A study of protein adsorption behavior and protein-resistance strategy of carbon materials for electrochemical sensing application

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With a wide potential window, chemical and electrochemical inertness, low capacitance, biocompatibility and low cost, carbon materials have been extensively used in biosensors and bioelectronics with highly promising applications[1]. However, most of the carbon material based devices reported in the literature have not been tested in real biological samples, thus their practical value remains difficult to ascertain. Nonspecific adsorption of proteins may contaminate the carbon electrode surface and have a severe impact on electrochemical signal response. In this way, numerous electrochemical biosensors are confined to laboratory stage. Therefore, biofouling arising from protein adsorption is a substantial challenge in biosensing systems, and antifouling sensing interfaces capable of resisting the nonspecific adsorption of proteins from biological complex samples are highly desirable[2].

In the study, the protein adsorption behaviors of representative carbon materials including glassy carbon (GC), graphene, boron-doped diamond (BDD) electrodes were investigated with electrochemical methods. Adsorption models of the interface between protein solutions and carbon electrode surfaces have been established. Based on the in-depth exploration of protein adsorption behaviors, a novel composite nanomaterial combining poly 2-methacryloyloxyethyl phosphorylcholine (PMPC) and reduced graphene oxide (rGO) nanosheets was prepared as a protein-resistance strategy. The PMPC/rGO (PMPC grafted rGO) modified carbon electrode can be easily achieved by electrodeposition, which was conductive and at the same time demonstrated satisfying antifouling ability in protein solutions. Figure 1 shows the peak current of different electrodes measured by Cyclic Voltammetry (CV) w/o Bovine Serum Albumin (BSA). The adsorption of protein onto electrode surface severely influenced the charge transfer efficiency, leading to the decrease of peak current in CV. Therefore, the rate of change (ROC) for the peak current indicated the biofouling vulnerability of the electrode materials. Among the carbon electrode materials of GCE, rGO, PMPC/rGO, H-BDD (hydrogen terminated BDD) and O-BDD (oxygen terminated BDD), PMPC/rGO remained highly conductive and demonstrated the best antifouling performances even compared with hydrogen-terminated BDD, indicating great potential of this novel nanomaterial in biosensors and bioelectronics for clinical applications.

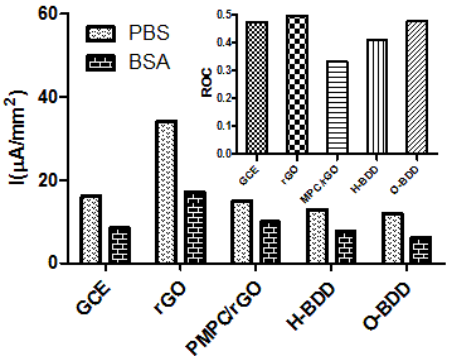

Figure 1. Peak current of different electrodes measured by CV. GC, rGO, PMPC/rGO, H-BDD and O-BDD electrodes were tested in PBS (pH 7.4) solutions containing 5 mM $[Fe(CN)_6]^{3-/4-}$ w/o 4.5mg/ml BSA. Inset showed the ROC of peak current from each electrode, and ROC was defined as $(i_{pbs}-i_{bsa})/i_{pbs}$.

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