ejpmr, 2024, 11(2), 48-53

SJIF Impact Factor 6.222

EUROPEAN JOURNAL OF PHARMACEUTICAL AND MEDICAL RESEARCH

www.ejpmr.com

Review Article

ISSN 2394-3211

EJPMR

AN OVERVIEW ON USAGE OF NANOPARTICLES AS A METHOD OF DRUG DELIVERY

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Article Received on 24/11/2023 **Article Revised on 14/12/2023** **Article Accepted on 04/01/2024**

ABSTRACT

For the past few decades, there has been a considerable research interest in the area of drug delivery using particulate delivery systems as carriers for small and large molecules. Nanotechnology is expected to bring revolutionary changes in the field of life sciencesincluding drug delivery, diagnostics, nutraceuticals and production of biomaterials. NPs can be synthesized chemically or biologically. Biosynthesis of NPs by microorganism is a green and eco-friendly technology, whereas chemically synthesized NPs are associated with a higher number of adverse effects and toxicity. Nanomedicine has enormous prospects for the improvement of diagnosis and treatment of human diseases. Nanotechnology has potential to transfigure a wide array of tools in biotechnology so that they are more personalized, mobile, economical, secure and unchallenging to administer.

KEYWORDS: Nanoparticles, Drug delivery, Nanotechnology, Site-specific targeting.

INTRODUCTION

'Nano' the word derived from the Latin word 'nanos', which means 'dwarf", and the term 'nanotechnology' was coined by a Japanese scientist Nori Taniguchi. Nanotechnology is a branch of science that specifically deals with the processes that occur at the molecular level and of nano- length scale size, i.e. 1nm = 10^{-9}m. However, the prefix 'Nano' commonly used for particles that are up to several hundred nanometers in size. Pharmaceutical nanotechnology contributes new tools, opportunities, scope, and colossal potential in drug delivery system (DDS) as the carrier for congruent and corporeal delivery of bioactive, diagnostics, and prognostics, along with the treatment of various diseases with its nanoengineered tools. Usually, drug utilization is outlined by deprived biodistribution, constrained effectiveness, dreaded side effects, and meagreness of selectivity. These methods help to reduce toxicity, ameliorate release, improve solubility, bioavailability and better formulation opportunities for drugs.[1,6]

Nanoparticles (NP), is also known as single-domain ultrafine particles can be defined as particulate dispersions or solid particles with a diameter range of 10 – 1000nm, which are increasingly used in diverse applications, covering drug carrier systems and to cross organ barriers. NP has enormous application as a carrier in drug delivery, is based on their important and unique features, such as their surface-to-mass ratio, which is much higher than thatof other particles, which allows the catalytic promotion of reactions and which increases their ability to adsorb and carry other compounds such as drugs, probes, and proteins. Since NP have less particle size and larger surface area, they might be more reactive compared to their fine analogues (>100nm). Hingeing upon the method of preparation, the drug is dissolved, entrapped, encapsulated or attached to a nanoparticle origin to form NP, nanospheres, or nanocapsules.[3,4]

Since the 1970s it was given due consideration, that pharmaceutical suspensions were impossible to be administered by intravenous route, due to the apparent risk of embolism. Nowadays, the development of NP suspensions that contain medicines, also called nanomedicines facilitates to increase the therapeutic index of many partites, such as improvement of the activity, and reduction of the toxicity by the process of drug-targeting.[5] An initiation in the concept of NP was introduced in 1976 by Peter Speiser, which focuses on its use in vaccination purposes, aiming for a slow-release profile of antigen, results in a better immune response. A yearlater he discovered the lysosomotropic effect of NP. In the late 70's, drug targeting by NPs were in its beginning stage due to constraint of the non-biodegradability of the polymers, but the development of nanodevices in accordance with biodegradable/ biocompatible polymers using albumin, polyalkylcyanoacrylate, polyacetate-co-glycolate, solid lipid or chitosan resolves the challenge of using non-biodegradable polymers, that pave the way for clinical

application in oncology. 'Steric repulsion' has overcome by the development of long circulating or PEGylated NPs. Regardless of splendid progress in the design of disease targeted NPs permitting new treatments with improved specificity, very few have reached the market, due the following reasons:

