International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2019): 7.583

Nanoparticles: As a Nano based Drug Delivery System

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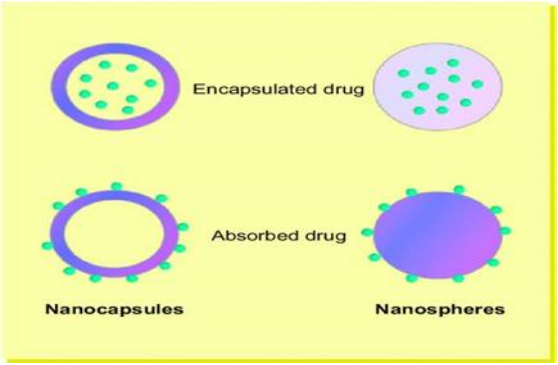
Abstract: ***Nanoparticles can offer important advantages over the administration of conventional drugs in terms of high stability, high specificity, high drug transport capacity, controlled release capacity, possibility of use in different routes of administration and the ability to administer drugs both hydrophilic and hydrophobic molecules. Nanoparticles are being used for various purposes, from medical treatments, use in various branches of the production industry such as solar and for energy storage, to a wide incorporation obsessed with various everyday materials such as cosmetics or dress, optical devices, catalytic, bactericidal, electronics, sensor technology, biological labelling and treatment of some cancers. Nanoparticles can be chemically or biologically synthesized. This review focuses on the need to develop nanoparticles, advantages, disadvantages, synthesis, properties, applications of nanoparticles exist in different forms. Nanoparticles are very capable in selective tumour contact cancer therapy due to their small size and modifiability. These particles consist of pure active pharmaceutical ingredients and are stabilized regularly with surfactant. Nanoparticles are tiny materials that have particle sizes in the range of 1 to 1000 nm.***

Keywords: Nanoparticles, polymeric nanoparticles, drug delivery

1. Introduction

The prefix "Nano" has found in the last section an increasing application to different fields of information. The prefix comes from the Latin nanus which literally means dwarf and, by extension, very small. Within the agreement of the International System of Units (SI) it is used to indicate a reduction factor of 109 times. Pharmaceutical nanoparticles are defined as solid drug carriers of submicron size (less than 100 nm in diameter) that may or may not be biodegradable.

The term nanoparticle is a combined name for "nanospheres" and "Nano capsules". Nanospheres are a matrix system in which the drug is homogeneously dispersed, while Nano capsules are the system in which the drug is surrounded by a single polymeric membrane.



Nanotechnology is the science of the little ones; the very small one. It is the use and manipulation of matter on a small scale. Nanotechnology has produced a wide variety of materials at nanoscale level. Nanoparticles (NP) are a broad class of materials that include particulate substances, which have a dimension less than 100 nm minimum. At this size, atoms and molecules work differently and provide a variety of surprising and motivating uses. Nanotechnology and nanoscience studies have appeared rapidly in recent years in many product topics. Provides opportunities for materials development. including those intended for medical applications, where conventional techniques can reach their limits. Nanotechnology represents the manufacture, production and use of materials on the atomic, molecular and macromolecular scale, in order to produce new nanometric materials. Engineered nanoparticles (NP) are commercially produced materials that have at least one dimension less than 100 nm[1]. In the medical field, NPs are being used as a new delivery system for drugs, proteins, DNA, and monoclonal antibodies[2]. The main objectives are to construct nanoparticles such as a delivery system to control particle size, surface structures, and the release of pharmaceutical agents for specific site-specific actionof the drug with the correct dose of Therapeutically and regimen dose [3].Nanotechnology has great potential to improve the quality of air, water and soil in the environment. It can improve the detection and detection of contaminants and help in the development of new technologies for remediation. Understanding the dynamic processes of nanoparticle formation and growth (for example, in the combustion system) allows the development of efficient methodologies to minimize the formation of pollutants in the first place and to reduce their emissions. Although nanotechnology has the potential to improve environmental quality, there are concerns that it may also lead to a new class of environmental hazards. These concerns are associated with virtually all new technologies and must be addressed early on. With proper care, careful research, and incorporating findings at an early stage, the safety of nanotechnology can be ensured [(4, 5, 6).]

Need for developing nanoparticles

The main objectives in the design of nanoparticles such as a delivery system to control particle size, surface structures, and the release of pharmaceutical agents to achieve a specific drug action a reasonable rate and dose[7]. Polymeric nanoparticles provide certain advantages over liposomes. for example, they help increase drug / protein stability and possess useful controlled release properties[8].

