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A single-liquid miniature biofuel cell with boosting power density *via* gas diffusion bioelectrode

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Table S1

Table S1. Kinetic parameters of GOx immobilized at different infiltrating interfaces under different conditions.

Modified molecules	MUA	C8	C12	C16
K_m^{app}(mM)	116.85	69.53	65.17	107.32
V_{max}(mM s^{-1})	57.87	103.04	177.64	100.69
k_{cat}(s^{-1})	30.86	54.96	94.74	53.70
k_{cat}/K_m^{app}($M^{-1}s^{-1}$)	264.13	790.45	1454	500.37

Table S2

Table S2. Comparison of potentially membrane-less glucose/O_2 BFCs.

Anode/cathode	Condition	Open circuit voltage [V]	Power output [μW cm^{-2}]	Reference
GOx-Lac	0.10 M PH 6.0 PBS with 10 mM glucose	0.58	15.8	28
GOx-Lac	0.10 M pH 5.5 PBS with 100 mM glucose	0.55	24.0	29
GOx-Lac	0.10 M pH 5.0 PBS with 10 mM glucose	0.41	27.0	30
GOx-Lac	0.10 M pH 7.0 PBS with 27.8 mM glucose	0.60	6.00	31
GOx-Lac	0.10 M pH 5.0 PBS with 28 mM glucose	0.53	8.15	32
CDH-BOD	0.10 M pH 7.4 PBS with 5 mM glucose	0.62	3.00	33
CDH-BOD	0.05 M pH 7.4 PBS with 5 mM glucose	0.63	0.60	34
GDH-BOD	0.10 M pH 7.4 PBS with 200 mM glucose	0.50	32.0	35
GDH-BOD	0.05 M pH 6.5 MES with 20 mM glucose	0.60	23.0	36
GDH-BOD	0.10 M pH 7.0 PB with 50 mM glucose	0.66	45.0	37
ALDH-Lac	0.05 M pH 5.0 SBS with 698 mM glucose	0.61	3.50	38
GOx-Lac	0.10 M pH 7.4 PB with 5 mM glucose	0.60	53.00	this work

Figure S1. Laccase activity assay. In a total reaction volume of 3 mL, 2 mL of 0.1 mM pH 5.0 acetate buffer containing 0.5 mM ABTS was added, and the enzyme solution was added to initiate the reaction, and the change in absorbance was measured at 420 nm. The unit of activity of the enzyme was defined as the increase in absorbance (ΔOD420 / (mL min^{-1})) caused by the oxidation substrate per minute (ABTS) of 1 mL of enzyme solution under the above conditions (25 °C, pH 5.0).

