Poly (ethylene glycol)-poly(3,4- ethylenedioxythiophene):poly (styrenesulfonate) Hydrogel Nanofibers for Sensitive Detection of Glucose

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Statement of Purpose: Quantification of certain neurochemicals could be a useful diagnostic tool for the early detection of neurological disorders. In particular, monitoring changes in extracellular glucose concentration in brain may improve the diagnosis and therapy for diabetes and brain tumors [1]. While studies have shown the feasibility of glucose detection using an enzyme-based amperometric biosensor, development of a glucose biosensor with higher sensitivity and longevity is still a challenge [2, 3]. Recently, we have developed a highly sensitive amperometric glucose biosensor using conducting polymer-hydrogel nanofibers with physically entrapped enzyme glucose oxidase (GOx). Sensitivity and longevity of the biosensor were improved with the incorporation of conducting polymer as an entrapping matrix of GOx. A low potential of +300mV (Ag/AgCl reference) was applied for the detection of glucose to facilitate the direct electron transfer between GOx and conducting polymer PEDOT and increase the bioactivity and stability of GOx.

Methods: The fabrication process includes electrospinning nanofibers from a solution containing 4% (w/v) poly (ethylene oxide) (PEO), 15-20% (w/v) poly (ethylene glycol) diacrylate (PEGDA), 0.5-1% (w/v) photoinitiator, 1-Hydroxy-Cyclohexyl-Phenyl-Ketone (HCPK) and 10-15% (w/v) doped conducting polymer poly (3,4-ethylenedioxythiophene): poly (styrenesulfonate) (PEDOT:PSS) on the surface of platinum electrodes. PEO-PEGDA-PEDOT:PSS nanofibers entrapped 200 U/mL GOx type VII during electrospinning. To prepare hydrogel nanofibers, PEO-PEGDA-PEDOT:PSS nanofibers were crosslinked during UV polymerization in the presence of HCPK. The sensitivity of the PEO-PEGDA-PEDOT:PSS nanofiber glucose biosensor was tested with eDAQ Quadstat. The increase in current in response to the successive injections of known amounts of glucose in a solution of stirred phosphate buffered saline was recorded at working potentials of +300mV and +700mV (Ag/AgCl reference). The sensitivity of the PEO-PEGDA-PEDOT:PSS nanofiber biosensor was compared with the control PEO-PEGDA nanofiber biosensor to demonstrate improved sensitivity achieved by the incorporation of PEDOT:PSS into hydrogel nanofibers.

Results: We characterized the surface morphology of both conductive PEO-PEGDA-PEDOT:PSS hydrogel nanofiber and non-conductive PEO-PEGDA hydrogel nanofiber glucose biosensors using scanning electron microcopy (SEM). SEM images showed (Fig. 1a and 1b) that PEO-PEGDA hydrogel nanofibers with immobilized GOx had diameters ranged from 500 to 900 nm. The amperometric response of the PEO-PEGDA hydrogel film glucose biosensor was measured to successive additions of glucose at an applied potential of + 700 mV (Fig. 1c). The current was linearly dependent on glucose concentration up to 10 mM of glucose. The sensor had a sensitivity of 0.2534 $\mu A \cdot cm^{-2} \cdot mM^{-1}$ and limit of detection of 0.1 mM.

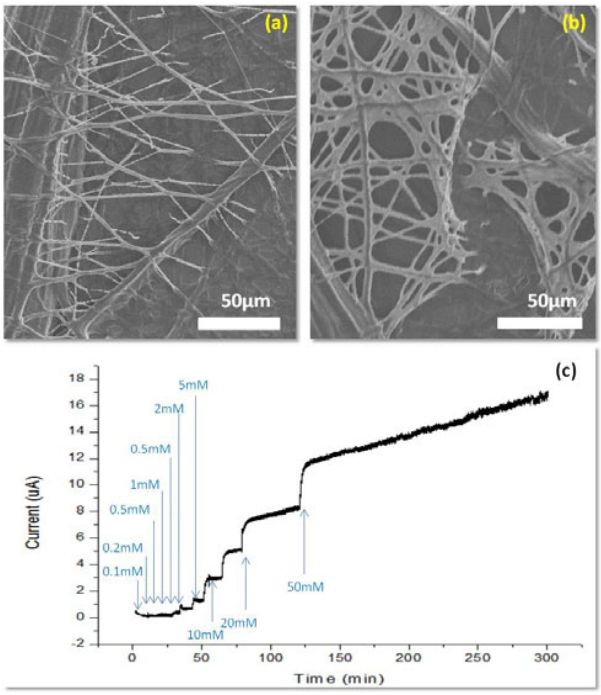

Figure 1. SEM images of a) PEO nanofibers and b) swollen PEO nanofibers, and c) amperometric current response of PEO-PEGDA hydrogel film to successive additions of glucose at + 700 mV.

Conclusions: We have developed a highly sensitive amperometric glucose biosensor with PEO-PEGDA-PEDOT:PSS hybrid hydrogel nanofibers. The use of conducting polymer in the PEO-PEGDA-PEDOT:PSS hydrogel nanofiber biosensor resulted in higher sensitivity compared to PEO-PEGDA hydrogel nanofiber biosensor. The future goal of this work is to improve the longevity and stability of the developed biosensor for continuous in-vivo monitoring of glucose.

References

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