«Fabrication and Characterization of Conductive Biomimetic Scaffolds for Neural Tissue Regeneration»

ABSTRACT

In Western countries, according to the World Health Organization, Neurodegenerative Diseases are a major cause of death and considered the pandemic of 21st century, with the risk rising significantly in recent years. The shortcomings of current medical needs abound with such problems and treatment of these diseases remains an unsolved problem, due to the complexity of the brain structure, the limited access of molecules that can cross the Blood Brain Barrier and the extremely difficult process comprising the replacement and regeneration of tissue at damaged nervous system. Nanomedicine comes to bear new approaches towards the prevention of Neurodegenerative Disorders in order to address solutions towards these diseases. Biodegradable nanomaterials with size around 1-100 nm, provide biomedical tools with wide variety of applications, due to their physico-chemical characteristics, the morphology and structure, crucial parameters that enhance the activation of specific characteristics, as well as, advanced polymer materials with novel capabilities that are able to mimic the Extracellular Matrix via biomechanical hydrogels and scaffolds. In this current work, we proceed towards the fabrication of biodegradable polymeric scaffolds via Electrospray Deposition Process, and studying their cytocompatibility behavior, in order to successfully develop a nanostructured composite system that is capable of promoting the growth of nerve cells and differentiate them into sympathetic neurons for Nerve Tissue Regeneration. These polymeric scaffolds matrices presents the unique ability to mimic the Extracellular Matrix of cells, thus providing a microenvironment in vitro that can enhance cell's adhesion, proliferation and differentiation in vivo. These engineered systems, once optimized based on the desired nano fiber-based morphology, were further studied as it concerns their structure and topography. The designation of the fabricated scaffolds was followed, with studies that took place in order to estimate the average fiber diameter, their morphology, topography, as well as the degree of degradation and swelling, and lastly their cytocompatibility behavior and the ability of cellular uptake and growth. At the last part of the thesis, onto the engineered optimized conductive fiber-based scaffolds of PVA: PEDOT: PSS, further took place a proper surface treatment in order to maintain their hydrophilic nature and thus enhance better their biocompatibility. A prototype neural cell line, PC12 derived from pheochromocytoma adrenal medulla of rats, was deposited onto the fabricated non-woven matrices.

Studies in order to control and manipulate nerve cell adhesion and differentiation with the presence of active growth factors to neurons, as morphologically and functionally onto the surface of the polymeric scaffold also took place. Lastly, bio functionalization process of the polymeric scaffolds with peptides and laminins was performed, in order to create an appropriate biofunctionalized microenvironment that promotes directly cell adhesion and differentiation into neurons. It is concluded that the conductive polymeric scaffolds appears an unique biocompatible microenvironment that can mimic the extracellular matrix, promoting cell attachment and proliferation and after a proper surface biofunctional modification, constitutes a valuable tool for nerve cells manipulation, thus a promising property that gives impetus to further Tissue Regeneration applications.