ARTICLE

Enzymatic deposition of PPy onto cPEG-grafted silk fibroin membrane to achieve conductivity

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Silk fibroins (SF) have many attractive properties, however, the practical applications of pure fibroin materials are severely restricted by its low elasticity. To improve flexibility of regenerated SF membranes, carboxyl-terminated polyethylene glycol (cPEG) was introduced into fibroin chains using 1-ethyl-3-(3-dimethylaminopropyl) carbodiimide hydrochloride (EDC) and N-hydroxysuccinimide (NHS). Subsequently, laccase-mediated graft polymerization of polypyrrole (PPy) onto SF-g-cPEG membrane was performed to achieve electrical conductivity. The results implied that cPEG was successfully grafted onto SF chains, the elongation at break of SF-g-cPEG membrane increased by three times compared to that of the untreated. Meanwhile, the introduced cPEG promoted the binding of pyrrole radical cations onto fibroin membrane, resulting in an efficient deposition of PPy conductive layer during the laccase treatment. Conductivity for the membrane of SF-g-cPEG/PPy meets the standard of conductive materials even after 48 cycles of bending testing. In addition, the composite membrane has acceptable in vitro biocompatibility. The present work provides a novel alternative for fabrication of the flexible and conductive SF biomaterials, which would expand the applications of fibroin materials as wearable electronics.

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Supporting Information

Table 1 The possible mass-to-charge (m/z) assignments of different copolymers formed between PHAD and Pyrrole by Laccase incubation.

m/z（Da）		Predicted compound
Detected	Predicted	
152.0,174.1,323.3, 449.2,670.5	152.2,174.2,323.4, 449.6,664.8	M_1+H, M_1+Na,2M_1+Na, 3M_1,4M_1+3Na
67.0,132.1,197.2, 262.1,327.2,392.3	67.1,132.2,197.3, 262.4,327.5,392.6	M_2,2M_2,3M_2,4M_2, 5M_2,6M_2
67.0,151.0,216.1,281.2, 411.3,430.8,560.5, 671.2,690.0,858.6	67.1,151.2,216.3, 281.4,411.6,430.6, 560.8,672,691.0, 859.2	M_2, M_1, M_1+M_2, M_1+2M_2, M_1+4M_2,2M_1+2M_2,2M_1+4M_1, M_1+8M_2,2M_1+6M_2,4M_1+4M_2

Supporting Information

Movie S1：Bending of pure SF membrane

SF.mp4

Movie S2：Bending of SF-g-cPEG membrane

SF-g-cPEG.mp4

Movie S3：Bending of SF-g-cPEG/PPy membrane

SF-g-cPEG PPy.mp4