Uncovered

Lending a helping, healing hand

Tissue engineering with electrospun polymers

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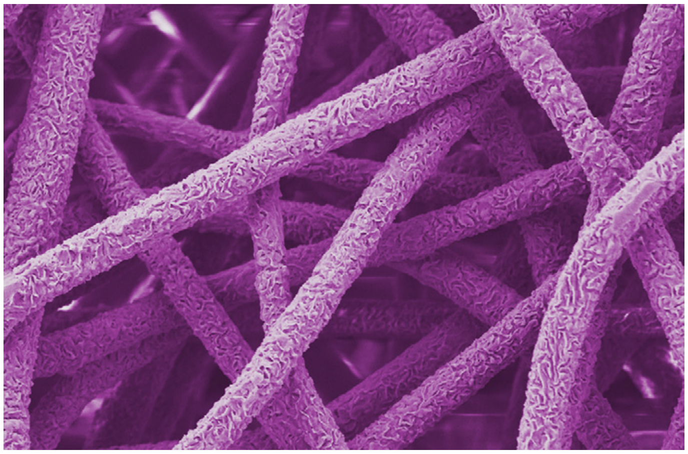

Tissue engineering is a valuable approach with significant potential for the repair or regeneration of damaged or malfunctioning tissues and organs. The pivotal idea is to offer a temporary scaffold to the biological environment in order to promote the formation of novel autologous tissue for an effective healing strategy. Such an approach is expected to contribute to the development of innovative prosthetic substitutes that guarantee a better outcome for the patient by providing metabolic exchange and growth factors, favoring cell proliferation, supporting tissue formation in its three-dimensional structure, and avoiding the typical drawbacks usually elicited by conventional medical devices. With this aim in mind, bioresorbable polymers can be regarded as valuable materials for tissue engineering applications. In addition, dealing with a polymeric scaffold whose microstructure resembles the natural extracellular matrix (ECM) can further improve the therapeutic potential since a proper microarchitecture can guide seeded cells to form tissue-specific ECM, and thus restore the impaired biological function.

The natural ECM is a complex mixture of structural and functional proteins, glycoproteins and proteoglycans arranged in a dynamic and unique tissue-specific microenvironment. These proteins provide mechanical support, binding sites for cell surface receptors, and a cascade of signaling factors that modulate several processes, such as angiogenesis, cell migration and proliferation, inflammation, immune responsiveness and wound healing [1]. Therefore, the reproduction of a similar architecture can be regarded as the first step toward the development of a suitable scaffold and this can be easily achieved by means of electrospinning. Fiber diameter, architecture, microstructural and mechanical properties can be tailored by carefully selecting the operating conditions. Electrospinning is performed by applying a high voltage to a polymeric solution flowing through a capillary in order to generate an electrically charged jet. The induced electrostatic force causes a cone-shaped deformation of the polymeric drop at the tip of the capillary and, for a critical value of the electric field, a jet is forced from the cone to move toward a metallic collector. The polymeric jet experiences instability phenomena that stretches and reduces fiber diameter, before being deposited onto the grounded target [2]. However, the fabrication of a fibrous mat is just a partial solution to the problem since polymers used for this purpose, either synthetic or naturally derived, do not offer all the biomechanical and biochemical signals needed for a significant cell response. Many polymers considered for tissue engineering applications are hydrophobic; a characteristic that can adversely affect cell attachment, spreading and migration within the scaffold – necessary requirements for an effective three-dimensional functional structure. The surface characteristics of a tissue-engineered scaffold have significant influence on initial protein interactions that subsequently mediate cell adhesion, being affected by a number of factors such as wettability, roughness and chemical functionality. To address this issue, surface modification can be

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considered as a valuable technique to improve the performance of scaffolds prepared in the laboratory.

Research at the Department of Industrial Engineering, University of Rome ''Tor Vergata'', Rome, Italy, has been focusing on the development of bio-inspired polymeric scaffolds for soft tissue regeneration. For this aim, the fabrication and characterization of bioresorbable polymeric scaffolds, mimicking the natural ECM, represent a fundamental starting point toward the definition of specific morphological and mechanical properties to be further enhanced by surface modification treatments to promote a favorable biological response.

This month's cover image shows a micrograph of poly(ε-caprolactone) (PCL) fibers modified to reduce the hydrophobic characteristics. The image was captured by using a field emission LEO Supra 35 scanning electron microscope with secondary electrons. PCL fibers were produced by electrospinning (average diameter 3.8 ± 0.4 μm). The collected scaffold was then treated by immersion in NaOH solution at 37 °C for 30 min and, subsequently, rinsed in deionized water and dried in an air flow cabinet. Alkali treatment is an effective method to improve the wetting and adhesion properties of polymer surface. This procedure leads to a rougher surface due to the etching function of NaOH, which provides mechanical interlocking and in turn contributes to the improvement of hydrophilic properties, due to the promotion of carboxylic acid exposure on the polymer surface [3].

Further reading

[1] S.F. Badylak, Semin. Cell Dev. Biol. 13 (2002) 377.

[2] A. Frenot, I.S. Chronakis, Curr. Opin. Colloid Interface Sci. 8 (2003) 64.

[3] G.E. Park, et al. Biomaterials 26 (2005) 3075.

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