ejpmr, 2020,7(12), 217-221

SJIF Impact Factor 6.222

EUROPEAN JOURNAL OF PHARMACEUTICAL AND MEDICAL RESEARCH

www.ejpmr.com

Review Article

ISSN 2394-3211

EJPMR

A REVIEW ON NANOPARTICLES

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Article Received on 07/10/2020 **Article Revised on 27/10/2020** **Article Accepted on 17/11/2020**

ABSTRACT
Nanoparticles are particles of sizes ranging from 1 to 100 nm with one or more dimensions. Then nanoparticles are generally classified into organic, inorganic and carbon based particles in nanometric scale that has improved properties compared to larger size of respective materials. The nanoparticles show enhanced properties such as high reactivity, strength, surface area, sensitivity, stability, etc. because of their small size. This paper presents a review on nanoparticles their types, properties, synthesis and application in various fields.

KEYWORDS: Nanoparticles, Drug Delivery system, Drug release.

INTRODUCTION

Nanotechnology represents a revolutionary path for technological development that concerns the management of material at a nanometer scale. Nanotechnology means any technology on the nanoscale that has numerous applications in the world. A nano particle defined as a particle of matter that is between 1 to 100 nanometers in diameters.[1] Living organisms are made up of cells, these cell parts are however nanosized.[2] Nano sized particles are basically small objects that act as a whole unit in accordance with their transport and properties. Fine particles have the range of 100-2500nm and ultrafine particles have the size of 1-100nm.[3] They can also be designed to improve the pharmacological and therapeutic effects of the drugs.[4]

Advantages

- After parenteral administration to achieve both passive and active drug targeting particle size and surface characteristics of nanoparticles can be easily manipulated.
- To achieve high drug therapeutic efficacy and fewer side effects, during the transportation they control and sustain release of the drug and at the site of localization, altering distribution of the drug and subsequent clearance of the drug.
- By attaching targeting lagans to surface of particles or use of magnetic guidance site-specific targeting can be achieved.
- Including oral, intra-ocular, parenteral and nasal, the system can be used for various routes of administration.
- Within the body, drug delivery to tiny areas can be achieved better by nanoparticles.
- Engineering enables researchers to exercise precisely on this scale and previously control over the biomaterials and physical features of polymers.[5]

Types

Silver Nanoparticles

Under atmospheric condition, silver ions are reduced by ethanol at 800°C to 1000°C to obtain the silver nanoparticles. They are the most commonly used type of nanoparticles. They have good antimicrobial efficacy and so they are used in textile industries for sunscreen creams and water treatment. Research studies have revealed the advantageous biosynthesis of silver nanoparticles by plants like *Azadirachta indica*, *Capsicum annuum* and *Carica papaya.*

Gold Nanoparticles Liquid chemical method is used to produce gold nanoparticles by Chloroauric acid (HAuCl4) reduction. They are utilized in immunochemical studies and detection of protein interactions. They are also used for detecting the presence of DNA in a fingerprint sample, amino glycoside antibiotics like gentamycin, streptomycin and neomycin. Cancer stem cells and different classes of bacteria can also be detected by gold nanorods.

Copper Nanoparticles

Under microwave irradiation, reduction of copper sulphate with hydrazine in ethylene glycol is a new method for preparing copper nanoparticles. Polyvinylpyrrolidone plays a crucial role on the size of the copper nanoparticles and increase in its concentration elicits smaller dimension particles. They are basically 1 to 100 nanometers in size. They can be applied to biosensors and electrochemical sensors. They also serve as antifungal or antibacterial agents.[6]


Fig-1 Silver Nanoparticles.


Fig-2 Gold Nanoparticles.


Fig-3 Copper Nanoparticles.

Properties

The properties of nanoparticles are generally categorized into physical and chemical. The properties of few common nanoparticles are given in Table.1

Table-1

Nanoparticles	Properties
Silver	Absorbs and scatters light, stable, anti-bacterial, disinfectant.
Gold	Interactive with visible light, reactive.
Copper	Ductile, very high thermal and electrical conductivity, highly flammable solids.

