Hamed & Chong, Kwok Feng & Ali, Gomaa. (2021). The Recent Progress on Silver Nanoparticles: Synthesis and Electronic Applications. Nanomaterials. 11. 2318. 10.3390/nano11092318.
2. Bamal, Deepak & Singh, Anoop & Chaudhary, Gaurav & Monu, Kumar & Singh, Manjeet & Rani, Neelam & Mundlia, Poonam & Sehrawat, Anita Rani. (2021). Silver Nanoparticles Biosynthesis, Characterization, Antimicrobial Activities, Applications, Cytotoxicity and Safety Issues: An Updated Review. Nanomaterials. 11. 10.3390/nano11082086.
3. Dawadi, Sonika & Katuwal, Saurav & Gupta, Aakash & Lamichhane, Uttam & Thapa, Ranjita & Jaisi, Shankar & Lamichhane, Ganesh & Bhattarai, Deval & Parajuli, Niranjan. (2021). Current Research on Silver Nanoparticles: Synthesis, Characterization, and Applications. Journal of Nanomaterials. 2021. 10.1155/2021/6687290.
4. Galatage, Sunil & Hebalkar, Aditya & Dhobale, Shradhey & Mali, Omkar & Kumbhar, Pranav & Nikade, Supriya & Killedar, Suresh. (2021). Silver Nanoparticles: Properties, Synthesis, Characterization, Applications and Future Trends. 10.5772/intechopen.99173.
5. Lin, Zhoumeng & Monteiro-Riviere, Nancy & Riviere, Jim. (2014). Pharmacokinetics of metallic nanoparticles. Wiley Interdisciplinary Reviews: Nanomedicine and Nanobiotechnology. 7. 10.1002/wnan.1304.
6. Panja, Amica. (2021). Silver Nanoparticles – A Review. Eurasian Journal of Medicine and Oncology. 10.14744/ejmo.2021.59602.
7. Reidy, Bogumiła & Haase, Andrea & Luch, Andreas & Dawson, Kenneth & Lynch, Iseult. (2013). Mechanisms of Silver Nanoparticle Release, Transformation and Toxicity: A

Critical Review of Current Knowledge and Recommendations for Future Studies and Applications. Materials. 6. 2295-2350. 10.3390/ma6062295.

8. Ritu & Verma, Krishan & Das, Asmita & Chandra, Prakash. (2023). Phytochemical-Based Synthesis of Silver Nanoparticle: Mechanism and Potential Applications. BioNanoScience. 13. 1-22. 10.1007/s12668-023-01125-x.

9. Salem, Heba & Eid, Kamel & Ma, Sharaf. (2013). Formulation and evaluation of silver nanoparticles as antibacterial and antifungal agents with a minimal cytotoxic effect. International Journal of Drug Delivery. 3. 10.5138/ijdd.v3i2.224.

10. Sukumaran, Prabhu & Poulose, Eldho. (2012). Silver nanoparticles: Mechanism of antimicrobial action, synthesis, medical applications, and toxicity effects. International Nano Letters. 2. 10.1186/2228-5326-2-32.

11. Syafiuddin, Achmad & Salmiati, Salmiati & Salim, Mohd & Kueh, Ahmad & Hadibarata, Tony. (2017). A Review of Silver Nanoparticles: Research Trends, Global Consumption, Synthesis, Properties, and Future Challenges. Journal of the Chinese Chemical Society. 64. 732-756. 10.1002/jccs.201700067.

12. Yadav, Sapna & Patil, Sudeep & Patel, Pratima & Nair, Vineeetha & Khan, Shahida & Kakkar, Shivani & Durve-Gupta, Annika. (2018). IJSRSET185425 | Green synthesis of silver nanoparticles from plant sources and evaluation of their antimicrobial activity.

13. Zahoor, Muhammad & Nazir, Nausheen & Iftikhar, Muhammad & Naz, Sumaira & Zekker, Ivar & Burlakovs, Juris & Uddin, Faheem & Kamran, Abdul & Kallistova, Anna & Pimenov, Nikolay & Khan, Farhat. (2021). A Review on Silver Nanoparticles: Classification, Various Methods of Synthesis, and Their Potential Roles in Biomedical Applications and Water Treatment. Water. 13. 2216. 10.3390/w13162216.

14. Zhang, Xi-Feng & Liu, Zhi-Guo & Shen, Wei & Gurunathan, Sangiliyandi. (2016). Silver Nanoparticles: Synthesis, Characterization, Properties, Applications, and Therapeutic Approaches. International Journal of Molecular Sciences. 17. 1534. 10.3390/ijms17091534.