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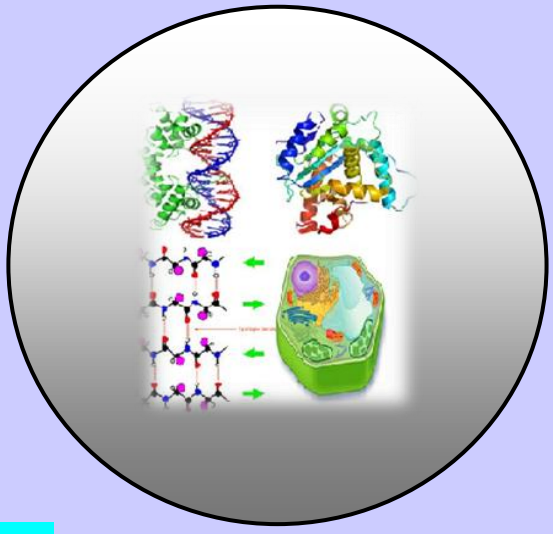

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Bionanotechnology and Applications: An Overview

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ABSTRACT

Nanoparticles such as metat, semiconductor and metal oxide are of great interest for its application in the field of information, energy, environment, agriculture and medical technology. In the present overview we described size, composition, structure, preparation and application of nanoparticles. Further it was observed in synthesis methodology included liquid phase, gas phase, liquid based gas phase and sol-gel assisted in-situ techniques along with continuous mass production technology.

Recently there has been great interest in the development of novel drugs called nano drugs by using nanoparticles. Nanoparticles offers significant advantages in terms of high specificity, high drug carry capacity and ability of controlled release and possibility to use different root of administration and the capability of delivery of both hydrophilic and hydrophobic drug molecule.

Keywords: Nanoparticles, Characterization, Application, Nanotechnology and Nanomedicine.

INTRODUCTION

Nanobiotechnology is also called bionanotechnology or nanobiology. These terms refers to the intersection of nanotechnology and biology (Ehud, 2007). This area of biotechnology has emerged very recent and helps in biological researches with nanotechnology.

The nano sized particles below 10 nm are of great interest because the chemical and physical behavior of these particles arising from the quantum size effect with application in electronics, chemical, mechanical and on living system (Kikuo and Wuled et al., 2004). A number of technologies for the preparation of nanoparticles have been developed by gas

and liquid phases. Now a days, several developed and under developed countries working on their national projects on nanoparticles funded by government biological (Nug et al., 2013).

The most important objectives that are frequently found in nanobiology, applying nano tools to relevant medical /biological problem and solving it by refining these application of nano tools. The imaging of native biomolecule, biological membrane and tissues are also a major area of nanobiology and application of nanophotonics for manipulating molecular process in living cell.

Recently, by the use of microorganism to synthesis functional nanoparticles has been of a great interest.

PREPARATION OF NANOPARTICLES

Nano means dwarf or tiny are very small or minute with in the convention of international system of unit (SI) that nano sized particles are technically measured in nanometer (1 nm = 10^{-9} M) generally > 1 nm and < 100 nm.

Thus, nanotechnology is a science of very small manipulation of matter at a tiny scale. At this size ato, and molecules work different (Pal et al., 2011). Nanotechnology represents the design, production, application and material at atomic molecules and naomolecular scale in order to produced new nanosized material (Hahnes et al., 2007) but pharmaceuticals nanoparticles are defines as solid sub microscopic sized (> 100 nm in diameter) drug carrierthat may or may not be biodegradable.

CLASSIFICATION OF NANOPARTICLES

Nanoparticles are classified based upon dimensions (Hett, 2004).

One Diameter Nanoparticles

It is widely used in electronic chemistry and engineering or thin film production (size 1 to 100 nm) or monolayer is now commonly used in solar cell or catalysis. The thin nanolayer film is used in different technological application including information storage system, chemical and biological sensors, fiber optic system and optical devices.

