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Synthesis and applications on sensing technique of silver nanoparticle

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Abstract

Customized healthcare has developed significantly over the previous few decades thanks to advancements in medical diagnostics and medical technology, such as metal nanoparticles with diameters under 100 nm. Because of their distinct physical and optical properties as well as their biochemical activity, silver nanoparticles (AgNP) have the potential to find applications in a wide variety of antimicrobial treatments, biomedical device coatings, drug-delivery carriers, imaging probes, diagnostic platforms, and optoelectronic systems. This research aimed to identify the most important synthesis methods for AgNPs, such as physical, chemical, and biological synthesis processes, and to characterise the unique physiochemical properties of AgNPs. Their cytotoxicity to cells and microorganisms, as well as the molecular processes underlying their plasmonic effects on mono- and bimetallic structures, are also explored. We conclude by discussing the current applications of AgNPs in nanoscience and nanomedicine, as well as their potential future usage.

Key words: Synthesis, Silver, Nanoparticle, Applications, Antimicrobial etc**.**

Introduction

Many different sectors have found use for metal nanoparticles. A wide range of applications for nanoscale materials technology may be found in sectors as diverse as chemistry and medicine due to the strong correlation between the physical, chemical, and optical characteristics of metallic nanoparticles. AgNPs have recently been the subject of extensive research due to their superior physical, chemical, and biological properties. The superiority of AgNPs over bulk silver comes in large part as a result of the nanoparticles' superiority in size, shape, composition, crystallinity, and structural design. Many efforts have been undertaken to discover and make use of their useful qualities, including anti-bacterial and anti-cancer treatments, diagnostics and optical electronics, water disinfection, and other medical and pharmaceutical uses. Silver is a natural resource with intriguing material characteristics, but the usage of “silver-based nanomaterials has been restricted owing to their instability, such as the oxidation in an oxygen-containing fluid.” As a result, gold nanoparticles have an untapped potential compared to AgNPs (AuNPs). The size, distribution, morphological form, and surface characteristics of AgNPs have been found to have a substantial impact on their physical, optical, and catalytic capabilities in previous studies. These factors may be altered using a variety of synthetic techniques, reducing agents, and stabilisers. When it comes to medication delivery, for example, AgNPs are often larger than 100 nm in order to handle the larger doses that need to be given. Shapes such as rods, triangles, circles, octahedrons, and polyhedra may be achieved by altering the surface characteristics of AgNPs. The antibacterial properties of Ag+ ions have been shown in antimicrobial applications using AgNPs. In the disciplines of nanomedicine, pharmaceutics, biosensing, and biotechnological engineering, these outstanding AgNP capabilities have made them useful.

Literature Review:

("Abou El-Nour et al., 2010) in the study Synthesis and applications of silver nanoparticles” says that Noble metal nanoparticles like silver have different physical, chemical, and biological properties than their bulk counterparts. Nanoparticles less than 100 nm in diameter are gaining interest for potential uses in several industries. Small particle size, high surface area, quantum confinement, and other factors can give different properties from bulk materials. Most nanoparticle properties need nano-sized particles that are disseminated without aggregation. The “electromagnetic, optical, and catalytic properties of silver nanoparticles” are greatly impacted by form, size, and size distribution, which can be altered by synthetic processes, reducing agents, and stabilisers. This review discusses methods for preparing silver nanoparticles and their applications.

(Pandey et al., 2012) in the study “Green synthesis of biopolymer-silver nanoparticle nanocomposite: An optical sensor for ammonia detection” says that Biopolymer used to make nanoparticles is gaining popularity. In the following article, we employ plant-based guar gum (GG). GG reduces 10 nm silver nanoparticles. SEM and TEM assessed the NPs' size homogeneity, and powder X-ray diffraction defined their face-centered cubic structure. Polymer/silver nanocomposite aqueous ammonia detection by SPR (SPR). Studying optical sensor performance. Ammonia solution response time is 2-3 s and detection limit is 1 ppm. This room temperature optical ammonia sensor can be used for clinical and medical diagnosis to detect low ammonia levels in biological fluids such as plasma, perspiration, saliva, and cerebrospinal fluid.

