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NANOPARTICLES: AN APPROACH FOR NOVEL DRUG DELIVERY SYSTEM-A REVIEW

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ABSTRACT

Nanotechnology defined as a tiny science. Nanotechnology is refered as design characterization, production, and applications of structures, devices and systems by controlling shape and size at nanometer scale. which we can achieve better therapeutic action, better bioavailability and better patient compliance by Nanotechnology. Nano-formulations are successfully used for brain delivery which includes nanoparticles system (polymeric/solid lipid), liposomes, dendrimers, nanoemulsions, nanosuspension and ligand mediated nanosystems. Nanoparticles are defined as particulate dispersions or solid particles drug carrier that may not be biodegradable. Several techniques are used for preparation of nanoparticles like Solvent Evaporation, Double Emulsification method, Emulsions - Diffusion Method, Nanoprecipitation, Coacervation method, and Supercritical fluid technology. Nanoparticles are subjected to several evaluation parameters such as yield of nanoparticles, Drug Content / Surface entrapment/Drug entrapment, Particle Size, SEM, TEM, Zeta Potential, Surface Morphology, In-vitro release Study, Kinetic Study and Stability.

KEYWORDS: Advantages of nanoparticle, classification of nanoparticle, preparation technique, evaluation of nanoparticle, application.

INTRODUCTION

The prefix "nano" comes from the ancient Greek vavoc through the Latin nanus meaning very small. "Nanotechnology are the design characterization, application and production of

the structures, devices and systems by controlling shape and size at nanometer scale". According to International System of Units (SI) nanotechnology is typically measured in nanometers scale of 1 billionth of a meter (1nm corresponding to 10^{-9} m) referred as the "tiny science". At this small size molecules and atoms work differently, behave as a whole unit in terms of its properties and transport, provide a variety of advantages. Nanoparticles (NPs) are defined as particulate dispersions or solid particles drug carrier that may or may not be biodegradable, where The drug are dissolved, entrapped, encapsulated or attached to a nanoparticle matrix. The term nanoparticle is a combined name for both nanospheres and nanocapsules in which the drug is confined to an aqueous or oily core surrounded by a shell-like wall, while nanospheres are matrix systems in which the drug is physically and uniformly dispersed. Where conventional techniques reaches their limits, nanotechnology provides opportunities for the medical applications.[1,2,3]

Nanotechnology is the science that deals with matter at the scale of 1 billionth of a meter (i.e., 10^{-9} m = 1 nm), and it is also the study of manipulating matter at the atomic or molecular scale. A Nanoparticle are the most fundamental component of the fabrication of a nanostructure and is far smaller than the world of everyday objects that are described by Newton's laws of motion, but bigger than atom or molecule that are governed by quantum mechanics.

In general, the Nanoparticle size range between 1 and 100 nm. Metallic nanoparticles have different physical and chemical properties from bulk metals (e.g., lower melting points, higher specific surface areas, specific optical properties, mechanical strengths, and specific magnetizations), properties that might prove attractive in various industrial applications.

Of particular importance, the optical property is one of the fundamental attractions and a characteristic of a nanoparticle. A silver nanoparticle is yellowish gray. Platinum and palladium nanoparticles are black. Not surprisingly, the optical characteristics of nanoparticles have been used from time immemorial in sculptures and painting even before the 4^{th} century AD.[4]

Table 1.1: Definitions of nanoparticles and nanomaterials by various organizations : International Organization for Standardization (ISO), American Society of Testing and Materials (ASTM), National Institute of Occupational Safety and Health (NIOSH), Scientifi c Committee on Consumer Products (SCCP), British Standards Institution (BSI), and Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAuA).[4]

	NANOPARTICLES	NANOMATERIAL
ISO	A particle spanning 1-100 nm.	-
ASTM	An ultrafine particle whose length in 2 or 3 places is 1-1000 nm.	-
NIOSH	A particle with diameter between 1 and 1000 nm, or a fiber spanning range 1-1000 nm.	-
SCCP	At least one side is in the nanoscale range.	The Material at least one side or internal structure is in the nanoscale.
BSI	All the field or diameters are in the nanoscale range.	The Material for at least one side or internal structure is in the nanoscale.
BAuA	All the field or diameters are in the nanoscale range.	Material consisting of a nanostructure or a nanosubstances.