Two Dimensional Nanoparticles

Carbon Nanotubes (CNTs)-

Carbon nanotubes are hexagonal network of carbon atom 1 nm in diameter and 100 nm in length CNTs are of two types.

Single walled CNTs (SW CNTs) and multi walled CNTs (MW CNTs).

When these carbon nanotubes are combined with their remarkable physical mechanical and electrical properties (Kohler et al., 2004). The current density that nanotube can carry is extremely high and can reach to 1 billion amperes per square meter making it superconductor and mechanical strength of CNT. It is 60 times greater than the best steel. CNTs have a great capacity for molecular absorption and chemically are very stable.

Three Dimensional Nanoparticles

Fullerenes C_{60} are spherical cages containing 28 to more than 100 carbon atom and contain C_{60} these hollow balls composed of interconnected carbon pentagon and hexagon.

Fullerenes display unique physical property. It can be subjected to extreme pressure and regain their original when the pressure is release. These molecules do not combine with each other. Therefore, having a major potential for application of as lubricant, they also have interesting electrical properties. Thus, suggested to be used them in electronic field for data storage and in solar cells. Similarly, the empty structure can also be used as biological active molecule and find a place in potential in medical application (Tomalia, 2004).

DENDRIMERS

It represented a new clock of controlled structure polymers with nanometric dimension usually with 10-100 nm in diameter with multiple functions group on their surface. Thus, they are ideal carries for targeted drug delivery (Wiener et al., 1994).

Structure and function of dendrimers has been well studied as highly specialized nanoparticle, encapsulating functional molecule (Li et al., 2007). As dendrimers have different reactive surface grouping (nanostructure). They are comparable to DNA and RNA.

Thus, particularly used in medical and biomedical field. The pharmaceutical industries using the dendrimers in manufacturing non-steroidals drug, antiinflamatory formulation, anti-microbial and anti-viral drug and anti-cancer drug, however it should be noted that dendrimers may be toxic because of their ability to disrupt cell membrane as a result of +ve charge on their surface (Macke et al., 2004).

Quantam Dots (QDs)

Quantam dots are very tiny devices that contain a tiny droplet of free electron. Quantam dots are colloidal semi conductor nano-crystals ranging from 2-10 nm in diameter can be synthesized from various types of semiconductor material through colloidal synthesis by electron-chemistry the most commonly used QDs are Cadmium seleride (Cd Se), Cadmium telluride (Cd Te), Indium phosphate (In P) and Indium arsenide (In As).

QDs has single electron to several thousands electrons and the developed semiconductor insulator, metal, magneticmaterial or metallic oxide and can be used for optical and opto electronic devices, quantam computing and information storage. Whereas QDs may be color coded used for DNA testing QDs nanocrystal are generally composed of atom from group IInd and group IVth (Cd Ac, Cds, Cd Te) or from group IInd and group Vth such as InD at their core. A shell can be further introduced to prevent the surface quenching. Hence, Tse photo stability and quantam field of emission (Goldberg et al., 2007). QDs provides enough surface area to attach therapeutic agent for simultaneously drug delivering and in vivo imaging as well as tissue engineering (Larson et al., 2003, Pal et al., 2011).

PREPARATION OF NANOPARTICLES

Method for preparation of NP are depend on the physco-chemical polymers and drug to be loaded primary method of nanoparticle preparation from polymers includes.

Emulsion Solvent Evaporation Method

It is most frequently used method for preparation of nanoparticle. Emulsion solvent involve evaporation can be carry out in to 2 step. The first step requires emulsification of the polymer solution into an aqueous phase and during the second step polymer solvent is evaporated.

Thus, polymer are precipitated as nanosphere, thereafter nanoparticle are collected by ultracentrifugation and washed with distilled water to removed stabilizer are any free drug and lyphilysed for storage (Song et al., 1997). This method modified and renamed as high pressure emulsification and solvent evaporation method (Jaiswal et al., 2004). This method involves preparation of emulsion which is than subjected to homogenization and high pressure followed b stirring to remove organic solvent (Soppinath et al., 2001). Size of the nanoparticle can be controlled by adjusting the stirring rate, type and amount of dispersing agent, viscosity of organic solvent and aqueous phase (Tic et al., 1985).

