IJAPB International Journal of Advances in Pharmacy and Biotechnology

Journal homepage: http://ijapbjournal.com/

Review Article

REVIEW ON METAL NANOPARTICLES

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ARTICLE INFO

Article history:
Received 16 July 2022
Received in revised form 27 February 2023
Accepted 03 March 2023
doi.org/10.38111/ijapb.20230901001

Keywords:
Metal Nanoparticles, Preparation methods of nanoparticles, applications of metal nanoparticles.

ABSTRACT

The submicron scale articles made of pure metals (like gold, silver, titanium, zinc, platinum, iron, thallium and cerium) or their compounds (like hydroxide, oxides, chlorides, fluorides, chlorides, phosphates and oxides) are metal nanoparticles. In compliance with ISO and ASTM standards, nanoparticles are units of magnitudes starting from 1 to 100nm with one or more dimensions. At the latest, due to their effective solubility, less size and better penetrability, nanoparticles are extensively employed in many dosage forms. They have gained eminence in technological developments estimated to their reconfigurable physical, chemical and biological properties with greater performance on top of their bulk complements. Nanoparticles are often equipped by using varied procedures like Emulsions Diffusion Method, Emulsion-Solvent Evaporation Method, Solvent Displacement method, Double Emulsion and Evaporation Method, Salting Out Method, Coacervation or ionic gelation method and Polymerization method. Implementation of nanoparticles in micro wiring airs cell-specific, internalization, biosensors, prolonged circulation, ocular delivery, vaccine delivery and gene delivery. These also are operated in catalysis and generate heat. Nanoparticles are applied in the area of medicines and also for the treatment of cancer or orthopaedic implants. Taking advantage of high solubility and fast penetration, they are employed in nearly all formulations nowadays.

Introduction

Nanotechnology refers to the branch of science and engineering dedicated to materials, having dimensions within the order of 100th of nm or less [1]. Despite being a new term, it has been broadly used for the happening of more effective technology. In recent years, nanotechnology has been elevated by industrial sectors because of its applications within the sector of electronic storage systems [2], biotechnology [3], magnetic separation and preconcentration of target analytes, targeted drug delivery [4, 5], and vehicles for gene and drug delivery [2, 4-6]. In the area of biotechnology, nanoparticles range in particle size from 10 to 500nm, seldom exceeding 700nm. The nano size of these particles allows various communications with biomolecules on the cell surfaces and within the cells in a way which can be decoded and designated to varied biochemical and physiochemical properties of those cells [7]. On top of traditional pharmaceutical agents, it is advantageous in drug delivery and non-invasive imaging. Recently, the different metal nanoparticles and their derivatives gained prevalent recognition for their efficient antimicrobial properties. Likewise, metal oxides and tampered metal oxides like titanium oxide, silver oxide, quicklime and periclase have inimitable properties, spectral activity, and influential potencies and showed first-rate antimicrobial activity.

Additionally, the morphology and physicochemical properties of nanomaterials are confirmed for their antimicrobial activities. The Metal nanoparticles carry the commanding bactericidal effect to fight the bacteria and this was proved. The binding ability of metal nanoparticles to negatively charged bacteria surfaces is aided by the charge on its surface. The form of the nanoparticle is furthermore a very crucial factor because it also features a strong influence on antimicrobial activity. Metal nanoparticles (NP), especially AgNP and AuNP, with unique properties, like the use of operation, economical production, sensitivity and ease of construction, are widely used as biosensors because of the sensitivity and selectivity of this detection method [7].

Nanoscale Iron Particles:

Iron particles with a size of less than a micron are known as nanoscale iron

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particles. Due to their huge surface area, they are quite reactive. They quickly oxidise to create free radicals when oxygen and water are present. They are extensively employed in laboratory and medicinal applications.

Iron (III) oxide (Fe_2O_3) is one of the key oxides of iron, whereas others are FeO and Fe_3O_4. It is sanguine brown and an inorganic emulsion which is paramagnetic.

The Fe_3O_4 is superparamagnetic and occurs as mineral magnetite by nature. Superparamagnetic iron oxide nanoparticles (SPION) owing to ultrafine size, biocompatibility and glamorous particles, have raised as promising supporters for colourful biomedical operations, like targeted medicine delivery and imaging, enhanced resolution discrepancy agents for MRI, gene remedy, hyperthermia, molecular/ cellular shadowing, physical cell shadowing, glamorous separation technologies (e.g., rapid-fire DNA sequencing) early discovery of seditious, cancer, atherosclerosis and diabetes.

