Review Article

A Review on Nanoparticles

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ABSTRACT

At present, nanotechnology considered as one of the highly attractive platform for new inventions. Nanotechnology is a field of developing materials and devices exist at nano-scale, up to 100nm. These things are easier to administer also cheap and safe. A nanoparticle is defined as particle of matter in a diameter between 1 and 100nm. They are usually tiny particles. Nanoparticles can be classified into different classes based on its properties, shape, and size. Nanoparticles are usually distinguished from micro particles, fine particles and coarse particles due to their smaller size, diverse chemical properties or physical property, also its optical, colloidal and electrical property. Nanoparticles are easier to administer. Nanoparticles are using for various branches of industries such as coating of solar cell, manufacturing of cosmetics, crack resistant paints, eye glasses, scratch proof eye glass, Biological labelling, and treatment of cancer. Nanoparticles are prepared by both chemically and mechanically.

Keywords: Nanoparticles, Synthesis, Application, Characterization.

INTRODUCTION

Nanotechnology is science, engineering technology at the nanoscale range. This technology introduced by physicist Richard Feynman. This technique has emerged at the starting of 20th century Nanotechnology is referred to as an emerging field of development and synthesis of materials, devices and system lies in nanoscale up to 1-100nm. Nano formulations have high surface volume ratio. Nanotechnology consist of creating small things such as electronic device, catalyst, sensor etc. In recent years, nanomaterial has become one of the most important and exciting field of research in physics, chemistry, biology, medicine, engineering and technology. Nanotechnology represent the design and development, application of materials at atomic, molecular, macromolecular range.

Nanotechnology should not be viewed as a simple technique that only affect specific areas, although, nanotechnology does not means as small structures. Applying nano-scale features to large surfaces. In nanotechnology, classified according as size, morphology, physical, chemical properties (e.g.: carbon based nanoparticles, semiconductors, lipid based nanoparticles and polymeric nanoparticles). Now a days we have witnessed as that, development of innovative methods to formulate new chemicals, materials and products. Also it substitute current experimental technique to developing experimental technique. Reduce the material consumption and energy consumption[1].

Nanoparticles are defined as the particles lies in size range of 1-100nm. At this size, both atom, molecules work differently, resulting unique uses as that of any other formulations. Undetectable by human eye. Nanoparticles are synthesised by using biocompatible and biodegradable polymer. These polymers are able to changes the actual activity of drug via, delay the drug release or increases the adhesively. Nanoparticles are differing from that of bulk material due to its size. Increase in surface area per mass of material which result large amount of the material can come into contact with surrounding material. Nanoparticles are sub-nano sized colloidal drug delivery systems. The properties of nanoparticles are quite different from that of large particles of the same substance. Pharmaceutical nanoparticles are defined as submicron sized drug carriers which, biodegradable or not[2].

Nanoparticles are made of at least of hundred atoms. Nanoparticle, is the combined name for nanosphere and nanocapsule. Nanoparticles are matrix system with in which drug equally dispersed, Nano capsule, drug encapsulated with polymeric membrane. Nanoparticles can be classified into as hard particles (titanic, silica) soft particles (liposomes, vesicles and Nano droplets). Nanoparticles be created as the by-product of combustion reaction / through engineering technique. . Nanoparticles can also found in natural sources such as volcanic ash, ocean spray, dust and fine sand also in biological matter such as viruses. Nanoparticles are well known for targeted drug delivery due to its targeting nature nanoparticles used to deliver DNA, drug, protein. This is because of its nature, size and optical property, helps nanoformulation easy to penetrate physiological barrier and reaches target cell. This review, aimed for method of preparation, classification, advantages and its disadvantages, and various application.

CLASSIFICATION OF NANOPARTICLES

Nanoparticles are classified as one dimension, two dimension, and three dimension[3].

1. One dimension nanoparticle

They are either thin film or manufactured surface. They are used for many years in the field of electronics, chemistry and engineering. Thin film or monolayer in a size of 1-100nm thin film is widely used in solar cell /catalysis. Also, in chemical and biological sensors, fibre-optic system, magneto-optic and optical devices, informational storage system.

2. Two dimension nanoparticle

Carbon nanotubes (CNTs) they are hexagonal networks of carbon atoms, with in a length of 1nm and length of 100nm. CNTs are two different types such as single walled nanotube (SWCNTs), multi-walled carbon nanotubes (MWCNTs). Due to their small dimensions and physical, mechanical, electrical property make differ from others. Carbon nanotubes have higher ability for molecular absorption .carbon nanotubes are very stable.

3. Three dimension nanoparticles

3.1 Fullerenes (carbon 60)

These are spherical cages with 28 carbon atom to more than 100 carbon atoms. They are similar to soccer ball by forming interactions with carbon as hexagon, pentagon resulting hollow ball. They are class material due to their physical property than others. When they take into high pressure get expanded, while upon release of the pressure it regain its previous structure. Those molecules were not having affinities together so, that they are considered as lubricant. Used in electrical field because of its electrical property. So that, used in data storage, solar cell. Its empty structure where filed with biological active molecule having similar dimension[4].

