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A REVIEW ON ROLE OF SILVER NANOPARTICLES IN VARIOUS SECTORS

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ABSTRACT

Materials known as nanoparticles range in size from 1 to 100 nm and are improbably small. Based on their size, shape, and material characteristics, nanoparticles can be classified into a number of different classes. Fullerenes, metal nanoparticles, ceramic nanoparticles, and polymeric nanoparticles are categorized separately. Due to their vast surface area and small size, nanoparticles have distinct physical and chemical characteristics. Because of their distinctive physical and chemical characteristics, silver nanoparticles (AgNPs) are increasingly used in a diverse range of industries, including medicine, food, health care, consumer goods, and electronics. Among them are high electrical conductivity, optical, electrical, thermal, and biological characteristics. They have been used for a wide range of things because of their peculiar properties, including antibacterial agents, industrial, domestic, and healthcare-related products, consumer goods, medical device coatings, optical sensors, and cosmetics, pharmaceutical and food industries, diagnostics, orthopaedics, drug delivery, as well as anticancer agents, and ultimately to improve the tumor-killing effects of anticancer medications.

KEYWORDS: NanoParticles, Fullerenes, Conductivity, AgNPs, Orthopaedics

INTRODUCTION:

Nanoparticles are materials that are impossibly small, with sizes ranging from 1 to 100 nm. Nanoparticles fall into a variety of different groups depending on their size, shape, and material properties. Among the different classifications are fullerenes, metal nanoparticles, ceramic nanoparticles, and polymeric nanoparticles. Nanoparticles have unique physical and chemical properties due to their enormous surface area and nanoscale size [1, 2]. For more than a century, metallic nanoparticles have intrigued scientists' interests. Presently, they are widely used in engineering and the biological sciences[3].The previous couple decades, The production of metallic nanoparticles has dramatically increased. As a result, multiple methods involving various physical and chemical processes have been devised for producing metallic nanoparticles. However, it is challenging to employ these conventional procedures on a big scale because of their shortcomings. These negatives include the production's high energy requirements, greater synthesis process costs, and the use of hazardous chemicals[4]. The goal of green synthesis is explicitly to utilise fewer dangerous chemicals. The synthesis of green nanoparticles has a wide range of possible applications in the environmental and medical sciences. Green synthesis can be used to create nanoparticles such as gold, silver, copper, palladium, platinum, zinc oxide, and titanium dioxide, among others [5].Silver nanoparticles (AgNPs) are one of the most significant and intriguing nanomaterials among the various metallic nanoparticles employed in biomedical applications. AgNPs in particular are essential for nanomedicine and other nanoscience and nanotechnology disciplines.

Despite the fact that numerous noble metals have been used for a variety of purposes, AgNPs have drawn special attention because of their potential for use in the prevention and treatment of cancer [6].

Silver nanoparticles (AgNPs) display various physical and chemical properties when compared to their macroscale analogues [7].

APPLICATIONS OF AgNP's

Silver nanoparticles (AgNPs) are being used more and more in a range of industries, including medicine, food, health care, consumer products, and electronics because of their unique physical and chemical properties. High electrical conductivity, optical, electrical, thermal, and biological properties are a few of them. Due to their unusual properties, they have been applied for a variety of purposes, such as antibacterial agents, industrial, domestic, and healthcare-related products, consumer goods, medical device coatings, optical sensors, and cosmetics, pharmaceutical and food industries, diagnostics, orthopaedics, drug delivery, as well as anticancer agents, and ultimately to enhance the tumor-killing effects of anticancer medications.

1.BIOCATALYSTS

The recent years have seen a significant increase in interest in size- and shape-specific nanoparticle syntheses and their catalytic applications. Due to its intrinsic benefits, such as gentle reaction conditions and good selectivity, homogeneous catalysis is significant.

However, compared to its heterogeneous equivalents, it has themajor disadvantage of catalyst-product separation and recycles, which limits their uses. An additional way for combining the benefits of heterogeneous and homogeneous catalysis is to use nanoscale catalysts. Silver nanoparticles are important as they find applications in catalysis, organic transformations, synthesis of fine chemicals and organic intermediates.

The use of Ag nanoparticles in the catalysis avoid the use of ligand and it tends to easy removal of catalyst which can be reusable. Catalytic efficiency of synthesized AgNPs was evaluated for the reduction/degradation of various organic dyes such as 4-nitrophenol (4-NP), methylene blue (MB), methyl orange (MO), phenol red (PR) and direct blue 24 (DB24). It was found that degradation of MB and DB24 was faster than that of other dyes. This is the first report on degradation of organic dyes PR and DB24 using $NaBH_4$ as reducing agent in the presence of catalytic amount of AgNPs.

