

Chapter 28

Bioinspired Nanoparticles for Efficient Drug Delivery System

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ABSTRACT

Bioinspired nanoparticles have been involved in biomedicine field such as biosensors and drug delivery due to their small size and interesting characteristics that made them highly biocompatible, less toxic and hence greater influence on the biological systems. An effective drug delivery system can be achieved when applying these bioinspired material and herein we present several research work that involved bioinspired nanotechnology in drug delivery for cancer, therapeutic genes, calcium apatite nanocomposites, protein drugs and others.

INTRODUCTION

Human biological system is made up of nanoscale particles that self-assembled to build biological tissues (Bhattacharya et al., 2014). It is well known that nanoparticles can be synthesized in several routes such as microwave, autoclave, sol-gel and other chemical routes resulting in different shapes and sizes. Hence, nanoparticles (NPs) has the suitable size to powerfully influence the biological systems, add to that their unique physical and chemical properties (Bhattacharya et al., 2014). Therefore, NPs have been recently involved in a wide range of biomedical applications in particular biosensors (Bhattacharya, 2014), biomolecular electronics (Bhattacharya et al., 2014) and drug delivery (Bhattacharya et al., 2014), (Thasneem et al., 2013) (Costa et al., 2014) (Peib et al., 2014). Today, NPs have been involved in the delivery of drugs for various sites and purposes including cancer therapy (Athinarayanan et al., 2015) Yigit et al., 2012) (Rena et al., 2013) (Ma'mani et al., 2014) (Jin et al., 2014) (Liechty et al.,

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2012), skin diseases (Tarl et al., 2011), heart diseases (Sylvester et al. 2013), ophthalmic disease (Jung et al., 2012) (Venkatesh et al., 2007), imaging purposes (Zhou et al., 2009)(Zhou et al., 2014), and gene delivery (Luvino et al., 2013).

During last decades, with the raise of advanced technologies, the synthesis of NPs has been developing rapidly allowing scientists to create advanced designs of nanoscale compounds that mimic natural systems in a very precise manner. Recently, bioinspired NPs have been applied in various biomedical applications and in particular in drug delivery. Most of these drugs delivered using a bioinspired design nanoscale compounds are cancer drugs. (Jin et al., 2014) reported the history of bioinspired NPs as a delivery vehicles of cancer drugs.

Natural nanocarriers that are found in biological systems circulating cargo in a prolonged and sustained manner have been the inspiration for researchers to design NPs that mimics the natural system (Chen et al., 2012) in uploading, delivering and releasing substances thereby apply this in drug delivery system (Yoo et al., 2011) (Wang Y. et al., 2014). Examples of natural nanocarriers are exosomes (Johnsen et al., 2014) (Stanley, 2014) (Johnsen et al., 2014), lipoproteins (Stanley, 2014), Ferritin magnetites (Stanley, 2014), viruses (Stanley, 2014), extracellular vesicles (Meel et al., 2014), magnetic graphite (Ribeiro et al., 2014), microbes (Althuri et al., 2013) and self assembled chitosan nanomaterials (Yang et al., 2014).

Approaches of mimicking natural carriers included, reproducing the characteristics of natural surfaces to build shelled carriers made of variety of structures (layer by layer approach) (Lorenzo et al., 2013), mimicking natural hard tissues (Lorenzo et al, 2013), (Wang S. et al., 2013), (Morton et al., 2013), mimicking pathogens (virus/bacteria like NPs) (Lorenzo et al., 2013), (Prozorov, 2013) and including natural materials during synthesis to enhance biocompatibility (Bae et al., 2011) (Yoo et al., 2011). For instance, bioinspired NPs such as polymeric NPs (Yoo et al., 2011) (Krannig et al., 2014) (Calderón et al., 2010) (Rica et al., 2012) (Jing et al., 2013), liposomes (Yoo et al., 2011) Rica et al., 2012), micelles (Yoo et al., 2011) (Costa et al., 2014) and protein based NPs (Bhattacharya et al. 2014) were functionalised for a successful drug delivery system which can achieve loading of relatively stable amounts of drugs with minimum leakage and side effects with steady and prolonged release (Lorenzo et al, 2013) (Jang S. et al., 2013) (Yoo et al., 2011). Furthermore, these bioinspired carriers should be affected by natural physiological conditions (pH, temperature and concentration) in order to control the release of drugs.

Herein, recent research work that included the development of bioinspired NPs for the design of novel drug carriers to achieve an efficient drug delivery system has been reported (Table 1). This chapter is divided into sections based on the kind of treatment including cancer treatment, gene, therapy, bone disease, protein drugs delivery and other treatments such as liver fibrosis, etc.

1. BIOINSPIRED DRUG DELIVERY FOR CANCER APPLICATIONS

Cancer has been the challenging disease of this era, due to the lack of an efficient treatment (Gunduz, 2014). One of the main treatments of cancer is chemotherapy which requires the delivery of certain anti-cancer drugs to the site of the tumor in order to destroy tumor cells (Du et al., 2014). However, such drugs are not only affecting the malignant tissue, but they also spread over the patient's body causing horrible side effects. Therefore, intensive research are carried out to improve the efficiency of the drug delivery such as improving the uptake behavior of these drugs and reducing their leakage over healthy tissues. Different nanoparticles (NPs) have been applied as carriers for anti-cancer drugs, such as, magnetite (Fe_3O_4) NPs (Wu J. et al., 2014), Silica NPs (Wu X. et al., 2014) (Gary-Bobo et al., 2012) (Ma'mani et

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