

## Nanotechnology: A modern approach in novel drug delivery

RUTUJA V YADAV, JAMEEL AHMED S MULLA\*

Department of Pharmaceutics, Shree Santkrupa College of Pharmacy, Ghogaon, Karad, Dist: Satara, MS – 415111, India

\*Author for Correspondence: Email: jameelahmed5@rediffmail.com

ARTICLE DETAILS	ABSTRACT
<p><i>Article history:</i> Received on 02 August 2022 Modified on 05 September 2022 Accepted on 10 September 2022</p> <p><i>Keywords:</i> Novel, Nanotechnology, Nanoparticles, Pharmacokinetic, Pharmacodynamic, Nanovaccine.</p>	<p>Nanoparticles are becoming key components in a extended type of applications and Nanoparticles are mostly used extensively for applications in drug discovery, drug delivery, diagnostics and for many others in medical field. In development of different dosage forms to deliver the drugs have been in use, the evolution and modern trends in the science and technology help the pharmaceutical companies to focus on the novel approaches. Nanotechnology is an extremely powerful emerging technology to modify the pharmacokinetic and pharmacodynamics activity of the drug medication system like nanoparticles has physical application. Scientists are to make traces in the field of nanotechnology to reformulate the existing essential drugs to minimize the harmful effects and to increase the therapeutic efficacy. This article on NDDS seeks to provide that advances in the field of NDDS are helpful in overcoming various problems and challenges with the current trends, the technology and science have future prospects that enable the healthcare professionals to develop even better applications to serve the human kind and also Disease detection, therapy and diagnosis can be done by advanced nanotechnology. Use of nanotechnology in nano-vaccine, targeted drug delivery system, Green Nanotechnology and Glucose Nanosensors will be discussed.</p>

© IDAAM Publications All rights reserved

### INTRODUCTION

The term “nanotechnology” was derived by Greek derived by Greek word “nanos” meaning “dwarf”. Nanotechnology involves the clustering of atoms, molecules and molecular fragments into the very small particles between 1 and 100nm. Nanoparticles have a much higher surface area to volume ratio [1].

Nanotechnology is an emerging technology which has significant use in the diagnosis and treatment of disease. Nanoparticles are able to enhance in capability and complexity. They are used to enhance the pharmacokinetic and pharmacodynamic profiles of many drug molecules. Biodegradable nanoparticles used in pharmaceutical formulations to effectively release and transport the drug. Different types of polymers have been used in the formation of nanoparticles. This review presents the most outstanding contributions in the field of nanotechnology [2, 3].

Compared to the traditional dose forms, novel drug delivery systems aim to deliver the drug at a rate that dictates the body's needs during the treatment period, and direct the active entity to the site of activity by reducing the side effects elsewhere. Nanotechnology is the emerging new technology in drug discovery and has the property of self-targeting in the sense that a particular ligand is not attached to it, the nanoparticles can be used to target, due to their specific small size, the infected pathological areas [4,5].

### Role in Life Sciences

Nanotechnology is an emerging technology which has significant use in the diagnosis and treatment of disease.

### Nanotechnology – As Drug Delivery

There are many valuable prospects in nanotechnology for drug delivery systems.

nanostructured applications used in orthopedics and wound management, controlled release drug delivery system, delivery vehicles that enhance circulation of drug and targets of drug at the specific cells, systems that improving the solubility of poorly water soluble drugs. The following are some types of nanotechnologies used in drug delivery:

- Polymer nanoparticles – Polymer drugs account for the percentage of cases incorporated into PEGylated liposomal nanoparticles as specified by GMP evaluation WHI-P131 showed intense in vivo activity that has a potentially potent help against bosom tumor than chemotherapy medications like paclitaxel, gemcitabine.
- Quantum dots –Impermeable fluorescent nanocrystals have a scope of application measuring approximately 2-10nm less than the wavelength of light produced for light-induced fluorescence to follow a course of helpful medications or to fix circulatory issues in the human body. Demonstration incorporating chitosan (N-(2-hydroxyl)propyl-3-trimethyl ammonium chitosan chloride, HTCC / CdS quantum nanodots as part of organic functions and biomolecule naming.
- Vaccines – nano-vectorsalso used as an alternative to traditional biological vaccine methods. A number of systems have been developed in the UK, especially for influenza. These systems have been very successful, as only a small number of intra-cellular deliveries are needed to trigger the body's immune system. So it is seems to be most useful.
- Nano-fabricated structures for gene/protein expression -this is an emerging field and uses a functional nano - made surface that acts as a barrier layer to release molecules but prevents the entry of macrophages [6].

