Conductive Fabrics for Electrically Stimulated Cell Culture

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Statement of Purpose: Electrical stimulation (ES) has been known to affect numerous cellular activities [1] and is used in clinic to improve bone healing even through the outcome remains questionable. We have previously showed that conductive polymer composite made of electrically conductive polypyrrole (PPy) and biodegradable polylactide (PLLA) is able to mediate ES to modulate cell proliferation, viability and cytokine secretion. We also previously reported electrically conductive fabrics that supported the growth of endothelial cells [2] and neurons [3]. However the electrical conductivity of this type of conductive fabrics deteriorates rapidly in aqueous environment. In this work we present an electrically conductive fabric and an ES protocol with which the conductive fabrics were sufficiently conductive and effectively stimulated the growth of human skin fibroblasts.

Methods: Freshly distilled pyrrole monomers (98%, Laboratoire MAT, Beauport, QC, Canada) was used to synthesize PPy on poly(ethylene terephthalate) (PET) fabric (Testfabrics, West Pittston, PA, USA). The fabric was thoroughly washed firstly in methanol (Laboratoire Mat) and then in isopropanol (Laboratoire Mat). The wash was carried out in triplicate. The PET fabric specimens were kept in pyrrole solution and then transferred to $FeCl_3$ (Laboratoire Mat) water solution for to complete polymerization. The electrical conductivity of the specimens was measured using a standard 4-point method. The surface morphology was investigated using scanning electron microscope (SEM). Surface chemistry was analyzed using X-ray photoelectron spectroscope (XPS). The thermal properties of the fabrics were studied with differential scanning calorimeter (DSC) and thermal gravimetric analysis (TGA). The mechanical properties were tested using Instron mechanical property tester. Finally, a pulsed electrical stimulation protocol was developed and used to test the electrical stability and electrical stimulated culture of human skin fibroblasts.

Results: The PET fabrics were covered with a uniform and very thin layer of PPy (Figure 1). The cross-section of the PET microfibers showed no difference between the PPy-coated and non-coated specimens, meaning that the PPy coating is very thin. XPS spectra revealed the presence of high concentration of nitrogen atoms originated from PPy, and the presence of chloride anions acting as dopants. The oxidation of the nitrogen atoms was confirmed with the high resolution spectra of N_{1s}. DSC results showed no shift of melting point and no change in heat of fusion between the PPy-coated and non-coated PET fabrics. Similar results were also found for the TGA. The stretch and strain curves of the fabrics changed little after PPy coating. All these data come to the conclusion that the PPy coating process did not bring any significant change to the molecular aggregation structures and the mechanical property of the fabrics, which was what we preferred.

The pulsed electrical current generated a continuous but slow deterioration of the conductivity of the fabrics. However, compared to continuous electrical current, this deterioration was confined to a much less extent. In fact, in a period of 24 hours experiment the fabrics lost only about 20% of its original conductivity. In comparison, continuous electrical current would have reduced the conductivity to almost zero. The same electrical parameters were used to stimulate the fibroblasts culture on the conductive fabrics. While fluorescence staining did not show difference in the number of cells, cell viability test using MTT assay recorded significantly enhanced activity of the cells following electrical stimulation. This observation demonstrated that the conductive fabrics have sufficient electrical conductivity for electrically stimulated cell cultures.

Compared with the PLLA/PPy membranes we reported previously, the PPy-coated fabrics have the advantages in mechanical properties, processability and handing properties such as bending, folding and suturing. This work also means that this simple wet chemical process may be used for biodegradable textiles such as non-woven polylactide textiles, which actually is part of our ongoing work.

Conclusions: An electrically conductive fabric was developed through a simple chemistry process. A pulsed electrical stimulation protocol was established to work with the conductive fabrics and proved effective in modulating the viability of human skin fibroblasts.

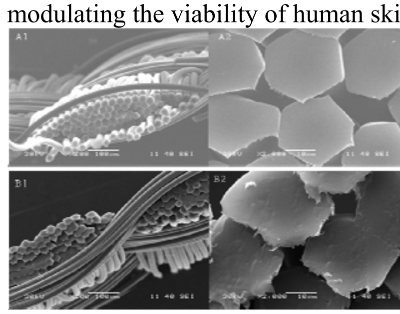

Figure 1. The SEM photos of the PPy-coated PET fabrics (B1&B2) in comparison with the original PET fabrics (A1&A2), showing similar morphology and cross-section.

References: **1.** McCaig. Physiol. Rev 2005; 85: 943–978. **2.** Zhang Z. J Biomed Mater Res, 2001; 57: 63–71.**3.** Zhang Z. Artificial Organs, 2007; 31: 13-22.