Advantages: -

Some benefits of using nanoparticles as a drug delivery system are as follows:

1) Many routes of administration are available including oral, nasal, parenteral, intraocular, etc[9].
2) Drug loading is very high and drugs can be introduced into systems without chemical reactions, this is important to maintain drug effectiveness.
3) Polymer-based nanoparticles are mostly biodegradable, do not accumulate in the body, and therefore possibly pose no risk.
4) Small nanoparticles can enter through smaller capillaries, which could allow efficient drug collection at target sites.
5) ease of manipulation of the particle size and surface characteristics of the nanoparticles to achieve both passive and active drug targeting after parenteral administration.
6) The surface of the nanoparticle can be modified to alter the biodistribution of drugs with subsequent clearance of the drug to achieve maximum therapeutic efficacy with minimal drug side effects[10].
7) Greater bioavailability Proportionality of the dose.
8) Smaller dosage form. The enlarged area causes the rapid melting of the active agent in a liquid environment, such as the human body.
9) Faster dissolution generally equates to greater absorption and bioavailability. Smaller drug doses reduce toxicity

Disadvantages: -

In spite of these advantages, nanoparticles have limitations such as,

1) Modified physical properties that lead to the aggregation of particles to particles, which makes the physical handling of nanoparticles in liquid and dry forms difficult due to their smaller size and greater surface area.
2) The smaller the particle size, the larger the surface area and this property makes nanoparticles very sensitive in the cellular environment.
3) The size of the small particles results in limited drug loading and sudden release, this problem can be addressed before the nanoparticles can be used clinically or made commercially available[11].

Types of nanoparticles: -

Polymeric nanoparticles are colloidal structures composed of synthetic or composite polymers. The drug dissolves or binds to a matrix of nanoparticles. Depending on the preparation method, nanoparticles, nanospheres or Nano capsules can be obtainedNano tablets are a system in which a drug is trapped in a hole surrounded by a single polymer membrane, and nanospheres are a matrix system in which a drug is physically or uniformly dispersed.

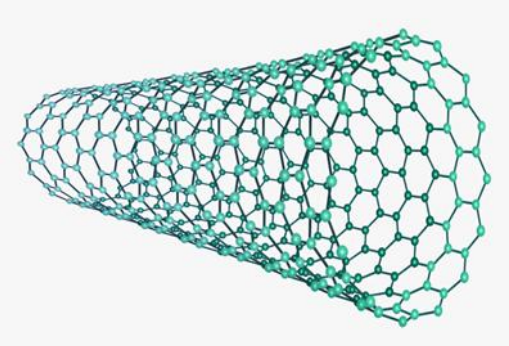
Classification of nanoparticles: -

There are several methods for the classification of nanomaterials. Nanoparticles are classified on the basis of one, two and three dimensions[12].

1) One-dimension nanoparticles: The one-dimensional system, such as thin film or fabricated surfaces, has been used for periods in electronics, chemistry, and engineering. The production of thin films (sizes 1 to 100 nm) or monolayer is now commonplace in the field of solar cells or catalysis. This thin film is used in a variety of technological applications, including data storage systems, chemical and biological sensors, and optical devices.

2) Two-dimension nanoparticles:

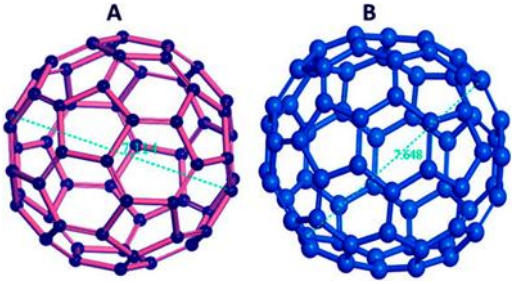
Carbon nanotubes: -Carbon nanotubes are a hexagonal lattice of carbon atoms, 1 nm in diameter and 100 nm in length. Carbon nanotubes are of two types, single-walled carbon nanotubes and multi-walled carbon nanotubes. Carbon nanotubes have small dimensions, combined with their outstanding physical, mechanical and electrical properties. They show metallic or semiconductor properties, depending on how the carbon sheet is twisted on itself. The current capacity of nanotubes can be extremely high and can be from one million amps per square meter, making it a superconductor.The mechanical resistance of carbon nanotubes is sixty times greater than that of the best steels. Furthermore, they are chemically very stable[13].



