

# Chapter 51

## Therapeutic Applications of Nanobiomaterials

**Anuj Garg**

*National Institute of Pharmaceutical Education and Research (NIPER), Raebareli, India*

### ABSTRACT

*The most exciting advancement in the fields of biomaterial science is its ability to engineer new materials at the nanoscale level for various biological applications particularly drug and gene delivery for therapeutic applications. The main focus of this chapter is to review the therapeutic applications of different nanobiomaterials. Thus, it is proposed to discuss type of nanobiomaterials, general biological barriers for therapeutics, surface functionalization of nanobiomaterials and their therapeutics application in the present chapter. The therapeutic applications are explained on the basis of type of nanobiomaterials. The biocompatibility and toxicological response towards nanobiomaterials is an important issue that requires investigation for clinical development and their commercialization. The commercial prospects and future challenges in development of nanobiomaterials particularly for drug delivery are also discussed in the present chapter.*

### 1. INTRODUCTION

The most exciting advancement in the fields of biomaterial science is its ability to engineer new materials at the nanoscale level for various biological applications particularly drug and gene delivery for therapeutic applications. Nanotechnology-based approaches are being explored for many applications such as for drug delivery, diagnosis, tissue engineering, and biosensors. Most of these approaches employ nanobiomaterials for developing unique functionalities required by these biomedical systems. The main focus of this chapter is to provide perspective of therapeutic application of nanobiomaterials. The application of nanobiomaterials to tumor delivery and targeting of therapeutics for cancer treatment have received significant attention in the last decade (Golla et al., 2013; Luo et al., 2010; Heister et al., 2009; Maeda et al., 2000). A wide range of nanobiomaterials materials have been used to construct nanoparticles for encapsulation of chemotherapeutics to increase the capability of delivery or to provide unique optical, magnetic, electrical and structural properties for therapy as well as imaging.

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Nanobiomaterials are used as reservoir of the drugs for prolonged or extended delivery. Therapeutics-drug and gene delivery systems include metallic, inorganic, organic/carbon, protein/peptide, polymeric and lipid, polymeric-lipid hybrid and biologically directed (virus) nanobiomaterials. These nanobiomaterials can be capable to provide a unique solution to overcome the limitations of existing conventional drug delivery systems, which include low bioavailability, non-targeting and potential toxicity. General biological barriers for therapeutics are also explained in this chapter for better understanding of the limitations of nanobiomaterials. The understanding of these limitations provides help in development of the nanobiomaterials based drug delivery systems to overcome the biological barriers.

Further, surface properties of these nanobiomaterials can be manipulated to enhance their therapeutic efficacy by increasing their targeting potential and immunocompatibility. Surface modification of nanobiomaterials can also influence their stability in *in-vivo*. The surface modification/functionalization of nanobiomaterials received significant attention in the treatment of cancers. Surface functionalization of nanobiomaterials includes conjugation with antibodies and receptor targeting ligands for active targeting of nanobiomaterials (Yu et al., 2013).

In the present chapter, therapeutic applications of nanobiomaterials are discussed with relevant examples on the basis of type of nanobiomaterials as shown in outline of the chapter. Metallic nanobiomaterials like gold nanoparticles are used for the drug delivery and photo thermal therapy in treatment of tumours. Inorganic based nanobiomaterials like hydroxyapatite possess a potential therapeutic application in the management of osteoporosis, a bone disease (Linovitz & Peppas, 2002). Carbon based nanobiomaterials like *carbon nanotubes* and *fullerenes* have various applications in the field of therapeutics like used as photosensitizers in photodynamic therapy (Zhou et al., 2009; Carlson & Krauss, 2008). The peptide based nanobiomaterials can incorporate the small hydrophobic molecules like lipophilic drugs and to be easily functionalized with targeting moiety. Also some peptide based nanobiomaterials exhibited strong antimicrobial properties. The application of peptide nanobiomaterials in gene delivery is also to be summarized in the present chapter. The polymeric and lipid based nanobiomaterials are widely used as drug delivery platform to overcome the stability, bioavailability and toxicity related issues for various type of drug molecules like anticancer agents, antimicrobial agents, anti diabetic agents etc. The main focus of this chapter is to review the therapeutic applications of different nanobiomaterials.

Thus, it is proposed to discuss type of nanobiomaterials, general biological barriers for therapeutics, surface functionalization of nanobiomaterials and their therapeutics application in the present chapter. The therapeutic applications are explained on the basis of type of nanobiomaterials. The biocompatibility and toxicological response towards nanobiomaterials is an important issue that requires investigation for clinical development and their commercialization. The commercial prospects and future challenges in development of nanobiomaterials particularly for drug delivery are also discussed in the present chapter.

## **2. TYPE OF NANOBOMATERIALS**

Nanobiomaterials can be classified based on the dimensions, which are not confined to the nanoscale range. The classification is as follows:

1. **Zero Dimensional (0-D):** All dimensions are at nanoscale like drug loaded nanoparticles
2. **One dimensional (1-D):** Two dimensions are at nanoscale, other dimension is not at nanoscale like nanowires, nanrods and nanotubes (carbon nanotubes)

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