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THERAPEUTIC POTENTIAL OF SILVER NANOPARTICLES AGAINST MULTI DRUG RESISTANT HIGHLY PATHOGENIC E. COLI O157:H7

Sidra Aftab[1*], Umbreen Shaheen[1], Abdul Samad[2], Asad Shah[1], Asadullah[2],
Sana Saeed Ahmad[1], Farkhanda[1], Farha Manzoor[1]

[1]**Department of Zoology** University of Balochistan, Quetta, Pakistan
[2]**Center for Advanced Studies in Vaccinology & Biotechnology (CASVAB),**
University of Balochistan, Quetta, Pakistan
*Corresponding Author: Sidra Aftab. E. mail: sidranazeeraftab@gmail.com

Abstract

Bio-Nanotechnology has quickly become a burgeoning field of study that encompasses the creation and improvement of various nanomaterials. Nanotechnology, including the use of substances with sizes on the atoms and molecules level, is gaining popularity in therapeutic diagnostics and is attracting a lot of attention as a way to kill or reduce the activity of a variety of bacteria. Silver nanoparticles, on the other hand, have piqued researchers' curiosity due to their antibacterial and antifungal capabilities. Silver nanoparticles enter bacterial cells and interact with their molecular structures, preventing them from growing. Silver nanoparticles of smaller sizes yield better results than those of larger sizes. SNPs have been shown to have antiseptic effect beside nearly drug-resilient microorganisms. Microorganisms resistant to numerous antimicrobial treatments have boosted demand for new disinfection technologies. There are many various types of antibacterial agents available, each with its own set of qualities; however, in order to achieve the intended antimicrobial effect, the correct disinfectant must be carefully selected for each application. This review suggests that silver nanoparticles were tested for antibacterial efficacy against E. coli O157h7 and these tests imply that SNPs can be employed as actual progress restraint in a variety of bacteria, potentially making them useful in medical devices and antimicrobial control systems.

Keywords: *E. coli (Escherichia coli), Hemolytic uremic syndrome (HUS), Silver nanoparticles (SNPs / AgNPs)*

INTRODUCTION

Nano is derived from the Greek word "dwarf." A nanoscale (109) is a millionth of a millionth of a billionth of a meter. A normal sheet of paper is about 100,000 nm thick, an erythrocyte is about 2,000 to 5,000 µm in diameter, and the size of DNA is in the region of 2.5 nm. One nanometer is about 60,000 times smaller than the width of a human hair or the size of a virus. Nanotechnology, thus works with materials ranging in size from one-half the diameter of DNA to one-tenth the diameter of an erythrocyte (1). Nano-technology has recently been developed by means of a rapidly growing field of systematic awareness around the sphere. Nano-particles are micro-scale particles with sizes alternating as of 1nm to 100nm (2). The term 'nano' indicates 1 billionth of a meter. In 1974 Lecturer Norio Taniguchi from University of Science, Tokyo invented the word 'Nano-technology' to e? accuracy of mechanized resources at nanometer stage (3). Nanotechnology gave rise the existence of various types of food products and reduce the amount of food that is wasted by microbes (4). Bio-nanotechnology creates a link across bio- and nanostructures by attempting to uncover the fundamental values behind biological processes as well as the development of instruments for precise material handling so at nanotechnology (5). Nano-biomaterials outperform other forms of biopolymers because of their great flexibility and sensitivity to natural systems, which also includes antivirulence systems, making them ideal instruments for bioscience studies. Ag nanoparticles are a good example of this; because of their intrinsic characteristics, cytocompatibility, and antimicrobial potential, they've been used in a variety of biological systems, resulting in the development of various nano particles carring vehicles (6). It's also worth noting that nanoparticles are so small that as bacteria might require a microscope to view them (7). Nanoscience has been one of the very productive scientific fields in the previous 20 years. Technological advancement appears to improve applications in areas like as processing, communications, and biomedical research, hence nanotechnology is crucial (8, 9). The functions of nanotechnology are spreading fastly in the various fields of science for developing latest products at nano scale (10). Because of their high surface-to-volume ratio, nm size nanoparticles have distinct and dramatically altered physiological, biochemical, and metabolic properties when compared to their macro-scaled equivalents. As catalysts and sensors for optical, antimicrobial property, and file storage, these nanoparticles have shape and structure characteristics (11, 12). To get a higher yield in drug delivery to a specified target while preventing a wide dissemination of the medicine, it is required to improve material characteristics and nontoxicity. In light of this, substance formation and synthetic organic science have improved the interaction of inorganic surfaces on metallic NPs with the surrounding media by the formation of covalent networks or polymers bioactivity (13, 14). Recent progresses in nanotechnology enable the control of nanoparticle size and shape, as well as a variety of applications for nanoparticles in the detection and treatment of many diseases. Small nanomaterials (less than 30 nm) seem to be the best at piercing bacterial cell walls. Nanoparticles of all sizes and shapes, especially those with a tiny diameter and a positive surface charge, are known to interfere with cell membranes, resulting in cell death. Nanoparticles having a positive surface charge interact electrostatically with negatively charged microbe surfaces, attracting them to the bacteria and allowing them to penetrate the membrane. Although one study found comparable quantities of free radicals even at small levels of nanoparticles that did not impair cell viability, this is a nearly globally accepted mechanism of nanoparticle antibacterial activity (15). Nanomaterials are currently widely employed in the manufacturing mills (16). Nanoparticles also customized to assist its use in additional sectors, like in life science and medication, using cutting-edge technology (17).

