International Journal of Pharmaceutics 528 (2017) 675–691

Contents lists available at ScienceDirect

International Journal of Pharmaceutics

journal homepage: www.elsevier.com/locate/ijpharm

Pharmaceutical Nanotechnology

# Polymeric nanoparticles: Promising platform for drug delivery

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ARTICLE INFO

*Article history:*
Received 25 February 2017
Received in revised form 14 June 2017
Accepted 15 June 2017
Available online 16 June 2017

*Keywords:*
Polymeric nanoparticles
Oral bioavailability
Cancer therapy
Gene delivery
Central nervous system

ABSTRACT

Nano medicine had viewed countless breakthroughs in drug delivery implementations. The main objective of nanotechnology application in delivering and carrying many promising therapeutics is to assure drugs carriage to their action sites, to maximize the pharmacological desired influence of remedies and to overcome their limitations and drawbacks that would hinder the required effectiveness. One of these applications was the particulates type of nano-range in size and tremendous impact in achievement. About this specific diversity of particulates, the different elaboration methodologies, mandatory and elementary components for design, and examples of splendid success stories for these particulates were emphasized in this humble review. Challenges such as oral delivery probability for peptide moieties and enhancement the harshly passage process of drugs across the blood brain barriers were accepted and defeated by the almost insurmountable latterly mentioned particulates. Behold, the polymeric nanoparticles.



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*Abbreviations:* 5-FU, 5-fluorouracil; APIs, active pharmaceutical ingredients; BBB, blood brain barrier; BCNU, 3-bis (2- chloroethyl)-1-nitrosourea; CBSA, cationic bovine serum albumin; CQ, clioquinol; EPR, enhanced permeability and retention; FA-BSA-CM-β-CD, folic acid-decorated bovine serum albumin conjugated carboxymethyl-β-cyclodextrin; HBOCs, haemoglobin-based oxygen carriers; HEMA, 2-hydroxyethyl methacrylate; HER, human epidermal receptor; MAT, *N*-methacryloyl-(l)-tryptophan methyl ester; MIPNPs, molecularly imprinted PNPs; mPEG, monomethoxy poly-(ethylene glycol); MTC, mannose-modified trimethyl chitosan-cysteine; NCs, nano-carriers; NiMOS, nanoparticles-in-microsphere oral system; NPs, nanoparticles; PAA, polyacrylic acid or carbomer; PACA, polyalkylcyanoacrylate; PAM, polyacrylamide; PBCA, poly-butyl-cyanoacrylate; PCL, poly (ε-caprolactone); PCL, polycaprolactone; PECA, polyethylcyanoacrylate; PEG, polyethylene glycol; PEO, polyethylene oxide; PGA, polyglutamic acid; PGA, polyglycolides; PLA, polylactides; PLGA, poly (lactide co-glycolides); PMAA, poly (methacrylic acid); PMLA, poly (malic acid); PMMA, poly (methyl methacrylate); PNPs, polymeric nanoparticles; POE, polyorthoesters; PPO, poly (propylene oxide); PVA, poly (vinyl alcohol); PVP, poly (*N*-vinyl pyrrolidone); RNA, ribonucleic acid; siRNA, small interfering RNA; TDDS, targeted drug delivery systems; Tf, transferrin; TNF- α, tumour necrosis factor alpha; VEGF, vascular endothelial growth factor.

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http://dx.doi.org/10.1016/j.ijpharm.2017.06.052
0378-5173/

