IJPSR (2016), Vol. 7, Issue 1 (Review Article)

INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES AND RESEARCH

Received on 02 July, 2015; received in revised form, 11 August, 2015; accepted, 19 October, 2015; published 01 January, 2016

NOVEL APPROACHES OF NANOPARTICLE TOWARDS DRUG DELIVERY SYSTEM

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Keywords:

Nanomedicine, Drug Delivery, Dendrimers, Nanoparticles, Polymeric

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ABSTRACT: Over the past few decades, the pursuit and exploration of nanotechnology is likely to have a significant impact on the drug-delivery system. This technology can be envisioned as playing a major role in revolutionizing the future of novel drug delivery system. Nanoparticles (NPs) are one of them which have many potential applications in clinical medicine and research. The encapsulation of therapeutic drugs in the form of nanoparticles shows advantageous effect over their corresponding drugs such as increases drug efficacy, specificity, tolerability and therapeutic index. The current review article focuses on the different nanoparticulate drug-delivery systems including nanoerythrosomes, Superparamagnetic nanoparticles, liposomes, Quantum dots, ceramic nanoparticles and dendrimers as well as their applications in different field.

INTRODUCTION: In the novel drug delivery system, there are various novel carriers which have advantage over conventional preparation (solution, suspension or emulsion) suffer from limitations like high dose and low availability, first pass effect, instability, and they exhibit fluctuations in plasma drug levels and do not provide sustained effect [1]. Novel drug delivery system is one of important tool expanding drug markets in pharmaceutical industry. This system can address issues by increasing efficacy, improving safety, patient compliance & product life [2].

QUICK RESPONSE CODE

DOI: 10.13040/IJPSR.0975-8232.7(1).25-30

Article can be accessed online on: www.ijpsr.com

DOI link: http://dx.doi.org/10.13040/IJPSR.0975-8232.7(1).25-30

Nanoparticles as a targeted drug delivery system:

The development of nanoparticles delivery systems for targeted drug delivery has been recently reviewed [3]. Targeted drug deliveries can be actively or passively achieved. Active targeting requires the therapeutic agent to be achieved by conjugating the therapeutic agent or carrier system to a tissue or cell-specific ligand [4]. Passive targeting is achieved by incorporating the therapeutic agent into a macromolecule or nanoparticles that passively reaches the target organ.

Nanoparticles (NP) are a type of sub-nanosized colloidal drug delivery system composed of synthetic and semi synthetic polymers with a size range from 10 to 1000 nm in diameter [5]. The system shows different inner structure.

a. Nanospheres in matrix type system in which oliogmer of polymer unit is entangled throughout the particle matrix.

b. Nanocapsules in which oily core is surrounded by polymeric shell (reservoir type).

Advantages of nanoparticles:
Nanoparticles has a number of advantages are

1) Ease of preparation& scale up,

2) Improved bioavailability,

3) Increasing resistance time in the body,

4) Targeting drug to specific location in the body (its site of action) and

5) Incorporation of both hydrophilic and hydrophobic substances [6].

Types of nanoparticles:
The current reviews focus on different types of nanoparticles and consider it as potential drug delivery system and show its application in imaging, diagnostics and therapeutics.

Polymeric Nanoparticle:
Biodegradable nanoparticles are considering being effective drug delivery devices over a past few decades [7]. Polymeric nanoparticles made from various natural and synthetic polymers have received attention due to their stability and having ability of surface modification [8].

These systems provide targeted (cellular or tissue) delivery of drugs, improve bioavailability, sustain release of drugs or solubilize drugs for systemic delivery. This process protects therapeutic agents against enzymatic degradation (i.e., nucleases and proteases). Anticancer activity reported in Polyethylene glycol–(PCL) amphiphilic block copolymeric nanospheres containing taxol [9].

Fullerenes:
A fullerene is a molecule which entirely composed entirely of carbon, in the form of a hollow sphere, ellipsoid, or tube. Fullerenes are somewhat similar in structure to the graphite [10]. Nanotubes are cylindrical fullerenes consists of carbon only a few nanometers wide and having a closed end as well as open end. Fullerenes possess a various medicinal properties like binding specific antibiotics to the structure to target resistant bacteria, used for light-activated antimicrobial agents [11] and target certain cancer cells.