(Alaqad & Saleh, 2016) in the study "s Gold and Silver Nanoparticles: Synthesis Methods, Characterization Routes and Applications towards Drugs" says that Biotechnology and biomedicine use nanoparticles extensively. Large surface area, extraordinary physical features, improved permeability, and retention effect make them intriguing biomedical candidates for diagnostic and therapy. The safest medication nanoparticles were gold and silver. Gold and silver nanoparticles have several uses. This review covers Synthesis, Characterization, and Applications of Au and Ag Nanoparticles. The review will focus on nanoparticles used in medicine delivery and sensing.

(Prabhu & Poulose, 2012) in the study "Silver nanoparticles: mechanism of antimicrobial" says that 1 to 100 nm silver nanoparticles. Silver nanoparticles help in molecular diagnostics, therapeutics, and medical devices. Physical and chemical approaches are utilised to make silver nanoparticles. Chemical and physical procedures are costly and can absorb hazardous substances. Biological methods offer a solution. Bacteria, fungus, and plant extracts are involved. Diagnostic and therapeutic uses of silver nanoparticles in medicine. Most medicinal applications focus on the antibacterial activity, while the anti-inflammatory property also has uses. Silver nanoparticles are widely used in medical treatments, electronics, and biological domains, however they're nanotoxic. This review examines the nanoparticles' mode of action, manufacture, medical applications, and health and environmental problems. The focus is on effective and economical synthesis of silver nanoparticles, as well as their potential applications and toxicity concerns.

(Mohammadlou et al., 2016) in the study "A review on green silver nanoparticles based on plants: Synthesis, potential applications and eco-friendly approach" says that Due to their distinct physico-chemical and antibacterial properties, silver nanoparticles (AgNPs) are widely used in a variety of sectors. "Proteins/enzymes, amino acids, polysaccharides, alkaloids, alcoholic compounds, and vitamins" are just a few of the natural biomolecules that can be found in plants (living plants, extracts from living plants, and inactivated plant tissue) that may be involved in the bioreduction, formation, and stabilisation of AgNPs. This review examines the features, antibacterial properties, and applications of plant-based biomolecules in the manufacture of AgNPs.

Applications of Silver Nanoparticles

Health

- **Antimicrobial Activity.**

Using silver metal as an antiseptic for wound healing lead researchers to discover the function of Ag NPs as antimicrobial agents against both fungus and bacteria. Due to Ag NPs' antibacterial action differing for various species, their resistance against multidrug-resistant bacteria and fungi is likewise variable. “Methicillin-resistant Gram-positive Staphylococcus aureus and methicillin-resistant Staphylococcus epidermidis and Streptococcus pyogenes” have the most strong antibacterial action. Antimicrobial activity against Gram-negative strains of Salmonella typhi and Klebsiella pneumoniae was rather modest; this might have been owing to the plasmolysis of the bacteria's cell walls by Ag NPs. Due to the variations in cell wall structure and quantity of functional groups on the cell surface of the two bacteria, the chitosan-Ag colloid is more effective against Escherichia coli than C. albicans. Pullulan-mediated Ag nanoparticles with greater negative zeta potential are more stable owing to repulsion among the particles and demonstrate significant antibacterial action against Gram-positive bacteria because of this.

- **Sensing and Therapeutic Application.**

Medical gadgets that are portable and wearable may be a preferable option for patient monitoring. Stretchable sensors benefit from the high conductivity of Ag NPs. A variety of carbon-based nanomaterials, including as graphene sponges, multi-walled carbon nanotubes, and carbon black, are coated or dispersed with Ag NPs to create these sensors. In order to demonstrate their outstanding temperature-sensing capabilities, the sensors were employed to generate electrocardiograms.

