Electronic supplementary information

Anode modifications with capacitive materials for a microbial fuel cell: an increase in transient or stationary power

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Preparation of high-capacitance anode materials

The starting anode substrate was a piece of graphite felt (3.0 cm × 2.0 cm × 0.5 cm) that was cleaned in a hot H_2O_2 (10%, 90 °C) solution for 2 h, followed by thorough rinse with deionized water and dry at 60 °C. A Ti wire (0.8 mm in diameter) was inserted inside the graphite felt to allow the external circuit connection. GO was synthesized from graphite powder by a modified Hummers method. The as-prepared GO was then added in deionized water with a concentration of 5 mg mL^{-1}. The solution was subjected to vigorous magnetic stirring at room temperature for 10 min and ultrasonication under the ambient condition for 5 min to obtain a homogeneous dispersion of GO. Pyrrole monomer (0.2 M) was then added to the solution.

Electropolymerization of pyrrole was performed in the solution which did not contain any other supporting electrolyte but only GO serving as a weak electrolyte. A CHI 660C potentiostat (Shanghai CH Instrument Company, China) was used for controlling the current applied on the working electrode. The room-temperature electrodeposition was performed in a three-electrode electrochemical cell including a working electrode (graphite felt), a reference electrode (saturated calomel electrode, SCE) and a counter electrode (Pt mesh). To deposit PPy doped-GO films on the graphite felt, a constant potential of 0.8 V was applied for the anodic electropolymerization in the solution that contained 0.2 M pyrrole monomer and 5 mg mL^{-1} GO.

Measurement of anode capacitance

Changes in the anode capacitance as a function of the controlled charges applied for electrodeposition were investigated by galvanostatic tests. Fig. S2 presents the galvanostatic charge-discharge curves of these electrodes at a current load of 0.5 mA cm^{-2} within the potential window from -0.6 to 0.3 V in 0.1 M Na_2SO_4 solution. All the curves featured a mirror-like profile during one charge-discharge cycle, indicating that all the anode materials exhibit good charge-discharge reversibility as capacitive materials. The specific capacitance (C) can be calculated from the curve according to:

$$C = \frac{I_{charge-discharge} \times t}{U_{charge-discharge} \times A} \qquad (1^*)$$

where $I_{charge-discharge}$ is the charge-discharge current; t is the discharge time; $U_{charge-discharge}$ is the potential window; and A is the projected anode surface area.

Procedures for calibration of C and i_C values

The flowchart in Fig. S4 illustrates the algorithm for calibrating C and i_C using the iterative method. The process starts with Sep 1, where the variable of charge-discharge current (i_0) for galvanostatic tests is initialized as i_t. In Step 2, the value of C is calculated from Eq. 1* in ESI† shown in the flowchart with known parameters and t obtained by the galvanostatic tests. In Step 3, i_C is calculated according to Eq. 6, followed by computing w_n, which is Step 4. Subsequently, if the iterative time n ($n \in N^+$) equals to 1, the process enters into Step 5 and i_c is accepted as a new i_0 in the next loop process. If the iterative time n fulfils the condition of $n \geq 2$, the process reaches Step 6. The iteration begins when the difference between two successive results of w_n is greater than 1%; otherwise, the iteration stops and the process goes into Step 7 with the calibrated C and i_C values achieved.