The polymers used in this method are PLA (Veda et al., 1997), PLGA (Tabata et al., 1989), EC (Bodmeir et al., 1990) cellulose acetate phthalate (Allemann et al., 1993), PCL (Poly caprolactatone) (Lemarchand et al., 2006), PHB (Poly β-hydroxybutyrate) (Koosha et al., 1989). This method only can be applied to Lycosoluble drugs.

Double-Emulsion and Evaporation Method

To encapsulate hydrophilic drug the double emulsion technique is employed, which involves addition of aqueous drug solution to aqueous polymer drug solution followed by vigorous stirring to from emulsion. Thus water organic emulsion added into second aqueous phase with continuous stirring to from water/organic emulsion. The emulsion then subjected to solvent removed by evaporation and nanoparticles can be isolated by centrifugation at high speed.

The nanoparticles thus from must be thoroughly washed before lyophilisation (Vandervoort et al., 2002). In this method hydrophilic drug to be incorporated and the concentration of stabilizer used, the polymer concentration the volume of aqueous phase are the variable that effect the characterization of NP (Ubrich et al., 2004).

Salting Out Method

This is based upon separation of water-miscible solvent from aqueous solution via salting out effect (Catarina et al., 2006). In this method polymer and drug are initially dissolve in a solvent subsequently emulsification an aqueous gel containing the salting out gel (Electrolytes such as $MgCl_2$, $CaCl_2$, NaCl) and a colloidal stabilizer such as polyvinylpyrrolidone or hydroxyethyl cellulose. Now the oil/water emulsion is form which is diluted by adding sufficient volume of water are aqueous solutions to enhance the diffusion of solvent into aqueous phase which induce the formation of nanoparticles, such NP are called nanospheres. Several variables like stirring rate, internal external phase ratio, concentration, type of stabilizer in aqueous phase (Allemann et al., 1993). Thus salting out method does not require and Tse of temperature and useful when heat sensitive substances have to processed (Lambert et al., 2001).

Emulsion-Diffusion Method

It is widely used method for preparation of nanoparticles, the encapsulating polymer is resolved in a partially water miscible solvent (Such as propylene carbonate, benzyl alchohol) and saturated with water to ensure thermodynamic equilibrium between both the solvent subsequently water miscible solving is emulsify in an aqueous solvent containing stabilizer leading to the solvent diffusion to the external phase which result the formation of nanosphere on nanocapsule.

Finally, the solvent eliminated by evaporation of filtration this techniques has many advantages such as high encapsulation capacity and several drug loaded nanoparticle were produced by this technique includes mesotra prophyrin loaded PLGA nanoparticle (Vargas et al., 2004 and Yoo et al., 1999) and cyclosporine loaded sodium glycolate nanoparticle (El-Shabouri, 2002).

Solvent-Displacement / Precipitation Method

In this method polymers (drug or lycophilic) Surfectaol or dissolve in semipolor water miscible solvent such as aceton or ethanol. The solution thus for is then pored in to an aqueous solution containing stabilizer followed by magnetic stirring nanoparticle or as by carped solvent diffusion. The solvent is then removed from suspension under reduced pressure. It is important to note the role of addition of organic phase into aqueous affect the particle size of nanoparticle (Fessi et al., 1989). This method is well salted for most of the poorly solvent drug.

Characterization of Nanoparticle

Nanoparticles are characterized by their size. Morphology and surface change. The characterization can be carried out by stirring electron microscopic (SCM). Transmission electron microscope (TEM) and atomic force microscope (AFM). The heavy particle diameter size distribution and charge affect physical stability and distribution of NP. Electron microscopy is very useful for determining the overall shape of nanoparticle which also can determine toxicity. Surface charge of NP affects the physical stability and polymer dispersion. The smaller particle having larger surface area with reserves the most of the drug loaded or them will be approached to particle surface loading to fast drug delivery. Where as, in larger size particle drug soluble diffuse inside. Hence, there is a compromise between a small size and maximum stability of nanoparticle (Redhead et al. 2001).