Physical

The physical properties include optical such as the colour of the nanoparticle, its light penetration, absorption and reflection capabilities, and UV absorption and reflection abilities in a solution or when coated onto a surface. It also includes the mechanical properties such as elastic, ductile, tensile strengths and flexibility that play a significant factor in their application. Other properties like hydrophilicity, hydrophobicity, suspension, diffusion and settling characteristics has found its way in many modern everyday things. Magnetic and electrical properties such as conductivity, semi conductivity and resistivity has led a path for the nanoparticles to be used in modern electronics thermal conductivity in renewable energy applications.

Chemical

The chemical properties such as the reactivity of the nanoparticles with the target and stability and sensitivity to factors such as moisture, atmosphere, heat and light determine its applications. The antibacterial, anti-fungal, disinfection, and toxicity, properties of the nanoparticles are ideal for biomedical and environmental applications. Corrosive, anti-corrosive, oxidation, reduction and flammability characteristics of the nanoparticles determine their respective usage.[7]

Synthesis

Nanoparticles can be synthesized chemically or biologically. Many adverse effects have been associated with chemical synthesis methods due to the presence of some toxic chemical absorbed on the surface. Eco friendly alternatives to Chemical and physical methods are Biological ways of nanoparticles synthesis using microorganisms, enzymes, fungus, and plants or plant extracts. The development of these eco friendly methods for the synthesis of nanoparticles is evolving into an important branch of nanotechnology especially silver nanoparticles, which have many applications.

Biosynthesis: Mechanism

Biosynthesis of nanoparticles by microorganisms is a green and eco-friendly technology. Diverse microorganisms, both prokaryotes and eukaryotes are used for synthesis of metallic nanoparticles viz. silver, gold, platinum, zirconium, palladium, iron, cadmium and metal oxides such as titanium oxide, zinc oxide, etc. These microorganisms include bacteria, actinomycetes, fungi and algae. The synthesis of nanoparticles may be intracellular or extracellular according to the location of nanoparticles.

Intracellular synthesis of nanoparticles by fungi

This method involves transport of ions into microbial cells to form nanoparticles in the presence of enzymes. As compared to the size of extracellular reduced nanoparticles, the nanoparticles formed inside the organism are smaller. The size limit is probably related to the particles nucleating inside the organisms.

Extracellular synthesis of nanoparticles by fungi

Extracellular synthesis of nanoparticles has more applications as compared to intracellular synthesis since it is void of unnecessary adjoining cellular components from the cell. Mostly, fungi are known to produce nanoparticles extracellular because of their enormous secretory components, which are involved in the reduction and capping of nanoparticles.

Microbes for production of nanoparticles: Both unicellular and multicellular organisms produce inorganic materials either intra- or extracellularly. The ability of microorganisms like bacteria and fungi to control the synthesis of metallic nanoparticles is employed in the search for new materials Because of their tolerance and metal bioaccumulation ability; fungi have occupied the center stage of studies on biological generation of metallic nanoparticles.[8]

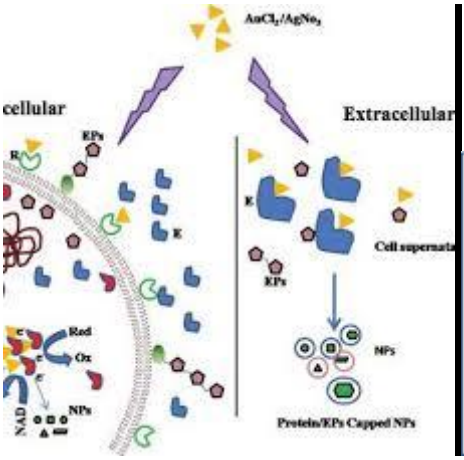

Fig-4 Biosynthesis of Nanoparticles.