SILVER NANOPARTICLES AND ITS APPLICATIONS

Silver nanoparticles' unique qualities make them appealing for use in commercial and research applications such as antibacterials, antiseptics, diagnostic materials, composite materials, cryogenic superconductivity materials, beauty products, and electrical items (18). AgNPs can be tangled in a matron using particular medication transport network or liquefied in a watery surroundings to prevent cluster formation (e.g., the medicine is liquefied, captured, condensed or involved to a nano-particle medium). Because of their efficiency at small dosages, minimal toxicity, and side effects, these particles are a promising choice for research as microbicides (19). The surface plasmon resonance of a silver nanoparticle determines its optical characteristics, at which Photon emission is the collaborative vibration of charged particles inside the silver nanoparticle. The size and shapes of the nanoparticle, the silvery species, and the underlying media are all known to affect the Polarization resonating maxima and lines length. Nanostructures made up of 2-8 metal atoms, for example, could be used to replace visual data collection. Furthermore, luminous discharges from colonies could be used for organic tags and luminescent panels (20, 21). Silver nanoparticles are synthesized and stabilized using a variety of physical and chemical processes (22, 23). Though numerous approaches are utilized in the development of nanoparticles, green methods are the most effective and have grabbed the interest of scholars due to their high efficiency and pollution-free nature (24). Antimicrobial property of SNPs in biomaterial has been demonstrated against a variety of bacteria species (25). AgNPs' bactericidal impact was studied, and four basic modes of action were discovered and these are (1) SNPs in the size around 1nm to 10 nm binds with the cell membrane's surface and significantly disrupt its working capability, like agreeability and metabolic processes, (2) SNPs can diffuse microbial unit then cause contamination, probably by combining along sulphur and phosphorus-concerning compounds, for example DNA (3) SNPs release Ag ions that are too sensitive and may react with the negatively charged cell membrane, adding to the overall contribution (4) AgNPs can penetrate bacterial cells and cause damage (26). AgNP movement within the cell starts with identification of cell membrane receptors, ingestion, and transportation, and finishes with cell breakdown, aggregation, or removal. Absorption is a time, dosage, and resources process for most cells, with phagosomes as the main targeted structures (27, 28). Silver has been used in form of particles for over a century, and it has been recognized as an antibacterial substance in the U. S. since 1954. Technological breakthroughs, on the other hand, have only recently created new potential uses for this substance at the nanometer scale. SNPs exhibit offer different biochemical, mechanical, electronic, and emission spectra, and were found to be more antibacterial than pure Ag due to their high surface-to-volume ratio (29, 30). SNPs are extensively used for a primary element in commercial, everyday life, and universal health care goods due to their strong antibacterial activity (31). Silver is known for its effectiveness in many fields like inhibit spread of infection, curing lesions thus acts as antibacterial and antifungal agents (32). The most essential properties of nanoparticle systems are particle size and size distribution. They determine nanoparticle systems' in vivo dispersion, biological destiny, toxicity, and targeting capabilities (33). Silver has a long history of usage in wound care. Silver was administered to wounds in Egypt about 1850 BC, and Hippocrates' publications mentioned silver's beneficial properties in wound healing (34). Silver-based lotions and moisturizers, as well as SNPs-based medicinal goods, including wound dressings, are now widely available on a wide range of medical applications due to their broad-spectrum antimicrobial potential (35). Silver-based