- Poor drug loading (less than 5%) leading to insufficient pharmacological action, or increased amount of carrier material result in toxic effects or other undesired side- effects.
- Burst release (too rapid release) after the drug administration, as a result of simple adsorption, the fraction of the drug gets adsorbed into the nanocarriers, causing lower activity and more side-effects.[5]

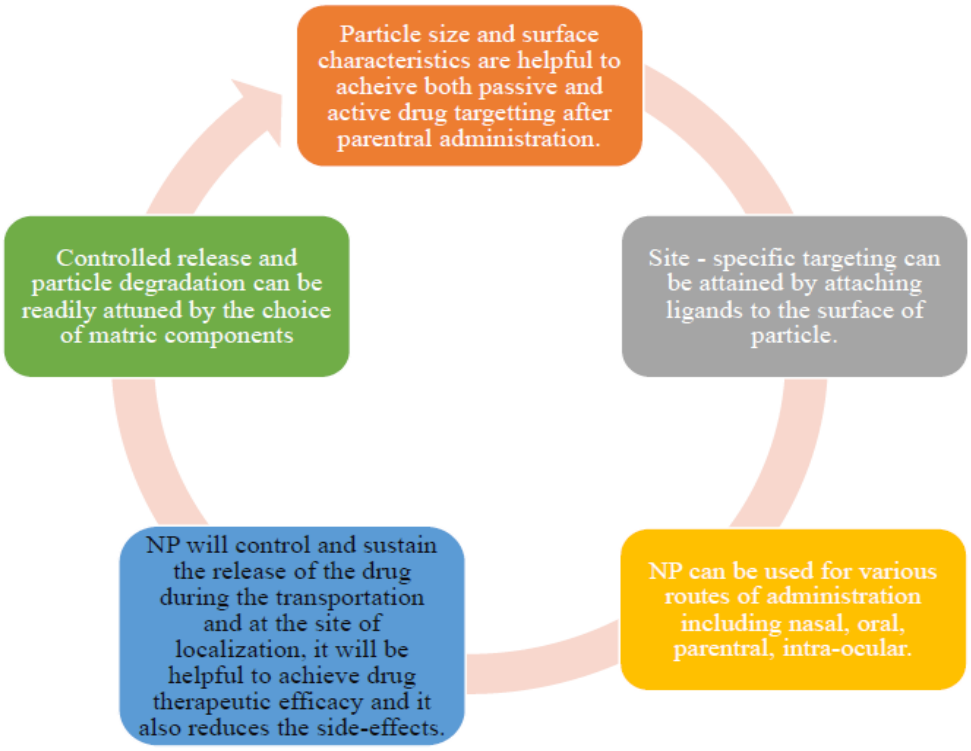

Fig. 1: Advantage of using nanoparticle as a drug delivery system.[4,6]

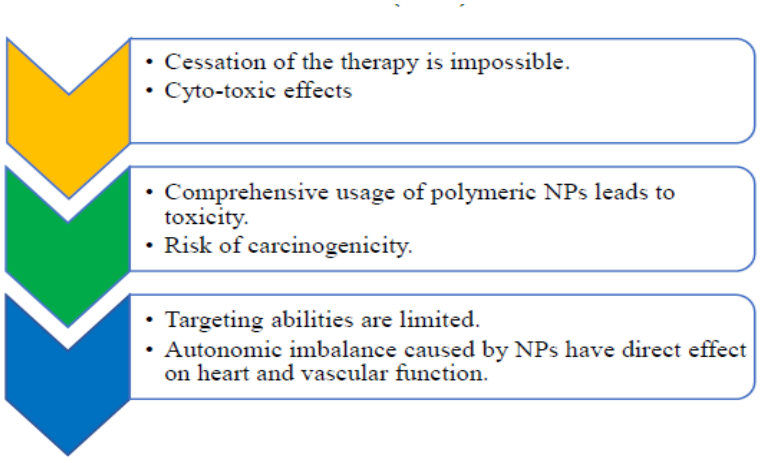

Fig. 2: Disadvantages of using nanoparticles as a drug delivery system.[6]

Comparison of Microparticle and Nanoparticle

The characterization of NPs and microparticles (MP) are primarily distinguished by particle size distribution and morphology. The difference in size between micro and nanoparticle have some numerous effects and it will be related to nano specific institutions and funding mechanisms. NP refers to the particle, where the dimensions of the particle are measured in nanometers. With the help of electron microscopy, it is possible to ascertain the morphology as well as the size of NP and the application of NP in drug release and targeting can be conveniently evaluated by various tools and it has been reported that particle size of NPs has profound effect on drug release. Microparticles are the particles, where the

dimensions of the particles are measured in micrometers respectively.[2,7]

General characteristics of nanoparticles

One can find numerous characteristics possessed by the NPs making them enticing DDS. The larger surface areas within NPs put up, a greater biological activity per mass.

