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Review Article

Study On Toxic Free Synthesis Of Silver Nanoparticles

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ABSTRACT

1-100 nm silver nanoparticles. Silver nanoparticles have uses in engineering, chemistry, and biology. Physical, chemical, and biological processes can be employed to produce silver nanoparticles, including "gamma irradiation, laser ablation, electron irradiation, and microwave processing". Silver nano-particles low toxicity has enhanced their use in biological research. In this paper aim of the study on toxic free synthesis of silver nanoparticles. this article describes the synthesis of silver nanoparticles and their toxic free use in medicine to treat cancer and antibiotic resistance. A mechanistic knowledge of SNPs' therapeutic activities will help design human-tailored healthcare solutions.

INTRODUCTION

Nanotechnology is a significant area of contemporary research that deals with the design, production, and manipulation of particle structures with sizes between one and one hundred nanometres (nm). Health care, cosmetics, food and feed, environmental health, mechanics, optics, biomedical sciences, "chemical industries, electronics, space industries, drug-gene delivery, energy science, optoelectronics, catalysis, single electron transistors, light emitters, nonlinear optical devices, and photo-electrochemical applications are just a few of the many fields in which nanoparticles (NPs) are used". A fast-expanding scientific field for creating and developing gadgets is nanobiotechnology. The synthesis of NPs with various chemical compositions, sizes, morphologies, and controlled disparities is a significant field of research in nanobiotechnology. Due to its numerous uses, nanobiotechnology has emerged as a fundamental branch of modern nanotechnology and has opened up a brand-new era in the domains of material science. The exploratory use of NPs in biological systems led to a multidisciplinary approach involving the fields of biology, biochemistry, chemistry, engineering, physics, and medicine. Additionally, the creation of safe, non-toxic, and environmentally acceptable processes for the synthesis and assembly of metal nanoparticles (NPs) with the inherent capacity to reduce metals through particular metabolic pathways is facilitated by the use of nanobiotechnology. Creating eco-friendly techniques that don't employ

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hazardous chemicals in the synthesis protocols is becoming more and more important in the modern world. Green synthesis techniques offer advantages over traditional ones that use chemicals with environmental toxicity, such as mixed-valence polyoxometalates, polysaccharides, Tollens, biological, and irradiation processes. The most critical factors that must be taken into account in the green synthesis of NPs include the choice of solvent medium and the choice of environmentally friendly, nontoxic reducing and stabilising agents.

Synthesis of Nanoparticles: Chemical synthesis

AgNps have been synthesised using a variety of techniques, including chemical, physical, photochemical, and biological ones. Each method has pros and cons, but they all have issues with costs, scalability, particle size, and size dispersion. Chemical processes are one of the most popular ways to produce Ag-Nps because they make it simple to make Ag-Nps in solution. The simplest approach involves reducing the metal salt AgBF4 chemically in water with NaBH4. In order to assess the quality of the silver nanoparticles, "transmission electron microscopy (TEM) and UV-visible" are used to measure their size, which ranges from 3 to 40 nm. Another technique, known as the polyol process, involves reducing silver nitrate with ethylene glycol in the presence of poly vinyl pyrrolidone (PVP), creating significant amounts of silver nanocubes. It was proposed that altering the experimental conditions could allow one to regulate the size of the silver nanocubes.

Fig 1: Chemical synthesis of silver nanoparticles

Precursor injection technique was used in a modified polyol process to create "spherical Ag-Nps with a controllable size and high" monodispersed concentration. Monodisperse Ag-Nps were reported to be produced by a straightforward oleyl amine-liquid paraffin system, and their formation could be divided into three stages: growth, incubation, and oatwald ripening. Throughout the entire process, "only three chemicals—silver nitrate, oleyomine, and liquid paraffin—are used".

Three main elements are typically involved in the chemical synthesis of Ag-Nps in Solution.:

a. Metal precursors,
b. Reducing agents
c. Stabilizing/capping agents.

Colloidal solution is created by reducing silver salts, which requires two steps of nucleation and development. It was discovered that those steps have a significant influence on the size and form of produced Ag-Nps, which could be changed by modifying the reaction's temperature, pH, precursors, reaction agents (such as eNaBH4, ethylene glycol, and glucose), and stabilising agents.

