ANTIMICROBIAL ACTIVITY OF SILVER NANOPARTICLES AND ACTION AGAINST MICROBS

Abstract

Currently, treating infectious diseases caused by microorganisms resistant to antibiotics is a huge concern for the entire globe**.** Finding alternate methods to cure diseases caused by resistant infections are urgently needed. And the Well-known and effective antibacterial agents are silver nanoparticles. This summary includes a retrospective of earlier reviews that have been written as well as recent unique addition on the development of research on the antibacterial activity of silver nanoparticles. The important subjects covered include bacterial resistance, cytoplasmic swelling (damage), Deoxyribonucleic acid (DNA) interaction, free radical production, release of Ag nanoparticles and Ag ions, and the link between resistance to Ag ions and resistance to AgNPs. The overview's main objective is to present a concise summary of the current idea of research on the antibacterial properties of AgNPs.

Keywords: Silver nanoparticles, nanotechnology, antimicrobial activity, antimicrobial mechanism, Bacterial resistance.

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I. INTRODUCTION

By manipulating structure and diameter at a nanoscale (1 nm to 100 nm), nanotech is described the characterization, pattern and application of structures, devices, and systems. It is a novel area of study with many scientific and technological uses, especially for developing new materials[1]. Recent years have seen the emergence of nanotechnology as a fast expanding subject with several biomedical research applications. Ag (Silver) has also been used as antibacterial agent that is generally devoid of side effects. A several types of Antimicrobial activities are present in AgNPs. AgNPs typically have dimension of less than 100 nm and consists 20 to 15,000 Ag atoms. even at low concentrations Silver nanoparticles have unique antibacterial action due to a high surface-to-volume ratio[2]. Additionally, they have minimal costs, low cytotoxicity, and immunological response[3]. As a result, there are several potential biomedical uses of AgNPs. They are utilised for molecular diagnosis, medical imaging, and medication administration[4]. AgNPs have been promoted as an effective antibacterial agent that can fight bacteria that cause illnesses both in vitro and in vivo. Gram -ve and Gram +ve bacteria, having multidrug resistant strains, are all covered by AgNPs' antibacterial ability. The capacity of AgNPs to kill different kinds of bacteria is a result of their varied modes of action, which permit them to target germs in many structures at once. AgNPs exhibit several simultaneous modes of action, and when combined with antibiotics or other biological substances that fight bacteria, they have a synergistic impact on pathogens like E. coli and Staphylococcus aureus[5]. AgNPs have received a great deal of interest, as shown by the considerable demand for related research. based on an expected 500 tonnes of nanoparticles yield each year in order to satisfy the requirement of various sectors, the market for AgNPs has been continuously expanding over the past 15 years[6]. The research of their biological process and the explanation of their precise mode of action in microbes and animal cells, has become a topic of concern because of the rise of the nanoparticle market globally and present offer of goods with included nanoparticles[7]. This analysis aims to identify factors that affect the antimicrobial and toxic effect of AgNPs, and highlight the benefits of make use of Silver NPs as new antimicrobial agents in addtion with antibiotics, which deduct the dose necessary and prevent secondary effects.

II. ANTIMICROBIAL MECHANISM OF SILVER NANOPARTICLE –

AgNPs have been demonstrated powerful antibacterial properties in opposition to both Gram +v &Gram -ve bacteria[8]. Silver nanoparticles can enter outer membrane of bacterial cell walls, affecting the composition of cellular membranes and potentially causing cell death[9]. They can create reactive oxygen species, make cellular membranes more permeable, and inhibit the duplication of DNA by releasing Ag ions[9]. Respiratory enzymes may become inactive and taking up of free silver ions into cells, producing reactive oxygen species (ROS) but inhibiting adenosine triphosphate (ATP) production[10]. Reactive oxygen species (ROS) have the potential to play a significant role in the damage of cellular membranes and DNA alteration. Since sulphur and phosphorus are crucial DNA building blocks, the dealing of Ag ions with sulphur and phosphorus can interfere with DNA replication, inhibit cellular growth, or kill the microorganisms. Ag ions can stop the formation of proteins by unfolding protoplasmic ribosomes[11].

