CHAPTER 11

Nanoparticle Drug Delivery: An Advanced Approach for Highly Competent and Multifunctional Therapeutic Treatment

SAIMA AMJAD • M. SERAJUDDIN
Department of Zoology, University of Lucknow, Lucknow, India

1. INTRODUCTION

Nanoscience and nanotechnology is the most emerging multidisciplinary scientific field at the beginning of the 21st century, which has given better opportunities using engineering and manufacturing principles at the molecular scale to design and develop complete, high performance products [1, 2]. Nanotechnology is revolutionizing the medical field by using nanomaterials because these nanomaterials have an ability to cure the disease by targeted drug delivery at the cellular and molecular level [3]. The prefix "nano" is derived from Greek (Latin nanus) which means dwarf. In the International System of Units, a nanometer is equal to one-billionth of a meter (10^{-9}) [4]. National Nanotechnology Initiative (NNI) defines nanotechnology as the manipulation of matter with all three dimensions at least one dimension range approximately 1–100 nm [5].

Richard Adolf Zsigmondy gave the first accurate observation and size measurement of the nanoparticle by using dark field ultramicroscopy and first to coin the term "nanoparticles" [6]. In the year 1959, physicist Richard Feynman expressed the concept of nanotechnology in his lecture "There's plenty of room at the bottom" and suggested the possibility of direct manipulation to make nanoscale machines that is assembling matter on an atomic scale [7]. Feynman further explained in terms of medicine that the use of tiny machines would become interesting in surgery if the patient swallows the surgeon, that is, the tiny machines or surgeons move inside the blood vessel and find out which valve is the faulty one and takes the knife and removes it out. Moreover, the other tiny machines might be permanently residing in the body to aid some improperly functioning organ [8].

The term "nanotechnology" was coined by Norio Taniguchi at the University of Tokyo (1974). Kroto's and Smalley's research team discovered fullerene C_{60} in the year 1985 and Saumio Lijima discovered carbon nanotubes in 1991 [9]. In 2000 the United States launched the NNI to make the way for the future advancement of nanotechnology. The first nanoparticles of 100-nm diameter of poly(methylmethacrylate) as a new adjuvant were made by Kreuter and Speiserin (1976) [10] in the drug delivery area. Nanomedicine is the branch of nanotechnology in which the procedure of treatment, diagnosis [11], and prevention of diseases [12] using the novel methods of drug delivery [13] such as biocompatible nanoparticles [14] and nanorobots [15] generate more efficient and effective therapy [16].

According to Emerich and Thanos [17], nanomedicine application for drug development depends on various molecular technologies which broadly included three classes which are represented in Fig. 1. Conventional drugs which are used by the traditional medical practitioner are not very effective because of their poor solubility and have limited bioavailability after oral and intravenous intake. Although these limitations of conventional drugs could be diminished by the application of nanotechnology approaches by the drug delivery method. The targeted nanoscale drug delivery system which has the potential to revolutionize drug delivery systems used nanomaterials such as nanocapsule, nanoparticles, nanopores, nanoliposomes, nanoshells, dendrimers, fullerenes, nanotubes, quantum dots, nanosphere, nanovaccines, and nanocrystals. Thus nanodrug formulation can be used for the intentional development of new drug delivery systems and reinvent existing drugs to enhance efficiency, patent protection,

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