NEED FOR DEVELOPING NANOPARTICLES[5]

The Goal of Nanoparticles is to control particle size, surface properties, and release of pharmacological active agents, so as to achieve the site specific action of the drug at the rational rate and dose.[6] Polymeric nanoparticles offer some specific advantages over liposomes. For instant, they help to increase the stability of drug and possess useful controlled release properties.[7]

ADVANTAGES OF NANOPARTICLES

Nanoparticles offer numerous advantages in drug delivery system. These advantages include,

- Nanoparticles have many significant advantage over conventional and traditional drug delivery system.
- They enhance drug circulation in blood, bioavailability, therapeutic efficacy and reduce the side effect.[1]

- Nanoparticles can be administer by various routes including oral, nasal, parenteral, intra-ocular etc.[1]
- In the tiny areas of body nanoparticles shows better drug delivery as compare to other dosage form and target to a particular cell type or receptor.
- Due to small particle size nanoparticles overcome resistance by physiological barriers in the body and easily penetrates to cell walls, blood vessels, stomach epithelium and blood–brain barrier.
- Nanoparticle enhance the aqueous solubility of poorly soluble drug, which improves bioavailability of drug.[1]
- Useful to diagnose various diseases.
- As a targeted drug carrier nanoparticles reduce drug toxicity and enhance efficient drug distribution.[1,8]
- By using polymers drug release form nanoparticles can be modified which makes polymeric nanoparticle an ideal drug delivery system for cancer therapy, vaccines, contraceptives and antibiotics.[1,9]
- Enhanced stability of ingredients.
- Prolonged shelf life.
- Used in dental surgery also as filling the tiny holes in teeth.
- Change the method of drug delivery to improve customer acceptance or reduce manufacturing costs.[1,10]

LIMITATION

In spite of these advantages nanoparticles do have limitations like,

a. Altered physical properties which lead to particle- particle aggregation, making physical handling of nanoparticles difficult in liquid and dry forms due to smaller size and larger surface area.
b. Smaller the particle size greater the surface area and this property makes nanoparticles very reactive in the cellular environment.
c. Small particle size results in limited drug loading and burst release. These practical problems have to be sorted out before nanoparticles can be used clinically or made commercially available.[5,11]

CLASSIFICATION OF NANOPARTICLES

There are various approaches for classification of nanomaterials. Nanoparticles are classified based on one, two and three dimensions.[5,12]

One dimension nanoparticles

One dimensional nanoparticle is a thin film or manufactured surfaces, has been used for decades in electronics, chemistry and engineering. Production of thin films (sizes1-100 nm) or monolayer is now common place in the field of solar cells or catalysis. This thin films are use in different technological applications including information storage systems, chemical and biological sensors, fibre-optic systems, magnetic-optic and optical device.[5]

Two dimension nanoparticles

Carbon nanotubes (CNTs)

Carbon nanotubes are hexagonal network of carbon atoms, 1 nm in diameter and 100 nm in length, as a layer of graphite rolled up into cylinder. CNTs are of two types, single-walled carbon nanotubes (SWCNTs) and multi-walled carbon nanotubes (MWCNTs). The small dimensions of carbon nanotubes, combined with their remarkable physical, mechanical and electrical properties, make them unique materials. They display metallic or semi-conductive properties. The current density of nanotubes can carry is extremely high and can reach one billion amperes per square meter making it a superconductor. The mechanical strength of carbon nanotubes are sixty times greater than the best steels. Carbon nanotube have great capacity for the molecular absorption and offering a three dimensional configuration. Moreover they are chemically and chemically very stable.[13]

Three dimension nanoparticles

Fullerenes (Carbon 60)

Fullerenes are spherical cages containing 28 to more than 100 carbon atoms, contain C60. This is a hollow ball composed of interconnected carbon pentagons and hexagons, resembling a soccer ball. Fullerenes are the class of materials displaying unique physical properties. They can be subjected to extreme pressure and reagain their original shape when the pressure is released. These molecules are not combine with each other, thus giving them major potential for application as lubricants. Fullerenes are give to potential application in the rich area of nanoelectronics. fullerenes have empty structures with dimensions similar to several biological active molecules. they can be filled with different substances and find potential medical application.[14]

Dendrimers

Dendrimers represents new class of controlled-structure polymers with nanometric dimensions. Dendrimers used in drug delivery and imaging are usually 10 to 100 nm in diameter with multiple functional groups on their surface, rendering them ideal carriers for targeted drug delivery. The structure and function of dendrimers are well studied. dendrimers has been highly specialized encapsulating functional molecules (i.e., therapeutic or diagnostic agents) inside their core.[15] They are considered to be basic elements for large-scale synthesis of organic and inorganic nanostructures with dimensions of 1 to 100 nm. They are develop compatible with organic structure such as DNA and fabricated to metallic nanostructure and nanotubes or to possess an encapsulation capacity. Dendrimers creat different reactive surface group(Nanostructure) and compatible with organic structure such as DNA so their prolific use is particularly in the medical and biomedical fields. The pharmaceutical applications of dendrimers include nonsteroidal anti-inflammatory formulations, antimicrobial and antiviral drugs, anticancer agents, pro-drugs, and screening agents for high-throughput drug discovery. Dendrimers can be toxic because of their ability to disrupt cell membranes as a result of a positive charge on their surface.