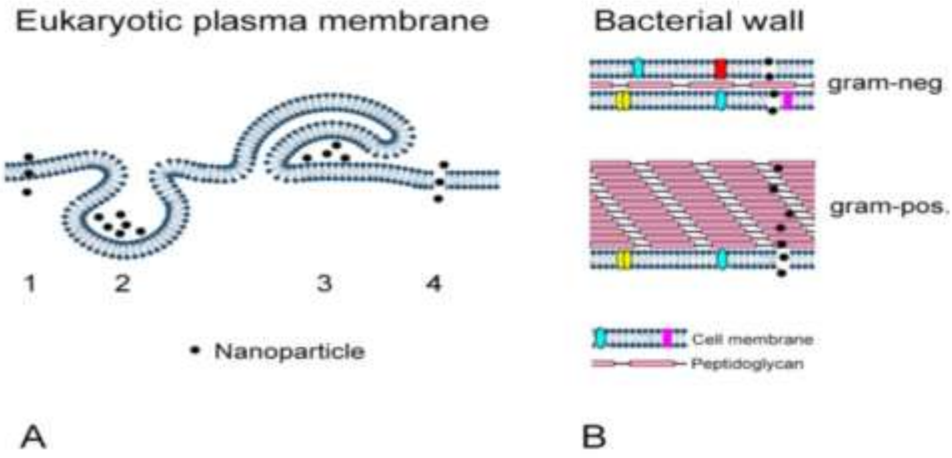

Figure 1: taking up of AgNPs by Animal cells (A) and by Microorganism(Bacteria) (B). (Source - Bactericidal and Cytotoxic Properties of Silver Nanoparticles by Chengzhu Liao, Yuchao Li et;al)

Denaturation of the cellular membrane can potentially split cell nucleus, centriole, mitochondria, ribosome and possibly cause cell distruction. AgNPs also perform major role in the transduction of bacterial signals. Protein phosphorylation of the substrate affected transmission of bacterial signal, and nanoparticles have the potential to dephosphorylate tyrosine residue on peptide substrate,Cell apoptosis and interruption of cell divisions are result from signal transduction disruption[12]. The level of Ag nanoparticle dissolution in exposure medium significantly impacts the antibacterial action and mechanism. The intrinsic features of AgNPs and the medium in which they are dispersed affect how well they dissolve[13]. Due to their increased surface area, smaller round or quasi-spherical AgNPs are more probably to release silver[14]. The surface of AgNPs is modified by capping agents, which can impact their dissolution behavior[15]. The existence of organic or inorganic components in the media impact how well silver nanoparticle dissolve. because they can aggregate with AgNPs or mix with Ag ions. In an acidic solution, AgNPs release Ag ions more quickly than in a neutral solution[16].

AgNPs are high effective against Gram -ve bacteria. Gram -ve bacteria have a unthicked cell wall than gram +ve ones. The strong plasma (cell) membrane may prevent NPs from entering cells[17]. The distinct antibacterial responses of both gram+ve and gram -ve bacteria to AgNPs show that the uptake of AgNPs is essential to the antimicrobial action[13]. It is known that Ag nanoparticle smaller than 10 nm have the potential to penetrate microbial cells, change cell permeability directly & harm cells.

