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RESEARCH ARTICLE

EFFECTS AND APPLICATIONS OF SILVER NANOPARTICLES IN DIFFERENT FIELDS

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ABSTRACT

Silver nanoparticles are the most important nanoparticles used in food and other industries. Silver nanoparticles may eventually offer treatment of various diseases. Their extremely large surface area permits the coordination of a vast number of ligands. The properties of silver nanoparticles applicable to human treatments are under investigation in laboratory and animal studies, assessing potential efficacy, toxicity, and costs.

INTRODUCTION

Silver is the single most used material in all of the nanotechnology; the desirable antimicrobial property activity of Ag is drastically increased at the Nano scale. Accordingly, AgNps have been incorporated into hundreds of personal and professional products ranging from surgical and food handling tool, water purifiers, textiles, cosmetics, contact lens cases, wound dressing, children's toy and mostly engineered scaffolds designed for tissue regeneration. One of the most beneficial uses of silver has been a potent antibacterial agent that is toxic to fungi, viruses and algae.

In nanotechnology, a nanoparticle is defined as a small object or particle that behaves as a whole unit in terms of its transport and properties. Nano technology takes advantage of the fact that when a solid material becomes very small the surface area increases, which leads to an increase in the surface reactivity and quantum-related effects. The physical and chemical properties of nanomaterial can become very different from those of the same material in larger bulk form and Nano particles are the particles that have at least one dimension in the range of 1 to 100 nm. Silver nanoparticles may be used in food packaging polymers with the intention to enhance the self-life of food. It has been seen that if AgNps is directly added into milk then microbial growth is decreased.

Elemental Silver characteristics and sources

It is a malleable and ductile transition metal with a white metallic luster appearance[1]. It has the highest electrical conductivity and thermal conductivity and has the lowest contact resistance[2]. 28 radioisotopes have been characterized, with a majority of them having a half-life of less than 3 minutes. The average concentration of silver in water is 0.5 ppm while its concentration in soil is approximately 10 ppm. Silver occurs naturally in pure form, beside this it is generally extracted by amalgamation and displacement using metals such as mercury or by smelting.

Silver Nanoparticles

Historically, ancient Phoenicians were known to place silver coins into their water jugs as a preservative[3], doctors administered silver nitrate solution to the eyes of newborns for the prevention of neonatal conjunctivitis[4] and Ag sulfadiazine creams have long been considered the gold standard for the prevention of widespread bacterial growth on burn patient's denuded skin[5]. Currently silver nanoparticles are the single most manufacturer-identified material used in all of nanotechnology products[6].While AgNps exhibit unique optical and electrical properties at the Nano scale, the enhanced antibacterial activity of AgNps has been the most valuable. So,

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mainly the nanoparticles are used in surgical, food handling, packaging and storage tools, water purifiers, textiles, cosmetics, contact lens cases, wound care products, implantable devices etc[6].

Synthesis

Generally, nanoparticle fabrication may be differentiated into two broad approaches:

1) The top-down approach, and 2) the bottom-up approach method, the mechanical technique of ball milling involves controlled erosion of a solid mass In the top-down approach a solid mass is milled into smaller portions. One such is to produce finer structures, or irregularly shaped Nano powders. However, this method usually results in nanomaterial with quite broad grain sizes between 200-300nm, and contamination from milling media or atmosphere[7].In the bottom-up approach the nanomaterial is built atom byatom in four steps, in which a precursor is first condensed to solid phase, initiates the format ion of multiple nuclei, growth is achieved on the nuclei, and finally stabilization terminates the procedure to yield a desired size[8].

Use of silver nanoparticles

Nanotechnology plays an important role on food Engineering. Silver Nanoparticles (AgNPs) decrease the microbial effect of food and increase the shelf life of food. Nanotechnology is a modern technology for preservation of perusable food. This advancement in their manufacturing techniques attracted the attention of many industries wanting to exploit the unique properties of silver nanomaterial for beneficial use. The applications of silver nanomaterial are scattered but they can be classified under three main categories: scientific, industrial, and consumer products.

Properties of Nano silver

Two primary factors cause nanoparticles to behave significantly differently than bulk materials: surface effects and quantum effects[9]. These factors affect the chemical reactivity of materials as well as their mechanical, optical, electric, and magnetic properties. Nano silver has chemical and biological properties that are appealing tothe consumer products, food technology, textiles/fabrics, and medical industries. Nano silver also has unique optical and physical properties that are not present in bulk silver, and which are claimed to have great potential for medical applications.

Antibacterial properties

Nano silver is an effective killing agent against abroad spectrumof Gram-negative and Gram-positive bacteria[10]. Gram-negative bacteria include genera such as Acinetobacter, Escherichia, Pseudomonas, Salmonella, and Vibrio. Acinetobacter species are associated with nosocomial infections, i.e., infections that are the result of treatmentin a hospital or a healthcare service unit, but secondary to the patient's original condition. Gram-positive bacteria include many well-known genera such as Bacillus, Clostridium, Enterococcus, Listeria, Staphylococcus, and Streptococcus. Antibiotic-resistant bacteria include strains such as methicillin-resistant and vancomycin-resistant Staphylococcus aureus, and Enterococcus faecium. Silver nanoparticles

(Diameter 5-32 nm, average diameter 22.5 nm) enhance the antibacterial activity of various antibiotics[11]. The antibacterial activities of penicillin G, amoxicillin, erythromycin, clindamycin, and vancomycin against Staphylococcus aureus and Escherichia coli increase in the presence of silver nanoparticles[12].