Silver nanoparticle synthesis (AgNPs)

Biological method

Biological approaches for synthesizing metallic NPs are productive, cost-effective, nontoxic, and environmentally benign. "Plants and plant products, algae, yeast, fungi, and bacteria can be employed to synthesize nanoparticles. Algae can be used to produce some noble metal nanoparticles; some algae have been tried to yield silver and gold NPs; some plants can be used to make silver, zinc oxide, gold, platinum, magnetite, and palladium NPs; bacteria and yeasts have been used to produce metal NPs; and fungi is used for gold, silver, and cadmium NPs synthesis".

Asymmetric synthesis of AgNP

Using hydrazine, "ascorbic acid, dimethylformamide, ammonium formate, and sodium borohydride, diverse forms of stable AgNPs can be generated through chemical reduction". The reducing agent determines AgNPs' size, shape, and dispersion. Anisotropic AgNPs can be formed at different hydrogen peroxide concentrations. "Citrate and borohydride react slowly with" neutral hydrogen peroxide. Hydrogen peroxide (H2O2) decomposes quickly to oxygen and water at the surface of metallic silver. When AgNPs grow large, bubbles form and the color changes from pale yellow to dark orange. Spherical, platelet, and irregular AgNPs dissolve and oxidize. Chemical reduction or other procedures are used to make Ag nanoprisms. Both procedures require on salt, "metal precursor, and reducing agents in solution medium. Chemical" procedures (trisodium citrate, etc.) and certain oxidizing agents (H2O2) generate oxidative etching in solution. When O2 and a ligand are in solution together, the reaction occurs. This can cause seed and nucleus oxidation. Colloidal solution reveals seed surface flaws. Triangular or hexagonal plates replace these clusters. In aided approaches, ultraviolet or visible light reduces silver ions (Ag2+) and oxidizing etching chemicals are not needed to generate anisotropic silver.

Resonance plasmon

Nanoparticles behave differently than bulk material due to their electron density and size. Quantum size effect describes this phenomenon. "LSPR of metallic NPs shows geometric constraints" and delocalized electrons. Nanoparticle shapes and sizes affect Plasmon resonance values. UV absorbance ranges exhibit different absorbance and peaks according on NP color. Many factors affect AgNPs' plasmon resonance. Shapes and sizes of particles, particle distance, and metal and surface dielectric constants. Spherical AgNPs show UV visible spectroscopic maxima at 400nm, depending on shape and size.

Nanosilver uses

Using silver nanoparticles' thermal, optical, and electrical capabilities, photovoltaic, biological, and chemical sensors can be made. Conductive inks, fillers, and pastes have high AgNPs electrical conductivity stability and "low sintering temperatures. Progressively general applications include AgNPs for antimicrobial coatings in titanium prosthetics, dental resins, and fabrics. Biomedical instruments such as keyboards and wound dressings now have AgNPs that constantly release silver ions and nanoparticles to defend and protect wounds from bacterial infections. Chemical sensing, photonic devices, biological sensing, and molecular diagnostics improve nanomaterials' optical characteristics". Colloidal silver nanoparticles make stable nanoparticle inks. Silver inks need nanoparticles 50 nm or smaller for good dispersion solubility. Key nanoparticle features include form, size, and monodispersity. Because conductivity depends on the density of nanoparticles in a desiccated printed trace's superstructure.

Uses for antibacterials

Shape and size of AgNPs determine their antibacterial activities. "Stability of AgNPs in media, coating types, and" final charges also affect AgNPs' activity with bacterial cells. Stabilization and dispersion are critical for evaluating AgNPs. AgNPs' form and size affect bacterial interactions. Using silver nanoparticles, researchers have studied "the change in wavelength of plasmonic nanoparticles when they interact with molecules. Silver ions in solution are strong antimicrobials, but chloride, phosphate, proteins, and other cellular components sequester them. Stable nano-silver has a far lower minimal inhibitory concentration than its dissolved ionic equivalent". "Nanoparticles are often coated with non-toxic, non-inflammatory capping agents such as collagen, peptides, and biopolymers to enhance their effectiveness and stability in biomedical and other applications". AgNPs conjugated with poly-lysine were less effective than collagen-capped AgNPs due to aggregation. Health professionals are concerned about multidrug-resistant bacteria because they are resistant to many antibiotics. New antimicrobial techniques are needed. Further research and advancements can boost AgNPs' antibacterial activity.