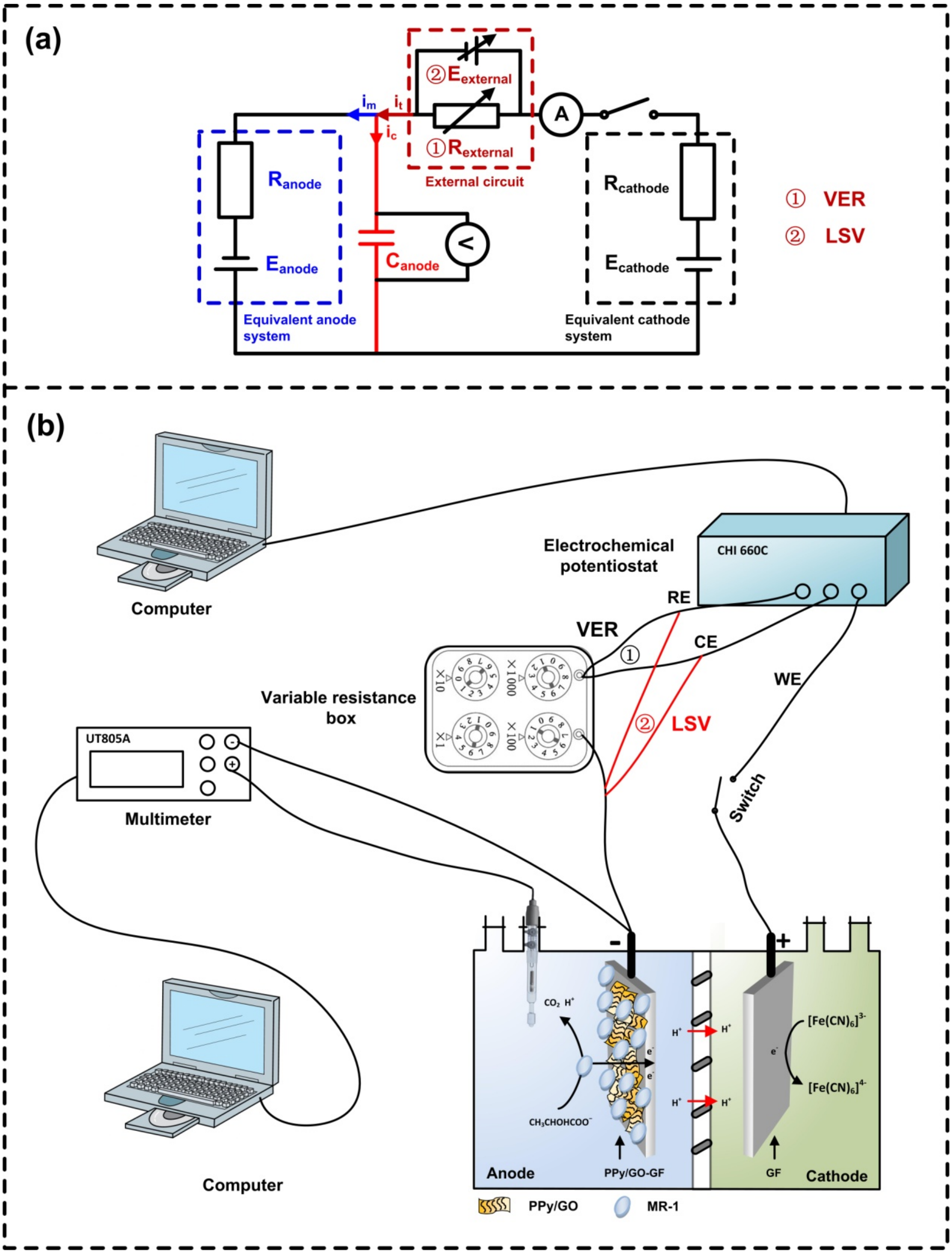

Fig. S1 Circuit diagrams of VCR and LSV methods for measuring power density and polarization curves