There are several tools determining for naonoparticles

DLS (Dynamic Light Scattering)

Fastest and more popular method of determining the nanoparticle using photon co-relation electroscopy (PCS) of DLA. This method is used to determine with size of Brownian nanoparticle in colloidal solution. In this method shining nanochromatic light (laser) passed into a solution which causes Brownian motion when light hil the naoparticle which change the wavelength of incoming light and this change is related to size of the particle by measuring the diffusion coefficient of the particle and using the autocorrelation function. We can accurate estimate the particle size (De Asis et al., 2008).

SEM (Scanning Electron Microscopy)

This is most common method for determine the particle morphology with direct visualized. It offers many advantages in determine the morphology, particle size and distribution, for SEM characterization nanoparticles solution should first converted in dry powder and mounted on a sample holder followed but coating with a sputter coater. The sample is then scanned with a focus fine beam of electrons (Jares et al., 2004).

The surface morphology of the sample is obtained from the secondary electrons emitted from the sample surface. This technique is costly and frequently need complementary information about the size distribution.

TEM (Transmission Electron Microscopy)

Its is complex technique and time consuming because it requires ultrasonic electron transmission. The nanoparticle dispersion is deposited on the support grid or films. In this method –ve materials. Such as phosphotungstic acid (PTA) or uranyl acid will use this ulternative method to export the sample to liquid nitrogen temperatures when beam of e^- is transmitted through an ultrasonic sample interact with sample and passed through it (Molpeceres et al., 2000).

AFM (Atomic Force Microscopy)

It offers ultrahigh resolution of particle size measurement based upon the physical scanning of sample using an atomic scale (Muhlen et al., 1996). Samples are usually seen in contact or nanocontact mode depending upon their properly a topographical map is generated across the sample moreover particle size obtain by AFM technique provides rare picture and most accurate transcription of the size of particle and distribution.

Surface Charge

Surface charge of nanoparticle is very important as s determines their electrostatic interaction with bioactive compound and the colloidal stability analyzed through zeta potential of nanoparticle. The measurement of zeta potential is allowed for prediction of storage stability of colloidal dispersion. A high zeta potential value either +ve or –ve ensured stability and avoid aggregation of the particle. The zeta potential also provides information regarding the nature encapsulated with in the nanocapsule or coated on to the surface (Pangi et al., 2003).

Surface Hydrophobicity

Surface hydrophobicity determines by several techniques such as hydrophobic interaction chromatography biphasic partitioning adsorption of probes and contact angle measurement. Surface analysis of electron X-ray photon correlation spectroscopy permits the identification of specific chemical groups on the surface of nanoparticles (Scholes et al., 1999).

Application of Nanoparticles (Pangi et al., 2003)

The application of nanoparticle in different field

Applied field	Application
Nanomedicines	Nano drugs. Medical device, Tissue engineering
Chemical and Cosmetics	Nanoscale chemical and compound, paints, coating
Materials	Nanoparticles, carbon, nanotubes, biopolymers, paints, coatings
Food Science	Processing, nutracetical food, nanocapsules
Environment and Energy	Water and air purification filters, fuel cues, photovaltic
Military and Energy	Biosensors, weapons, sensors enhancement
Electronics	Semiconductors chips, memory storage, photonica optoelectronics
Scientific Tools	Atomic force, microscopic and scanning tunneling microscope
Agriculture	Atomic foce, microscopic and scanning tunneling microscope

Application of bionanotechnology are extremely wide spread it provides more tool to study the bionanotechnology, recreates biological mechanism and pathways.