Silver nanoparticles:

Silver nanoparticles are particles of silver, with particle sizes from 1 to 100 nm in proportions. Though these frequently being referred to as "silver," some include a significant amount of silver oxide due to the high surface-to-bulk-to-mass silver atom ratio. Similar to Ag nanoparticles, ionic silver has a lengthy history and was first discovered the propensity of yellowing glass. Silver nanoparticles are now being tried to be included in a variety of medical equipment, such as surgical tools, bone cement, face masks, etc.

Besides, ionic silver in the right quantities proved to be effective in treating wounds. Silver nanoparticles are now substituting silver sulfadiazine as an effectual means in the treatment of wounds [8-11].

Samsung has also created and is selling a fabric called Silver Nano that features silver nanoparticles on the faces of home appliances. Additionally, these nanoparticles are commonly used in biological applications because of their outstanding physiochemical characteristics Surface Enhanced Raman Spectroscopy imaging (SERS). The resonance of the surface and enormous effective scattering of a single silver nanoparticle makes them ideal candidates for molecular labelling [12]. As a result, several targeted silver oxide nanoparticles are being created right now.

Gold nanoparticles:

Gold nanoparticles are employed for finding protein interactions in immunochemical studies. To find out the existence of DNA in the sample, it is operated as a lab tracer in DNA fingerprinting. Aminoglycoside antibiotics like neomycin, Streptomycin, and gentamycin are also depending on these nanoparticles. Detection of cancer stem cells, diagnosis of cancer and identification of different classes of bacteria are done by using gold nanoparticles [13, 14].

Production of nanoparticles

Requires, the choosing of the pertinent method, which is based on the drug to be filled and the physicochemical properties of the polymer.

The primary preparation methods of nanoparticles include:

1. Polymerization method
2. Emulsion- solvent evaporation method
3. Solvent displacement/ Precipitation method

<u>1. Polymerization method</u>: Aqueous solutions are used for monomer polymerization. Once the polymerization process is finished, the medication is absorbed either by dissolving in the polymerization solvent or by adhering to the nanoparticles. The suspension of nanoparticles is subsequently polished in an isotonic by resuspending the particles to get rid of different stabilisers and surfactants used for polymerization by ultracentrifugation, a surfactant-free medium may be created. Generating polybutylene cyanoacrylate or poly (alkyl cyanoacrylate) nanostructures has been described using this method. The formation of nanocapsules and their particle size is pretentious by the surfactants and stabilizers concentration used [15].

<u>2. Emulsion-Solvent Evaporation Method</u>: Generally, nanoparticles are prepared by using this method. There are 2 steps in the method:

Step-1: The primary step is the emulsification of the polymer in an aqueous phase. In this step the drug and polymer are dissolved in an organic solvent and this mixture is added to 100ml of light liquid paraffin or any other aqueous phase with stirring. The addition is done very slowly and stirring is continued until emulsion is formed which is known by turbidity of continuous phase.

Step-2: Evaporation of solvent and formation of nanospheres aided by polymer precipitation is the second step. The mixture of first step is continuously stirred for 6 to 8hrs to facilitate the evaporation of solvent and later crosslinking agent for the polymer is added so that nanospheres or nanoparticles are formed. Later, ultracentrifugation is done to remove free drug or residue and nanoparticles are collected, the method is terminated by washing with distilled water and further, they are lyophilized for storage [16, 17].

<u>3. Solvent Displacement/Precipitation method</u>: In the solvent displacement technique, the solvent diffuses in an aqueous medium with or without the addition of surfactant, and the polymer precipitates from an organic solution. Almost polar polymers and lipophilic surfactants are dissolved using water-soluble solvents (acetone, ethanol). The solution is poured or injected using magnetic stirring, into stabilizer containing solution. The frequent technique used for the formation of nanoparticles is the rapid solvent diffusion technique. The solvent then moves out from the solution at low pressure, and the incorporation of the organic solution into the aqueous phase further reduces the size of the particles. Drug entrapment and particle size have been reported to decrease with increasing the mixing process's speed. Several medications that are poorly soluble are compatible with this precipitation technique. By changing preparation settings, it is frequently possible to successfully regulate the size and release of drugs of nanospheres. While adjusting the concentration of polymer leads to good production of smaller-sized nanospheres [16].