Quantum Dots (QDs)

Quantum dots are small devices that contain a tiny droplet of free electrons. QDs are colloidal semiconductors nanocrystals ranging from 2 to 10 nm in diameter. QDs can be synthesized from various types of semiconductor materials such as colloidal synthesis or electrochemistry. The most commonly used QDs are cadmium selenide (CdSe), cadmium telluride (CdTe), indium phosphide (InP), and indium arsenide (InAs). Quantum dots have anything from a single electron to a collection of several thousands. The size, shape and number of electrons can be precisely controlled. They are developed to form of semiconductors, insulators, metals, magnetic materials or metallic oxides. It can be used for optical and optoelectronic devices, quantum computing, and information storage. Colour coded Quantums dots are used for fast DNA Testing. Quantum dots are (QDs) refer to the quantum confinement of electrons and hole carriers at dimensions smaller than the Bohr radiuos. QDs nanocrystals are generally composed of atoms from groups II and VI (that is CdSe, CdS, and CdTe) or II and V (such as In P) at their core. A shell (that is ZnS and CdS) are introduce to prevent the surface quenching of excite in the emissive core and hence increase the photostability and quantum yield of emission. QDs are also provide enough

surface area to attach therapeutic agents for simultaneous drug delivery and in vivo imaging, as well as for tissue engineering.[16]

NANOPARTICLES PREPARATION[17,18]

Nanoparticles are aimed to be prepared from a variety of materials such as proteins, polysaccharides and synthetic polymers. The selection criteria of Nanoparticles matrix materials depends on many factors such as: (a) Size of nanoparticles required; (b) Inherent properties of the drug, e.g., aqueous solubility and stability; (c) Surface characteristics means such as Charge and Permeability; (d) Degree of biodegradability, biocompatibility and toxicity; (e) Drug release profile desired; and (f) Antigenicity of the final product.

Nanoparticles preparations are mostly frequently by three methods: (1) Dispersion of preformed polymers; (2) Polymerization of monomers; and (3) Ionic gelation or coacervation of hydrophilic polymers. However, other methods such as supercritical fluid technology.

Dispersion of preformed polymers[19,20]

Dispersion of preformed polymers is a common technique used to prepare biodegradable nanoparticle from poly (lactic acid) (PLA); poly (D,L-glycolide),PLG; poly (D,L-lactide-coglycolide) (PLGA) and poly(cyanoacrylate) (PCA), This technique can be used in various ways as described further:

Solvent evaporation method[17,21]

In this method, the polymer is dissolved in organic solvent such as dichloromethane, chloroform or ethyl acetate, which is also used as the solvent for dissolving the hydrophobic drug. The mixture of polymer and drug solution is then emulsified in aqueous solution containing a surfactant or emulsifying agent to form a oil in water (o/w) emulsion. After the formation of stable emulsion and the organic solvent is evaporated either by reducing the pressure or by continuous stirring. Particle size was found to be influenced by the concentrations of stabilizer, homogenizer speed and polymer concentration. In order to produce small particle size, use to high-speed homogenization or ultrasonication may be employed.

Spontaneous emulsification or solvent diffusion method[17,22]

This is modified version of solvent evaporation method. In this method, the water miscible solvent along with small amount of water immiscible organic solvent is used as oil phase. the

Spontaneous diffusion of solvents at interfacial turbulence are created between the two phases leading to the formation of small particles. As the concentration of water miscible solvent increases and a decrease in the size of particle can be achieved. Both Solvent evaporation and Solvent diffusion methods are used for hydrophobic or hydrophilic drugs. In the case of hydrophilic drug, a multiple w/o/w emulsion needs to be formed with drug dissolved in the internal aqueous phase.