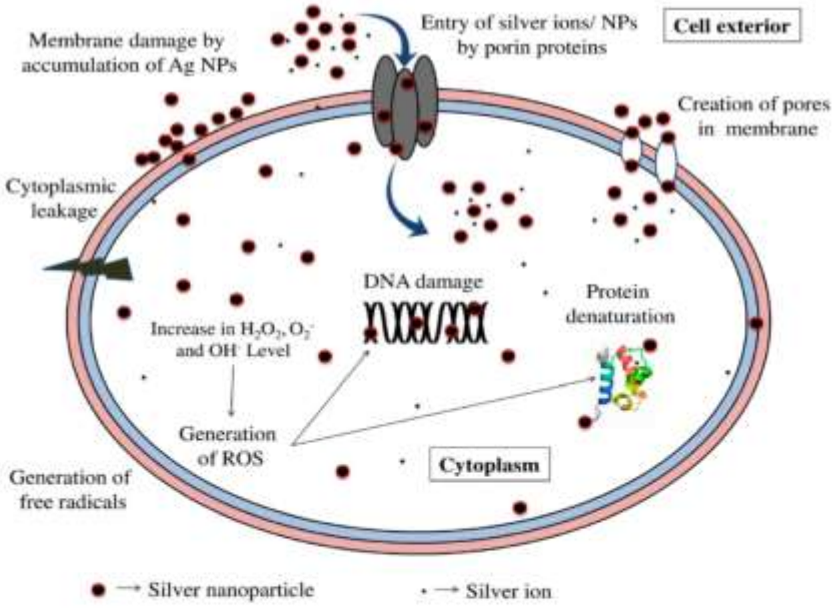

Figure 2: Bactericidal mechanisms of Silver nanoparticle because they make direct contact with the bacterial cell wall and release Ag ions. (Source -Bactericidal and Cytotoxic Properties of Silver Nanoparticles by Chengzhu Liao, Yuchao Li et;al)

III. AGNPS AS A DISTINCT METHOD OF FIGHTING HUMAN PATHOGENIC BACTERIA

Silver NPs have demonstrated a viable choice for killing certain bacteria. Additionally to being capable to stop the development of multidrug-resistant strains, Silver nanoparticle have certain qualities that make them effective against these bacteria[18-19]. Silver is the most effective metallic NPs against microorganisms. Additionally, silver is very biocompatible and simple to use in medicinal applications[20]. Another feature is that its antibacterial effect has been suggested to be mediated by a variety of mechanisms, some of which are thought to act on the cellular membrane, influence inside the cell components, and change the electron transport chain[21]. This final one is viewed as important for bacteria to become resistance against Silver nanoparticles, They would've been able to engage in numerous concurrent attacks. These reasons are why silver nanoparticles further been marketed as an alternative to antibiotics.[22-23].

Using AgNPs in addition with antibiotics, functionalizing or conjugating AgNPs with other molecules has also been suggested as a successful option to achieve significant bactericidal activity without causing the development of bacterial resistance[24]. Ashmore et al. [74] investigated the antibacterial efficiency of uncoated Silver nanoparticles vs coated Silver nanoparticles with PVP (Ag + PVP) and with a synthetic polymer (Ag + Polymer) against E. coli with the aim of testing this concept. Growth inhibition and MIC test findings revealed that Ag + Polymer was twice as effective as Silver nanoparticles[25-26] . Given the history described above, which is summarised in Table 1, there are still a number of benefits to using nanoparticles to combat germs.

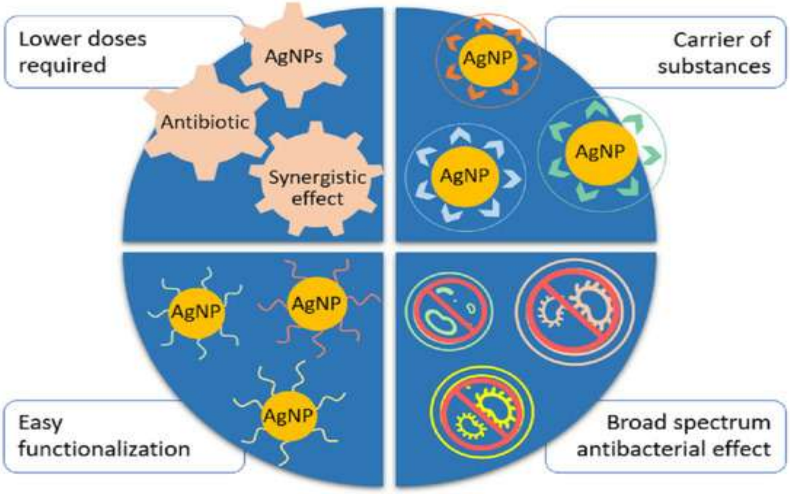

Figure 3: Significance of utilising AgNPs in combination or as an alternative to antibiotics.(Source; Tamara Bruna , Francisca Maldonado-Bravo, Paul Jara and Nelson Caro; Silver Nanoparticles and Their Antibacterial Applications)

Table 1: AgNPs combined with Antibiotics and their antibacterial parameters.