## 1. Introduction

Nano medicine, as a start-up of a new auspicious discipline in the 21st century, is simply renowned as the nanotechnology utilization to get enhancements in healthcare and improvements in pharmaceuticals (Langer and Weissleder, 2015). This encompasses the nano-scale particles utilization, which probably diverge from the larger scale particles of the same materials used for nano-scale particular assembly (Chang et al., 2015). Nano medicine could greatly equip real advances in idioms of cost-effective and bettered healthcare, an axial element in remedies manufacture and making medications affordable and obtainable. So, nanotechnology is predicted to considerably enhance therapeutic forms and diagnostic tools for diversified diseases (Satalkar et al., 2016). Nanoparticles (NPs) and Nano-carriers (NCs) are particles which commonly not passing 100 nm in length (Kassem et al., 2016). This size range was accepted and well renowned for some previous researches in nanotechnology (Deguchi et al., 2013; Gupta et al., 2010). All NCs used in various medical implementations are made from biocompatible constituents which make them apart from toxicity and also display a highly characteristic selectivity and uptake adequacy in diseased cells rather than healthy ones. Besides, they are recognized by their prolonged circulating half-life and extended shelf life (Ai et al., 2011). The most familiar and exceedingly used NCs systems are micelles, dendrimers, nanofibers, niosomes, liposomes and NPs (Torchilin, 2005). Another major classification of NPs systems according to the compositional structure is inorganic nanoparticles, lipid based nanoparticles and polymeric nanoparticles (PNPs). In this review, our focus and main interest will be on PNPs, types, how can be prepared, their uses and impact on many medicinal agents efficacy and safety, and how they can bring betterments for such drugs elaborated with.

## 2. Polymeric nanoparticles (PNPs)

In recent times, PNPs are extensively employed as biomaterials because of their favourable characteristics in terms of simple elaboration and design, good biocompatibility, a broad structures variety and noticeable bio-imitative characteristics. Expressly in smart drug delivery discipline, PNPs had a marked role as they are able to bring therapeutics right into the purposed position in human body, with excellent efficiency. Advantages and characteristics of PNPs are many as follows (Kayser et al., 2005). In terms of efficacy and bioavailability, they show a remarkable enhancement over intravenous and oral administration routes. Also, in relation to drug delivery, PNPs can be easily integrated into other activities such as tissue engineering. In addition, they transport active ingredients to a targeted tissue or organ with the specified concentration and impart stability and longer activity duration for volatile active ingredients. Moreover, PNPs can be considered as an ideal candidates for vaccines delivery, cancer therapy, and targeted antibiotics delivery in accordance with the polymer choice and capacity to adjust drug release from PNPs.

The perfect necessities for PNPs delivery system design are to efficiently control their superficial feature and particulate size to control infiltration, adjust solubility, enhance elasticity and manage remedies release pattern from PNPs to acquire the selected specific action and the designated target site at a desired time and level (Bennet and Kim, 2014).

## 3. General types of PNPs

As “PNP” term is a collective expression and can be given for many polymeric nanoparticle forms, it can be more bounded for two major types; nanocapsules and nanospheres. Nanocapsules are acting as a drug reservoirs, due to their vesicular structure, in which the retained active pharmaceutical ingredients are reserved in an aqueous or non-aqueous liquid core placed in the vesicle cavity and enclosed by the solidified polymeric shell. On the other hand, nanospheres can be described as a solid/mass of matrix polymers. In other words, any nanosphere may portrayed as an entire polymeric spherical mass in which, as result, drug molecules may be trapped within the sphere centre or adsorbed at the mass surface (Counreur et al., 1995; Rao and Geckeler, 2011). A graphical drawing of PNPs types is presented in Fig. 1.

## 4. Polymers used for PNPs preparation

To elaborate PNPs, many materials and components needed to be composed together to formulate PNPs of the desired features

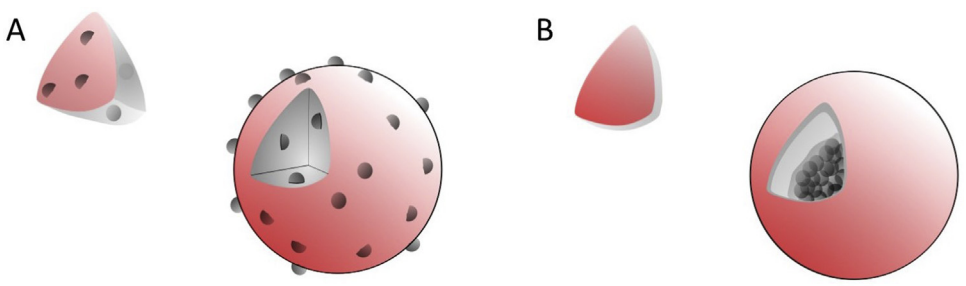


**Fig. 1.** PNPs different types which either nanospheres with drug adsorbed on surface or entrapped within (A), or nanocapsules containing drug in oil or water vehicle (B).