wound dressings have been developed and refined, with more intricate designs and spent a great deal when opposed to traditional dressings (36). When compared to conventional 1 percent Silver sulfadiazine cream or ordinary pelumpong gauze, Silver nano particles used in wound dressings can improve soothing in trivial burn injuries while having no effect on medicinal in deep burn wounds, speeding up re-epithelialization while preventing new cell growth, i.e., tissue regeneration and development (37). Nanosilver can be found in a fluid state, such as an emulsion (covering and spraying), or in a conditioner (solvent), as well as incorporated in a firm, as in a polymeric master batch or embedded in a mild cleanser (solid). Nanosilver (AgNPs) is said to have antimicrobial effects (38). Anti-inflammatory (39). Moreover, anti-viral activity (40). The antimicrobial action of several metallic nano-particles, including Ag smash, is, for example, thoroughly associated to its size; that is, the slighter the Ag cores, the stronger the antimicrobial action. Furthermore, these nanoparticles' incentive action influenced by their mass, arrangement, character, size distribution, and organic-corporeal situation. To combat the uneven size distribution, diverse synthesis techniques, reducing agents, and stabilizers are used to achieve particular control of shape, size, and size distribution (41). Absorption, toxicity, capacity to enter cellular boundaries, and specific antibodies are all mediated by SNPs size (42, 43). Excellent thermal and electrical resistivity, ground Emission spectrum, nontoxicity, high conductivity, and nonlinear optical phenomena are all characteristics of AgNPs (44). These characteristics suggest that they could be useful in adhesives, nano technology, and diagnostic devices (45). In 1995 Dr. Robert Burrell makes the worlds earliest found nano silver lesion bandage. He makes silver dressings for wound care, which accelerate the curing procedure and eradicate wounds (46).SNPs have many exclusive functions and uses in daily life (47). In a broad field of user materials like cleanser, anklets, sprayer, cushions, dentifrice, shampoos, detergents and so on, Silver Nanoparticles are utilized as antifungal and antibacterial agents (48). Additionally, they are utilized in a wide range of commercial products, such as textiles, detergents, pastes, cosmetics, and fabrics, thereby enhancing their market value (49, 50). AgNPs are used in Soaps, creams, baby wipes, antiperspirants, mouth treatments, and face and body foams (51). A cleansing soap containing nano silver was shown to have antibacterial and fumigant characteristics and was effective in treating pimples and sun exposure (52). SNPs coated on a filtration system, for example, are resistive to cleaning and might be used to eliminate microorganisms from the water (53). AgNPs are involved in cutaneous stiffness and epithelial keratinocytes following healing process, and they lead to a faster wound closure rate (54). The AgNPs put on to soft cloth and bandages resulted in a significant improvement in healing process in an average time of 3.35 days, and pathogen elimination from open wounds was also enhanced with no negative impacts (55, 56, 57, 58). SNPs have antibacterial capabilities, causing lesion irritation to decrease and profibrotic mediators to be regulated (59). Silver nanoparticles are employed in T-shirts, athletic apparel, undergarments, stockings, and other items by integrating them into fibers or coating them with fibers (60). AgNPs have recently gained interest for cancer targeted therapy as tumoral agent, in detection, and in research, therefore this study looks into the mechanism of tumoral action, treatment methods, and restrictions of nanomaterials in tumor hospital treatment. Silver nanoparticles are also efficient against a wide range of gram-positive and gram-negative bacteria, as well as antibacterial drugs species (61). It is stated that silver even at very low concentrations exhibit a strong bactericidal effect that's why it is described as 'oligodynamic' (62).