### **Nanotechnology – As Diagnostic Applications**

Nanotechnology used for atomic diagnostics to nanoscale. The significant progressive demonstrative innovation is lab-on-a-chip innovation speedy procedure, little measures of test and depends on the wide range of investigation. By using of nanotechnology, we can make little chip size analyzer for dissecting

specimens without even a moment's pause as opposed to sending examples to the research center inside of couple of minutes. The innovation done at the micrometer scales and organizations are working progressively towards the improvement of microchip-based expository items that require just nanogram or picolitre-sized specimens. This allows numerous "objective" medications to be immediately evaluated and which required a small amount of the time regularly taken – and at a small amount of the cost [6,7].

### **Nanoparticles Drug Designing [8-19]:**

Nanoparticles can also be formed from a variety of materials such as natural or synthetic polysaccharides, proteins and synthetic polymers. The nanoparticles which are filled with proteins stimulate the immune responses which can be used in formulation of inhalable vaccines. Nanodiamonds are carbon nanoparticles filled with protein molecules to enhance bone growth, treat brain tumors and leukemia. They are also used to enhance the pharmacokinetic and pharmacodynamic profiles of the various drug molecules Biodegradable nanoparticles are used to release and transport the drug efficiently.

Delivery of nanoparticles drugs used in formulation such as oral, parenteral, pulmonary and topical. Topical nanoparticles provide fewer side effects, long-term controlled drug delivery and bypass first-pass metabolic effects. Pulmonary administration of nanoparticles is through micronization technique instead of encapsulation technique.

Smaller drug particles penetrate well in the lungs through IV administration in the form of microspheres, inhalations in the form of dry powder. Nanoparticles offer various applications and promising drug delivery method such as enhanced biological and physiological stability, improves permeability.

Nanoparticles reduce drug exposure to healthy organs by limiting the distribution of drugs to the target site by delivering a thick dose of drug to the target tumor site by improving permeability using a high-performance computational model and data mining. Nanoparticulate systems convert poorly soluble drugs into deliverable drugs. Nanoparticles enclose a variety of enzymes, drugs, genes and are characterized by a long circulation period due to the hydrophilic

shell that protects the recognition by the reticular-endothelial system. Drugs can also form in nano-suspension of particles (with diameters <100 nm). Nano-sized compounds are used to improve the solubility of poorly water-insoluble drugs. Solubility can be improved by improving the dissolution rate by improving the surface area of the particle and by adjusting pH by improving pharmacokinetic profiles and bioavailability. As healthcare costs and drug development have increased, the quality of bio-equivalence and bioavailability studies has rapidly improved to ensure drug safety and efficacy.

### **Nanoparticles in Targeted Drug Delivery System**

The Novel drug delivery system (Nanoparticles) is used to deliver drugs through oral, nasal, parenteral, intra-ocular etc. Nanoparticles can change particle size and achieve active and passive drug targeting. After parenteral administration came the most benefits in the treatment of many chronic diseases.

Nanoparticles have the ability to control and keep the drug at the specific site of action and protect the drug from rapid degradation and maintain drug concentrations at specific locations or in target tissues, so with lower doses of the drug shows high therapeutic efficacy and reduced side effects. The important advantage of nanoparticles is that high levels of drugs can be incorporated without any chemical reaction leading to the preservation of the pharmacological activity of the drug. Used in targeted drug delivery (therapy) to brain and cancer therapy, Drug and gene delivery, Bio detection of pathogens, Detection of proteins, Biomarker mapping Probing of DNA structure ,Tissue engineering, Destruction of tumours through heating process (hyperthermia), Separation and purification of biological molecules and cells, MRI contrast enhancement and Phagokinetic studies. Nanoparticles have become a very useful and popular drug delivery system because it increases stability and protects drug molecules from rapid degradation [20].

### **Nanovaccines**

Nanoparticles are vaccines that consist mainly of nanoparticles and vaccines that target the site in the body where the infection or disease originates, as it is incompatible with conventional stimulants that can interfere with whole body parts.

Number of advantages have been shown by different researchers explore and running the different features related to Nanovaccine [21].