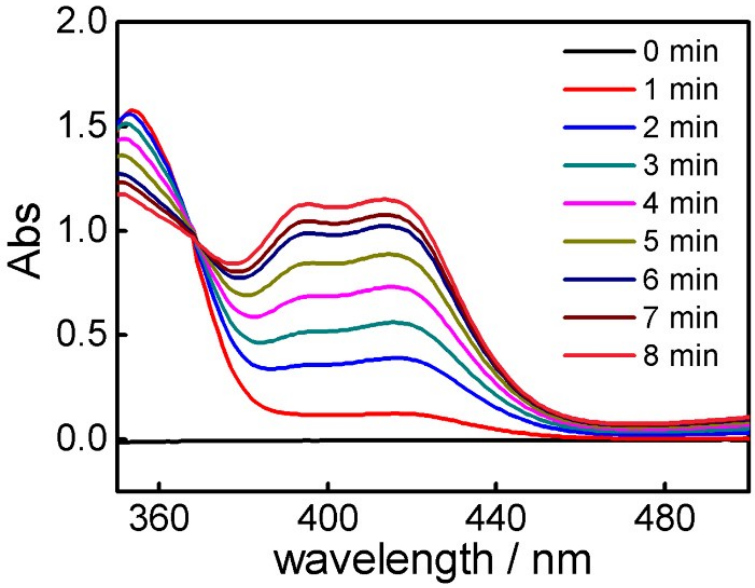

Figure S2. Photograph of glucose/O_2 button biofuel cell. (a) gas diffusion anode (b) gas diffusion cathode. Firstly, PDMS sol was formulated by mixing solution A and B (10:1) of PDMS coagulant, which was put in an air oven at 80 ℃ to form PDMS films (diameter: 2 cm; thickness: 4 mm for one-piece and 1 mm for other 4 pieces). Then, a hole with diameter of 1 cm was formed in the middle of all five PDMS films by using a puncher. After that, the two pieces of 1 mm PDMS films were bonded to both side of 4 mm PDMS by a plasma cleaner, respectively. Next, the other two pieces of 1 mm PDMS was semi-bonded to above PDMS for gas diffusion anode/cathode inserting. Finally, two needles were planted to 4 mm PDMS film for electrolyte ang glucose injection. The gas diffused anodic and cathodic electrodes were fixed in both sides of the cell. To prevent the electrolyte leaking from two sides, Vaseline White was employed to reduce the fit gap between the electrode and the PDMS.

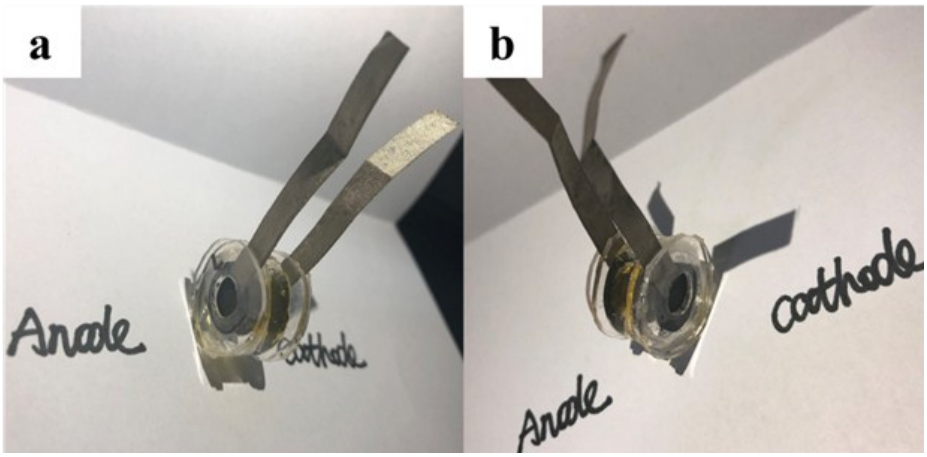

Figure S3. The commercial carbon paper was immersing in PTFE solution with different concentration (0 wt.%, 5 wt.%, 10 wt.%, 15 wt.%, 20 wt.%, 25 wt.% and 30 wt.%) with the water contact angle (CA) (a) 95.1°±1.4°, (b) 99.8°±1.7°, (c) 109.6°±2.1°, (d) 119.5°±2.3°, (e)126.7°±3.1°, (f) 133.1°±1.5°, (g) 139.7°±2.3°, respectively.

