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Review Article

Nano Enabled Drugs, Their Emergence and Application in Pharmaceuticals

Navya Dalakoti[1*], Reema Singh[2], Bindu Rani[3], Gaurav Pant[2]

[1]School of Pharmaceutical Education and Research, Jamia Hamdard, Delhi, India

[2]Centre for Translational & Clinical Research, Jamia Hamdard, Delhi, India

[3]Maharishi Dayanand University, Rohtak

*Corresponding Author E-mail: navya.dalakoti97@gmail.com

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ABSTRACT

As the pharmaceutical industry is generating the largest revenue in the worldwide economy based on the new innovations. Pharmaceutical companies are launching the medicines with improvements e.g., more bioavailable substitute, mucoadhesive to protect the API from gastric environment, effervescent tablets, enteric coated tablets, buccal tablets, sublingual tablets, osmotic pumps and much more. Meanwhile, there comes a science where a matter can be manipulated in a specific size range and can be used to sideway the common drawbacks of conventional methods of achieving health, and this manipulation is done in the size of $1x10^{-9}$ *m. This range is known as Nano meter and the technology involved is called Nanotechnology. Nanomedicines are the newer achievements in the field of pharmaceuticals exhibiting nanotechnology. This paper is a brief review of Nano technological tools involved in medical science, their types, their application and their mode of action with special focus on specific characteristics of each type.*

Keyword: *Nano Enabled Drugs, Nanotechnology, Quantum dots, Liposomes, Fullerenes, Carbon Nanotubes, Polymeric micelles, Applications of nanotechnology.*

INTRODUCTION

Nanoparticle is the name given to a particular substance occupying the size limit of $1x\ 10^{-9}$m. NPs are composed of 3 layers viz., Surface Layer, Shell Layer, and the core. The core is pivotal and fundamental and its nature is chemically different as that of the Shell layer. These specially dimensioned particles are classified in various classes e.g., Carbon-based NPs, Metal NPs, ceramic NPs, Semiconductor NPs, Polymeric NPs, and Lipid-based NPs. These last two classes are of utmost importance in Life Sciences. While Semiconductor and Metallic NPs show their fundamental application while diagnosing a cancer patient (Khan, et al., 2019).

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Liposomes, Dendrimers, Carbon Nanotubes, Quantum dots, Polymeric Nanoparticles, Carbon Nanotubes, Polymeric Micelles are some of Nano-systems that have their precise application in prophylaxis, diagnosis, and treatment of many health-related issues (Ugwu et al., 2017). For the ability of optimum drug delivery, they are seeking attention in the pharmaceutical world (Khan, et al., 2019). A disease is susceptible by biomarkers and these are the explicit features that become the selective target of nano-pharmaceuticals to release the active moiety containing within them and thus enhancing the efficiency by harming less. This kind of target delivery also improves the availability of the drug at the site of action. To make a nanoparticle more effective against a specific disease it is challenging to look for an optimum biomarker (Varshney & Shailender, 2012). As the only conclusive ambition of pharmaceutical science is to improve the quality of life, these nano-sized tools are used for diagnosing, treating and preventing the ill ailments and are named as Nanomedicines. (Khan, et al., 2019) Not only Nanomedicines but nano-cosmetics are also trending these days. Due to the smaller size, these molecules possess a greater surface area to the volume and thus have greater penetration into skin cells and thus providing optimum results in skincare products (Challa & Kumar, 2010). Higher consumer compliance has been noticed in beauty-oriented industry because of better absorption, improved dispersion, unique texture, greater penetration, and efficient transparency of these engineered nanoparticles (Singh & Nanda, 2012). Some of the biomaterials used in the cosmetic industry are Ethosomes, Liposomes, Nanosomes, Nanosponges, Nanoshells and Nanopearls (Mehta et al., 2014). NPS are available in three dimensions starting from 0 to 1 and lasting at 2 dimensions. (Khan et al., 2019) Conventional drugs follow a broad pathway to reach the site of action but using this technology, Active Pharmaceutical Ingredient can be targeted to the specific site and/or section that subsequently improves drug's efficiency with minimum side effects (Ugwu et al., 2017).

Need of Nano enabled Drugs

As particle size directly affects the drug delivery system and thus making it more efficient, therefore nanoscience is playing a vital role in pharmaceuticals. A remarkable increase in solubility can be observed because of smaller size and larger surface area of API. This very property of nano-enabled drugs improves the proportion of API in blood circulation (Nanda et al., 2016). Nanoscience is a lifesaver for the drugs having poor solubility, therapeutic agents showing toxicity, and less bioavailable potent agents (Singh & Nanda, 2014).

Application of Nanoscience in Pharmaceuticals

1. Drug delivery

The point of concern is to get the drug at the site of action so that potential side effects can be avoided. So, nanoscience provides itself as a tool to restrict the drug delivery at a specific site because of its unique size allowing better penetration into cell membranes (Capretto et al., 2011 & Rastogi et al., 2014).

Another important tool is surface chemistry that affects the pharmacokinetics and shows better particle uptake (Xu et al., 2013 & Guo et al., 2013).

2. Cancer treatment

Chemotherapy targets to eradicate the rapidly growing cells and this turns into drastic side effects because other dividing cells are also destroyed. (Bakry et al., 2007 & Karuppusamy & Venkatesan, 2017). Nanoscience has been a proven alternative pathway to conventional approach by specifically targeting tumor sites and protecting other cells and tissues (El-shabouri, 2002).

Nanotools e.g. Combidex, NK 105, CYT-6091, Aurolase, Docetaxel PNP, C-DOTS are used in cancer therapy (Jong & Borm, 2008).

