Chapter 53
Pharmaceutical and Medical Applications of Nanofibers

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ABSTRACT

Nanofibers as a main group of nanoparticles have a vast range of applicability for therapeutic purposes, duo to their outstanding attributes such as very large surface to volume ratio and high porosity. These types of nanoparticles are more known as tissue scaffolds and drug delivery carriers. Nanofiber-based carriers are able to control the release pattern of drugs. In addition, they can act as multidrug-loaded materials with programed dual release profile. Electrospinning is a simple method, which is recognized as the most efficient approach for the fabrication of nanofibers. Production of ultrafine fibers based on various natural or synthetic polymers is possible by means of electrospinning. In this chapter, a comprehensive review is presented on various medical applications of electrospun nanofibers in the case of tissue engineering and drug delivery. Several investigations on therapeutic nanofibers and their processing methods are also summarized in this chapter.

INTRODUCTION

During recent years, the science of nanoparticles has received great importance owing to their applications in various aspects of medical and pharmaceutical sciences, engineering, and other areas of human life (Barzegar-Jalali et al., 2008; Burgess et al., 2010; Kamaly, Xiao, Valencia, Radovic-Moreno, & Farokhzad, 2012; Mohanraj & Chen, 2007). To reach a successful treatment process for various diseases and abnormalities in human body, the key factor is to smartly use of the therapeutic agents (either pharmaceuticals or other medical applications). In order to deliver the therapeutic agents to the site of

DOI: 10.4018/978-1-5225-1798-6.ch053

action and to control their fate in patients' body, nanotechnology and more specifically nanomedicine is a promising approach because of the unique and outstanding physicochemical properties of the nanoparticles (Yang, Chang, Yang, & Lin, 2010). Biomedical nanoparticles, with a diameter in the nanometer size range and modified physicochemical properties, are appropriate for several biomedical purposes. Nanoparticles could be applied as targeted delivery systems (Brannon-Peppas & Blanchette, 2012; Cho, Wang, Nie, & Shin, 2008), as tissue scaffolds (Berry & Curtis, 2003; Goldberg, Langer, & Jia, 2007; Hans & Lowman, 2002; Qian et al., 2008; Zhang et al., 2008), and for improving the bioavailability of drugs (Li & Huang, 2008). Nanoparticles also have some other advantages like high capacity of drug loading due to their porosity and reduced size, which improves water-solubility of the poor soluble drugs. This submicron diameter also enhances their membrane permeation in order to modify the absorption profile of the drug via different tissues. In addition, reduced dose, less toxicity, less adverse effects, and also better patient compliance are other attributes which draw attention toward apprising nanoparticles as an interesting novel drug delivery system (Adibkia, 2014; Dizaj, Barzegar-Jalali, Zarrintan, Adibkia, & Lotfipour; Jahangiri et al., 2014). With the purpose of improving controlled drug delivery devices, nanofibers made of biocompatible materials as well as other nanomedicines are of the most highly considered choices, which are used as ideal carriers or vehicles for therapeutic agents. They profit all the advantages mentioned for nanoparticles beside some unique specificities, which makes them play a potential promising role in various biomedical applications including medical prostheses, tissue template, wound dressing, and cosmetics (Huang, Zhang, Kotaki, & Ramakrishna, 2003).

BACKGROUND

Nanofibers are ultrafine fibers with nano-scaled diameter and very large surface area. High porous structure is also one of the outstanding properties of the nanofibers. They have many different applications in various fields; they can be used as filters to remove particles via different mechanisms, may act as vehicles for catalysts and enzymes, may be used as sensors, or may be applied to store energy (Fang, Niu, Lin, & Wang, 2008). Therapeutic applications of the nanofibers, as another advantageous aspect of these ultrafine fibers, have become the field of interest by many researchers who work on biomedical devices. Nanofibers with therapeutic purposes have shown a promising potential in the case of both drug delivery and tissue engineering (Fang et al., 2008; Sill & von Recum, 2008; Vasita & Katti, 2006).

Nanofibers for medical purposes can be produced using biodegradable materials (e. g. polymers) along with various additives in order to gain the planned functionality. Biopolymer-based nanofibers can be used as a carrier for bioactive materials or drugs. Consequently, nanofibers can provide improved bioavailability, especially for the poorly soluble drugs. Furthermore, their structure and size can be optimized for tissue engineering studies. Nanofibers prepared from biopolymers such as collagen, polylactic acid (PLA), and polycaprolactone (PCL) are potential substrates for growing the cells. It has been shown that electrospun collagen, for example, promotes cell growth and penetration of the cells into the engineered scaffold. Special properties (structural, material, and biological) of the electrospun collagen propose this material as a nearly ideal tissue-engineering scaffold. Preparation of the scaffolds that are appropriate for implanting by different types of the cells is possible by means of biomaterial-based nanofibers. During the preparation of nanofiber-based scaffolds, the incorporation of different bioactive materials such as growth factor and the drugs such as an immunosuppressant is possible.

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