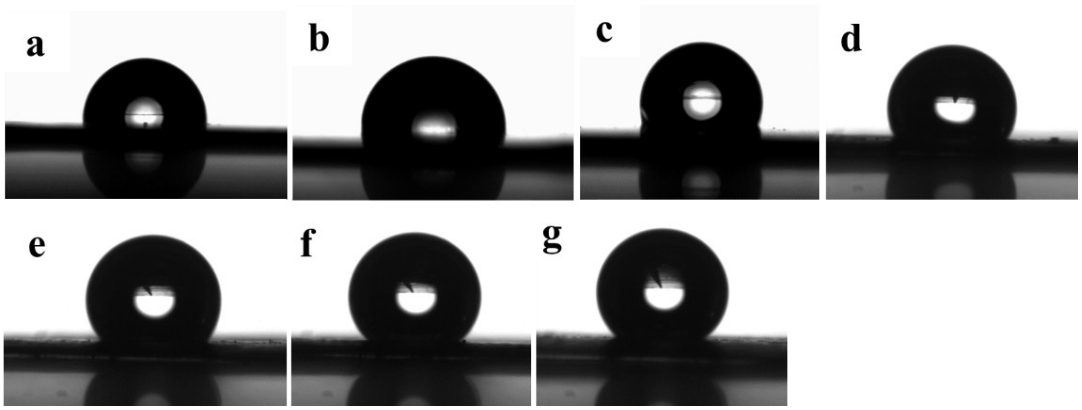

Figure S4. SEM images of commercial carbon paper with different concentrations of PTFE (a) 0 wt. %, (b) 5 wt. %, (c) 10 wt. %. (d) 15 wt. %, (e) 20 wt. %, (f) 25 wt. %, (g) 30 wt. %. Scale bar: 20 μm.

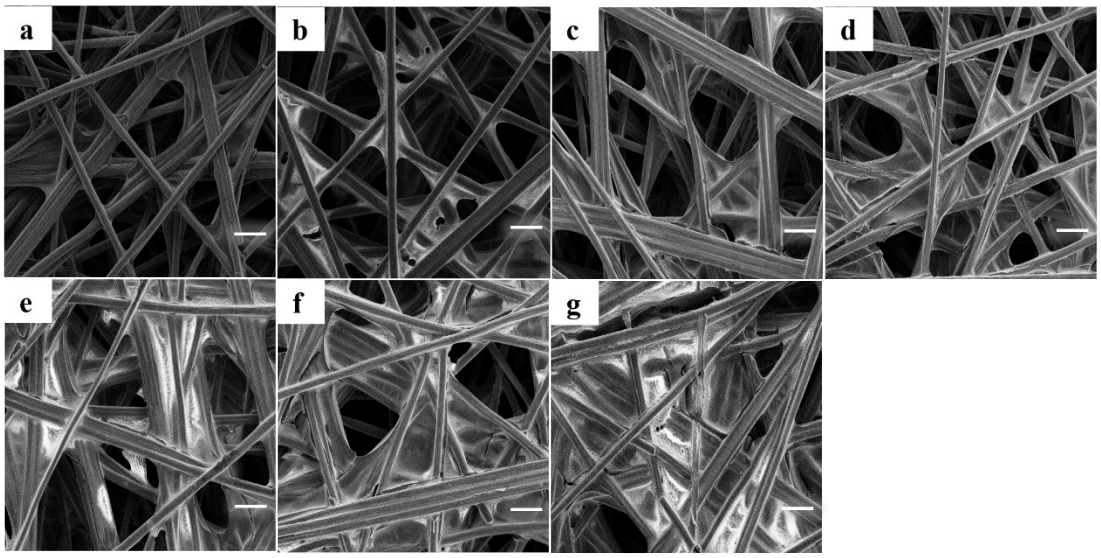

Figure S5. SEM images of gold nanoparticles on carbon paper surface under different scan cycles; (a) 8 cycles, (b) 11 cycles, (c) 14 cycles, (d) 17 cycles, (e) 20 cycles, (f) 23 cycles. scale bar: 50 nm.