3. Tissue Engineering

Nanoscience is very crucial to trigger the production of cells responsible for new bone formation and to reduce the chance of rejection (Koziara et al., 2004). There are likely chances of rejection by the body if the surface of the artificial implant were left smooth. This can be achieved by building nano-sized characters on prosthetic implants of the knee or hip (Zhang et al., 2003).

4. Protein Detection

Metal nanoparticles made up of Gold are generally used to analyze protein-protein interaction (Margarida & Barroso, 2011).

5. Biological Assay & Imaging

Organic dyes used in bio-tagging have been replaced with quantum dots these days (Zhang & Johnson, 2009). Specific properties of nanotools like extensive excitation spectrum, limited range of emission, enduring fluorescence, and slight photochemical alteration of fluorophore make them useful biological applications (Zhang et al., 2008). Core of quantum dots is generally made up of Cd and Se wrapped in a semiconductor shell made up of ZNs that raise optical properties (Herranz et al., 2011)

Table 1: Types of Pharmaceutical Nanosystems

Type	Structure	MOA	Advantage	Use
Liposomes	Vesicles made up of amphiphilic phospholipids & cholesterol, encapsulating an aqueous interior between bilayers.	API is released on the fusing of the lipid bilayer with the cellular bilayer.	-Lesser Toxicity -Controlled P'codynamics & P'cokinetics -Smaller Size -Increased efficiency	Cancer Therapy (9)
Dendrimers	Globular structure possessing an initiator core (generally termed as a generation zero) with multiple layers each containing active group at terminals. Each layer is identified as a generation. An active Pharmaceutical agent is incorporated into the hollow core.	Active functional groups infer the solubility and capture release feature is provided by generation zero.	-Target drug delivery -Improved solubility	-Anticancer Agent (9) -Gene Therapy -Immunoassay -MRI (10)
Carbon Nanotubes	These are cylindrical structures made up of benzene rings and having a diameter of 1-2 nm	Carbon Nanotubes don't possess cell penetration properties for that reason they are functionalized first and labeled with fluorescent dyes to track their delivery at the site of action. Cellular uptake generally happens either with endocytosis dependent method or endocytosis independent method.	-Potent biological carrier -Compatible with the biological system - site-specific delivery	-Diagnostic devices - Sensor for DNA & Protein - Carrier to deliver drugs, vaccines, and protein. (11)
Quantum Dots	A semiconductor core made up of CdSe/CdTe/InP/InAs and coated with ZnS. ZnS coat improves the optical properties.	These nanosystems are rendered as contrasting agents. These work by absorbing the white light and reemitting the same within the nanoseconds, and thus provide greater resolution.	-Competent and orderly uniform size -Adjustable drug linking and doping -Large surface to volume ratio -The extensive spectrum of functional groups -More resistant to degradation -Enhanced optical activity -Great versatility	-Magnetic Resonance Imaging (3) -DNA array technology -Cell biology - Immunofluorescence assays. - Evaluating biomarkers -Bimodal molecular imaging (12)
Polymeric nanoparticles	They exist in 2 forms i.e. nanospheres and nanocapsules. Nanospheres are the solid mass adsorbed on the outer sphere and nanocapsules are the solid mass encapsulated inside the system wholly.	1.Rate Controlled drug delivery is ensured by: -Permeation -Diffusion -Reservoir partition-controlled system 2. Activation Modulated drug delivery: An external stimulus is used to achieve optimum drug delivery. Stimuli may be of any energy form viz., physical, chemical, electrical 3. Feedback Regulated drug delivery: A triggering agent is used to release the drug. 4. Site Target drug delivery: Achieved by diffusion and partitioning.	-Tumor targeting properties -Reduced side effects - Increased Efficacy -Improved Biocompatibility, non-immunogenicity, non-toxicity and biodegradability	-Anticancer Agent -Bone-Osteoporosis -Gene therapy (13)
Polymeric micelles	These micelles contain hydrophobic core but the hydrophilic shell	The loaded drug is protected from the gastric environment, the estimated release of drug is achieved by the target delivery (absorption window), mucoadhesion improves the residence time and efflux pumps are used to improve drug accumulation. Region-specific delivery is achieved by coupling the PM with pH-sensitive or receptor sensitive groups	-Enhanced bioavailability -Thermodynamic and kinetic stability - site-specific delivery	-Systematic delivery of water-insoluble drugs (14)
Metallic nanoparticles	These are made up of metals e.g. silver, gold.	Used to identify protein-protein interaction.	surface functionalization capacity	-Drug discovery -Bioassays -Diagnostics (15)
Fullerenes	These are the hollow spheres composed of carbon.	They inactivate the biomarkers by binding efficiently to the same	-Low toxicity -Unique chemical, physical and photodynamic properties of fullerene spheroid.	-Anti-ParkinsonDrugs -Anti- Alzheimer Drugs -Cardiovascular Drugs (16) -Antiviral agents Photosensitizers -Antioxidant activity -Diagnostics (17)

CONCLUSION

Technology that is too small in size to affect the potential function of a cell is seeking the attention of pharmaceuticals to detect ill effects, diagnosis and treatment of the same with optimum results and reduced side effects. Such science is versatile for human beings to lead towards better and healthy lifestyles. This is nothing, but the manipulation and/or alteration of matter at a size range. A domain size of $1x10^{-9}$ make these particles enough to be used in bio tagging or labelling. This range make them extensive probe to be used in many domains viz., Drug Discovery, Drug Delivery, Magnetic Resonance Imaging, Gene Therapy, Cancer Therapy, Molecular Diagnostics, Stem Cell Therapy and Tissue Engineering.

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