### **Nanovaccines Advantages**

- Small dose of antigen cells improved systematic processing and long time stability during storage.
- Encapsulated use of antigens that give discharge Due to the slow release of the single dose antigen is sufficient for an effective response.
- Immunity has been enhanced by the use of nanoparticles due to the lack of alum which acts as an inflammatory mediator.
- Tolerance and efficacy are improved by the use of a mixture of antigens and nano-emulsions by nasal immunization.
- Nano-emulsion is effective for 30 days at 25°C and requires no refrigeration.
- Nanoparticles are non-invasive in nature, which can be easily delivered by nasal or oral routes or by diffuse patches that cause subtle damage and primarily smooth delivery.
- Polysaccharides, amino acids and synthetic biodegradable polymers are used to prepare biodegradable nanoparticles.

### **Green Nanotechnology**

It have goal of scientific development is to increase the well-being and human health. Novel strategies are used to achieve the safe and effective therapeutic treatments over the conventional ones. Green nanotechnology is a branch of green technology that utilizes the concepts of green chemistry and green engineering. Phytoforming has a number of benefits associated with the development of nanotechnology-based dosage forms, e.g. solid lipid nanoparticles (SLNs), polymeric nanoparticles (nanoparticles and nanocapsules), proliposomes, liposomes, nano emulsions, etc., for herbal drugs. These include increasing solubility and bioavailability, enhancement of pharmacological activity, sustained delivery, improving tissue macrophage circulation, improved stability, suppression of toxicity, and defense against physical and chemical degradation. So the Problems with herbal drugs or herbal medicines can be overcome with nano-sized drug delivery systems (NDDS). Herbal medicine systems would be used for chronic diseases like diabetes, cancer, asthma [22, 23].

### Glucose Nanosensors

Nanomedicine application in glucose monitoring-Enhanced nanotechnology for in vivo glucose monitoring includes glucose nanoparticles and is a 'smart tattoo' consisting of glucose-based and fluorescent nanoparticles implanted into the skin. Fluorescence for detecting analyte changes and susceptible to electro active tissue interference, and because Near infrared (NIR) light with a wavelength above about 600 nm passes through several centimeters of tissue, allowing implantation and non-invasive measurement at the body surface [24].

### Nanomedicine Field have Novel Applications in Many Health Care Areas

Some of the most promising areas are the following

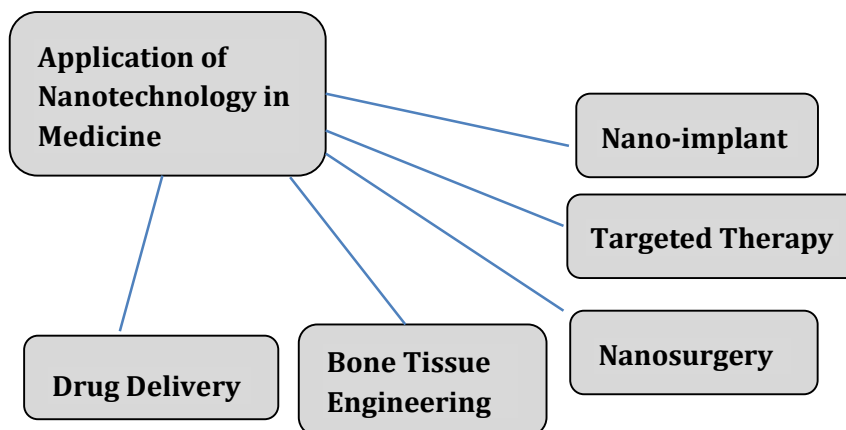


Figure 1: Applications of nanotechnology

### Current Advancement in Nanotechnology

- Scientific communities are developing ways to use carbon nanoparticles called Nano diamonds in medical applications. Nano-diamonds attached to protein molecules can be used to increase bone growth around dental implants and joints
- Tumor-targeting nanoparticle is produced, to help specialists analyze previous malignancy. The nanoparticle is covered with an exceptional protein that searches for certain symptoms that leave tumors.
- Nanoparticle has potential for more effective delivery of chemotherapeutic drugs to treat cancer.
- Silver nanoparticle solutions are used to treat mouth infections and used in hospitals as preventive care. The silver added to mouth washes help denture wearers prevent the growth of biofilms.
- Nanodiagnostics (molecular diagnostics, imaging using NPbased contrast materials, nanobiosensors).
- Nanopharmaceuticals (targeted drug delivery, nanotechnology based drugs, implanted nanopumps, nanocoated stents).
- Reconstructive surgery (tissue engineering, implantation of rejection resistant artificial tissues and organs).
- Nanorobotics (vascular surgery, detection and destruction of cancer).
- Nanosurgery (nanolasers, nanosensors implanted in catheters).
- Regenerative medicine (tissue repair)
- Ultrafast DNA sequencing [25,26].
- Researchers are developing a technique for releasing insulin using a matrix like an insulin-containing sponge and an enzyme-containing Nano capsules when the glucose level rises, the nanocapsules release hydrogen ions, which bind the fibers in the matrix. The hydrogen ions charge the fibers, repulsing each other and creating spaces in the matrix through which insulin is released.
- The nanoparticles contain nitric oxide gas and are known to destroy bacteria. Studies on mice have shown that these nanoparticles significantly reduce the release of nitric oxide gas at the site of staph abscesses by infection.
- Researchers have demonstrated a new method for using nanoparticles for early diagnosis of infectious diseases. The nanoparticles bind to molecules in the bloodstream that indicate the initial stage of infection. When the sample is scanned