Antifungal properties

Nano silver is an effective, fast-acting fungicide against a broad spectrum of common fungi including genera such as Aspergillus, Candida, and Saccharomyces[13]. The exact mechanisms of action of silver nanoparticles against fungi are still not clear, but mechanisms similar to that of the antibacterial actions have been proposed for fungi[14]. Silver nanoparticles (diameter 13.5 ± 2.6 nm) are effective against yeast isolated from bovine mastitis[15].

Antiviral properties

Silver nanoparticles (diameter 5-20 nm, average diameter ~10 nm) inhibit HIV-1 virus replication[16].

Anti-glycoprotein film properties

Glycoproteins are proteins that contain oligosaccharide chains that are covalently attached to polypeptide side-chains. These proteins are important for normal immune system function such as white blood cell recognition, and often play a role in cell-cell interactions. Examples of glycoproteins in the immune system include molecules such as antibodies that interact directly with antigens. In the case of impregnation of medical-grade silicone with silver nanoparticles (diameter 10-100 nm) there is both a depot effect and a diffusion pressure available to equilibrate the silver concentration and to push silver through the glycoprotein conditioning film[17].

Plasmonic heating properties

Plasmonic photo activation of hollow polyelectrolyte-multilayer capsulesincorporating silver nanoparticles and containing drug models has been demonstrated as proof-of-principle[18]. Silver nanoparticles were remotely activated using laser irradiation, causing not only absorption of photons but also heat transfer from the nanoparticles to the surrounding polymer matrix. The local heating disrupts the polymer matrix and allows the encapsulated material to leave the interior of the capsule.

Scientific applications

The remarkable physical, chemical and optical properties of silver nanomaterialallows for their utilization in various scientific applications. These properties significantly depend on the size, shape and surface chemistry of the nanomaterial. Metallic nanoparticles, including Nano silver, exhibit surface plasmon resonance (SPR) upon irradiation with light giving rise to SPR peaks in the UV-Vis wavelength range[19]. The SPR is a result of the interactions between the incident light and the free electrons in the conduction band of the nanomaterial. The width and location of the SPR peaks are dependent on the size, shape and surface properties of the nanomaterial[20]. Silver nanomaterials are widely used for surface enhanced Raman scattering (SERS). Raman scattering by molecules could be enhanced if the analyte molecules are adsorbed on rough metal surfaces, the enhancement factor which allows for enough sensitivity to detect single molecules[21]. As a consequence of the SPR and SERS, silver nanomaterial are a promising tool for sensing applications, including detection of DNA sequences[22]. Laser desorption/ionization mass spectrometry of peptides[23], colorimetric sensors for Histidine, determination of fibrinogens in human plasma[24], real-time probing of membrane transport in living microbial cells[25], enhanced IR absorption spectroscopy[26], colorimetric sensors for measuring ammonia concentration[27], biosensors for detection of herbicides[28] and glucose sensors for medical diagnostics[29] Silver nanomaterial are also known to be used for metal enhanced fluorescence applications. The intrinsic spectral properties offluorophores can be altered by metallic nanostructures. The proximity of metallic Nano silver results in an increase in the intensity of low quantum yield fluorophores. The effects include fluorophore quenching at short distances, spatial variation of the incident light field, and change in the radioactive decay rate[30]. These characteristics enable Nano silver to be used in applications such as immunoassays and DNA/RNA detection. As previously mentioned, the characteristics of the silver nanomaterial are greatly influenced by their surface properties. Modifying the surface of silver Nano prisms by alkanethiol makes them potential candidates for streptavidin and anti-biotin sensing and may also aid in the diagnosis of Alzheimer's disease[31].

Application in food industry

Nanotechnology, which uses tiny particles measuring one billionth of a metre, is already used for various applications in areas such as food supplements, functional food ingredients and in food packaging. To provide packaging which would protect the food from dust, gases (O2, CO2), light, pathogens, moisture; be safe, inert; cheap to produce, easy to dispose and reuse. Nanocomposite LDPE films containing Ag and ZnOnanoparticles were prepared by melt mixing in a twin-screw extruder. Packages prepared from the films were then filled with fresh orange juice and stored at 4 °C Fresh meat is a highly perishable commodity. Under normal aerobic packaging conditions, the shelf life of refrigerated meat is limited by the growth of bacteria. It is used to avoid the proliferation of undesirable microorganisms and also to provide desired texture to the food, encapsulate food components (e.g., control the release of flavors), increase the bioavailability of nutritional components. Detection of small molecules – ripening of fruits, spoilage of fish (pH reactive dye reacts with spoilage compounds trim ethylamine, ammonia).[32]

Other applications

The nanoparticles are also used in industry as catalyst for the high surface to volume ratio of silver nanoparticles provides high surface energy, which promotes surface reactivity such as adsorption and catalysts. These are also used in electronics and electrical purposes. Silver nanoparticles are used as antimicrobial agents in a diverse range of applications including air sanitizer sprays, socks, pillows, slippers, face masks, wet wipes, detergent, soap, shampoo, toothpaste, air filters, coatings of refrigerators, vacuum cleaners, washing machines, food storage containers, cellular phones.

CONCLUSION

The unique properties of silver nanoparticles make them ideal for numerous technologies, including biomedical, materials, optical, and antimicrobial applications, as well as for use in Nano-toxicology studies. Recent researches of silver nanoparticles are going on the food maintenances and handling sector. The toxicity and other chemical properties of silver nanoparticles are in laboratory process and yet to be discovered.

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