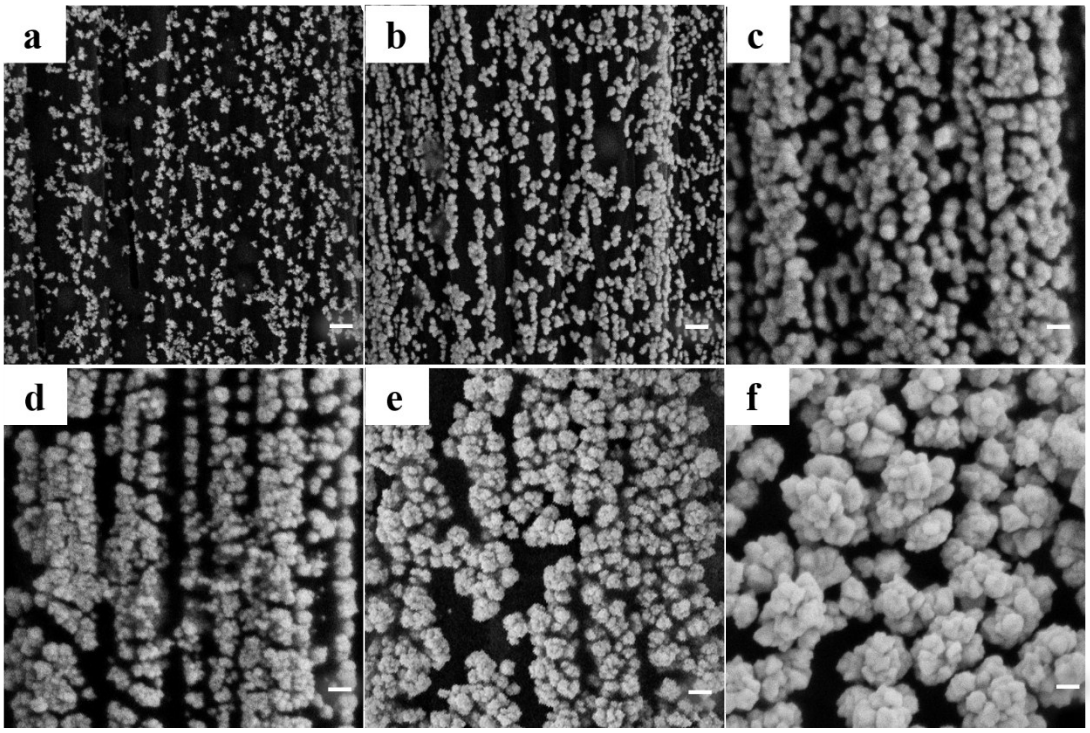

Figure S6. Linear sweep voltammogram (LSV) for GOx/AuNPs/PTFE/CP with modifying different dimension of AuNPs (a)8 circles, (b)11 circles, (c)14 circles, (d)17 circles, (e) 20 circles, (f) 23 circles in 0.1 M, pH 7.4 PB in the presence of various glucose concentrations: 0 to 50 mM (scan rate: 100 mV s^{-1}). (g) the current response of GOx/AuNPs/PTFE/CP taken from LSV of (a-f) at 0.6 V with 50 mM β-D-glucose.

