Novel PETA-PEDOT:PSS Hydrogel Nanofibers for Electrode-Tissue- Interfaces

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I. Background

IMPLANTABLE bionic devices interact with electrically active living cells such as nerve and muscle cells through translation of biological signals to electrical signals at the electrode-tissue interface. In these devices, long-term functionality of the biotic-abiotic interface is vital. While existing electrodes are fabricated from biocompatible metallic materials; the hard, dry, static nature of these metals does not conform to biological tissue. Therefore, the quality of recording and stimulating signals often deteriorates, due to the process of electrode encapsulation by fibrous tissue formation and cell death in the vicinity of the electrodes.[1] Conducting polymers (CPs) are attractive alternatives to conventional implant materials due to the following characteristics: their (1) organic nature, (2) dynamic behavior (volume, color, and wettability changes), (3) ability to be decorated with biomolecules, and 4) ionic and electronic conductivity.[2] While CPs have mechanical properties more similar to biological tissue than metals have, they are still more rigid than most native tissues, limiting their biomedical applications. Incorporation of soft hydrogels with the CPs may lead to an ideal material for soft electronics, interfacing with biological systems. The goal of this study was to fabricate electrode-free soft conductive nanofibers.

II. Materials And Methods

CPs cannot be fabricated into nanostructures without using a hard templating method. Here, we present a novel fabrication method with fewer steps including the electrospinning of poly(ethylene oxide) (PEO) solutions with 0 to 25 wt% of conducting polymer poly(3,4-ethylenedioxythiophene): polystyrene sulfonate (PEDOT:PSS) nanoparticles. Nanofiber morphologies and diameters were characterized using scanning electron microscopy. Energy-dispersive X-ray spectroscopy was performed on nanofibers to confirm successful incorporation of PEDOT:PSS during electrospinning. We used impedance spectroscopy and cyclic voltammetry to characterize the electrical performance of conductive hydrogel nanofibers. Tensile mechanical tests were conducted on a mechanical tester with a 10N load cell.

III. Results and conclusions

The diameter of conductive hydrogel nanofibers ranged between 220 nm and 435 nm (Fig 1). The inclusion of higher amounts of PEDOT:PSS decreased the impedance of the substrates. The addition of the PEDOT:PSS nanoparticles into hydrogel nanofibers decreased the swelling ratio of the material from 50 for plain PEO nanofibers (0 wt% PEDOT:PSS) to approximately 40 for those containing the nanoparticles (25 wt% PEDOT:PSS). The average Young's modulus reduced from 14 ± 1.6 kPa to 4.3 ± 0.5 kPa as the percentage of PEDOT:PSS increased from 0 to 25 wt%. Future applications may range from electrically controlled drug delivery, neural tissue engineering, and flexible electronics.

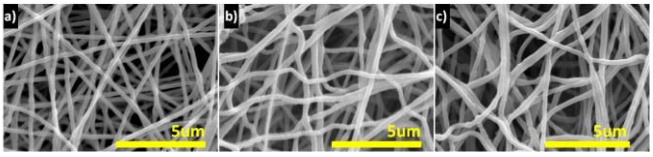

Figure 1. SEM images of electrospun PETA hydrogel nanofibers consisting 0% PEDOT:PSS (a), 10% PEDOT:PSS (b), and 15% PEDOT:PSS (c).

References

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