Nanopharmaceuticals: The Pharmaceuticals of the Present Era

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At present pharmaceutical industry is facing titanic pressure to provide great quality pharmaceuticals to patients while retaining profitability. Nanopharmaceuticals owe nanotechnology is nowadays broadly regarded as the enabling technology of the present century. Nanopharmaceuticals may be utilized to detect diseases at considerable earlier stages. Nanopharmaceutics is an emergent arena where the sizes of the drug particle or delivery system work at the nano level. Providing the right dose of a particular drug to specific site of disease still remains challenging in the industry. Nanopharmaceuticals have huge potential to tackle this disappointment of old-style therapeutics which deals site-specific targeting of drugs. Nanopharmaceuticals may lessen toxic systemic side effects and thereby bring about better patient compliance. Therefore pharmaceutical corporations are focusing their vision towards nanotechnology based pharmaceuticals to augment the formulation and drug target discovery.

Nanopharmaceutics shelter all aspects of nanotechnology based pharmaceutics that applies to formulation, development and delivery aspects of pharmaceuticals. Nanomaterials (nano size materials) that bring unique shapes and functionalities and nanodevices show a strategic role in pharmaceutical nanotechnology. Nanopharmaceutics is the hope of healthcare and has enormous promise. The pharmaceutical industries has invested huge amounts of money in developing drugs, but for the most part of them are shelved when they start giving redundant results. It is accepted that nanotechnology will facilitate to redesign some of the older pharmaceuticals, and several may even find their path to the market.

Nanopharmaceuticals provide greater surface area and nano scale properties, therefore used as a hopeful tool for drug and gene delivery advancement. Nanopharmaceuticals have distinctive physical, chemical and biological properties as compared to their large counterparts. The properties of nanopharmaceuticals can impressively influence their interactions with biological molecules and cells, due to their charge, chemical composition, peculiar size, shape, surface structure, and solubility. Merging of nanotechnology with other technologies leads to emergence of innovative hybrid technologies. Furthermore, nanopharmaceuticals are resistant to settling and may possess higher saturation solubility, fast dissolution and improved adhesion to biological surfaces. These features render them therapeutically effective and more bioavailable.

The nanopharmaceuticals have wide scope that includes smart material for tissue engineering aspects, intelligent tools for drug delivery aspects, diagnostics purpose and many more. Existing claims of nanotechnology in pharmaceutical field are development of advanced diagnostic, bioactive surfaces, biomarker, biosensor, image enhancement device, implant technology, nanocarrier, nanomedicine, nanorobots, tissue engineering, etc. An enormous number of nanosystems that have been explored in pharmacy to date are carbon nanotubes, dendrimers, liposomes, metallic nanoparticles, nanofibres, polymeric nanoparticles, quantum dots etc. Nanopharmaceuticals applications are growing exponentially. This will overcome the shortcomings of conventional administration. For example, in chemotherapy treatment, cytostatic drugs damage not only cancerous cells but also normal cells, thus methods of selectively directing abnormal cells are more beneficial. Certain nanotechnology based formulations are there in the market like Ambisome® DaunoXome® and Doxil®[1-3].

Nanopharmaceuticals are presently used in various applications including drug delivery, proteins and peptide delivery, cancer treatment, treatment of neurodegenerative disorders, etc. There are some approved products like Gendicine [4] (adenoviral vector-based) and Glybera [5]. There also some products which are under process like MYDICAR®[6].

Carbon nanotubes are made up of hexagonal networks of carbon atoms. They are cylindrical shaped about 1 nm in diameter and 1-100 nm in lengthwise and rolled up in a layer of graphite. Nanotubes provide distinct benefits over other drug delivery due to appropriate physicochemical properties like ordered structure with great aspect ratio, ultra-light weight, higher mechanical strength, higher thermal conductivity, higher electrical conductivity, metallic or semi-metallic behavior and higher surface area [7]. Quantum dots consisting of semiconductor core (like Cd, Se) which is coated by a shell (like ZnS) to augment optical properties, and a cap which allows better solubility in aqueous buffers. Quantum dots are semiconducting materials. Their semiconducting properties originate from their physical size (ranges from 10 - 100 Å in radius). They have been widely used and adopted for in vitro bioimaging for factual time monitoring or tracking of intracellular processes for longer time, which is possible due to their specific properties like bright fluorescence, broad UV excitation, narrow emission and high photostability [8]. Dendrimers are tree-like hyper branched structures. Dendrimer comprise three different regions: core, branches, and surface. The macromolecule components radiate in the form of branches from the central core, creating an internal cavity plus a sphere of end groups that can be tailored made accordingly [9]. Polymeric nanoparticles are colloidal transporter, 10 nm–1 μm in size, consisting of polymers. They may be of both vesicular systems (nanocapsules) and matrix systems (nanospheres). Nanocapsules are systems where the drug is confined to a cavity enclosed by unique polymeric membrane while in nanospheres the drug is dispersed throughout the polymer matrix. Mangifer in nanocapsules are a promising formulation to improve the bioavailability of the drug [10]. Metallic nano particles have been used in drug delivery, specifically in cancer treatment and in biosensors. Amongst numerous metals, gold and silver nanoparticles are of prime importance. They are used in controlled and/or targeted delivery of bioactive compounds to macrophages and liver [11]. Liposomes are about 50 to 200 nm in size. Once dry phospholipids are hydrated, sealed vesicles will be formed. Liposomes are versatile, biocompatible and have good entrapment efficiency. It catches application in passive and active delivery of gene, protein and peptide. Proliposomal drug delivery system for Paclitaxel showed improved pharmacokinetics [12].
β-cyclodextrin based nanosponges loaded with Imiquimod shows a high encapsulation efficiency, slow and prolonged in vitro kinetic release, a greater antiproliferative effect [13]. Buccal mucoadhesive clotrimazole loaded nanofibers showed its therapeutic effectiveness in the treatment of oral candidiasis [14].

There are several drawbacks to this technology as well which need to be addressed to reap the full benefits of nanotechnology for pharmaceuticals. The current restrictions are the lack of accurate data and guiding principle for full identification, toxicity testing studies, level of detection of exposure, assessments of environmental impact, safety data, etc. Moreover, since nanopharmaceuticals are very small, human bodies may not detect them, and they may exist throughout indefinitely in body with no means of flushing them out from body. This may be a probable human health risk. There are several scientific, regulatory, ethical, and social issues posing a variety of challenges in practical insight of nanopharmaceuticals. Chief health risk associated with nanosystems includes cytotoxicity, toxicity, translocation to undesired cells, unpredictable and undefined safety issues, environmental impacts and non-biocompatibility. In case of ethical issues nanosystems may alter gene expression, altered/permanent abnormality in cell behavior/responses on short or long term exposure. Overall these challenges create burning need to regulate these nanopharmaceuticals. However there are few FDA approved nanopharmaceuticals which have entered the market are nanoparticles, liposome, polymer-protein conjugate, polymer drug conjugate and monoclonal antibody based products. In order to use the benefit of nanopharmaceuticals without hampering its development genuine efforts of industries, researchers, government, and academic over regulation guidelines must be drawn.

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