- ✓ Enhanced potential chemical reactions on the surface is related to the increase in surface area of the NPs.
- ✓ The smaller size of NPs has an upper hand as it expedites an increased uptake of the particles into the cells and cellular structures compared to larger particles.
- ✓ The progress in effective surface modifications on NPs has enormous potential for site- specific drug delivery.
- ✓ Regulation of surface properties of NPs permit the targeting of therapeutic agents to specific organs as well as certain intracellular regions like mitochondria, endo-lysosomes, nucleus and cytoplasm.[8]

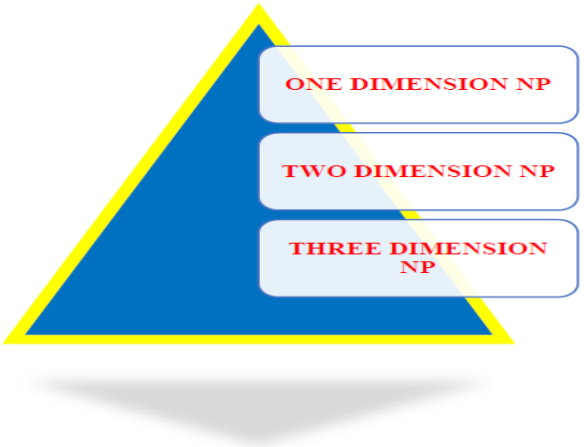

Fig. 3: Classification of nanoparticles.[2]

- ➢ **One dimension nanoparticles:** One dimensional nanoparticle is those with dimension within the range between 1 and 100 nm. E.g.: Magneto-optic and optical devise, fiber optic system
- ➢ **Two dimension nanoparticle:** Two dimensional nanoparticles are atomically thick nano material, that consists of single to few layers of atoms. E.g.: Carbon nanotubes.
- ➢ **Three dimension nanoparticles:** Three dimensional nanoparticles are materials that are not incarcerated to the nano scale in any magnitude**.** E.g.: Dendrimers, Quantum Dots, Fullerenes.[2]

Drug Loading & Site-specific targeting

Before starting with drug loading, will start with the difference between active & passive targeting,

- **Active targeting** is the process of modifying the surface of drug delivery vehicles which purposefully targeting various regions within the body in particular.
- **Passive targeting** makes use of the defense mechanism in the body, the drug particle employed for passive targeting undergo interaction with macrophages and other phagocytic immune cells.

Drug loading into NPs can be done through the adsorption, encapsulation or by covalent attachment of the drug to particle matrix. Generally, for parenteral drug administration long systemic circulation is desirable, but in specific targeting modification of the surface of the particle with ligands/antibodies, addition of proteins, peptides, polymers and oligosaccharides are being utilized.[8,9,10]

Synthesis of nanoparticles

NPs can be synthesized either chemically or biologically. Since chemically synthesized NPs are associated with a higher number of adverse effects and toxicity, biologically synthesized NPs are more likely alternatives, as they are synthesized using micro-organisms, enzymes, fungus and plant/plant extracts.[11]

Types of biosynthesis

Prokaryotic & eukaryotic micro-organisms are used in synthesis of metallic NPs via silver, gold, platinum, zirconium, iron and metal oxides like titanium oxides, etc. The synthesis of NPs can be intracellular or extracellular based on the location of NPs.

❖ **Intracellular synthesis of nanoparticle by fungi**

Intracellular synthesis of NPs involves transportation of ions into microbial cells to develop NP with the presence of enzymes.