Nanomedicine

Nanomedicine is a field of medical science. Its application is increasing due to the discovery of nanorobal, biological mechanism and researcher's help, with the help of bionanotechnology have done many tools and develops nanorobots. Bionanotechnology also useful to develop a new way of treating and dealing with diseases such as cancer. AIDS with less effects of chemotherapy have been control even eliminated at a clinical level cancer treatment with nanomedicine will consist on with supply of nanoparticle to the patient's through an injection with which kills cancerous cells leaving untouched health disease.

Agriculture

Nanobiotechnology is also useful in agricultural industries in the agricultural industries enginerred naoparticle serves as nano carrier, coating herbicides, chemical or genes. When target particle plant parts to release their content (Raja et al. 2016). Previously nanocapsules containing herbicides have been reported to effected penetrate through articles and tissues allow and constant release of the active substances. Similarly nano encapsulated slow release of fertilizer have been developed to save more consumption of fertilizer and minimize environmental pollution, in several cases nanoparticles when used in treatment of plant diseases and also facilitated promosing growth in grass (Raja et al., 2016).

Several nanoparticle showed beneficial results on various plants species with less or no toxic (Raqual et al., 2009, Hediat 2012). Several nanoparticle AgNPs treated leaf of Asparagus showed the increase content of ascorbate and chlorophyll. Similarly AgNPs nanoparticles when treated common bean and corn has increased shoot and root length, leaf surface area. Chlorophyll, carbohydrate and protein content (Hediat et al., 2012).
Similarly AuNPs have been used to induce growth and seed yield in *Brassica juncea* (Arora, 2012). DNA nanotechnology is an important area of bionanotechnology (Zadegan, 2012). Its utilization for improve inherent properties of nucleic acid used to generate synthetic membrane and understanding of protein folding it is also used in lipid, anti folding and cell could provide fruitful bionanotechnology in future.

Health Implication of Nanoparticle

It is important to differentiate between free and fixed nanoparticles. The free nanoparticles of the direct health treat they are generally air born and can be inhaled through breathing. The nanoparticles can enter in human body stream to vital organ

- From lungs to blood stream to vital organ
- Via intestinal tract
- Through skin (Hoet et al., 2004)

Influence of Nanoparticle through Lungs

It was demonstrated that untrafine nanoparticle enter into lungs and produce potential adverse effect may cause inflammation and tumors. Thus smaller sized nanoparticles play a significant role in nanoparticles toxicity (Lee et al., 1998).

Intestine

The epithelium of small and large intestine absorbed +vely charged small nanoparticles faster. It was noted that 40 nm diameter nanoparticles can be trap by villi of intestrine with in 2 min. and 415 nm nanoparticles were translocated into the intestine in 30 min wise 1000 nm nanoparticles can not be translocated through intestine (Jari et al, 1990).

Skin

Particles of 500-1000 nm sized can spread through skin and reach to the lower part of the dermis where as 18 nm smaller particles are likely to be connected deeper in to the skin (Lademann et al., 1989).

Advantages of nanoparticles

- Increased bioavailability
- Does proportionality
- Smaller surface area results in a faster dissolution of the active agent in an aqueous environment, such as the human body, faster dissolution generally equates greater absorption and bio availability
- Smaller drug doses less toxicity
- Reduction in fed/fasted variability
-

Future opportunities, Challenges and Conclusion

There are several future opportunities as nanoparticles are useful in drug delivery system and drug targeting. There are many challenges as to develop technically virus light system, architecting of biometric polymer and control of sensitive drug function, nanochips should be developed as a carrier fast advanced polymers delivery for therapeutic polypeptides protein. The recent program on drug delivery and polymer formulation and distribution containing compound down to nano sized.

It is concluded, nanotechnology successfully used in drug delivery. It is opening prospective in pharmaceuticals. It can also be used in prevention of drug toxicity, reduce cost of treatment. A number of nanoparticle project are actively conducted in several country. To establish a good correlation between nanoparticle and particle based nano structures are devices research and development program for high rate of synthesis of nanoparticle also depend upon the evaluation at particles generation in liquid and gas phases examine experimentally and design the reactor made by the use of numerical simulation.

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