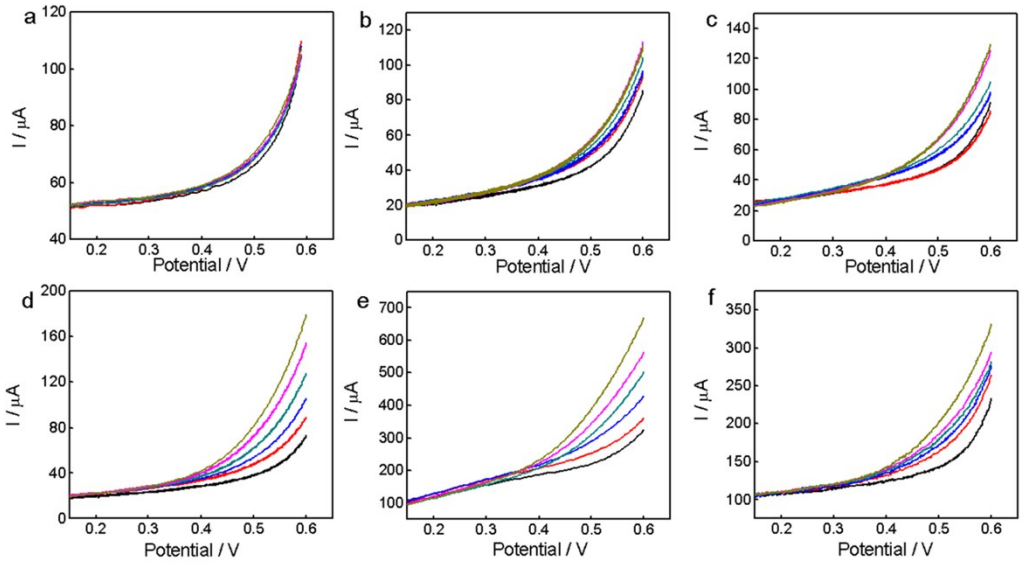

Figure S7. Cyclic Voltammetry (CV) for (a) MUA/AuNPs/PTFE/CP, (b) C16/AuNPs/PTFE/CP, (c) C8/AuNPs/PTFE/CP, (d) C12/AuNPs/PTFE/CP in 0.1 M, pH 7.4 PB in the presence of various β-D-glucose concentrations: 0 to 50 mM (scan rate: 100 mV s^{-1}).

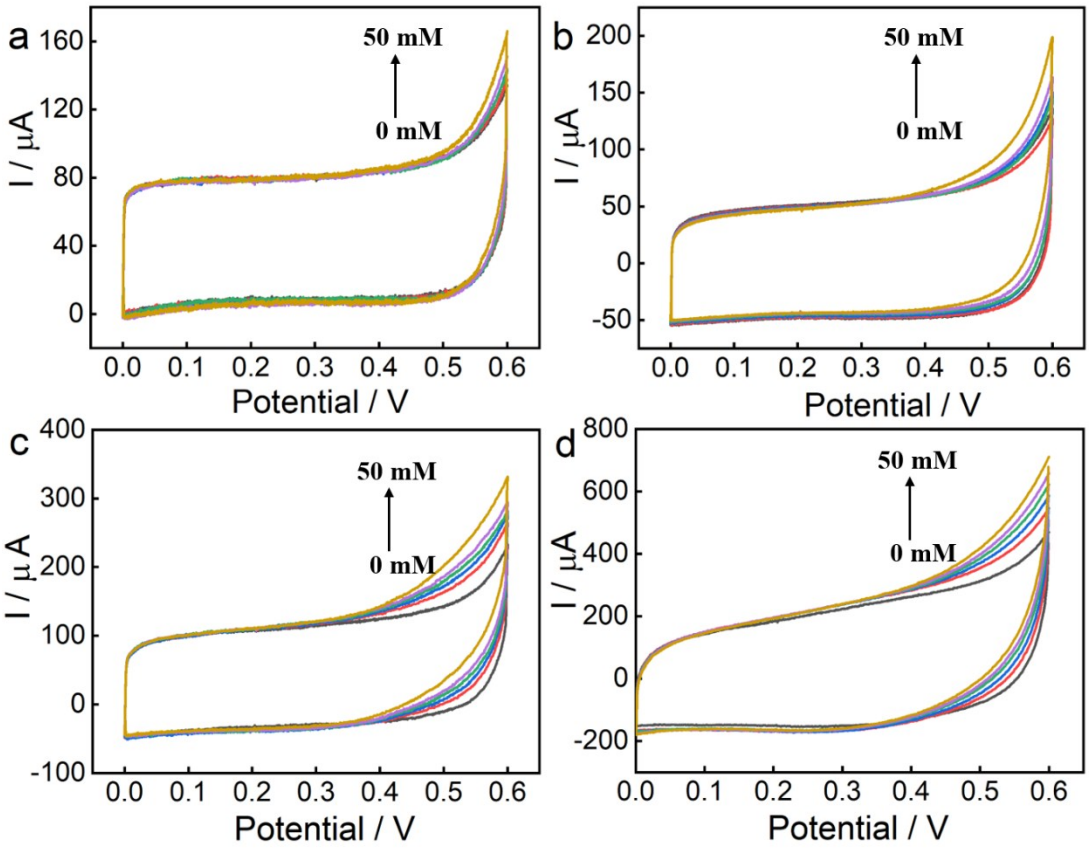

Figure S8. Current-time plot of anode (GOx/C12/AuNPs/PTFE/CP) with successive addition of β-D-glucose (0 ,5, 10, 20, 30, 40 and 50 mM) in 0.1 M, pH 7.4 PB at an applied potential of 0.5 V (*vs*. SCE).