Environment

- **Sensors**

Heavy metal ions such as Ni, Co, and Hg (II) and sulphide anions may be detected using Ag NPs' colorimetric sensing capability. A greater anisotropy and lightning rod effect may be achieved by using silver nanoplates with triangular sections. It has been shown that these ions may be detected in solutions using plasmon sensors, which show an increasing blue shift when Hg2+ ions are present. Films of Ag NPs coated with tris(4,7-diphenyl-1,10-

phenanthroline)ruthenium(II), dichloride complex (Ru(dpp)3Cl2) enclosed in plasticized polymethyl methacrylate (PMMA) have been utilised to construct the sensors, which detect dissolved oxygen in aqueous solutions via ratiometric sensing. ' Ag NPs has created an electrochemical sensor that can detect the herbicide atrazine (Atz). It is possible to swiftly collect and identify malachite green residues using SERS sensors based on the in situ development of Ag NPs on polydopamine- (PDA-) templated filter sheets (FP).

- **Pollution Degradation.**

Ag NPs' catalytic activity is dependent on the size, shape, and surface structure, as well as the bulk and surface composition, of the reducing agent (electron donor) and dye (electron acceptor) with which they are exchanged. Smaller Ag NPs in tubular nanocomposite catalysts resulted in better catalytic activity than larger ones. It doesn't matter whether kind or location of substituents are present in the nitroarene series; Ag NPs are excellent catalysts. By using sodium borohydride to degrade 4-nitrophenol, the biosynthesized Ag NPs demonstrated an extremely high chemocatalytic activity, resulting in the complete degradation of 4-nitrophenol into 4-aminophenol, 4-methyl orange (MeO), and Methylene Blue (MB). Organic dyes may be bleached at room temperature using potassium peroxodisulphate in an aqueous solution containing silver-bearing nanoparticles. When the amount of Ag NPs utilised as a catalyst increased, the rate constant rose. While Ag NPs have been shown to breakdown dye in wastewater/effluents, they also exhibit unique features for carbon dioxide electrolysis that play an important role in the conversion of CO2 into CO. In the reduction of halogenated organic pollutants by BH4, Ag NPs serve as a heterogeneous catalyst".

- **Water Treatment**

Biosynthesized Ag NPs were impregnated into nitrocellulose membrane filters at a concentration of 1 mg/L and showed complete inhibition of the microbial community of E.coli, Enterococcus, Pseudomonas, and S. aureus suspension, as well as inactivation and removal of E. coli up to 6 and 5.2 orders of magnitude, respectively, in the water purification process of the bactericidal membrane. Additionally, the polyimide (PI) membrane was enhanced by the addition of zwitterionic sulfobetaine methacrylate (SBMA), which was grafted onto the membrane. Ag NPs may be easily isolated from beads in a water sample to limit bacterial growth. MWCNTs with integrated iron oxide and silver nanoparticles are antimicrobial.

Pathogenic microorganisms are preserved on water-treatment PAN sorbent. Using Ag NPs, however, no biofilm growth was seen on the surface of the substrates. Water that has been polluted by microorganisms may be treated in an emergency by passing through Ag NPs-coated paper.

Conclusions

The malleable properties of Ag NPs have long piqued the interest of scientists. Sodium borohydride, ascorbic acid, and citric acid are frequently utilised in the reduction of silver salts to nanoparticles. Nanoparticles are often made using biochemical metabolites derived from living organisms. Ag NPs' antibacterial properties make them useful for treating water and destroying plants to control the spread of disease. However, further research is needed before the particles may be used anywhere outside of a laboratory setting. There isn't a foolproof method for synthesising nanoparticles, hence manufacturing them is always difficult. Further study of how Ag NPs aggregate and behave within the human body is required because of potential concerns over their impact on the environment and human health if they are used on a large scale.

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