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Graphene-glucose oxidase bioanodes for enzymatic biofuel cells

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Enzymatic biofuel cells (EBFCs) are electrochemical devices, that produce electricity from energy stored in fuel molecules under catalysis of enzymes, Fig. 1a. An EBFC contains a bioanode and/or a biocathode, in which enzymes are used to catalyse oxidation of fuel molecules such as sugars, and dioxygen reduction, respectively. The advantage of EBFCs is to generate energy from abundant fuel molecules without using expensive noble metals. On the other hand, development of EBFCs is still at the research stage due to instability of the biocatalysts. Here, we are developing a bioanode using graphene [1] as supporting material, polyethyleneimine (PEI) as linker and glucose oxidase (GOD) as the chosen enzyme, Figure 1b. GOD can catalyze oxidation of glucose to gluconolactone, but needs a mediator to assist electron transfer between the enzyme and electrodes [2]. The redox molecule ferrocene carboxylic acid (FcCOOH) is immobilized together with GOD on the bioanode. Structure and composition of the graphene-GOD bioanode are shown in Fig. 1b. Electrochemical catalytic performance of the prepared bioanode has been observed, Fig. 1c. An EBFCs with the bioanode and the commercial Pt cathode have been successfully assembled and systematically investigated. The assembled EBFCs show good reproducibility. EBFCs provide maximum output power density 2.47 µW cm^{-2} at 35 ℃, indicating the optimized activity of EBFCs fed with glucose.

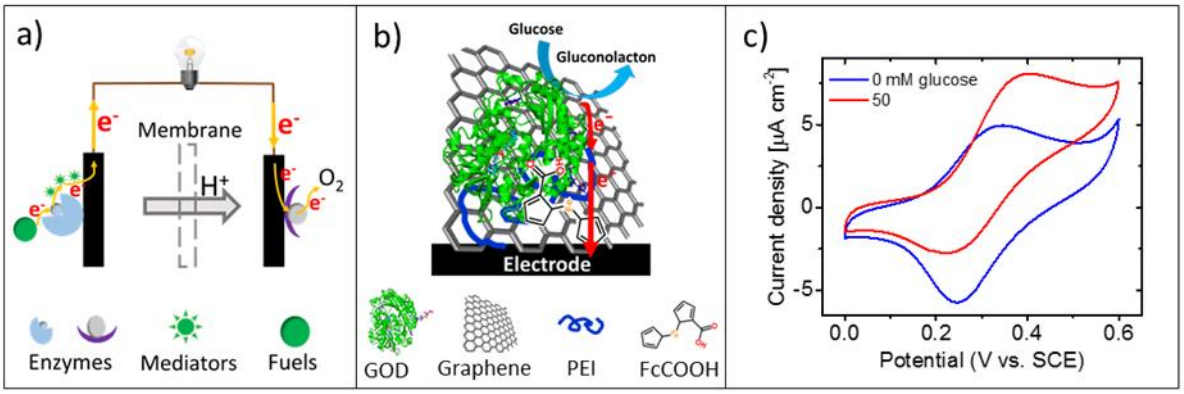

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Fig. 1. Illustration of (a) an enzymatic biofuel cell and (b) the graphene-GOD bioanode. (c) Cyclic voltammetry of the graphene-GOD in the absence (black) and presence (blue) of glucose in 20 mM phosphate buffer, pH 7.0. Scan rate 10 mV/s. The graphene-GOD bioelectrode was prepared by dropcasting 20 µL graphene-PEI-FcCOOH-GOD solution synthesized by mixing 200 µL 18 mg/mL GOD and 800 µL graphene-PEI-FcCOOH ink for 20 hours at 4 °C, and then 10 µL 1.0 wt% Nafion solution on the 4.0 × 5.0 mm^2 carbon paper electrode. The ink was produced by first heating 17 mL Milli-Q, 5.0 mg FcCOOH, 2.0 mL 1.0 mg/mL graphene oxide solution, and 1.0 mL 40 mg/mL PEI solution together for 60 minutes at 95 °C and concentrating to 4.0 mL.

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