A variety of uses depending on the size "of silver nanoparticles"

"Larger AgNP surface areas facilitate smooth entry" into cells, increasing their interaction percentage compared to other large particles. As particle size decreased from 10 m to 10 nm, particle contact surface area increased, boosting bactericidal activity. Smaller particles are better for cell entry and reaction. NP size affects bactericidal activity. Silver NP shape-dependency "AgNPs react differently with different biosystems, and microbicide demand" will rise. Same-sized nanoparticles with different shapes have different microorganism-interacting surface areas. Shape affects AgNPs' antibacterial properties. Shape of nanoparticles affects antibacterial efficacy. Different-shaped NPs inhibit bacterial growth differently. Truncated triangular NPs inhibited bacteria with 1 g Ag. While spherical nanoparticles had 12.5 g. Rod-shaped nanoparticles need 50 to 100 g of silver. Different-shaped AgNPs interact differently with bacterial cells.

The Cap-Agent Effect

Since NP stability is ligand-specific, non-capped NPs may not be stable. Examine colloidal stability under specific conditions. Surfactants or polymers are often used to cap and stabilize AgNPs to prevent aggregation. "Colloidal stability of NPs varied with ionic values, charges, acidity, and organic species". AgNP charge density Positive zeta potential promotes particle-bacteria (gram-negative and gram-positive) interactions. Positive nanoparticle potentials cause electrostatic forces that kill microorganisms with oppositely charged layers. In this review, AgNP's positive zeta potential may clarify its antibacterial effect. Nanoparticle charge impacts cellular absorption. Cations on the cell surface bind and are absorbed more quickly due to electrostatic interactions. Antibacterial silver nanoparticles are negatively charged. Linking calix arenes to Ag nanoparticles reduces the negatively charged "calix-arene tail groups, allowing Ag nanoparticles to enter membranes". Negatively charged AgNPs may be effective due to their redox potential, which generates free radicals and reactive oxygen species. Opposite surface charges promote bacterial cell membrane-AgNP interactions. Increasing NaBH4 for AgNPs production reduces their zeta potential. NaBH4 releases electrons, which causes an increase in nanoparticle size. Since increasing NaBH4 concentration gives free electrons, it reduces zeta potential, which affects silver nanoparticle aggregation. Positively charged AgNPs and negatively charged microbial cell membranes interact electrostatically to fight bacteria. Electrostatic forces may also contribute to Ag nanoparticles' antibacterial activity (AgNPs). AgNP's structure, size, cationic characteristics, and positive zeta potential likely promote antibacterial action against gram-positive bacteria. Synthetic AgNPs with produced cationic surfactants have a zeta potential greater than +30 mV, which accounts for their remarkable stability and prevents agglomeration. The high zeta potential shows that silver nanoparticles have a high surface charge, which prevents agglomeration and keeps them stable. Positive zeta potential values are due to the capping agent's cationic surfactant, which carries positive charges.