Solid lipid nanoparticles (SLNs):
SLNs mainly are lipids that remain solid phase at the room temperature and range from 50 nanometer to 1000 nanometer and effective colloidal drug delivery applications. They are made-up of solid hydrophobic core having a monolayer of phospholipids coating. SLN stabilized by surfactant(s) for emulsification and possess many such as good tolerability, biodegradability [12], a high bioavailability by ocular administration [13] and a targeting effect on the brain [14].

SLN formulations include fatty acids (e.g. palmitic acid, decanoic acid, and behenic acid), triglycerides (e.g. trilaurin, trimyristin, and tripalmitin), steroids (e.g. cholesterol), partial glycerides (e.g. glyceryl monostearate and gylceryl behenate) and waxes (e.g. cetyl palmitate). Different surfactants which are commonly used as emulsifier, including soybean lecithin, phosphatidylcholine, poloxamer 188, sodium cholate, and sodium glycocholate [15]. They all stabilize lipid dispersion in formulation.

SLNs carrier possess application in the field of tumour accumulation, antibacterial activity, and allows brain delivery of anticancer drugs not capable of crossing the blood brain barrier [16].

Liposomes:
Liposomes are vesicular structures having an aqueous core which is surrounded by a hydrophobic lipid bilayer, created by the extrusion of phospholipids which reduce the side effects and promotes release of its contents. These versatile properties of liposomes made them used in drug delivery and cosmetic delivery applications. Nanoliposomes are liposomes that have vesicles in the range of nanometers [17, 18]. Liposome properties vary with lipid composition, size, surface charge and the method of preparation. Nanoliposomes mainly used as potent carrier for various drugs like

antibacterials, antivirals, insulin, antineoplastics and plasmid DNA.

Nanostructured lipid carriers (NLC):
Nanostructured Lipid Carriers are formulated by blend of solid and liquid lipids and particles remain in solid state at a room temperature. Lipids form differently structured solid matrices, such as the nanostructure lipid carriers (NLC) and the lipid drug conjugate nanoparticles (LDC) and both improve drug loading capacity and increase bioavailability [19]. They are useful in topical drug delivery, oral and parenteral (subcutaneous or intramuscular and intravenous) route. Besides therapeutics property they also exhibit application in field cosmetics, food and agricultural products. These have been utilized in the delivery of anti-inflammatory compounds, cosmetic preparation, and topical corticotherapy.

Nanoshells:
Nanoshells are also termed as core-shells which is a 1-20 nanometers thick. Nanoshells are spherical cores of concentric particles which is surrounded by a shell or outer coating of thin layer of another material [20]. Nanoshells mainly used biomedical imaging and therapeutic applications. Nanoshells have versatile properties by improving optical property and reduced susceptibility to chemical/thermal denaturation [21].

Quantum dots (QD):
The quantum dots are size tuned from 2 to 10 nm and termed as a semiconductor nanocrystals and coreshell nanocrystals which containing interface between different semiconductor materials [22]. QD serve as a drug delivery system for hydrophilic therapeutic agents including small interfering RNA (siRNA) and antisense oligodeoxynucleotide (ODN)) and targeting biomolecules such as antibodies, peptides and aptamers. QD shows its application in the imaging contrast agent and small molecule hydrophobic drugs can be embedded between the inorganic core and the amphiphilic polymer coating layer.

Superparamagnetic nanoparticles:
Superparamagnetic molecules are those that are attracted to a magnetic field but do not retain residual magnetism after the field is removed. Superparamagnetic nanoparticles range in the size of 5-100nm and used for selective magnetic bioseparations and can be visualized in magnetic resonance imaging (MRI) and work on the principle of magnetic field and heated to trigger the trigger the drug release [6].

Superparamagnetic nanoparticles played a major role in cancer therapy and diagnosis [23]. Superconducting quantum interference device (SQUID) is a device using superparamagnetic nanoparticles and a microscope and this technique is a highly sensitive, specific and quantitative and used for rapid detection of biological targets [24].

Dendrimers
Dendrimers is derived from a Greek word in which dendra, mean reminiscent of a tree. They are polymeric molecules made up of multiple perfectly branched monomers that capable of self organization property and emanate radially from a central core [25, 26].