3.2 Dendrimers

It's a new class of controlled structure polymer with nanometric range. Dentrimers Used for drug delivery imaging. Dentrimers surfaced with multiple functional groups, considered as carrier for targeted delivery. Dentrimers are therapeutic or diagnostic agent they encapsulate the functional molecules inside its core. Its size is varies from 1-100nm. Dendrimers are highly compatible with DNA. So that it is used in medical, and biological field. It is pharmaceutically used as non-steroidal anti-inflammatory agent, antimicrobial, antiviral, anticancer, screening agent and also as a prodrug. Perhaps it has a chance to disrupt cell membrane and leaving positive charge on its surface, consider dentrimer as a toxic.

3.3 Quantum Dots (QDs)

Quantum dots are very small device containing minute droplets of free electrons. They are colloidal semiconductors of nano-crystals in 2-10 nm size range. Prepared from different type of semiconductors by colloidal synthesis. Cadmium selenide (CdSe), cadmium tellurid (CdTe), indium phosphide (InP) size, shape of QDs can be easy to controlled. QDs can be developed in the form of semiconductors, metals, insulators, metallic oxide, and metals. Used in optical quantum computing, information storage. Colour coded QDs applied for fast DNA testing[5].

PREPARATION OF NANOPARTICLES

The selection of appropriate method for preparation of nanoparticles depends on the characteristics of drug and polymer. Therefore, to achieve the properties of interest the mode of operation play a vital role. Different methods are employed in synthesis of nanoparticles. Method selection depends upon nanoparticles well defined structures and morphology include physical, chemical, biological, and physiological factors[6].

1. Solvent Evaporation Method

It was the first method for the preparation of nanoparticles. In this method polymer solution were prepared in volatile solvent as emulsion by using dichloromethane and chloroform. In order to obtain polymeric particles less than 500nm in size replace the solvent with ethyl acetate because of its much better toxicological profile. During the preparation solvent get evaporated and emulsion is converted into a nanoparticle suspension. Then allow the emulsion to diffuse (single emulsion) and double emulsion such as W/O/W .double emulsion technique need ultracentrifugation and high speed homogenisation and evaporation of solvent. Nanoparticles are formed by continuous magnetic stirring at reduced pressure or controlled temperature. Then the product formed is collected and subjected to ultracentrifugation washing and lyophilisation. Both single and double emulsion techniques widely used. Solvent evaporation method used to manufacture pharmaceutical formulations such as, encapsulation of hydrophilic and hydrophobic anticancer drugs, anti-inflammatory drugs, antibiotic drugs, amino acids and proteins.

2. Nanoprecipitation

In this technique polymers are incorporated in to the solvents like acetone, ethanol, or methanol in presence or absence of surfactant. Then this solvent phase diffused with poly-lactic acid. Due to intermediate polarity of PLA helps to dissolve it in water-miscible solvent leads to formation of nanosphere.

For nanoparticles, after injecting polymer to the aqueous phase and followed by nanoprecipitation gives NPs of submicron size (<210nm). To reduce the toxic effect of NPs use biodegradable polymers. In the absence of surfactant in solution phase leads scattering of nanoparticles that's called 'ouzo effect'. Advantage of nanoprecipitation is low energy input[7].

3. Emulsification diffusion

It is also known as solvent diffusion method. Emulsification diffusion is the modified form of solvent evaporation technique. Turbulence generated in a mixture of water miscible solvent and water immiscible solvent due to spontaneous diffusion. As a result, nanosized particles formed. Product formation depends on rate of diffusion of solvent on dispersed phase. The Presence of stabilizer and oil-polymer ratio in aqueous solution offer greater solvent diffusion to external phase. Followings are the advantages of emulsification diffusion technique they are, high capsulation efficacy, high batch to batch consistency, no need of homogenisation, ease of scale up and simplicity. Nanoparticles such as, doxorubicin-loaded PLGA, DNA-loaded PLA and coumarin loaded PLA were prepared by using emulsification diffusion.

4. Salting out

It is a modified form of emulsion solvent diffusion technique. Solvent contains mixture of polymer and drug which is emulsified into aqueous gel. Salting agent such as electrolytes (magnesium chloride, calcium chloride, magnesium acetate) non-electrolyte (sucrose) are used. Salting out agents are used in this technique will alter its encapsulating efficiency of drugs. Filtration removes salting out agent after completion of the process.

5. Dialysis

Its mechanism is similar to as that of nanoprecipitation. It is Suitable for the preparation of small and narrow distributed nanoparticles. Here the dialysis tube is filled with polymer containing organic solvent. Homogenous suspension of nanoparticles is formed, by the aggregation of polymer due to loss of solubility. Semi-permeable membrane allows passive transport of solvent as a result, reduce the mixing of polymer solution[8].

6. Supercritical Fluid Technology (SCF)

SCF is suitable for mass production of nanoparticles. This technique is devoid of drawbacks as that of other technique. SCF used as an alternative method to prepare biodegradable micro particles and nanoparticles. SCF fluid is eco-friendly. Carbon dioxide is one of the widely used SCF due to non-toxic and non-inflammatory nature.