❖ **Extracellular synthesis of nanoparticles by fungi**

Presence of enormous secretory compounds will be helpful for the reduction and capping of NPs, which are produced extracellularly.[11]

Preparation of nanoparticles

NPs can be prepared from a variety of materials such as proteins, polysaccharides and synthetic polymers. There are mainly three methods which have been performed in the preparation of NPs:

i. Dissipation of preformed polymers
ii. Polymerization of monomers
iii. Ionic gelation method

➢ **Dissipation of preformed polymers**

This method is frequently used in the preparation of bio-degradable NPs from Polylactic acid (PLA); Poly D, L-glycolide (PLG); Poly D, L-lactide-co-glycolide (PLGA) e.g. Triptorelin, recombinant human growth hormone & Poly cyanoacrylate (PCA). This method can be used in divergent approaches, which are solvent evaporation method, spontaneous emulsification method or solvent diffusion method.

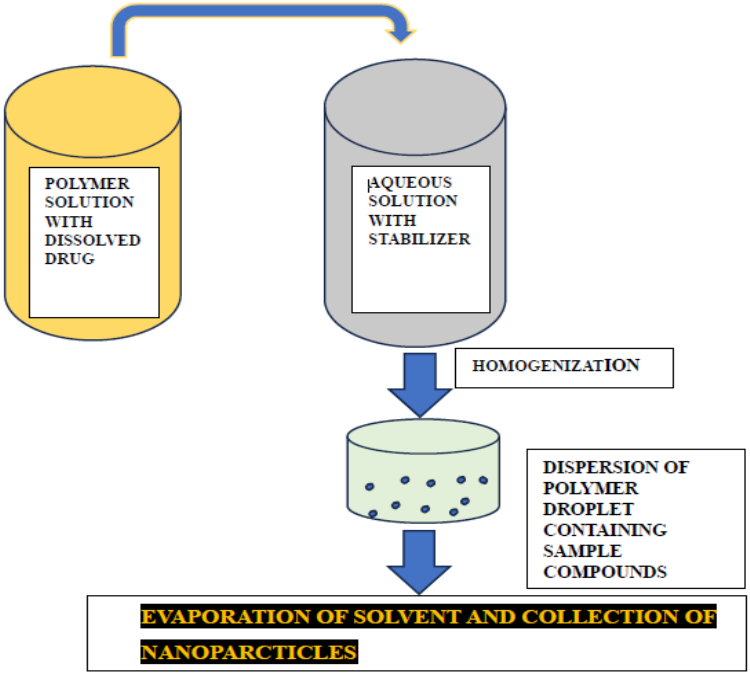

Fig. 4: Evaporation of Solvent and Collection of nanoparcticles.[13]

➢ **Polymerization of monomers**

In this technique the monomers are combined chemically to produce network molecule to form NPs in aqueous solution and the drug is being encompassed either by adsorption of NPs or by the dissolution into the polymerization medium.

➢ **Ionic gelation method**

This process involves the mixture of two aqueous phases: chitosan, di-block co-polymer ethylene oxide & polyanion sodium tripolyphosphate. In this technique, the coacervates are formed by the interaction between chitosan, appositively charged amino group and negatively charged tripolyphosphate, which are formed due to the electrostatic interaction between two aqueous phases & they undergo transition from liquid to gel due to ionic interaction condition at room temperature.[4,12,13]

Table 1: Types of nanoparticles used in drug delivery.[6,10,14]

Sl. No.	Types of nanoparticles	Material used	Applications
1	Nanosuspensions & Nanocrystals	Drug powder is dispersed in surfactant solution	Stable system for controlled delivery of poorly soluble drug
2	Solid lipid nanoparticles	Melted lipid dispersed in aqueous surfactant	Least toxic and morestable Colloidal carrier systems as alternative material to polymers
3	Polymeric nanoparticles	Biodegradable polymers	Controlled and targeted drug delivery
4	Polymeric micelles	Amphiphilic block co-polymers	Controlled and systematic delivery of water insoluble drugs
5	Magnetic nanoparticles	Magnetite Fe2O3, Meghe Mite coated with dextran	Drug targeting diagnostics in medicine
6	Carbon nanotubes	Metals, semiconductors or carbon	Gene and DNA delivery Controlled release of drug

7	Liposomes	Phospholipid vesicles	Controlled target drug delivery
8	Nanoshells	Dielectric core & metal shell	Tumor targeting
9	Ceramic nanoparticle	Silica, Alumina, Titanium	Drug and biomolecule delivery
10	Nanopores	Aerogel, which is produced by cell gel chemistry	Controlled release drug carriers
11	Nano wire	Silicon, Cobalt, Gold or Copper based nanowires	Transport electron in nano electronics
12	Quantum dots	cdSe-cdS core shells	Targeting, imaging agent
13	Nano films	Polypeptides	Systemic or local drug delivery
14	Ferrofluids	Iron oxide magnetic nanoparticles surrounded by polymeric layer	For capturing cells and other biological targets