The different polymers which are incorporated in formulation of Dendrimers are polyamidoamine (PAMAM), melamine, poly L-glutamic acid (PG), polyethyleneimine (PEI), polypropyleneimine (PPI), and polyethylene glycol (PEG), Chitin.

They have applications in gene and antisense property, magnetic resonance imaging and targeting cancerous cells.

Ceramic nanoparticles:
Because of having porous nature and ultra low size less than 50 nm paid a special attention in field of drug delivery system. Ceramic nanoparticles possess a several advantage as sol-gel process, work in ambient temperature condition and product produced of desired size, shape and porosity [27] and effective in evading the uptake by the RES [28].

They serve as an application in novel nonviral vector for gene delivery [29], a novel NP based drug carrier for photodynamic therapy [30], bacteriostatic roles in diabetic wound healing [31]. A ceramic nanoparticle plays a vital role as orthopedic biomaterial because it has ability to provide chemical, biological and mechanical properties of natural bone [32].

XPclad® nanoparticles:
Recently development of XPclad® nanoparticles is a novel carrier for the poor aqueous soluble drug facing significant problem such as bioavailability and absorption. XPclad® nanoparticles is prepared by novel formulation method that uses planetary ball milling & vibratory ball milling that provide a particles of uniform size, 100% loading efficiency of hydrophobic or hydrophilic drugs. This formulation is used in subsequent coating for targeted delivery, and control of Log P for systemic, cutaneous, or oral administration of cancer drugs, vaccines, or therapeutic proteins [33].

Novel XPclad nanoparticles regarded as a useful in tumor therapy because of its lower toxicities and cause the destruction of prostate tumor cells and Treg cells [34].

Nanofibre:
Nanofibre is produced by electrospining technique in which fabrication of polymers fibre in a fine and dense meshworks directly from solution and requires a electric field and having dimension less than 100nm [35]. Polymeric nanofibers are effective carriers for drug delivery and offer advantages such as specific surface with small pore size, porosities, reduced toxicity [36] and increased therapeutic level and biocompatibility [37]. For producing polymeric nanofibres, wide range of polymers such as polyvinylalcohol, gelatin, collagen, chitosan and carboxymethylcelulose [38]. Due to versatile property, it is ideal for the development of biosensors and biochips, drug delivery systems, wound care and scaffold for tissue engineering.

Studies reported electrospun nanofibres of indomethdacin for colonic drug drug delivery sytem and found to be very effective [39].

Gold Nanorods:
Gold nanorods were first synthesized in the mid-1990 and gain much popularity among the nanoparticles based on electrochemical reduction into rod shaped templates [40] and absorb light of varying wavelength due to formation of Plasmon resonances on their surface [41, 42]. They have a unique optical and electronic properties and depend on their shape, size and aspect ratio [43]. They easily get stabilized, conjugated to antibodies and have a biological application [44].

Nanoerythrosomes:
Nanoerythrosomes are derived from a red blood cell membrane by the process of haemodialysis through filter. Nano-vesicles is of defined pore size and composed of proteins, phospholipids and cholesterol. They load a variety of biologically active agents like proteins. Nanoerthroysomes compose of a natural membrane which allows the insertion of recombinant ligands along with better stability. The membrane allows the conjugation by using simple and well known molecule for example, monoclonal antibodies.

CONCLUSION: Currently modern pharmaceutical industry uses the targeted and novel drug delivery system for improving dosage form and increasing bioavailability. Though no doubt nano delivery system is the most preferred and targeted challenge for diverse number of formulation. The versatile property of nanoparticulate system has a potential to carry a lipophilic or hydrophilic drugs or diagnostics and hold wide range of applications. Importance of nano drug delivery system capturing a good market which will grow further in future. Various nano based product are already in market and many of them are under clinical assestment.

CONFLICT OF INTEREST: We declare that we have no conflict of interest.

ACKNOWLEDGMENTS: The authors are very thankful to the Department of Pharmaceutical Sciences, Faculty of Health Sciences, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Deemed to be University, Allahabad (U.P).

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How to cite this article:
Singh D, Verma A and Alok S: Novel approaches of nanoparticle towards drug delivery system. Int J Pharm Sci Res 2016; 7(1): 25-30.doi: 10.13040/IJPSR.0975-8232.7 (1).25-30.

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