Implementations

1. Antimicrobial activity:

Studies on antimicrobial exertion have been conducted to meliorate functions of antimicrobial activity because the microbes become resistant to regular usage of antiseptics and antibiotics. According to in vitro antimicrobial studies, the metallic nanoparticles effectively obstruct several microbial species [18]. Two parameters define the effectiveness of metallic NP antimicrobial activity (a) materials (carbon-based, metal-based) used for merging the nanoparticles and (b) their flyspeck size. Significant trouble in public health is seen as microbial resistance has gradationally increased to antimicrobial medicines. For case, antimicrobial medicine-resistant bacteria contain methicillin-resistant, sulphonamide-resistant, penicillin-resistant, and vancomycin-resistant parcels [19]. Similar to assertive multidrug-resistant mutants and biofilms, antibiotics underwent numerous challenges. As microbial resistance increases, there will be a high chance for a fleet fall in the effectiveness of antibiotics. Hence, conditions will persist in living beings when bacteria are treated with large boluses of antibiotics. Biofilms play an important role in furnishing multidrug resistance against heavy boluses of antibiotics. Resistance to medicines occurs substantially in contagious conditions similar to lower respiratory tract infections and gingivitis [20, 21].

2. MRI:

Iron oxide nanoparticles which are superparamagnetic are used in cancer identification. Their characteristics are magnified by examining the liver, lymph nodes, and bone marrow. Paramagnetic properties will alter resonance relaxation times of selected regions or fluids in vivo [22].

3. Drug and gene delivery:

Liposome and polymer-based nanoparticles have applications in cancer treatment. Their characteristics are targeted delivery by surface functionalization, strategies for prolonging residence times in vivo (e.g., PEG attachment), strategies for solubilizing water-insoluble drugs (e.g., paclitaxel), multi-layer and multi-functional (e.g., chemotherapeutic and anti-angiogenic) [23].

4. Optical imaging:

Nanoscale semiconductor crystals are used in-vivo site-specific imaging. Their characteristics are an examination of lymph nodes, pulmonary arteries, and tumours. Photobleaching has greater intensity and resistance when compared to traditional methods. Site-specific targeting is through surface functionalization. Subcutaneous imaging without surgical incisions [24].

5. Neurodegenerative disease therapy:

Metal nanoparticles due to their nano size act as carriers across blood–brain barrier (e.g., by PEG incorporation). Metal nanoparticles are used for therapies for diseases unresponsive to small molecule drugs (gene therapy) as these are superior to direct drug administration [25].

6. Ocular disease therapy:

These can increase drug retention times within the ocular mucus layer or retina. These can also use as an alternative high-drug concentrated drop.

7. HIV/AIDS therapy:

Solubilizing water-insoluble drugs by emulsification. These nanoparticles can transfect the cells by DNA incorporation.

8. Disposable biosensors:

The coronavirus disease 2019 (COVID-19) pandemic has called attention to the need for disposable biosensors for their fast response in detecting viruses in infected patients quickly and also at a low cost. Enzymatic and non-enzymatic sensors for glucose and hydrogen peroxide, immunosensors, and Geno sensors (DNA biosensors that detect known events) are all disposable biosensors based on metal nanoparticles for quick diagnosis, which includes the hybridization reaction.

Disposable COVID-19 biosensors: For remote testing, paper-based biosensors have several advantages over chip-based ones, including biodegradability, affordability, and ease of design and modification. The most popular lateral flow test strips [20, 21] are used to identify IgG and IgM for the identification of COVID-19 in arteries, serum, and plasma samples. The underlying assumption is that when IgM and/or IgG are prevalent in the patient sample, a complex is created by the interaction of antibodies with a gold COVID-19 antigen.

9. Respiratory disease therapy:

Mitigation of inflammatory responses in the respiratory tract [26].