for Raman scattering of the nanoparticles enhances the effect of the Raman signal, providing a clear detection of the molecules indicating infectious disease at a very early stage [27, 28].

## CONCLUSION

This article was an attempt to review aspects of nanomedicine, nanoparticles and advanced nanotechnology have applications in drug discovery, drug delivery, Disease detection, therapy and diagnosis can be done and also advancement in nanotechnology is discussed. Aim in designing Novel drug delivery system i.e. nanoparticles is to alter or modify particle size of the drug which helps in stability, surface properties which helps in site specificity and also quantity of dose is minimal and reduced dosing frequency and improving the pharmacokinetic profiles and enhancing the bioavailability. Expectations from nanotechnology in medicine are high and have potential for the future treatment and disease management and also have benefits in health care and medicine.

## REFERENCES

- [1] Pandey A, and Pandey G, Department of Nanotechnology, Gyan Ganga College of Technology, Jabalpur, Madhya Pradesh, India. Nanotechnology for Herbal Drugs and Plant Research. Research & Reviews: Journal of Pharmaceutics and Nanotechnology. Vol. 2, Issue 1. Jan- March, 2014.
- [2] Rita B, Akhilesh T, Department of Pharmaceutics, G. Pulla Reddy college of Pharmacy, Osmania University, Hyderabad, India. A Novel Pharmaceutical Drug Designing: Nanoparticles. Research and Reviews: Journal of Pharmaceutics & Nanotechnology, June 14 2015.
- [3] Manivannan Rangasamy. Nano Technology: A Review. Journal of Applied Pharmaceutical Science 01 (02); 2011: 08-16. March 14, 2011.
- [4] M.C. Roco. Nanoparticles and nanotechnology research. Journal of Nanoparticle Research 1: 1-6, 1999.
- [5] Kumar Babu G. Department of Pharmacy, Scient Institute of Pharmacy, Hyderabad. Advancements in Novel Drug Delivery Systems and Opportunities for Indian Pharmaceutical companies. Research and Reviews: Journal of Pharmaceutics and Nanotechnology, e-ISSN: 2347-7857 p-ISSN: 2347-7849. Feb 14, 2015.
- [6] Tripathi V, Amity Institute of Biotechnology, Amity University, Noida. India Nanotechnology and its Role in Life Sciences. Research and Reviews: Journal of Pharmaceutics and Nanotechnology. Vol3, Issue 1. Jan 28, 2015.
- [7] Malika V, et al. Nano-Carrier for Accentuated Transdermal Drug Delivery. J Develop Drugs. 2014; 3:121.
- [8] Mulla JA, Mabrouk M, Choonara YE, Kumar P, Chejara DR, du Toit LC, Pillay V. Development of respirable rifampicin-loaded nano-lipomer composites by microemulsion-spray drying for pulmonary delivery. Journal of Drug Delivery Science and Technology. 2017 Oct 1; 41:13-9.
- [9] Mulla JAS and Karande BS. Microemulsion Based Hydrogel Formulation for Topical Drug Delivery - A Concise Review. Indian Journal of Novel Drug Delivery. 2021 Apr-Jun; 13(2): 63-69.
- [10] Mulla JA, Khazi MI, Khan AY, Gong YD, Khazi IA. Design, Characterization and In vitro Evaluation of Imidazo [2, 1-b][1, 3, 4] thiadiazole Derivative Loaded Solid Lipid Nanoparticles. Drug Invention Today. 2012 Aug 1; 4(8).
- [11] Chakorkar SS, Mulla JAS. A Novel Corticosteroid Cubosomes - for Ocular Drug Delivery. Indo American Journal of Pharmaceutical Research. 2020: 10(06).
- [12] Mulla JAS. Drug Delivery and Therapeutic Approaches to Prostate Cancer. Indian Journal of Novel Drug Delivery. 2018; 10(3): 98-109.
- [13] Mulla JS, Khazi IM, Sharma NK. Solid Lipid Nanoparticles: Measures of Characterization. Indian Journal of Novel Drug delivery. 2011; 3(4): 259-264.
- [14] Mulla JS, Khazi IM, Sharma NK, Hiremath SP, Jamakandi VG. Solid Lipid Nanoparticles: Methods of Preparation. Indian Journal of Novel Drug delivery. 2011; 3(3): 170-175.
- [15] Panchamukhi SI, Mulla JA, Shetty NS, Khazi MI, Khan AY, Kalashetti MB, Khazi IA. Benzothieno [3, 2-e][1, 2, 4] triazolo [4, 3-c] pyrimidines: Synthesis, Characterization, Antimicrobial Activity, and Incorporation into Solid Lipid Nanoparticles. Archiv der Pharmazie. 2011 Jun; 344(6):358-65.
- [16] Mulla JS, Khazi IM, Jamakandi VG. Solid lipid nanoparticles: Potential Applications. Indian Journal of Novel Drug Delivery. 2010; 2(3): 82-87.

