The First International Conference on Advanced Materials for Printed Electronics and Sensors
(ICAMPS2020), 10-11 September 2020
E-Conference, Faculty of Science, Chiang Mai University, Chiang Mai, Thailand

Surface Modification for Improved Biocompatibility of Absorbable Nerve Guides Fabricated by Electrospinning and 3D Printing

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Abstract

The principal aim of this project is to develop an absorbable nerve guide for use as temporary scaffold in peripheral nerve repair. New approaches in surface modification of biodegradable copolyester scaffolds are showing great promise. Specialty medical grade poly(L-lactide-*co*-ε-caprolactone) (PLCL) and poly(L-lactide-*co*-glycolide) (PLGA) copolymers according to ASTM F1925-17 guidelines (Standard Specification for Semi-Crystalline Polylactide Polymer and Copolymer Resins for Surgical Implants) were synthesized and characterized to meet the specific requirements of nerve guide applications. In addition, conductive polymers (CPs) such as polypyrrole (PPy) have been demonstrated as having the ability to provide electrical stimulation for neurons in guided axonal extension. In this research, a combination of 3D printing and electrospinning has been used to fabricate biodegradable, conductive scaffolds by dispersing PPy particles on PLCL and PLGA scaffolds. The fabricated scaffolds were characterized using X-ray photoelectron spectroscopy (XPS) and scanning electron microscopy (SEM), as well as the measurements of surface wettability and conductivity test were performed. It was found that a highly electrospun fiber is clearly embedded within the 3D printed construct which exhibited uniformly oriented channels and pores having micrometer resolution. Furthermore, PLCL and PLGA scaffolds were successfully deposited of the PPy particles on fibers. Scaffolds deposited with PPy particles showed significantly greater hydrophilicities which were a consequence of nitrogenated carbon functional groups in PPy. Cells cultivated of both the PLCL and PLGA scaffolds showed high viability (>95%). Furthermore, attachment and proliferation of Mouse fibroblast cells (L929) on PPy-coated and uncoated of 3D printed scaffolds with electrospun fibers were increased when compared to those without the fibers. The results of this study demonstrate the potential to create scaffold prototypes by combining 3D printing and electrospinning techniques. Moreover, PPy-coated and uncoated of 3D printed scaffolds with electrospun fibers of polymers enhanced both cell viability and growth without incurring any cytotoxic effects.

Keywords: Surface modification; poly(L-lactide-co-ε-caprolactone); poly(L-lactide-co-glycolide); 3D printing; electrospinning; conductive polymers; biocompatibility