Carbon nanotubes

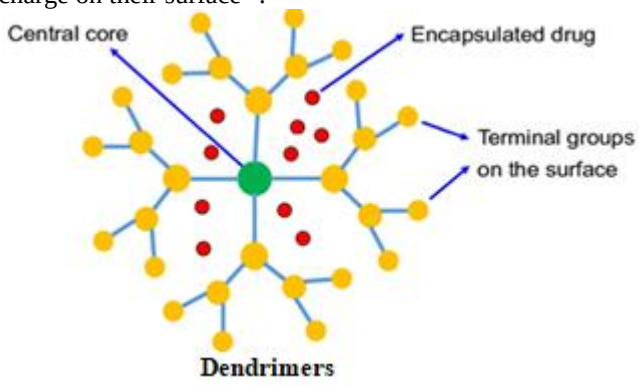
3) Three-dimensional nanoparticles:

a) Fullerenes: -Fullerenes are spherical cages that contain from 28 to more than 100 carbon atoms. This is a hollow ball made up of consistent carbon pentagons and hexagons, like a soccer ball. Fullerenes are a class of materials that display unique physical properties. They can be exposed to extreme pressure and return to their original shape when the pressure is released. These molecules do not combine with each other, which gives them a greater possibility of application as lubricants. Fullerenes are a potential contributing application in the rich area of nanoelectronics. Since fullerenes are empty dimensional structures similar to several active biological molecules, they can be filled with different substances and find a possible medical application[14].



Different form of fullerenes

b) Dendrimers: -Dendrimers are used in drug delivery and usually have a diameter of 10 to 100 nm with multiple functional groups on their surface, which interprets them as ideal carriers for targeted drug deliverythe structure and function of dendrimers are well studied. Contemporary dendrimers can specialize; encapsulating functional molecules within the nucleus [16]. They are considered a basic element for the large-scale synthesis of organic and inorganic nanostructures with dimensions from 1 to 100 nm[15]. Dendrimers have different groupings of reactive surfaces and a well-adapted organic structure, like DNA, which is why their use is mainly found in the medical and biomedical fields. Pharmaceutical applications of dendrimers include non-steroidal anti-inflammatory formulations, antimicrobial and antiviral drugs, anticancer agents, prodrugs[17]. Dendrimers can be toxic due to their ability to alter cell membranes as a result of a positive charge on their surface[18].



c) Quantum Dots (QDs): -Quantum dots are small devices that contain a small drop of free electrons. Quantum dots are fluorescent inorganic semiconductor nanoparticles composed of 10-15 atoms 2 to 10 nm in diameter. It can be synthesized from various types of semiconductor materials. The most commonly used quantum dots are cadmium selenide (CdSe), indium phosphide (InP) and indium arsenide (InAs). Quantum dots also provide sufficient surface area to bind the therapeutic agent for simultaneous drug delivery, as well as for tissue engineering[19].

Preparation of Nanoparticles: -Nanoparticles can be prepared from natural materials such as proteins, polysaccharides, and synthetic polymers. The selection of the inert matrix material depends on many factors such as[20]:
a) The final size of the required nanoparticles,
b) The properties of the drug, such as aqueous solubility, stability,
c) Surface charge and permeability, d) the degree of biodegradability

Nanoparticles can be classified as follows,
a) Bottom-up approach
b) top-down approach

a) Bottom-up approach: - Bottom-up approaches start with the drug molecule in solution. This approach is used in reverse, since nanoparticles are formed from relatively simpler substances, which is why this approach is also called an accumulation approach.

Examples of this are sedimentation and reduction techniques. Includes spinning and biochemical synthesis.

These nanoparticles have excellent colloidal properties. In the bottom-up approach, the bismuth acetate was boiled in ethylene glycol, while in the top-down approach bismuth was converted into a molten state and then dissolved in a mixture of boiled diethylene glycol to produce nanoparticles. The size of the nanoparticles obtained by both methods was varied from 100 nm to 500 nm. These processes are costly and environmentally friendly. Bacteria, yeast, fungi, aloe vera and even human cells are used for the synthesis of nanoparticles.

b) top-down approaches: - In contrast to bottom-up approaches, it starts with a larger molecule, which is broken down into smaller units and then these units are turned into suitable nanoparticles. therefore, this process is considered top-down technologies. A very important technology is based on the wet ball mill. To produce nanocrystalline dispersions, a grinding chamber is loaded with grinding media. Moving grinding media causes high shear forces and therefore wear of the drug particles. For large-scale production, the mill can be operated in circulation mode, which means that the suspension is continuously pumped through the grinding chamber until the desired particle size of the drug nanocrystals is obtained. Drug particles are separated from the grinding media separating the space

Examples of this method are grinding and grinding. This approach is used to synthesize coconut shell nanoparticles.