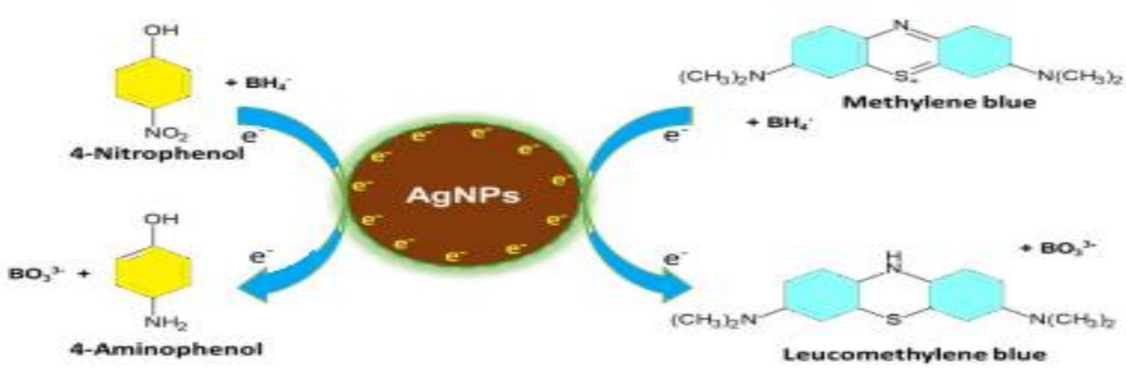

Fig 1: Schematic representation of catalytic process occuring in presence of AgNPs

2. ANTI-MICROBIALS

Food borne illnesses have grown to be a serious public health issue all over the world. Around 30% of people in industrialized countries experience food borne infections each year, according to the WHO (2014). The consumption of foods contaminated with food borne pathogens such bacteria, fungi, viruses, and toxins is frequently recognized as the main contributor to food borne illness in humans. Food can become contaminated at any point in the preparation process, including before, after, during transit, and even while minor preparation. The most common foodborne pathogens that can be found in food include Salmonella spp., Listeria spp., Escherichia coli O157 (Heiman et al., 2015), Campylobacter spp. (Kaakoush et al., 2015), and Clostridia spp. (Lee et al., 2016). (Chukwu et al., 2016). AgNPs with a size range of 10–100 nm demonstrated a potent antibacterial action on both Gram-positive and –negative bacteria. The smaller particle size of AgNPs, which makes it easier for them to adhere to cell walls and enter bacteria cells, has improved their antibacterial action against bacteria. A variety of studies have identified the antimicrobial effects of AgNPs against multidrug resistant bacteria, and it has been shown that these bacteria, including multidrug resistant Escherichia coli, a multidrug resistant strain of P. aeruginosa, and methicillin-resistant Staphylococcus aureus, are successfully combatted by AgNPs. Unknown is the precise antibacterial mechanism of AgNPs[8] Some studies, however, have hypothesized that AgNPs capacity to infiltrate cells, the generation of free radicals within cells, the degradation of cell proteins by silver ions, and AgNPs ability to kill bacteria can be attributed to a number of reasons, including the production of reactive oxygen species (ROS).