ESCHERICHIA COLI O157:H7

Though maximum *E. coli* straining are nonpathogenic, few types produce verotoxins, like *Escherichia coli* O157:H7 (produces contaminants that are similar to those generated by Shigella dysenteriae) (63). This strain of *E. coli* is regarded to become the most pathogenic. *Escherichia coli* O157:H7 infections have been related to the intake of animal-sourced foods (for example, undercooked meat) (64). *Escherichia coli* O157:H7 is a common source of diarrhea, hemorrhagic colitis, and hemolytic-uremic disease all around the world. Intake of tainted and raw milled beef, along with unpasteurized fruitlet extracts, is frequently associated to the sickness (65). These bacteria are suspected of causing more than 73,000 cases of sickness per year in the United States, as well as 250 deaths (66). *Escherichia coli* O157:H7 transmission has grown additionally communal in kids under the age of five, with significant rates of death. *E. coli* O157:H7 is thought to cause between 0.6 percent and 2.4 percent of all dysentery with blood, and specifically 15 percent to 36 percent of all diarrhea with blood (67). Cattle are the main unaltered vector for *E. coli* O157:H7, and outbreaks are typically linked to infected beef. Various food elements, including as dairy products and green vegetables, are also linked to outbursts (68). Sheep and cows are the maximum common carriers of *Escherichia coli* O157:H7 infections and the majority of illnesses are linked to infected cow dietary items (69). Dogs, birds, horses, and deer are also carriers of this bacterium (70). Every year, this bacterium causes around 73,480 foodborne diseases in the United States, resulting in 61 deaths and 2168 hospitalized cases (71). The disease Enterohemorrhagic Escherichia coli (EHEC) O157:H7 is one of the most important foodborne pathogens in the food business, causing a slew of high-profile and costly recalls (72). The infection induced by E. coli O157:H7 can cause colon swelling, gastroenteritis, and stomach cramps, as well as severe diarrhea (73). Infection with *Escherichia coli* O157:H7 can lead to mortality, especially in those with weakened immune systems. (74). HUS is the product of *Escherichia coli O157:H7* infections that are illustrated by thrombocytopenia, renal injuries and hemolytic anemia (75).

EFFECT OF SILVER NANOPARTICLES ON *E. COLI O157:H7*

Silver is a non-toxic inorganic antibacterial that can kill a wide range of disease-causing germs (76). SNPs are emerging as new bactericidal drugs, with potency compared to ordinary medications and even higher antibacterial strength (77). For Centuries silver is used as a safe, non-poisonous antimicrobial agent and has the ability to kill over 650 infectious microbes (78). SNPs show efficient properties in opposition to bacteria that are defiant to antibiotics (79). It is familiar that SNPs are extremely poisonous to microbes and exhibit great bactericidal effect on different bacterial species along with *E. coli* (80). SNPs with a diameter of approximately 12 nm being put into agar medium at levels of 10–100 g/ml to examine the performance of SNPs concentrations to inhibit microbial activity on petri dishes (81). Silver Nanoparticles (SNPs) after invading the bacterial cell form a microscopic mass inside the cell and eventually failed the bacterial respiratory system which results in bacterial cell death (82). Bacterial death happens once ions arrive the cell barriers and vacuoles of bacterium, resulting harm to cell components like the cellular membrane, cytoplasmic sheath, and sheath components. Ag ions bond to RNA and DNA particles inside the cell, causing them to condense. This makes ribosomes work harder to transcribe or read DNA and RNA, which is required for protein synthesis and cell division (83). Silver's antibacterial functions are because of its great response to protein, alterations in the structure of membrane and cell wall, which result in cell death (84). It is approved the antibacterial applications of SNPs in opposed to *E. coli* O157:H7 in Lysogeny Broth (LB) medium. There found inverse relationship between survived *E .coli* and Silver Nanoparticles concentration. Rise in SNPs concentration results in reduced bacterial numbers (85). From metals the discharge of silver ions greatly enhances the antibacterial consequences. In comparison, silver Nanoparticles with increased surface area results in powerful antibacterial reactions (86). SNPs are efficient disinfectants unconcerned with the cure fighting system that occurs in many drug resistant like ampicillin-protective *E. coli* O157:H7 etc. Thus, SNPs are suggested as an effective vast ranged disinfectant (87).

CONCLUSION

Because standard antibiotics are becoming increasingly ineffective, nanoparticles are gaining potential for practical antimicrobial effects and applications. This makes the possibility of using nanoparticles to treat infection highly appealing. The basic aspect of a nanomaterials and the mechanism it interfaces with and enters bacteria looks to provide certain novel antibacterial processes when particle size decreases into the nanometer zone (owing to the higher surface to volume ratio of a known mass of nanoparticles).

In contrast to standard antimicrobial treatments, silver nanoparticles' antimicrobial activity is gaining traction due to their broad variety of cell targets. AgNPs were found to have antibacterial activity against *E. coli* O157:H7. The inhibitory effects increase as the concentration of AgNPs increased. Results indicate that AgNPs may distort and damage bacterial cell membrane, resulting in a leakage of intracellular contents and eventually the death of bacterial cells.

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