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Review article

Promising benefits of nanoparticles in drug delivery system

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ABSTRACT

The advent of nanotechnology has reflected profound impact on numerous research areas and healthcare system. The field of nanotechnology grown exponentially because of diverse novel applications that improves therapeutic actions of number of drugs. Administration of nanoparticles serve as promising drug delivery carriers and offers variety of benefits in detection and treatment of various diseases such as cancer. Incorporation of drugs in nano particulate formulations provides effective encapsulation, sustained release profiles of drugs enhances drug bioavailability, and biocompatibility with body tissues and offers less toxic effects which makes nanoparticles suitable drug delivery carriers in the field of pharmaceutical and medicines. In this review the overview of nanoparticles, advantages, disadvantages, structural features and types of nanoparticles have been discussed briefly.

Keywords: Drug delivery system, Nanoparticles, Bioavailability.

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INTRODUCTION

In the past few decades the word “Nano” has made great impact in various fields of healthcare and engineering due to growing applications. The prefix comes nano originated from the Latin word “Nanus” which mean dwarf or very small. The International System of units (SI) describes nano system in the form of reduction factor of 10^9 times. The implementation of nano technology as a matter of tiny scale in which atoms and molecules work differently and offers a wide variety of advantages. The field of nano technology comprises of design, production and presentation of resources at atomic, molecular and macromolecular level, for production of novel nano sized drug delivery carriers [1,2]. Nanoparticle (NP) carriers includes various nano formulations such as carbon nanotubes, nano fibres, nano membranes, nanosized silicon chips and polymeric NPs etc. having size less than 100 nm improves the therapeutic responses of many drugs. Biocompatible and biodegradable materials have been extensively studied and utilized for development of NPs as drug delivery carriers for effective targeting of drugs for treatment of various diseases specially cancer. The main purpose behind the fabrication of NPs is to attain site specific drug targeting by controlling the particles size, surface characteristics and release profile of medicinal agents. Various types of NPs formulations have been designed and fabricated depending on the development technique to hold novel characteristics and release properties for the delivery of active ingredients [3-6]. Marketed products on different NPs formulations are enlisted in Table 1.

Table 1: Marketed Products on Nanoparticles [7]

Product Name	Active Ingredient	Mechanism of Action	Indication
DaunoXome®	Daunorubicin citrate	Passive targeting	HIV-related Kaposi sarcoma
Doxil®	Doxorubicin hydrochloride	Passive targeting	Myeloma, ovarian cancer
Marqibo®	Vincristine sulfate	Passive targeting	Acute lymphoid leukemia,
Myocet®	Doxorubicin	Slow release into blood circulation	Metastatic breast cancer
Oncaspar®	PEGylated L-asparaginase	-	Acute lymphoblastic leukemia
Eligard®	Leuprolide acetate	Sustained release	Advanced prostate cancer
NanoTherm®	Paclitaxel	Passive targeting	Glioblastoma
	Aminosilane-coated superparamagnetic iron oxide	Heat generated directly within the tumour tissue	Local ablation in glioblastoma, prostate, and pancreatic cancer
Genexol®	Paclitaxel	Passive targeting	Metastatic breast cancer, pancreatic cancer

Advantages of nanoparticles [8-9]

- Active and passive targeting of drugs can be achieved by involvement of NPs as delivery carriers by reducing particle size and altering surface properties of NPs.
- The maximum therapeutic effects with less toxic and side effects of the drug can be achieved by encapsulating drugs in nano size.
- By incorporation of variety of biocompatible and biodegradable polymeric materials-controlled release of therapeutic agents at desired site is possible.
- The drug loading is optimum in NPs and drug activity can be maintained by encapsulating the drug into the system without any chemical reaction.
- Site specific targeting of drugs at different tissues is achieved by attaching active agents at surface of particular ligands.
- Accumulation of NPs in the body is minimized by utilization of biodegradable polymeric materials.
- Nanoparticles are feasible to administer by various routes such as oral, nasal, topical and parenteral etc.