High pressure homogenization is another very important downstream technology. The main disadvantages of this process are the required production time.

Toxicity

These tiny particles can easily enter the interior of the body through the skin, lungs or intestinal tract, depositing in various organs and can cause serious adverse biological reactions by altering the physicochemical properties of tissues. Non-biodegradable particles when used for drug delivery can show accumulation at the drug delivery site, leading to chronic inflammatory reactions. Most nanoparticle toxicity reactions are observed due to inhalation of particulate material leading to lung and cardiovascular diseases.

Characterisation of nanoparticles

Different classification methods have been developed for the analysis of various physicochemical features of nanoparticles. Nanoparticles are generally characterized by size, morphology, and surface charge, using very small techniques such as electron microscopy scanning (SEM), transmission electron microscopy (TEM), and atomic force microscopy (AFM).

a) **Particle size:** Distribution of particle size and morphology are the most important parameters for the separation of nanoparticles. Morphology and size are measured by electron microscopy. the main use of nanoparticles is drug delivery and selection. The smaller particles provide a larger surface area. As a drawback,

the smaller particles tend to aggregate during storage and transport of the nanoparticle dispersion. Therefore, there is a compromise between a small size and maximum stability of the nanoparticles[21]. Polymer degradation can also affect particle size. For example, the poly degradation rate was found to increase with increasing particle size in vitro[22].

b) **Scanning electron microscopy:** Scanning electron microscopy (SEM) provides a morphological examination with direct visualization. Techniques based on electron microscopy offer several benefits in morphological analysis; however, they provide limited information on the size distribution. The mean size obtained by SEM is comparable with the results obtained by dynamic light scattering. In addition, these techniques are time-consuming, expensive, and often require additional information on size distribution[23].
c) **Transmission electron microscope:** The preparation of the sample for the transmission electron microscope is complex and time consuming. They are fixed using a negative staining material, such as uranyl acetate, etc., the characteristics of the sample surface are obtained when an electron beam is transmitted through an ultra-fine sample.
d) **Dynamic light scattering (DLS):** Currently, the fastest and most popular method for particle size determination by photon correlation spectroscopy (PCS) or dynamic light distribution (DLS). DLS is widely used to determine the size of Brownian nanoparticles in colloidal suspensions in nano and submicron environments. Photon Correlation Spectroscopy (PCS) represents the most frequently used technique for precise estimation of particle size and size distribution based on DLS[24].
e) **Atomic force microscopy:** Atomic force microscopy (AFM) offers ultra-high-resolution particle size measurement and is based on physical scanning of samples at the submicron level using the atomic scale probe tip[25]. Atomic force microscopy provides the most accurate description of the size and size of the distribution. Furthermore, the particle size obtained by the atomic force microscopy technique provides a real image that helps to understand the effect of various biological conditions[26].
f) **Surface hydrophobicity:** The hydrophobicity of the surface can be determined by various techniques, such as hydrophobic interaction chromatography, biphasic partition, etc. X-ray photon correlation spectroscopy allows the identification of specific chemical groups on the surface of nanoparticles[27].
g) **Surface Charge:** The nature and intensity of the surface charge of the nanoparticles is very important because it determines their interaction with the biological environment and their interaction with electrostatic and bioactive compounds. Colloidal stability is analysed by the strength of zeta nanoparticles.

Use of nanoparticles

Nanoparticles have attracted growing interest from all branches of medicine through their ability to deliver drugs at the right level, which often leads to better drug performance, less side effects, and better compliance. of the patient[28].

Nanoparticles are super paramagnetic iron oxide nanoparticles with suitable surface chemistry can be used for numerous in vivo applications, such as magnetic resonance contrast enhancement, tissue repair and immunoassay, biological fluid hyperthermia detoxification, drug delivery, and cell separation.

All of these biomedical applications require nanoparticles to have a high magnetization value, a size less than 100 nm, and a narrow particle size distribution.

Most metallic and semiconductor nanoparticles have immense potential for cancer diagnosis and therapy.

For diagnosis and bioimaging

Various molecular imaging techniques are available, such as optical imaging (OI), resonance imaging (MRI), ultrasound imaging (USI), positron emission tomography (PET), and more. in vitro and in vivo biological samples [29,30].

Future Opportunities and Challenges

Nanoparticles and nano formulations have already been applied as drug delivery systems with great success; and nanoparticulate drug delivery systems have even greater potential for many applications, including antitumor therapy, gene therapy, AIDS therapy, radiation therapy, in the delivery of proteins, antibiotics, virostatics, vaccines, and as vesicles to traverse the blood-brain barrier.

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