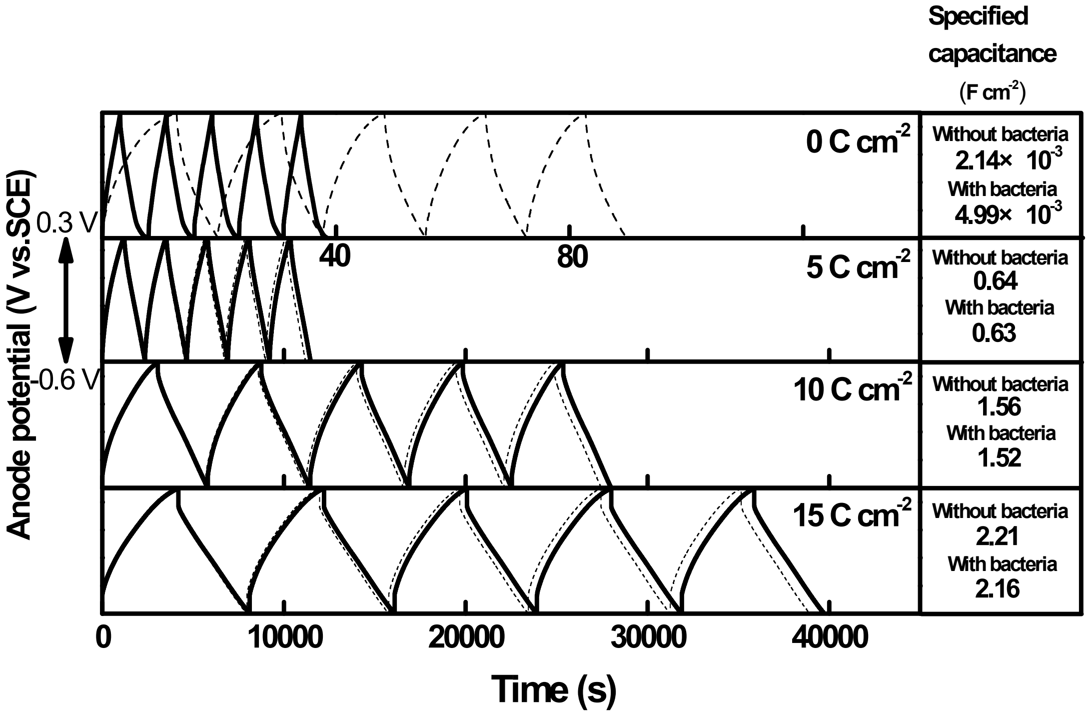

Fig. S2 Variations in galvanostatic charge-discharge curves as a result of different charge applied for the growth of PPy/GO composites on the felt electrodes. It should be noted that the capacitances of both the fresh (dash line) and the inoculated (solid line) anode materials were recorded.