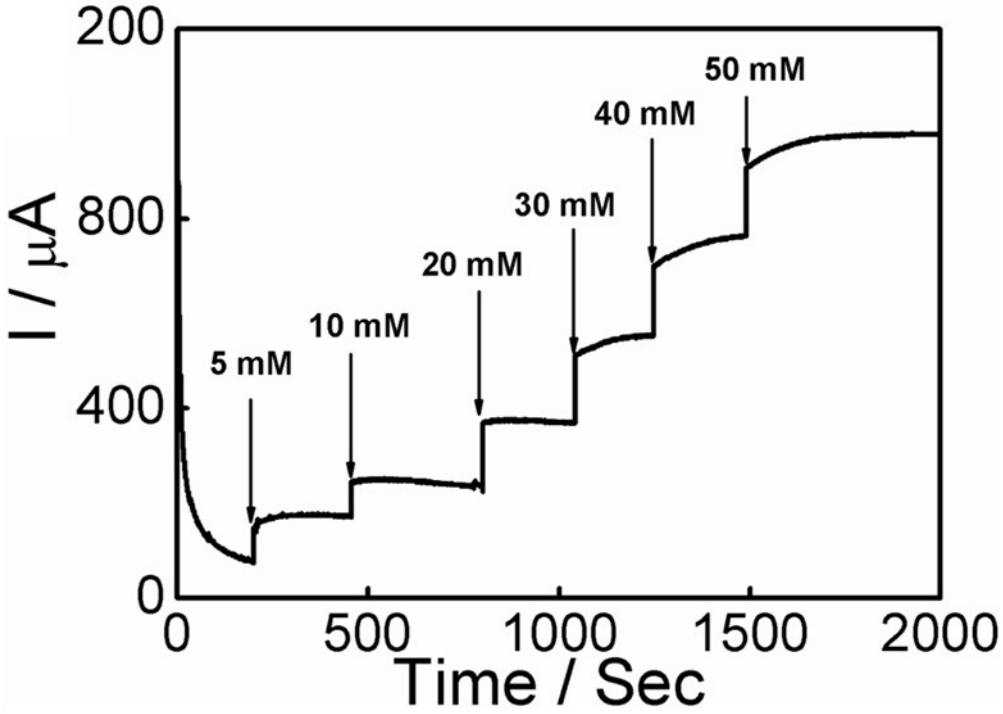

Figure S9. Schematic illustration for the construction process of a channel with gas-diffusion anode.