Polymerization method[23,24]

In this method, monomers are polymerized to form nanoparticle in an aqueous solution. Drug is incorporated either by dissolved in the polymerization medium or by adsorption to the Nanoparticles after polymerization completed. The nanoparticle suspension is then purified to remove various stabilizers and surfactants employed for polymerization by ultracentrifugation and re-suspending the particles in an isotonic surfactant-free medium. This technique has been reported for making polybutylcyanoacrylate or poly (alkylcyanoacrylate) nanoparticles.

Coacervation or ionic gelation method[25]

The nanoparticles preparation is carried by using biodegradable hydrophilic polymers such as chitosan, gelatin and sodium alginate. Developing a method for preparation of hydrophilic chitosan nanoparticles by ionic gelation method. In this method, Positively charged of Amino group of chitosan have interacts with Negative charged of tri-Polyphosphate to form the Co-acervates with the size range of Nanometer.

Production of Nanoparticles using supercritical fluid technology[26]

The Conventional methods such as solvent extraction-evaporation, solvent diffusion and organic phase separation methods require the use of organic solvents which are hazardous to the environment as well as to physiological systems. the supercritical fluid technology was investigated as alternative to prepare biodegradable microparticle and nanoparticles because supercritical fluids are environmentally safe. the supercritical fluid can be generally defined as solvent at a temperature above its critical temperature, at which the fluid remains a single phase regardless at pressure. Supercritical CO_2 (SC- CO_2) is the most widely used supercritical fluid because of its mild critical conditions (Tc = 31.1 °C, Pc = 73.8 bars) nontoxicity, non flammability, and low price. The most common processing techniques involving supercritical fluids are supercritical anti-solvent (SAS) and rapid expansion of Supercritical solution (RESS). The process of SAS employs as liquid solvent, eg; methanol,

which is completely miscible with the supercritical fluid to dissolve the solute to be Micronized, at the process conditions because the solute is insoluble in the supercritical fluid and the extract of the liquid solvent by supercritical fluid leads to the instantaneous precipitation of the solute, resulting the formation of nanoparticles. RESS differs from the SAS process, in that solute can be dissolved in Supercritical fluid and then the solution is rapidly expanded through a small nozzle into a region lower pressure, Thus the solvent power of supercriticalfluids dramatically decreases and the solute eventually precipitates.

This technique are clean, because the precipitate is basically solvent free. RESS and its modified process has been used for the product of polymeric nanoparticles. Supercritical fluid technology are environmentally friendly and suitable for mass production requires specially designed equipment and is more expensive.

Table 2.2 Types Of Nanoparticles Applied In Drug Delivery[27]

Sr.no	Types of nanoparticles	Material used	Application
1	Nanosuspention and nanocrystals	Drug powder is dispersed in surfactant solution	Stable system for controlled delivery of poorly soluble drug
2	Solid lipid nanoparticles	Melted lipid dispersed in aqueous surfactant	Least toxic and more stable colloidal carrier system as alternative material to polymers
3	Polymerics Nanoparticles	Biodegradable Polymers	Controlled and targeted drug delivery
4	Polymeric micelles	Amphiphilic block co-polymers	Controlled and systemic delivery of water insoluble drug
5	Magnetic nanoparticles	Magnetic Fe_2O_3, megha mite coated with dextran	Drug targeting diagnostic to in medicine
6	Carbone nanotubes	Metal, semiconductor or carbon	Gene and DNA delivery controlled release of drug
7	Liposomes	Phospholipid vesicles	Control targeted drug delivery
8	Nano-shells	Dielectric core and metal shell	Tumor targeting
9	Ceramic nanoparticles	Silica, alumina, titania	Drug and biomolecule delivery
10	Nanospores	Aerogel which is produced by cell gel chemistry	Controlled release drug carriers
11	Nanowires	Silicon,cobalt, gold or copper based nanowires	Transport electrone in nano electrone
12	Quantum dots	Cds-cds core shell	Targeting, imaging agent
13	Nano-films	Polypeptides	Systemic or local drug delivery.
14	Ferrofluids	Iron oxide magnetic nanoparticles surrounded by polymeric laye.	For capturing cells and other biological targets

EVALUATION PARAMETER OF NANOPARTICLES

Yield of Nanoparticles

The yield of nanoparticles was determined by comparing the whole weight of nanoparticles formed against the combined weight of the copolymer and drug.[1,28]

$$\% \text{ yield} = \text{amount of nanoparticles} / \text{amount of drug} + \text{polymer} \times 100$$