Membrane-AgNP interactions in bacteria

Silver ions interact with thiols in microbial proteins, affecting DNA replication . Ag2+ ions uncouple respiratory chain from oxidative phosphorylation. Bacterial infections cause death, illness, and financial losses. Antibiotic-resistant bacteria complicate matters. Drug-resistant bacteria favor new antimicrobials. Nanoparticle-based sterilizing and other therapies improve diagnostic and preventative frameworks. Green nanoparticle production employing proteins or biomolecules. It's important to understand biosynthesized AgNPs' interactions with bacteria and cells to maximize their biological usage. AgNPs' antibacterial mechanism and efficacy are uncertain. AgNPs-induced cell death may involve membrane disruption, "oxidation of cell components and organelles, inactivation of respiratory chain molecules, production of reactive oxygen species (ROS), and cell segment disintegration. Antibacterial AgNPs". AgNPs make bacterial cell membranes permeable. intracellular material leakage and osmotic cell disintegration. AgNPs interact with cell surface proteins or carbohydrates, causing cell death. AgNPs' antibacterial activity is connected to oxidative stress. AgNPs block respiratory enzymes, creating ROS such hydroxyl and superoxide radicals, which damage cells and biological components. AgNPs dissolve bacteria's cell membranes. AgNP entrance depends on bacterial cell size and wall structure. Gram-negative bacteria have a peptidoglycan coating between their membranes. Gram-positive bacteria have 30 nm of peptidoglycan. Gram-positive cell walls protect cytoplasm from AgNPs or Ag+ ions. The barrier resists Gram-positive AgNPs. Cell wall lipids and proteins repel invaders. Gram-negative bacteria lack peptidoglycan. Outer membrane proteins porins and LPS (endotoxin) Each has flagella. Biosensors are proteins, DNA, RNA. Microbes affect Ag2+ bioavailability by: Extracellular bacteria degrade AgNPs ("peptides, bio surfactants, and organic acids"). Cells take absorb Ag+ through cell-NP charge. Gram-positive bacteria contain Mg2+-binding teichoic acids. Peptides are antimicrobial because of their macrocyclicamido functional group. Antibacterial polypeptides PE and BA (AMPs). E. coli, P.aeruginosa, S. aureus, and B. amyloliquefaciens were treated with AgNPs made from peptides. Immobilizing peptides on AgNP doubled antibacterial mobility without developing resistance. Bacitracin A and polymyxin E bind Mg2+ and Ca2+ from teichoic acids, changing cell walls. Bacterial nucleoids include BA/PE-nanoparticles. AgNPs bind to ribosomes and chromosomes, inhibiting ribosome activity and DNA replication. AgNPs' antibacterial action may be reduced by incomplete oxidation and Ag+ release. Bacterial cell wall and membrane peptididoglycan binds to AgNPs, inhibiting protein synthesis, DNA replication, and cell death. AgNPs reduce bacterial resistance. AgNPs destroy membranes and walls. Recent "reports describe the" importance of "interactions in the antimicrobial action of AgNPs, as they can translocate inside the cell through the vesicles or cytoplasm, whose subsequent breakdown caused by an oxidizing and acidic pH of plasma membrane may prompt high concentrations of Ag2+ ions. AgNPs are antibacterial since microorganisms aren't antibiotic-resistant. AgNPs effect on bacterial cell surface charge, roughness, chemical composition, cell wall rigidity, and adhesion needs more study".

HeLa cell line showed anti-cancer activity

Cancer caused 8.2 million deaths and 14 million new cases in 2012. Lung cancer causes the most deaths (1.5 million) among cancers (s). Other cancer deaths include liver (745,000), stomach (72,000), colorectal (694,000), breast (521,000), and oesophageal (400,000). New cancer cases will rise 70% or more in the next two decades. Africa, Asia, Central and South America account for 70% of cancer fatalities, and 60% of new annual cancer cases. Several therapies treat cancer. Chemotherapy with cytotoxic drugs is the most common and feasible treatment. These therapeutic techniques might induce substantial side effects, especially MDR. Chemotherapy, cytotoxic drug therapy, and radiation therapy all have negative side effects. "On the basis of these unpleasant side effects, the National Cancer Institute (USA) has" pushed plant extract research. Nanoparticles use natural chemicals to treat chronic disorders, including cancer. AgNPs interact with and disintegrate the mitochondrial respiratory chain, making them a good alternative for illness management. AgNPs damage DNA by disrupting mitochondrial activity, generating ROS, and suppressing ATP production. Characterizations of nanoparticles are vital for assessing their potential toxicity, however main parameters that determine AgNPs' biological activity have not been completely studied. Following points may require a detailed characterisation of AgNPs. Size, shape, "chemistry, solubility, surface area, dispersion state, surface chemistry, and other physico-chemical features . Many nanotechnology researchers indicate that AgNPs cause necrosis or death in numerous cell types, e.g. AgNP less than 3 nm in size may induce cytotoxicity in macrophages. AgNPs reduced liver and neuron cell viability. Gender-related tissue distribution, genotoxicity, and 28-day oral toxicity in rodents". AgNPs' subchronic inhalation lethality was also studied. Histopathological investigations of AgNP-treated lesions demonstrated dose-dependent responses, including persistent alveolar aggravation and small granulomatous sores. Cellular and molecular evidence on the harmful effects of non-modified AgNPs is sparse. Unmodified AgNPs are unstable in cell line culture conditions, hence this isn't completely researched.