- [17] Mulla JAS, Shetty NS, Panchamukhi SI, Khazi IAM. Formulation, Characterization and *in vitro* Evaluation of Novel Thienopyrimidines and Triazolothienopyrimidines Loaded Solid Lipid Nanoparticles. International Journal of Research in Ayurveda & Pharmacy. 2010; 1(1): 192-200.
- [18] Mulla JA, Suresh S, Khazi IA. Formulation, characterization and *in vitro* evaluation of methotrexate solid lipid nanoparticles. Research J. Pharm. and Tech. 2009 Oct;2(4):685-9.
- [19] Mulla JS, Khazi IM. Influence of Process Variables on Particle Size of Solid Lipid Nanoparticles. Indian Journal of Novel Drug Delivery 2009; 1(1): 47-49.
- [20] Sriharitha, Preethi J, Hemanth Swaroop, M. Pharmacy, ASN College of Pharmacy, Tenali, AP, India. A Review on Nanoparticles in Targeted Drug Delivery System. Research & Reviews: Journal of Material Science, Sep 28, 2014.
- [21] Mamatha M, Prist University, Tanjore, Tamil Nadu, India. Review on Nanovaccination. Research and Reviews: Journal of Pharmacological and Toxicological Studies. Vol 4, Issue 4. Nov 28, 2016.
- [22] Verma A, Gautam SP, Bansal KK, Prabhakar N, Rosenholm JM. Green Nanotechnology: Advancement in Phytoformulation Research. Medicines (Basel). 2019 Mar 14; 6(1):39.
- [23] Sharma M, Devi Ahilya Vishwavidyalaya, Indore, Madhya Pradesh, India. Applications of Nanotechnology Based Dosage Forms for Delivery of Herbal Drugs. Research and review: Journal of Pharmaceutics and nanotechnology. Dec 29, 2013.
- [24] Shaik Rahiman and Bilal Ahmad Tantry, Department of Biochemistry, College of Medicine, Al Jouf University, Saudi Arabia. Nanomedicine Current Trends in Diabetes Management. Journal of Nanomedicine & Nanotechnology. Vol 3, Issue 5, 1000137.2012,
- [25] Surendiran A, Sandhiya S, Pradhan SC, Adithan C (2009) Novel applications of nanotechnology in medicine. Indian J Med Res 130: 689-701.
- [26] Nel A, Xia T, Madler L, Li N (2006) Toxic potential of materials at the nanolevel. Science 311: 622-627.
- [27] Sowjanya K, Department of Industrial Pharmacy, Gokaraju college of Pharmacy. A Review on Current Advancements in Nanotechnology. Research and Reviews: Journal of Medical and Health Sciences. June 6 2015.
- [28] K. Y. Rokde, Dr. P. B. Dahikar, Dr. M. J. Hedau, S.S. Shende, Department of Electronics, M.M Science College, Nagpur, India. A Role of Nanotechnology in Biomedical Applications, International Journal of Innovative Research in Computer and Communication Engineering (An ISO 3297: 2007 Certified Organization) Vol. 2, Issue 9. September 2014.