Drug Content/Surface entrapment/Drug entrapment

After centrifugation amount of drug present in supernatant (w) determined by UV spectrophotometery. After that standard calibration curve plotted. Then amount of drug present in supernatant subtracted from the total amount used in the preparation of nanoparticles (W). (W-w) is the amount of drug entrapped. % drug entrapment calculated by[1,29]

$$\% \text{ drug entrapment} = W - w / W \times 100$$

Particle size

The Particle size distribution and morphology are the most important parameters of characterization of nanoparticles. Morphology and size are measured by electron microscopy. The major application of nanoparticles are drug release and drug targeting. It has been found that particle size affects that drug release. Smaller particles means larger surface area. As a result, most of the drug loaded will be exposed to the particle surface leading to fast drug release. On the contrary, drugs are slowly diffuse inside larger particles. As a drawback, smaller particles leads to aggregate during storage and transportation of Nanoparticle dispersion. Hence, there is result in small size and maximum stability of nanoparticles.[30]

There are several tooles for determining nanoparticle size as discussed below:

Scanning electrone microscopy

The Scanning electron microscopy (SEM) is show to morphological examination with direct visualization. This techniques is based on electron microscopy give to several advantages in morphological and sizing analysis. They provides limited information about the size distribution and true populations average. Nanoparticles solution are firstly converted into a dry powder, which is then mounted on a sample holder followed by coating with a conductive metal, such as gold, using a sputter coater. The sample is scanned with a focused fine beam of electrons. The surface characteristics of the sample has been obtained from the secondary electrons emitted from the sample surface. The nanoparticles should be able to withstand vacuum, and then electron beam can damage the polymer. The mean size obtained by SEM is

comparable with results obtained by dynamic light scattering. Moreover, these techniques are time consuming, costly and frequently need complementary information about sizing distribution.[31]

Transmission electron microscope

The TEM operates on different principle than SEM, its same type of data. The sample preparation for TEM are complex and time consuming because of its requirement to be ultra thin for the electron transmittance. The nanoparticles dispersion is deposited to support grids or films. The nanoparticles make the instrument vacuum and facilitate handling, they are fixed using either a negative staining material, such as phosphotungstic acid or derivatives, uranyl acetate, etc, or by plastic embedding. Alternate method is to expose the sample converted to liquid nitrogen temperatures after embedding in vitreous ice. The surface characteristics of the sample are obtained when a beam of electrons is transmitted through ultra thin sample, interacting with the sample as it passes through.[31]

Zeta potential

The Zeta potential of Nanoparticles is commonly used to characterized the surface charge of property of nanoparticles. It reflects the electrical potential of Nanoparticles and is influenced by the composition of the particle and the medium in which it is dispersed. Nanoparticles with a zeta potential above (±) 30 mV have been shown to be stable in suspension, as the surface charge prevents aggregation of the particles.[17]

In vitro release study

In-vitro drug release studies were performed in USP Type II dissolution apparatus at rotation speed of 50 rpm. The prepared immersed in 900ml of phosphate buffer solution in a vessel, and temperature was maintained at 37±0.20°C. Required quantity 5ml of the medium was withdrawn at specific time periods and the same volume of dissolution medium was replaced in the flask to maintain a constant volume. The withdrawn samples were analyzed using UV spectrophotometer.[32]

Kinetic Study

For estimation of the kinetic and mechanism of drug release, the result of in vitro drug release study of nanoparticles were fitted with various kinetic equation like zero order (cumulative % release vs. time), first order (log % drug remaining vs. time), Higuchi's model (cumulative %

drug release vs. square root of time). r2 and k values were calculated for the linear curve obtained by regression analysis of the above plots.[1]

Stability of Nanoparticles

Stability studies of prepared nanoparticles determined by storing optimized formulation at 4°C ±1°C and 30°C ± 2°C in stability chamber for 90 days. The samples were analyzed after a time period like at 0, 1, 2, and 3 months for their drug content, drug release rate (t50%) as well as any changes in their physical appearance.[33]

APPLICATION OF NANOPARTICULATE OF DELIVERY SYSTEM

a) Tumor targeting using Nanoparticulate delivery systems

The rationale using nanoparticles for tumor targeting is based on:

1. Nanoparticles has be able to deliver a concentrate dose of drug in the vicinity of the tumor targets via the enhanced permeability and retention effect or active targeting by ligands on the surface of nanoparticles;