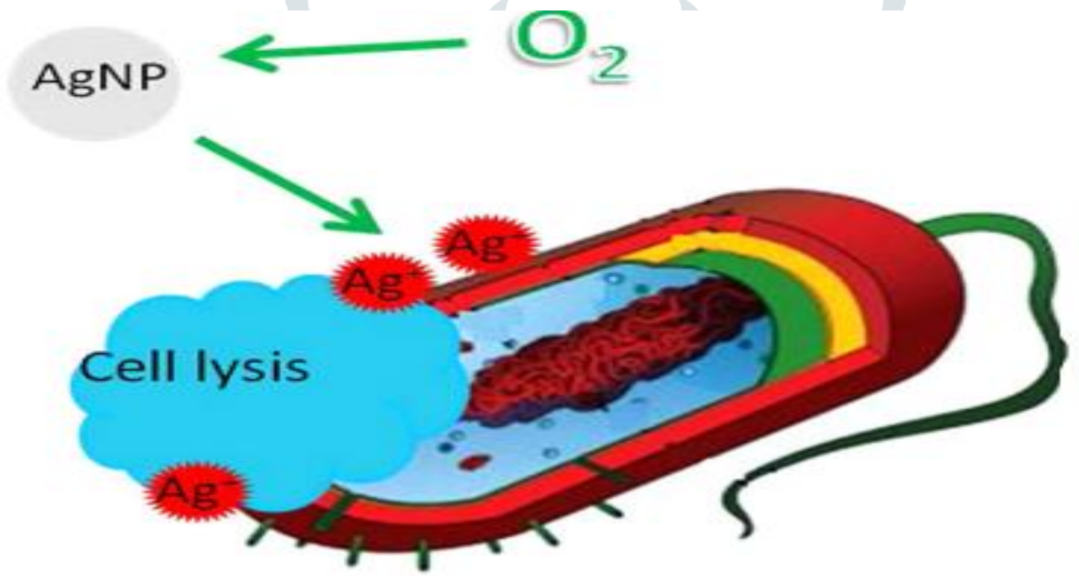

Fig 2: Killing of bacterial cell by AgNPs

3. ANTI-CANCER

The silver nanoparticles created through green synthesis shown positive anti-cancer effects. The green manufactured sliver nanoparticles were found to be sensitive to and to exhibit cytotoxic action toward the human breast cancer (MCF-7) and mammary cancer (EVSA-7) cell lines[9]. The AgNPs' ability to induce apoptosis was discovered using Hoechst-33342 staining. By using the MTT assay, it was demonstrated that AgNPs cytotoxicity on MDA MB-231 cells is concentration- and time-dependent. The lowering of MTT decreases with increasing AgNP concentration. Ag-NPs' cytotoxicity may be affected by the kind of coating materials employed. Commonly, the processes that cause toxicity to be induced include the creation of ROS, the degradation of antioxidant defence mechanisms, and also the loss of mitochondrial membrane potential. However, the mechanism and level of Ag-NPs toxicity vary depending on the coating materials utilised. Ag-NPs coated with polysaccharides made from chitosan, for example, have demonstrated antibacterial activity without causing damage to eukaryotic cells[9].

4. ANTI-FUNGAL

Using starch as a stabilising agent and ribose as a reducing agent, AgNPs were created, and they demonstrated considerable antifungal action against C. albicans and C. tropicalis. Based on a process that tears cell membranes, the starch-stabilized AgNPs have antifungal properties. AgNPs demonstrated antifungal characteristics comparable to those of amphotericin B, indicating that they may be used as an alternative to amphotericin B in the treatment of fungi[10,11].

5.ANTI-VIRAL

The antiviral activity of AgNPs is significantly influenced by their size and shape. Research has shown that surfaces with widths under 10 nm are noticeably more reactive. Moreover, the structure may fluctuate, taking in the form of a triangle, bar, or spiral, which dramatically modifies the viral action; spherical and cylindrical shapes are more readily phagocytosed. Human coronaviruses (HCoVs), a particular viral kind that has caused catastrophic respiratory infections including those produced by the Middle East respiratory syndrome (MERS-CoV), SARS-CoV2, and severe acute respiratory syndrome, have recently piqued the interest of the scientific community (SARS-CoV). The novel SARS CoV 2 coronavirus was discovered to be a natural carrier in bats and to be capable of spreading to humans via specific intermediate hosts. AgNPs stop the spike (S) glycoprotein from interacting with its specific receptor, inhibiting the virus from entering the cells[12].