CHARACTERIZATION OF NANOPARTICLES

1. Particle size

Particle size, morphology are the most important parameters of nanoparticles. Using electron microscopy. Main aim for nanoformulations is in drug release and targeted drug delivery. From these collected data it has to been found that drug release affected by particle size. So that, loaded drug will be exposed to the surface of particle as a result faster the drug release. Smaller particles have tendency to foam aggregates during storage. Hence make a link between stability and smaller particle size. Rate of degradation for PLGA was found to be increases with increased with particle size. Several other methods for nanoparticle size determination[9].

a. Dynamic light scattering (DLS)

Most popular and fastest method for particle size determination is Photon-correlation spectroscopy (PCS) and dynamic light scattering (DLS). DLS used for determining nano and submicron range of size determination of Brownian nanoparticles in colloidal suspension. Occurrence of Doppler shift due to shining monochromatic light (laser) on solution of Brownian motion of spherical particles and the light hit the mobile particle, resulting a change in the wavelength of incoming light due to size of particles.

b. Scanning electron microscopy (SEM)

It can be used to measure the surface phenomenon by visual investigation. Following technique have advantages in sizing analysis and morphology.

Here first convert the nanoparticle solution into dry powder and place the sample in sample holder and it coated with metals as such gold by using sputter coater. Then the sample, focused, scanned with fine beam of electron. Characteristics of sample surface are obtained from emitted secondary electron from sample. In vacuum condition nanoparticles were withstand but polymer can damage by electron beam. Then the obtained mean size from SEM is comparable with DSC. Disadvantages of SEM are time consuming, high cost, need for complementary information about size distribution[10].

c. Transmission electron microscope

As that of SEM technique TEM operated by using different principle. Also, it gives similar data. But as compared to SEM sample preparation is time consuming and complex as due to requirement of ultra-thin for electron transmission. Disperse nanoparticles in surface grid or films. Using negative staining materials phospho-tungstic acid or derivatives, uranylacetate, etc may with plastic embedding. Similarly, another method, expose the sample on liquid nitrogen in vitreous ice. Electron beam transmission to ultra-thin sample, gives surface characteristics of sample[11].

d. Atomic force microscopy

Atomic force microscopy provides ultra-high resolution in particle size measurement on the basis of sub-micron level of physical scanning of sample by using probe tip of atomic scale. Depending on sample properties samples are scanned on non-contact or contact mode. Contact mode tapping the probe into the sample surface for topographical map generation, over the conducting surface. Advantages of atomic force microscopy is, provide image of non-contacting sample without requirement of any specific treatment, gives delicate biological, polymeric nano, microstructure images. This technique results, size description of size, size distribution for mathematical

treatment. As a result, image obtained from AFM gives understanding on biological condition[12].

2. Surface charge

Both intensity and nature of surface charge is important to find if any electrostatic interaction between sample and any interactions with biological environment, zeta potential of nanoparticles gives colloidal stability. Zeta potential obtained gives surface charge indirectly. Zeta potential is corresponding to potential difference between surface of shear and the potential difference between outer Helmholtz planes. Zeta potential is used for the determination of storage stability of colloidal dispersion. The value of zeta potential may be positive or negative depending on the stability or devoid of aggregation. Zeta potential can be also finding out from extent of surface hydrophobicity.

3. Drug release

Drug loading means the amount of drug bound per mass of polymer also it gives percentage relative to the polymer. Analytical technique such as HPLC, UV spectroscopy, ultracentrifugation, gel filtration, ultra filtration, and centrifugal ultrafiltration techniques are used[13,14].

Advantages of nanoparticles

- Bioavailability increases with solubility Increases
- It offers targeted delivery of drug
- It increases drug resistance time
- Polymer used in the preparation of nanoparticles are biodegradable so that, nanoparticles are less toxic.
- It can be administered through various routes such as, oral, parenteral, intra-ocular route.
- Drug can be easily incorporated into the system without any need of chemical reaction[15].
- Degradation characteristics and controlled release pattern can be alter by matrix constituent.

Disadvantages of nanoparticle

- Ostwald ripening- due to high free energy of nanoparticles resulting the formation of aggregates/agglomerates
- More complex operational procedure
- Higher chances of contamination.
- Handling of nanoparticles are very difficult in their liquid and dry forms due to smaller size and larger surface area.
- Due to its larger surface area and smaller size, nanoparticles are very reactive towards external phase[16].

Applications of Nanoparticles

1. Drug and gene delivery
2. Tissue engineering
3. Protein detection
4. Bio-detection of pathogens
5. DNA probing
6. Destruction of tumour cell through heating

Future opportunities and challenges

Nanoformulations are used already with greater success in drug delivery system. Nanoparticles have huge success in many applications such as AIDS therapy, Radiotherapy, Protein, Antibiotic, Virostatics, and Vaccine also vehicle s to transfer to blood-brain barrier[17].

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