Antibiotic used with AgNPs	Bacteria tested	Antibacterial parameters	Reference
Erythromycin, ampicillin, cephalothin	Multiresistant S. aureus, S.mutans, S.oralis, S. gordonii, Enterococcus faecalis, E. coli	When coupled with AgNPs, antibiotics' antibacterial activity inhanced synergistically from no growth inhibition into the vulnerable range	27
Vancomycin, ampicillin, penicillin	S. aureus, E.coli, K pneumoniae	Ampicillin combine with AgNPs is efficient opposed to all microorganisms. When conjugated with AgNP, all antibiotics will have increased antibacterial activity.	28
Azlocillin	P. aeruginosa	The antibacterial activity of silver NPs combine with azlocillin increased from MIC = 8 ppm for azlocillin alone to MIC = 4 ppm AgNPs + azlocillin.	29

Vancomycin, amikacin	E. coli, S. aureus	Antibiotic-functionalized AgNPs shown synergistic antibacterial activity. Vancomycin resistance to susceptibility in the instance of E. coli.	30

IV. ANTIMICROBIAL AGNPS IN HEALTHCARE APPLICATION

The fields of medicare and health are those where antimicrobial nanoparticle technology is being researched and developed the most[31-32]. Silver nanoparticle may be applied to many products with bactericidal properties due to their biocompatibility and rapid functionalization. The usage of AgNPs in face masks to enhance their level of protection is one of their primary uses. The face mask invented by Y. Li et al.[33] that was coated with nanoparticles made from titanium dioxide and silver nitrate shown the capacity to eliminate up to 100% of E. coli and S. aureus Colony Forming Unit (CFU) within 24 hours. Same research involved treating a industrially obtainable mask with compound of AgNPs at 50 and 100 ppm concentration, producing masks with intigrated NPs that may stop the development of E. coli and S. aureus[34]. These findings are extremely encouraging since face masks enhanced with silver nanoparticles might prevent from infections in settings like hospitals where harmful bacteria are persistent in high levels[35]. additionally the silver's antibacterial action, studies on its healing characteristics and its NPs have led to the expansion of a variety of wound dressings with improved healing and antimicrobial affects. In order to treat superficial wounds, Tian et al.[36] applied a compound of AgNPs. They discovered that this therapy helped the wounds heal more quickly and with greater skin regeneration. Due to this identical characteristic, research led to the synthesis of a topical AgNPs solution for treatment on burns and other skin lesions. The outcome was a establishment antibacterial activity without harmful side effects and the capacity to accelerate the healing of wounds[37]. Additionally, research has been done on the possibility of improving antibacterial action by combining AgNPs with organic compounds. For instance, lignin and polyvinyl alcohol were used to formulate a hydrogel which contained in-situ synthesised AgNPs. The synthesised compound shown strong antimicrobial activity against S. aureus and E. coli, after 10 hours of treatment, practically all bacteria had been killed[38].

V. CONCLUSION

AgNPs are an amazing antibacterial agent and currently have excellent antibacterial properties. They address a number of requirements that are thought to be necessary for new antimicrobial technologies to meet in must be in order to effective, including antibacterial performance, fast action, and lower cytotoxicity. Moreover, Nps can be altered to attain delivery & selectivity to certain targets. Their usage opposed to microorganisms must be controlled & assessed to prevent inappropriate exposure of pathogens to sublethal dosages that may encourage the emergence of toleration to this against. Utilising AgNPs minimises the dosages of antibiotic and nanoparticle needed to exert efficient antibacterial activity opposed to variety of bacteria, reducing the possibility of adverse effects. In addition, NPs have antimicrobial action against a range of different bacterial species (gram +ve and gram -

ve) as well as resistant strain and may be functionalized with various compounds to increase their antibacterial efficacy. Nanoparticles can form complexes can operate as drug carriers or antibiotics. This research highlights the antibacterial mechanism, potential, and possible medicinal uses of silver nanoparticles and offers an overview of their antibacterial usage.

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