CONCLUSION

Nanoparticulate drug delivery system seems to be a viable and promising strategy for the biopharmaceutical industry they can increase the bioavailability, solubility and permeability of many potent drugs which are otherwise difficult to deliver orally. Due to incredible propertiesNPs have become significant in many fields in recent years such as energy, healthcare, environment, agriculture etc. It is now well known that inherent physical and chemical properties of NPs (size, shape, surface characteristics) as well as the environment it comes intocontact with, can dictate a NP degree of bio-compatibility.

ACKNOWLEDGEMENT

We would like to express our deepest gratitude and sincere thanks to our family members, whohelped us a lot in finalizing this review within the limited time frame. We also take this opportunity to thank our principal **Dr. A.P Basavarajappa** who offered us to acquire knowledge from this institution. The blessing and leadership given by him shall carry us a longway in our careers.

ABBREVIATIONS

Sl. No.	Abbreviations	Expansion
1	NP	Nanoparticles
2	DDS	Drug Delivery System
3	PLA	Polylactic Acid
4	PLG	Poly D, L-glycolide
5	PLGA	Poly D, L-lactide-co-glycolide
6	PCA	Poly Cyano-Acrylate

BIBLIOGRAPHY

1. Agnieszka Z. Wilczewska et al. Nanoparticles as drug delivery systems. Pharmacological Reports, 2012; 64(5): 1020-1037.
2. Saurabh Bhatia. Nanoparticles types, classification, characterization, fabrication methods and delivery applications. Natural Polymer Drug Delivery Systems: Nanoparticles, Plants, and Algae, 2016; 33-93.
3. Paul J. A. Borm, Wolfgang Kreyling. Toxicological Hazards of Inhaled Nanoparticles – Potential Implications for Drug Delivery. Journal of Nanoscience and Nanotechnology, 2004; 4(5): 521-531.
4. V J Mohanraj, Y Chen. Nanoparticles – A Review. Tropical Journal of Pharmaceutical Research, 2006; 5(1): 561-573.
5. Patrick Couvreur. Nanoparticles in drug delivery: past, present and future. Advanced Drug Delivery Reviews, 2013; 65(1): 21-23.
6. Nishikant C. Shinde et al. Nanoparticles: Advances in Drug Delivery Systems. International Journal of Advances in Pharmacy, Biology and Chemistry, 2012; 3(1): 922-929.
7. Daniel S Kohane. Microparticles and nanoparticles for drug delivery. Biotechnology and bioengineering, 2007; 96(2): 203-209.
8. Simardeep Gill et al. Nanoparticles: Characteristics, Mechanisms of Action, and Toxicity in Pulmonary Drug Delivery – A Review. Journal of Biomedical Nanotechnology, 2007; 3(2): 107-119.
9. Avnesh Kumari, Sudesh Kumar Yadav, Subhash C. Yadav. Biodegradable polymeric nanoparticles-based drug delivery systems. Colloids and Surfaces B: Biointerfaces, 2010; 75(1): 1-18.
10. Usman Ali Ashfaq et al. Recent Advances in Nanoparticle – Based Targeted Drug-Delivery Systems Against Cancer and Role of Tumor Microenvironment. Critical Reviews^{TM} in Therapeutic Drug Carrier Systems, 2017; 34(3):

317-353.
11. Saba Hasan. A Review on Nanoparticles: Their Synthesis and Types. Research Journal of Recent Sciences, 2015; 11, 4: 1-3.
12. Jayanta Kumar Patra et al. Nano based drug delivery systems: recent developments and future prospects. Journal of Nanobiotechnology, 2018; 16(1): 1-33.
13. Dustin L Cooper, Christopher M Conder, Sam Harirforoosh. Nanoparticles in drug delivery: mechanism of action, formulation and clinical application towards reduction in drug-associated nephrotoxicity. Expert Opinion on Drug Delivery, 2014; 11(10): 1661- 1680.
14. Sheva Naahidi et al. Biocompatibility of engineered nanoparticles for drug delivery. Journal of controlled release, 2013; 166(2): 182-194.