Biosensor based on silver nanoparticles

Surface plasmon resonance (SPR) biosensors utilise SPP waves. "SPR as biosensors to screen and provide data on organic" processes shows promising results, especially when considering biomolecular interactions. SPR-based biosensors are sensitive "to changes in the refractive record of the analyte", therefore they may detect biomolecules with biocompatible components, such as DNA, protein, catalysts, antibodies, and peptides. Silver nanoparticles (AgNPs) are a noble metal nonmaterial with attractive physicochemical features. AgNPs have an exceptional SPR band. The AgNP SPR band is more responsive to environmental changes. Functionalized AgNPs can identify target species at lower concentrations than gold . Sharp edges or gaps in nanostructures boost SERS. "Nanorods, nano stars, nanoholes, and bipyramids have all been used to develop nanoparticle plasmonic sensors".

Use of AgNP as a chemosensor, with a focus on heavy metal detection

Heavy metals include "chromium (Cr), cadmium (Cd), thallium (Tl), arsenic (As), mercury (Hg), and lead (Pb)". Refining, mining, mechanical manufacture, and usage of non-metals and metallic compounds cause pollution and human activities. Natural metal breakdown, climate changes, metal soil disintegration, "draining of substantial materials, sediments re-suspension, and metal vanishing from water assets to soil and ground water can produce natural pollution". Volcanic emissions and weathering cause heavy metal contamination. "Metal coal in power plants, oil burning and high strain lines, polymers, materials, microelectronics, wood protection, and paper handling". Brain, kidney, and lung damage. Mercury causes acrodynia and Hunter-Russell syndrome. Methylmercury damages human health. Anaerobic bacteria methylate oxidized mercury. Hg2+ is one of the deadliest heavy metal particles, even after little exposure. Hg2+ can cause "long-term injury to natural living systems by disrupting organic and cellular functions at the cellular level". Mercury accumulates in food systems, yet it's poisonous. EPA regulates drinking water Hg2+ to 2 ppb (10 nM). WHO recommends 1.6 g kg1 per week. EPA and NRC set a daily adult standard value of 0.1 g/kg. 1970s ban on organo-mercury in rural regions. Dumped mercury undergoes biogeochemical changes and can become harmful methylmercury. Industrial nations have tried to replace "mercury in goods (e.g. amalgam fillings, thermometers, switches) and modern processes (e.g. acetaldehyde synthesis, amalgam in chlorine-antacid electrolysis") with new chemicals or techniques. Despite numerous Hg2+ recognition methods, procedures must be precise and honest. An assay that identifies analyte components is desirable.

Old methods involve painstaking specimen preparation, expensive equipment, and educated workers to research heavy metals in the earth. Conventional equipment delivers instantaneous and quantifiable Hg2+ concentration. Several optical techniques have been established to recognize Hg2+ in fluorophores, chromogens, polymers, and noble metals. AgNPs are popular due to their physicochemical features. AgNPs are ideal for sub-atomic and molecular labeling due to their plasmon resonance and wide diffusing cross-section.

CONCLUSION:

Silver nanoparticles are employed in numerous sectors and commercial items. Because of their adaptability in terms of synthesis as well as their one-of-a-kind properties, silver nanoparticles have found applications in virtually every industry. Several different experiments demonstrated that their use in biological applications is harmless. Applications of AgNPs with antimicrobial properties have seen widespread use. Synthesis of AgNPs has been attempted using a variety of approaches, including physical, chemical, and even biological approaches.

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