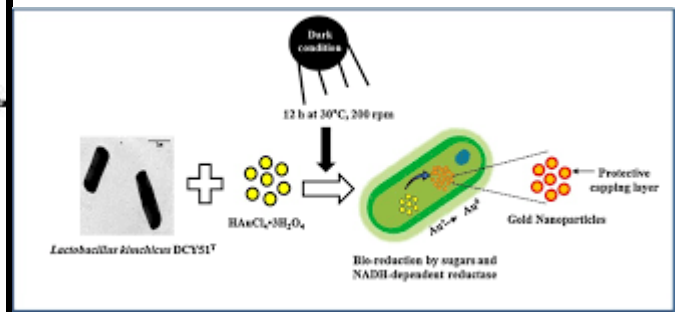

Fig-5 Intracellular synthesis of nanoparticles.

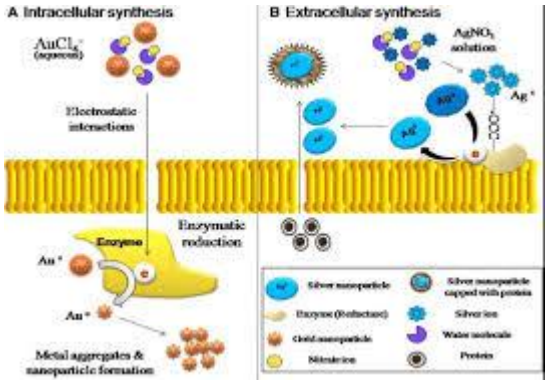

Fig-6 Extracellular synthesis of Nanoparticles.

Fig-7 Microbial synthesis of Nanoparticles.

Applications of Nanoparticles

In Drug Delivery System

Firstly, the most significant advantages of nanoparticles used on drug carrier are high stability, high carrier capacity, expediency of accommodation of both hydrophilic, hydrophobic substances and various routes of administration including oral application and inhalation. Certain drugs cannot pass the first pass metabolism. The nanoparticles can be modified to overcome this and they also allow controlled sustained drug release from the matrix. These attributes can enhance the bioavailability of the drug and also in the reduction of the dosing frequency. Quantum dots are miniature semiconductor particles of few nanometers in size. They are also called as artificial atoms with distinct electronic states. When light or electricity is applied to them, they emit light of variable frequencies. These frequencies can be altered by changing the dots' sizes, shapes and materials eliciting many applications in the process. The most advanced approach of quantum dots technology associated with anticancer drug therapy is called ZnQ Quantum dots. The essence of this technology is that the quantum dots are loaded with anti-cancer agents and are encapsulated with biocompatible polymers. This is how the tumor targeted drugs are delivered and this is one of the important applications of Quantum dots technology. Verdun et al established that when mice were treated with doxorubicin integrated into isohexylcyanoacrylate nanospheres, there were higher concentrations of doxorubicin in liver, spleen and lungs than in mice which were treated with free doxorubicin. The greatest objection of using nanoparticles for tumour targeting is the prevention of particle uptake by mononuclear phagocytic system in liver and spleen. This was demonstrated by Bibby et al through the biodistribution and pharmacokinetics of a cyclic doxorubicin-nanoparticle formulation in tumour-bearing mice. These nanoparticles are been modified as delivery vehicles for many more therapeutic pharmaceuticals such as liposomal nanoparticles, layered double hydroxide, water soluble polymers drug conjugate to enhance half life with potent anticancer effect. It is more difficult to deliver drugs to the central nervous system and brain but

the nanoparticles can overcome these obstacles ensuring the success rate of the drug delivery in the brain.

In Food

The major areas where nanotechnology has potential utility in the food sector are encapsulation and emulsion formation, in food contact materials and sensor development. Cultivation, producing, packaging and processing of food using nanoparticles is demonstrated as nanofood by Garber. FSAI determined some applications of nanofood which include sensory improvements (flavor/color enhancement and texture modification), increased absorption, targeted delivery of nutrition bioactive compounds, stabilization of active ingredients such as nutraceuticals in food sources, packaging and product improvement to extend shell life, sensors for food safety and antimicrobials to eradicate pathogenic microbes in food. Bionanocomposites are hybrid nanoparticles with enhanced mechanical, thermal and gas attributes. They are utilized in packaging of food, increase its shelf. This is environment friendly as it reduces reliability on plastics for packaging. An example is zein which is a prolamin and a major component of corn protein which, when dissolved in ethanol or acetone can produce a biodegradable zein film with improved tensile and water barrier properties. In Australia, nanocapsules are utilized to accommodate omega-3-fatty acids to white bread. In Asia, the development of non-toxic nanoscale herbicides to intervene weed's seed coating and prevention of germination is in progress. So, the application of nanotechnology in food is emerging rapidly and is involved in all areas of food chain.