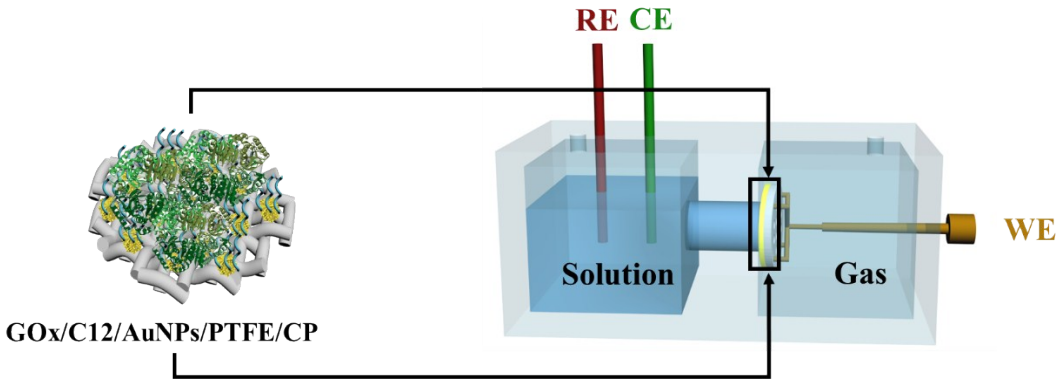

Figure S10. Cyclic Voltammetry (CV) for GOx/AuNPs/PTFE/CP in (a) N_2-equilibrated and O_2-equilibrated solution in the presence of 10 mM β-D-glucose concentration and (b) in 0.1 M, pH 7.4 PB in the presence of various glucose concentrations: 0 to 1 mM (scan rate: 100 mV s^{-1}).

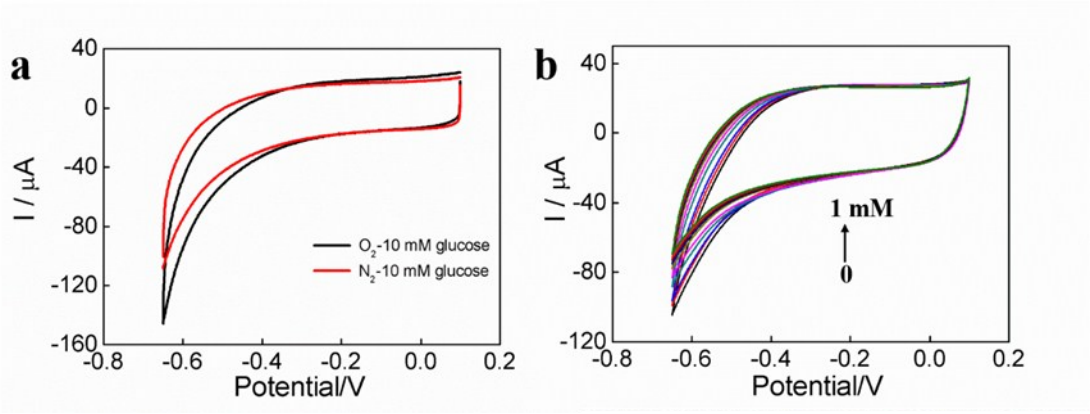

Figure S11. (a) The change of the polarization curves in the presence of 0.1 M, pH 7.4 PB or 5 mM glucose in N_2, air or O_2 saturated atmosphere. (b) Power density curves as the glucose concentration variation and (c) The change of the polarization curves. In presence of glucose (10 to 50 mM) in air atmosphere. Scan rate, 100 mV s^{-1}.

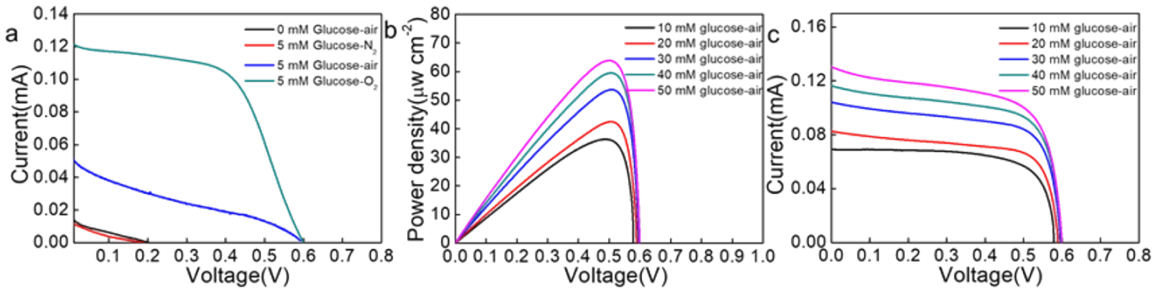

Figure S12. Electrochemical stability test of glucose/O_2 button biofuel cell with adding 5 mM β-D-glucose at 0.43 V.