Disadvantages of nanoparticles

- By reduction of particle size to great extent alters the physical properties leads to aggregation of particles cause difficulty in handling of NPs especially in liquid and dry forms.
- Small particle size of NPs increases reactivity of particles in tissue environment.
- Sometimes reduced particle size of NPs causes burst release which needs to be resolved before NPs can be used clinically [9].

Classification of nanoparticles

A number of approaches have been utilized to classify the NPs. Classification of nanoparticles on the basis of dimensions are discussed in the following text.

One-dimension nanoparticles

In the field of chemistry, electronics and engineering one dimensional systems like thin films or devices, has been utilized. Currently development and use of thin films or monolayer devices is very common place in the area of solar cell or catalysis. Thin films are possessed by number of benefits and involved in various technical fields such as information storage devices, sensors (chemical and biological) fibre optic systems and optical devices [10-11].

Two-dimension nanoparticles

Carbon atoms arranged and forms a network of hexagon type having 100 nm length and 1 nm diameter forms carbon nanotubes as a layer of graphite rolled up into cylinder. Further, carbon nanotubes are classified into two categories, namely single wall carbon nanotube and multiwall carbon nanotube. The small dimeter of carbon nanotubes offers wide advantages make them suitable materials for metallic and superconductive effects due to their electronic, physical, and mechanical properties. It has been estimated that the mechanical strength of carbon nanotube is about sixty times higher than the best steels. Carbon nanotubes are chemically very stable and have an abundant capability for molecular absorption and present 3-D configurations [12].

Three-dimension nanoparticles

Fullerenes (carbon-60)

When twenty-eight to more than 100 carbon atoms are arranged and forms a spherical cage like structure is termed as fullerenes. Fullerenes resembles with a soccer ball which is hollow ball contains interconnected carbon hexagons and pentagons. These types of NPs are characterized by unique physical and chemical properties. These materials can bear extreme pressure conditions and return to their original shape and structure when the pressure is released. Due to their remarkable electrical and mechanical properties fullerenes are utilized in the preparation of solar materials. Fullerenes also provides unique applications in the medicinal field due to their hollow structure with dimensions like with various biological molecules. A number of medicinal agents can be filled inside them and can be used for diagnostic and treatment purpose [10].

Dendrimers

Dendrimers are unique polymeric materials represents an innovative class of controlled and nonmetric dimensions. Their unique structural properties make them suitable carriers for site specific drug targeting effects because of having general size range of 10-100 nm in diameter with attachment of number of functional groups on their surface. Dendrimers have been found compatible with biological organic structures like DNA. The medicinal and pharmaceutical benefits of dendrimers include encapsulation and screening of nonsteroidal anti-inflammatory, anti-viral, anti-microbial and anti-cancer agents for drug discovery. Dendrimers possess positive charge on their surface due to which they may be toxic because of their ability to disrupt cell membrane [9,11].

Quantum dots

Quantum dots are colloidal semi-conductor nano crystals (2-10 nm) devices that enclose a tiny droplet of free electrons. Colloidal synthesis or electrochemistry approaches are used for synthesis of semi-conductor materials to construct quantum dots. The frequently used quantum dots are cadmium selenide, cadmium telluride, and indium phosphide and indium arsenide. These may consist of a single electron to a group of several thousands. Quantum dots number of applications ranging from their utilization in optical and optoelectronic systems and information storage devices. Coloured coded quantum dots are employed for fast DNA testing analysis. These nano particulate carriers are provided with adequate surface area for attachment of therapeutic agents for targeting of drugs and *in vivo* imaging as well as for tissue engineering practices.

CONCLUSIONS

Nanoparticles represents an extremely impressive platform wide variety of applications in the diagnostic and medicinal field. The

size and surface characteristics of these systems can be modulated by using diverse construction materials for individual applications. NPs carrier systems have promising potentials to convert poorly soluble and poorly absorbed biologically active substances into drug delivery forms.

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CONFLICT OF INTEREST

None

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