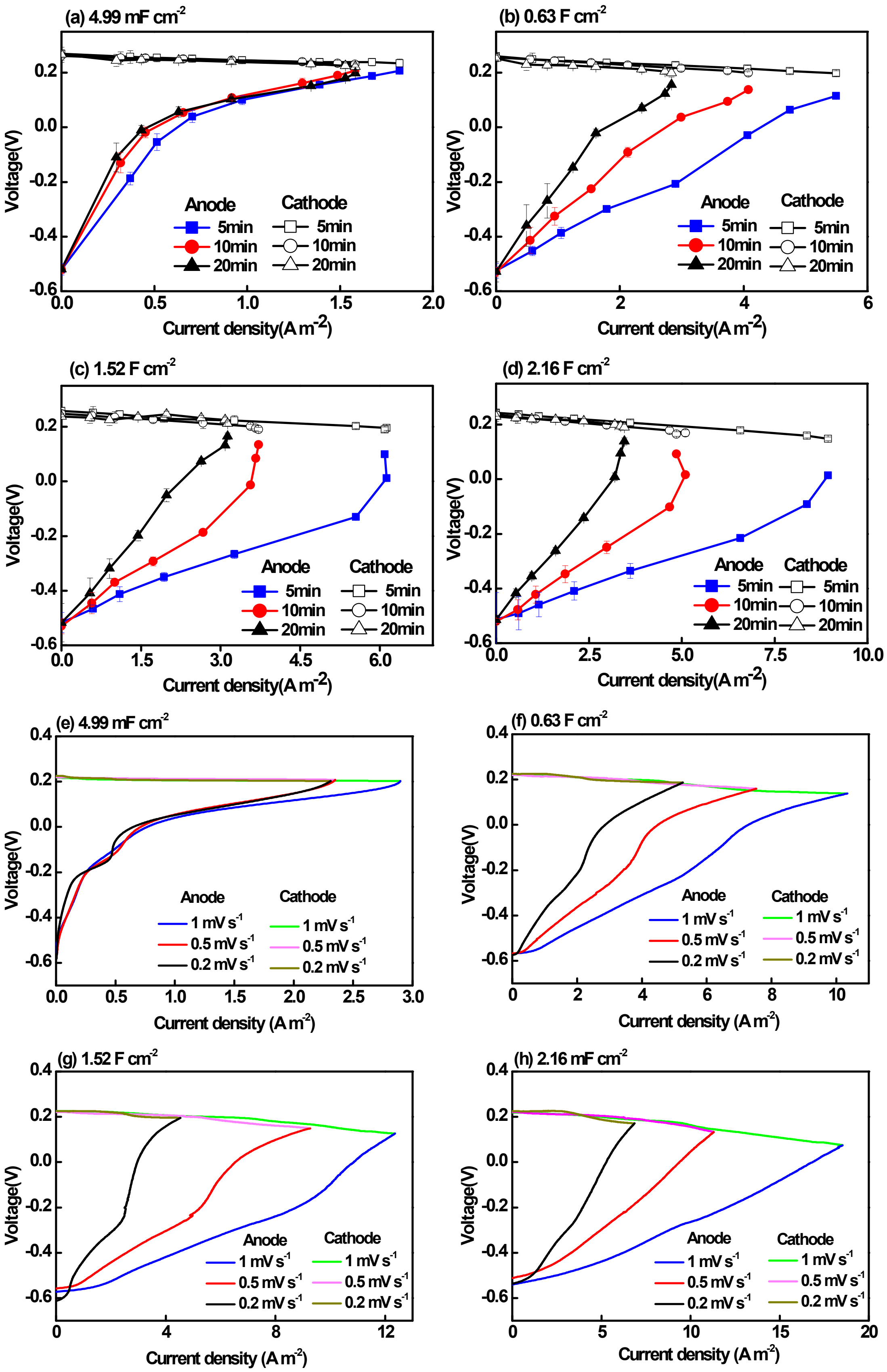

Fig. S3 Anode and cathode polarization curves of MFCs with different PPy/GO-modifed graphite felt anodes obtained from VCR (a~d) and LSV (e~h) methods.

