Journal of Fiber Bioengineering and Informatics 6:3 (2013) 225–235
doi:10.3993/jfbi09201301

Electrospun nanofibers for Tissue Engineering

Xiumei Mo [a,b,*], Dawei Li [a,d], Hany A. EI-Hamshary [b,c]
Salem S. Al-Deyab [b]

[a] *College of Chemistry, Chemical Engineering and Biotechnology, Donghua University, 2999 Renmin Road North, Songjiang, Shanghai 201620, China*

[b] *Petrochemical Research Chair, Department of Chemistry, College of Science, King Saud University Riyadh 11451, Saudi Arabia*

[c] *Department of Chemistry, Faculty of Science, Tanta University, Tanta 31527, Egypt*

[d] *College of Textiles, Nonwovens Department, Donghua University, 2999 Renmin Road North Songjiang, Shanghai 201620, China*

Abstract

Electrospun nanofibers have increasingly attracted attention to be used as new generation tissue engineering scaffolds since they have the nanofibrous structure, which can biomimic the native Extracellular Matrix (ECM). This paper gives the review of our 10 years research on electrospun nanofibers for tissue engineering. Natural polymers like collagen and chitosan have been electrospun into complex nanofibers to biomimic the native ECM both in structure and components. Collagen-chitosan or silk fibroin (SF) was also blended with synthetic poly (L-lactide-co-ε-caprolactone) (P(LLA-CL)) and electrospun into collgen-chitosan-P (LLA-CL) nanofibers or SF-P(LLA-CL) nanofibers to achieve both good mechanical properties and biocompatibility. Coaxial electrospinning was used to encapsulate the biomolecules into nanofibers to display antithrombotic properties. The nanofiber scaffolds have been used for skin, nerve and blood vessel tissue engineering in vivo.

Keywords: Nanofiber; Electrospinning; Tissue Engineering; P (LLA-CL); Scaffolds

1 Introduction

1.1 Ideal Tissue Engineering Scaffolds Need Nanofibrous Structure

Tissue defect is a common phenomenon daily happening in clinic. Tissue engineering and translational medicine have introduced efficient methods for the repair and regeneration of defected tissue. The key issue for tissue regeneration is to provide a temporary scaffold for the defected tissue, which can induce the infiltration of cells and form new tissue with its gradually degradation. The existing procedures for constructing tissue engineering scaffolds are suitable to bulky tissue

*Corresponding author.
Email address: xmm@dhu.edu.cn (Xiumei Mo).

September 2013

such as bone and cartilage. For some fine tissues and functional tissues, like vessel and nerve, there are no ideal regeneration scaffolds. Biomimetic functional electrospun nanofibers offer us new ideas and methods for those fine tissue engineering scaffolds and bring tissue engineering to a new stage, namely nano-biomimetic tissue Extracellular Matrix (ECM). Actually, the ECM in a body is essentially constructed by nanofibrous network containing protein and glycosaminoglycans, with a diameter ranging from 50 to 300 nm [1]. Cells are embedded in these nanofibrous network, thus form body tissue (Fig. 1). Cells are specifically combined with the ligands on the ECM by the receptor in the cell membrane, which also respond to the external signal and affect the behaviors of cells. An ideal tissue engineering scaffold should mimic the native ECM. In addition, if the size of the scaffold's skeleton is too large, during the formation of tissue, untimely degradation of the scaffold can always block the organized regeneration of the new tissue, which may lead to scar formation. This cannot achieve the aim of the regeneration of organized tissue, thus, new demands are required to the scaffold, which should be similar to the native ECM. That the phenomenon of scar formation is disappeared when the size of scaffold's skeleton decreases from micron to nano fiber [2]. Recently, researchers found that the nano-fibrous structure has improved the application of tissue engineering scaffolds to bone, cartilage, cardiovascular, nervous and bladder regeneration with less scars [3].

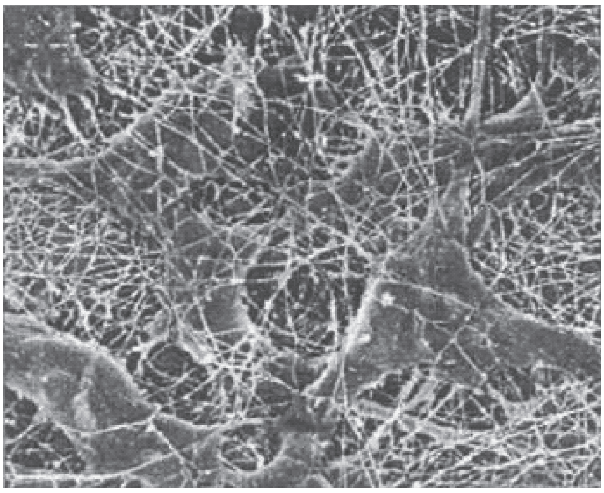

Fig. 1: SEM photo of connective tissue (cells are embedded in nanofibrous network of collagen)

Researches showed that nano-materials can affect the behavior of cells notably. Pattison *et al.* [4] utilized nanoscale PLGA scaffold culture smooth muscle cell (SMC) to construct tissue engineering bladder. Compared with traditional microscale scaffold, cells demonstrated better adhesive and proliferation ability and secreted more collagen and elastin on nanoscale scaffold. Elias *et al.* [5] also proved that the proliferation ability of osteoblasts increased as the diameter of carbon nanofiber decreased. Osteoblasts secret more alkaline phosphatases and calcium on finer nanofiber scaffold. In 2005, Stevens *et al.* [6] published their article in Science, comparing the impact of scaffolds with different structure on the behavior of cells. They thought the cells adhere on the microscale scaffold in a tiled manner, which is similar to the stretched cells on a flat surface. On the other hand, with a high specific surface area, nanoscale scaffold could absorb more protein; provide more adhesion site for the receptors in cell membrane. The absorbed protein could expose more secret adhesion site by changing the conformation, facilitating the adhesion and proliferation of cells (Fig. 2). Thus scaffolds made of nanofibers can mimic the physical structure of extracellular matrix and promote tissue regeneration.