In Medicine

Nano medicine aids in early detection and prevention, enhanced diagnosis and follow up of diseases. Invention of nano devices like gold nano particles has made gene sequencing less difficult. They are also used to detect genetic sequences when they are adhered with the short DNA segments. Damaged tissue can be repaired or reproduced using nanotechnology. Organ transplantation or artificial implantation can be revolutionized using nanotechnology. Magnetic nanoparticles have proven to be successful in isolating and grouping stem cells. Quantum dots on the other hand, have been used for molecular imaging and tracing of stem cells etc. Controllable regulation of proliferation and differentiation of stem cells is made possible by designed unique nano particles. Another added benefit of nanotechnology is regeneration and neuroprotection of Central Nervous system. Parkinson's disease is one of the most known neurodegenerative disorders. Intracranial nano-enabled scaffold device (NESD) for the site specific drug delivery of dopamine to the brain is an excellent method to reduce the peripheral side effects of Parkinson's disease therapy. Novel methods include activation of signaling cues for controlled axon growth and peptides and peptidic nano particles as novel tools for various Central Nervous system diseases. They can also provide functional regeneration of damaged neurons so as to provide neuro protection and facilitation of drug delivery and molecules across the blood brain barrier. Amyloid beta plaques are mainly found in the brains of Alzheimer patients. These nanoparticles may suppress these plaques as they have high affinity for them, thereby improving the Alzheimer's disease condition. Tuberculosis is a deadly infectious disease. A more effective and an affordable TB pharmacotherapy was made possible due to the recent improvements in nano-based drug delivery systems for encapsulation and release of anti- TB drugs. In par with operative dentistry, nano filled composite resin materials provide effective wear resistance, tenacity and excellent aesthetic values as a result of their unique luster retention and polish ability. Spherical silicon dioxide nano fillers elicit the possibility of modifying the load of inorganic phase in operative dentistry. These nano composites have extreme hardness, great bend strength, good elasticity, reduced polymerization shrinkage. Some of the applications of nanotechnology in ophthalmology include treatment of oxidative stress, intraocular pressure measurement, treatment of choroidal new vessels, prevention of scar formation post glaucoma surgery, prosthetics etc. Treatment of severe evaporative dry eye is done by nanoscale dispersed eye ointment (NDEO) in the recent times. Histological evaluation suggested that the normal corneal and conjunctive morphology was restored through NDEO. The resistance to antibiotics can be minimized by using Zinc Oxide nanoparticles thereby enhancing the antibacterial activity of Ciprofloxacin against microorganisms. This is brought about by intervention of these nano particles with the proteins interacting in the antibiotic resistance. The nano device buckminsterfullerene's (Bucky balls) can change the immune response by preventing the release of histamine from mast cells into the blood and the tissues. Nano pharmaceuticals minimize toxic systemic side effects to an extent resulting in better patient compliance. They play a crucial role in detecting the failure of traditional therapeutics which provide site-specific targeting of active agents. Nanoparticle based thrombocytic agents have enough potential to accelerate the clot removal effect. In nanodentistry, treatment possibilities include the application of nanotechnology to dentition renaturalization, the permanent solution for hypersensitivity, complete orthodontic realignments etc. Eradication of Caries-causing bacteria and reparation of tooth blemishes where decay has adhered to, are made possible with the help of nanorobots in accordance with a computer to control them.[9]

CONCLUSION

The lack of nanotechnology to engineer matter at the smallest scale is re-developing areas such as information technology, cognitive science and biotechnology. Poorly soluble and poorly absorbed substances are re-modified to promising deliverable drugs through the recent advancements of nanotechnology. To optimize this drug delivery system, greater understanding of the different mechanisms of biological interactions, and particle

engineering, is still required. Further advances are needed in order to turn the concept of nanotechnology into a realistic practical application as the next generation of drug delivery system.

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