Electrically Conductive Nerve Guidance Channel

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Statement of Purpose: Transected nerve can be bridged with nerve graft. Current medical practice uses autografts such as sensory nerves taken from other part of the patient's body, which causes not only additional scar and pain but also the permanent loss of sensory of the donor site. To overcome this limitation, intensive studies have been done to explore the possibility of using man-made materials to repair severed nerve. Among other things, nerve guidance channels made of synthetic or naturally occurred polymers in combination of various biological factors showed promising results. In addition to the biological cues, physical cues such as weak direct electric field have also been reported effective on the growth of nerve cells both in vitro and in vivo [1, 2]. To apply electrical stimulation (ES) to axon, we previously reported polypyrrole (PPy)/polylactide (PLA) composite that was compatible with nerve tissues and supported neuron growth [3]. In this work, we report an electrically conductive nerve guidance channel made of PPy-coated polyester fabric and electrically stimulated release neurotrophic factors from cultured axon.

Methods: Poly(ethylene terephthalate) (PET) fabric was cut into specimens and washed thoroughly. After wash, the specimens were incubated in an acid solution and then washed with distilled water. Then, the specimens were transferred into a pyrrole monomer solution for appropriate period of time, and then transferred into the solution of oxidant to initiate polymerization. The polymerization was carried out at room temperature under normal atmosphere. After being carefully washed in distilled water the PPy-coated fabric specimens were dried in atmosphere and kept for the further experiments. Light and scanning electron microscopes were used to observe the surface morphology of the PPy-coated fabrics. The surface electrical resistivity was measured with a 4-point method. The fabrics were cut into appropriate size and sutured with a 5-0 polypropylene suture into nerve guidance channels measured 10 mm long and 1.5 mm inner diameter. The two ends of the channel were connected to a constant electrical power source (Figure 1). The electrical stability of the constructed guidance channels was tested in cell culture medium. Freshly harvested rat axons were cut into segments and inserted into the channels. The channels were electrically stimulated and culture for various periods time. Neurotrophic factors in culture medium were tested with ELISA.

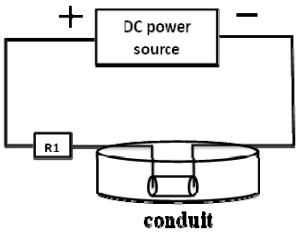

Figure 1. Schematic diagram of nerve guidance channel

Results: The surface of the fabrics was very smooth, showing the uniform coating of PPy on the microfibers without blocking the inter-fibre space, as showed in Figure 2. The resistivity of the conducting fabrics was in the order of 10^3 ohm/square.

Figure 3 shows the change of electrical potential measured at the resistor R1 (Fig. 1) over time, which is proportional to the change of current in the circuit. The potential gradually decreased to ca. 60% of initial value at the end of 6 hours. This was because of the deterioration of the electrical conductivity of conductive polymers in aqueous environment, which is well known. Importantly, ELISA experiment showed that under the constant ES there was a significant increase of ciliary neurotrophic factor (CNTF) in comparison with the non-ES control groups. This testified the sufficient electrical stability of the fabric conductive guidance channel.

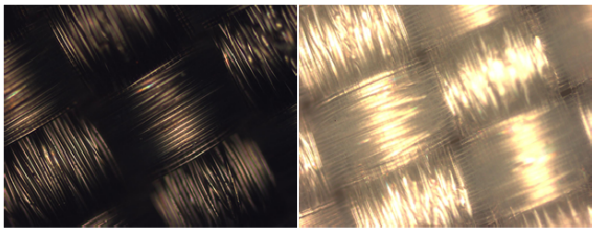

Figure 2. Surface morphology of the PPy-coated and original PET fabrics

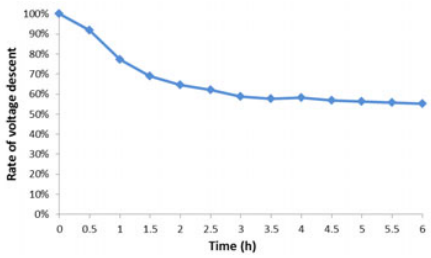

Fig. 3 Electrical stability of the nerve guidance channel over time

Conclusions: A fabric electrically conductive nerve guidance channel was developed for the first time and proved sufficiently stable to mediate ES to nerve tissues. ES using such conductive nerve guidance channels is able to increase neurotrophic factors and therefore has significant potential in nerve regeneration.

References:

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2. McCaig, C.D. BioEssays, 1997, 19: 819-826.
3. Zhang, Z. Artif Organs, 2007; 31:13-22.