

CHAPTER 11

Graphene-based drug delivery systems

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11.1 Introduction

The process of administering a pharmaceutical compound, in a living organism, to obtain a therapeutic effect is known as drug delivery. Conventional medicine has some precincts such as poor bioavailability, weak targeting specificity, systemic and organ toxicity, etc.; however, modern medicine has created a variety of delivery systems for efficient delivery of therapeutics to overcome these limitations. These advanced drug delivery systems are composed of nanomaterials, polymeric carriers, proteins, complex biomacromolecules, liposomes, proliposomes, microspheres, gels, prodrugs, and lipids that regulate the natural functioning in the body, etc. [1, 2]. Nanoparticles are materials that lie in the size range of 1–100nm. They exist in numerous shapes such as spheres, rods, wires, planes, etc. The physical and chemical properties of nanomaterials are entirely different from that of their bulk counterparts due to the uniqueness of these nano-formations.

High surface-to-volume ratio, high surface energy, exceptional mechanical, thermal, electrical, magnetic, and optical features are some of the characteristics observed in nanomaterials. These outstanding properties enable an extensive range of applications, such as electronics, energy storage, hybrid materials, medicine, etc. The chemical reactivity and dispensability of nanomaterials in various solvents can be controlled by surface modifications. Applications of nanotechnology for treatment, diagnosis, monitoring, and control of biological systems are referred to as nanomedicine by the National Institutes of Health. The ultimate aim of nanomedicine is the delivery and targeting of pharmaceutical, therapeutic, and diagnostic agents which enables specific targeting and thus more efficient therapy while minimizing the side effects. Nanomedicine is a multidisciplinary field of science, in which nanotechnology enables the precise designing and formulation of therapeutics

with efficient carriers for site-specific drug delivery and diagnosis [3, 4]. Moreover, the origin of many diseases are the abnormalities at the molecular level where most of the cellular and subcellular organelles are in the nano-range, thus the incorporation of nanosized therapeutics have an upper hand in the treatment of diseases where the blood-brain barrier creates a barrier/challenge to deliver the agents to the infected site. Nanomedical devices are designed to ensure the transport of diagnostic and therapeutic entities, through biological barriers, to efficiently reach the specified target location and treat the disease by molecular interactions [5–7]. Nanomedicine consists of the diagnostic, therapeutic, and theranostic fields of nanomaterials. For nanodrug delivery, a carrier material is employed to overcome cellular barriers, nanocarriers enter through mechanisms of cell internalization by different types of phagocytic and non-phagocytic routes [8]. The rapid growth and development of nanomedicine products holds great promise to improve therapeutic schemes against a variety of diseases and their early detection by diagnosing the biomarkers [9, 10].

Cancer is one of the leading causes of death worldwide. Compared with current cancer therapeutics, nanomedicine offers improved treatment modalities and diagnostic tools. Moreover, a wide range of nanomaterials has been successfully investigated at the preclinical and clinical levels. Carbon nanomaterials, especially graphene and its derivatives, are excellent biomaterials used in nanomedicine. In this chapter, we discuss more about graphene-based drug delivery systems that have been investigated in preclinical and clinical studies [11].

11.7 Conclusion and future perspectives

Graphene nanomaterials are outstanding carrier materials for drug delivery applications. The specific structure-associated properties enable high loading efficiency, functionalization capacity for targeting, imaging, sensing, stimuli responsive release, etc. Multifunctional drug delivery systems and theranostic systems are the future of graphene-based nanodrug delivery systems. However, more preclinical analysis must be performed to understand the source of toxicity issues associated with graphene nanomaterials. Despite the toxicity concerns and associated biosafety issues, graphene nanomaterials offer an exceptional platform for developing multifunctional nanotherapeutic systems.

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