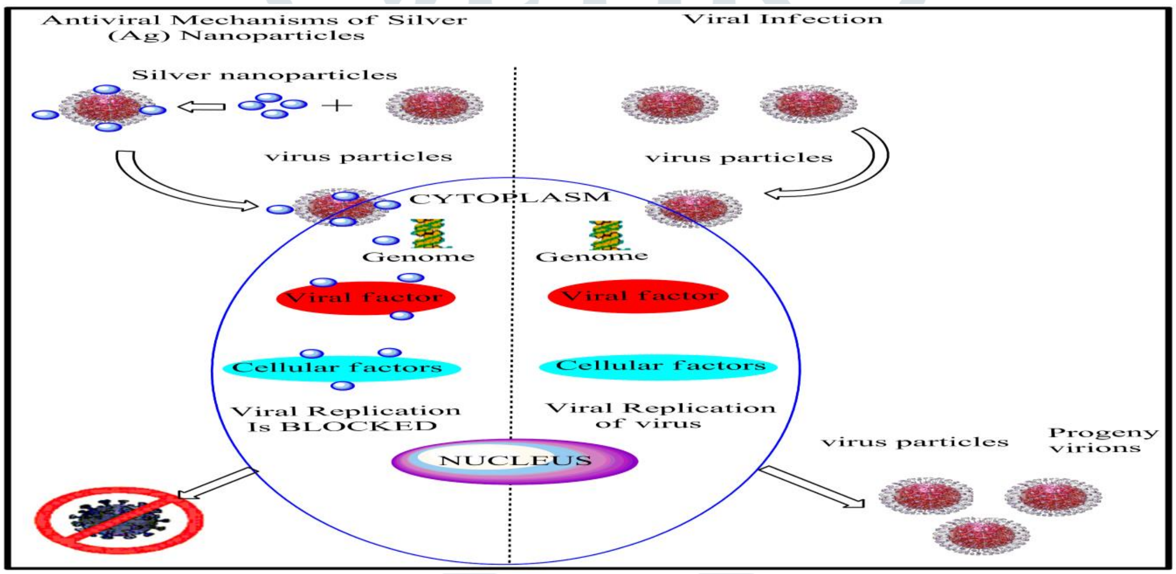

Fig 3: Schematic illustration of Anti-viral mechanism of silver nanoparticles[19]

6. AGRICULTURE

The most researched and used nanoparticle for biosystems is nano silver. It is reported to have potent inhibitory and bactericidal properties in addition to a wide range of antibacterial actions. Compared to bulk silver, silver nanoparticles with a high surface area and high surface atoms have a stronger antibacterial impact. Aside from this, AgNPs are well known for having anti-inflammatory, anti-viral, anti-bacterial, and anti-fungal effects. It is well known that the application of AgNPs in agriculture is largely hypothetical, but that researchers will soon have access to a variety of silver nanoparticle applications.

Enhancement of plant growth

AgNPs have been used to enhance seed germination and plant growth in order to increase crop yield. Ag nanoparticle concentration (AgNPs) affects how well plants grow in either a good or negative way[13]. A significant impact on seed germination, an increase in protein and carbohydrate synthesis, a decrease in total phenol contents, and an increase in catalase and peroxidase activities were all observed in the few studies that examined how biogenic AgNPs affected the growth metabolism of Bacopa monnieri grown hydroponically.Moreover, ecologically produced AgNPs enhanced the morphological (shoot and root length, leaf area), biochemical (chlorophyll, carbohydrate and protein contents, antioxidant enzymes), and seed germination and seedling growth of Boswellia ovalifoliolata trees, common beans, and maize plants[14].

Plant disease management and crop protection

A financially significant and urgently needed research area is the management of plant diseases in fruit and food crops. the use of nanoparticles as transporters or protectants to provide crop protection shows that highly dispersed and stabilized colloidal AgNPs are more adsorption to bacterial and fungal cell surface, acting as better bactericide and fungicide. Bacterial infection is a significant factor in crop yield loss worldwide. When used against the pathogen Erwinia cartovora, AgNPs have been found to have greater antibacterial activity than generic antibiotics. In planter soils and hydroponics systems, AgNPs eliminates unwanted bacteria and is an excellent plant growth stimulant[13].

Controlled Released Nano Fertilizers

Effective optimum concentration, time-controlled release, improved activity at the target region, and least negative effects are all desirable characteristics of nanoencapsulated agrochemicals. By means of osmotic pressure, diffusion, biodegradation, and dissolution at a specific pH, it aids in the controlled, delayed release of an agricultural agent to a particular host. Silver nanoparticles, which are likewise very stable and biodegradable, release agrochemicals gradually. It can therefore be used to produce nanocapsules for the slow, efficient administration of fertilizers, pesticides, and agrochemicals in agricultural applications[14].

7. FOOD PACKAGING

Post-harvest management, which includes the preservation of agricultural goods, is one of the most important facets of agriculture.The shelf life of fresh fruits and vegetables is increased by antimicrobial packaging manufactured with AgNPs, according to earlier research[15]. The advantage of silver antimicrobial agents is that they can be easily incorporated into a variety of materials, including plastics and textiles, making them useful in a wide range of applications. Traditional agents would be unstable in these situations. AgNPs may be incorporated to non-degradable (polyethylene, polyvinyl chloride, vinyl alcohol) and biodegradable polymers (cellulose, starch, chitosan, agarose) to create food packaging[16].