2. Nanoparticles will reduce the drug exposure of health tissues by limiting drug distribution to target organ.[34]

Long circulating nanoparticles

To be successful as a drug delivery system, nanoparticles must be able to target tumors which are localized outside mononuclear phagocytic system -rich organs. In the past decade, A great deal of work has been devoted to developing so called as stealth particles or PEGylated nanoparticles, which are invisible to macrophages or phagocytes. A major break through in the field of came when the use of hydrophilic polymers (such as polyethylene glycol, poloxamines, poloxamers, and polysaccharides) to efficiently coat conventional nanoparticle surface produced opposing effect to the uptake by the MPS. These coatings are provide a dynamic “cloud” of hydrophilic and neutral chains at the particle surface which repel plasma proteins. As a result, which coated nanoparticles become invisible to MPS, therefore, remained in the circulation for a longer period of time. Extensive efforts have been devoted to achieving “active targeting” of nanoparticles in order to deliver drugs to the right targets, based on molecular recognition processes such as ligand-receptor or antigen-antibody interaction. Considering that fact that folate receptors are over expressed on the surface of some human malignant cells and the cell adhesion molecules such as selectins and integrins are involved in metastatic events. The Nanoparticles have bearing specific ligands such as

folate may be used to target ovarian carcinoma while specific peptides or carbohydrates may be used to target integrins and selectins.[35,36]

b. Nanoparticles for oral delivery of peptides and proteins

Significant advances in biotechnology and biochemistry have led to the discovery of a large number of bioactive molecules and vaccines based on peptides and proteins. The Development of suitable carriers remains a challenge due to the fact that bioavailability of these molecules is limited by the epithelial barriers of the gastrointestinal tract and their susceptibility to gastrointestinal degradation by digestive enzymes. The Polymerics Nanoparticles are allow encapsulation of bioactive molecules and protect them against enzymatic and hydrolytic degradation. It has been found that insulin-loaded nanoparticles have preserved insulin activity and produced blood glucose reduction in diabetic rats for up to 14 days following the oral administration.[37]

c. Targeting of nanoparticles to epithelial cells in the GI tract using ligands

Targeting strategies to improve the interaction of nanoparticles with adsorptive enterocytes and M-cells of Peyer's patches in the GI tract can be classified into those utilizing specific binding to ligands or receptors based on nonspecific adsorptive mechanism. The surface of Enterocytes and M-cells has been display the cell-specific carbohydrates, which may serve as binding sites to colloidal drug carriers containing appropriate ligands. Certain glycoproteins and lectins are bind to selectively to this type of surface structure by specific receptormediated mechanism. The Different lectins such as bean lectin and tomato lectin have been studied to enhance oral peptide adsorption. Vitamin B12 absorption from the gut under physiological conditions occurs via receptor-mediated endocytosis. The ability to increase oral bioavailability of various peptides (e.g., granulocyte colony stimulating factor, erythropoietin) and particles by covalent coupling to vitamin B12 has been studied.[38]

d. Nanoparticles for gene delivery

The Nanoparticles loaded with plasmid DNA could also be serve as a efficient sustained release gene delivery system, due to their rapid escape from the degradative endo-lysosomal compartment to the cytoplasmic compartment. Hedley et al. reported that following their intra-cellular uptake and endo-lysosomal escape, Nanoparticles could release DNA at a sustained rate resulting in sustained gene expression. This gene delivery strategy could be applied to facilitate bone healing by using PLGA nanoparticles containing therapeutic genes such as bone morphogenic protein.[39]

e. Nanoparticles for drug delivery into the brain

Strategies for nanoparticle targeting to the brain rely on the presence of nanoparticle interaction with specific receptor-mediated transport systems in the BBB (blood brain barrier). For example, Polysorbate 80/LDL, Transferrin receptor to binding antibody (such as OX26), lactoferrin, cell penetrating peptides and melano transferrin have been shown capable of delivery of a self non transportable drug into the brain via the chimeric construct that can be undergo receptor-mediated transcytosis. It has been reported poly(butylcyanoacrylate) nanoparticles was able to deliver hexapeptide dalargin, doxorubicin and other agents into the brain which is significant because of the great difficulty for drugs to cross the BBB. This system have many short comings including desorption of polysorbate coating, rapid NP degradation and toxicity caused by presence of high concentration of polysorbate 80.[40]

CONCLUSION

Nanotechnology is opening prospective future in pharmaceutical sciences. Nanoparticle is novel approach for drug delivery which we can achieve better therapeutic action, better bioavailability and reduce toxicity. Today nanoparticles are successfully used in brain targeting and in cancer therapy. Nanoparticles gives us an opportunity to enhance patient compliance for better therapy.

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