Imaginary Perspectives

Due to their crucial role in nanomedicine and other natural processes, essence-anchored nanoparticles feel like they will continue to play a significant role in the twenty-first century. The tiny objects are often produced using a variety of synthetic ways and successfully used in fascinating nanomedical and natural processes. To estimate the cost, there is still a need to arrange these nanoparticles on a billboard size. The natural sources used to treat these nanoparticles should be abundant, reasonably priced, environmentally benign, and devoid of harmful chemicals. Monodispersed nanoparticles must be made available for upcoming exploration. Even nevertheless, the material used to create nanoparticles is still not completely understood. So, future research should focus on the method used to regularly modify the shape and size of nanoparticles. Expanding the use of nanoparticles in remedial operations and determining the extent of toxicity poses further significant challenges. By using metallic elements, new tactics are being developed implicitly in nanoscience to overcome obstacles to nanoparticles. The impact on anthropological health aspects must be taken into account before widespread usage. [27]

Modified biomedicine can greatly benefit from the use of nanoscience. In the future, it has to be investigated in much greater detail. The metallic element nanoparticles can perform as active agents in opinion and other therapeutic procedures since they display fresh packages in both supramolecular and infinitely small positions. In the health care, medical, and natural diligence sectors, there is now considerable demand for colourful feathers of nanomaterials and their mixtures. Thus, it is important to emphasise security precautions to protect mortal health. In-depth safety biography investigations are required, particularly in the case of employing metallic nanoparticles in health services. Future research should focus on investigating the use of certain essence nanoparticles for various processes. [28] Future marketable medical size for the treatment of metallic element nanoparticles must be over-gauged from laboratory size. Metallic nanoparticles have been created and are currently undergoing challenging multidirectional testing. At the moment, it is mostly utilised to treat malignant cells. Essence nanoparticles underline their efficacy as fresh agents for developing tumour treatment approaches. Are the metallic element nanoparticles harmful or biocompatible? is a question that has to be addressed. Thus, it's important to examine the relationships between nanoparticles at the laboratory size and improve the nanoparticles. Biocompatibility with malignant cells to prevent harm to healthy cells. While most investigation is now being done on a laboratory scale, modern discourse should focus on the implied activities of nanoparticles at the marketable position. Disquisition at a position that is marketable might cause a revolution among the population to continue [29].

TOXICITY OF NANOPARTICLES:

Though thousands of NP have been synthesized to date, there are no established guidelines regarding their toxicity yet. The toxicity of common metallic and metal oxides includes Titanium dioxide (TiO_2), Argentum (Ag), Aurum (Au), Zinc (Zn), and Copper (Cu). This metal NP toxicity is based on size (small size means more penetration), surface charge, and concentration. They mainly cause cell membrane dysfunction, Cytoskeleton component damage and DNA damage. Some methods by which the toxicity can be reduced include surface functionalization, Antibody (using ligands) functionalization and Coating modification. The main aim is to identify the potential hazards of nanoparticles and by changing its design, we can minimize the ADRs of nanoparticles. Nanoparticles can also be used in biological treatments in their safe threshold doses [30].

Outcome:

The importance of nanoparticles in conventional and alternative medicine is discussed in this paper. Due to substantial medical research, substance-based nanoparticles have received significant interest. Tests and a variety of other natural processes. Because of their distinctive physicochemical properties, substance-based nanoparticles have the potential to inflict harm to many body parts, including cells, subcellular units, and proteins as well as various organs and bodily pains. Similar to how particle size decreases, certain substances such as silver, Gold, Zinc, and Copper can exhibit high toxicity while being inactive at larger scales. Applied covers for antibacterial research have included substance-oxidized or pure substance nanoparticles. Antimicrobial nanoparticles may be used for treatments and medical devices that utilise disinfection.

Compounds, substance oxide, or composites made of substance, substance oxide, and substance are frequently used to generate basic, low-cost antibacterial agents. It will act as an alternative to conventional antibiotics. Due to their antibacterial properties, usage in medication administration and pivotal role in several medical procedures, nanomaterials and their composite materials are of tremendous relevance. The hazardous effects of the material oxide nanoparticles, which are often under intense scrutiny, limit their application as well. It is suggested that functionalization and ion doping to assist lessen the tone-poison impact, process and conjugated polymer material oxide nanoparticles can be used. In the end, that substance, or oxide, or emulsion may be used. Future cancer treatments will make use of nanoparticles with lesser toxicity to treat a variety of deadly infectious diseases.

Acknowledgements

Authors are thankful to the Principal and Management of G. Pulla Reddy College of Pharmacy providing necessary facilities and actions towards the fruitful completion of this manuscript.

Conflict of Interest

The author(s) confirm that this article content has no conflict of interest.

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