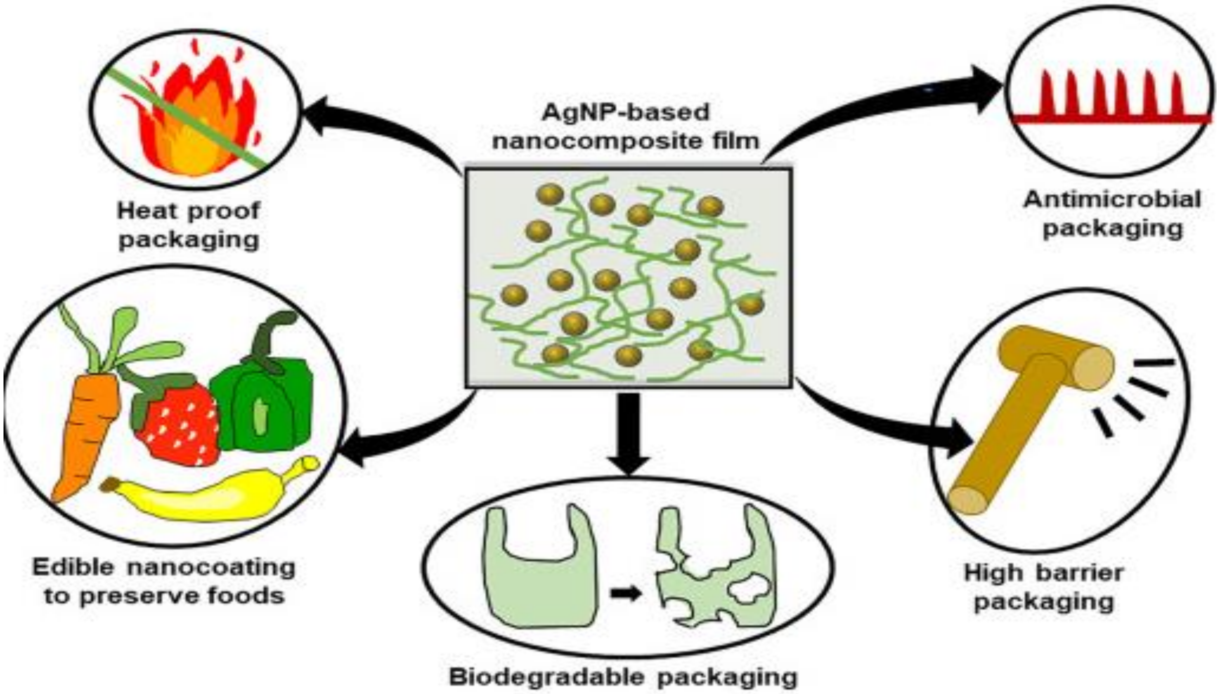

Fig 4: Application of AgNPs in food packaging[20]

8. DENTISTRY

Silver nanoparticles (AgNPs) have been successfully used in a range of fields due to their powerful antibacterial action against a variety of microorganisms. Dental prophylaxis, cleanliness, and infection prevention in the oral cavity are all possible with AgNP. Silver nanoparticles have already been proven to be effective against bacteria that are resistant to many drugs. AgNP would be directly applied in dentistry with the goal of acting as an antimicrobial and disinfectant in the oral cavity. The main use of these particles is for preventative measures. Silver nanoparticles are present in a variety of dental composites, including Chitalac-Ag, AgNP-methyl polymethylmethacrylate, amorphous calcium AgNP-phosphate, and fluorides (Nano Silver Fluoride). Silver plasma or silver nanoparticles can also be used on their own. Numerous dental specialties, including prosthodontics, orthodontics, endodontics, periodontics, and preventive dentistry, have been suggested for use of silver nanoparticles in studies. Additionally, some research has examined the possibility of using silver nanoparticles by assessing their antibacterial activity against the most common oral illnesses. The two most prevalent applications of AgNP in the several dental disciplines and allied fields are dental prosthesis (25.6%) and oral microbiology (19.5 percent)[17].

9. BIOSENSORS

Silver nanoparticles (AgNPs) have received a lot of attention recently because of their excellent conductivity, high surface-to-volume ratio, and plasmonic properties. Regarding use applications, Ag is an attractive resource for use in many applications, including applications in electronics, electronics, environmental protection, and as an antibacterial agent. Ag is an attractive resource for use in many applications, including applications in diagnosis, drug administration, environmental protection, environmental protection, and electronics.Because of surface Plasmon resonance (SPR), which has a significant impact on the molecules that are adsorbed on its surface and whose wavelength can be controlled by the concentration of AgNPs. AgNPs have a wide variety of applications for biosensing. Therefore, it has been examined whether Ag NPs can be employed to sense a variety of analytes, such as glucose, triacylglyceride, and others. AgNPs are utilized to increase the effectiveness of detection with biomolecules such as DNA, proteins, entire cells, etc[18].

10. WATER TREATMENT

AgNPs are mainly applicable to the removal of three major pollutants like pesticides, heavy metals, and microorganisms. They help to remove organic pollutants and dyes from the untreated water released from the industries and pharmaceutical companies. The fabricated hybrid aerogel graphene–carbon sphere decorated with AgNPs (G/AgCS) is used for the reduction of anionicdye (CR/congo red) and cationic dye (MB/methylene blue) which is present in the waste water.

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