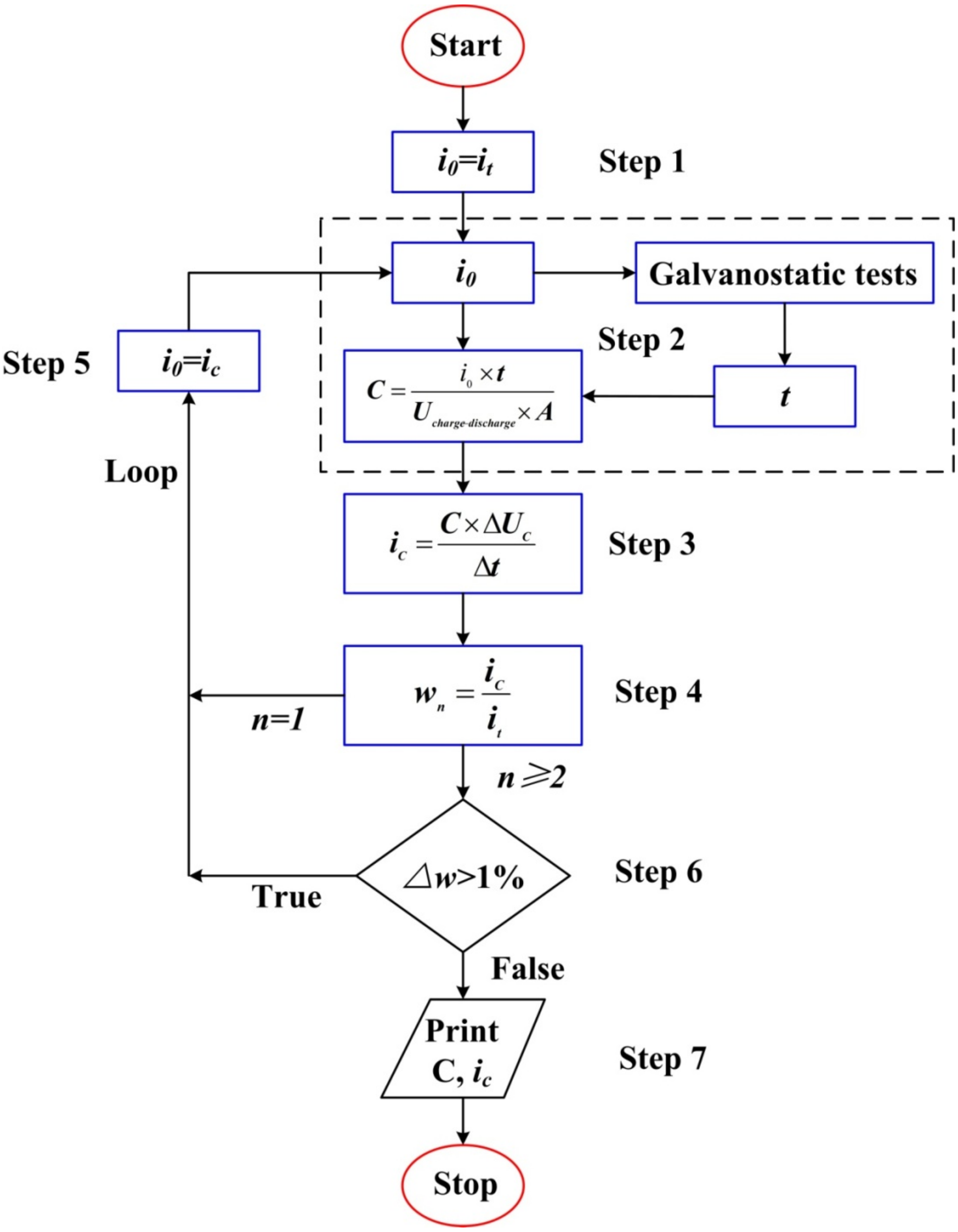

Fig. S4 The flowchart for calibrating C and i_C values by the iterative method.

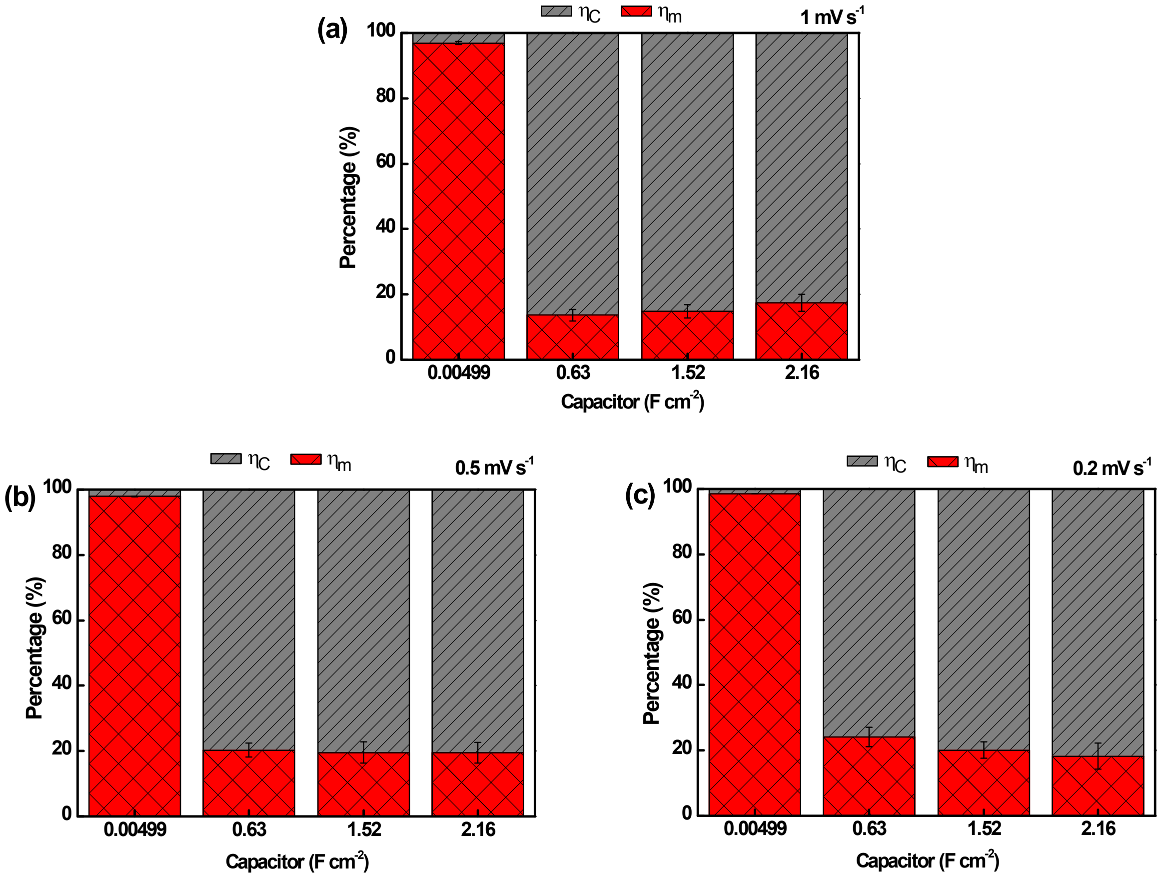

Fig. S5 Variations in the percentage of each part accounted for the measured maximum power density obtained by LSV. η_m and η_C represent the microbial contribution and capacitor contribution, respectively.

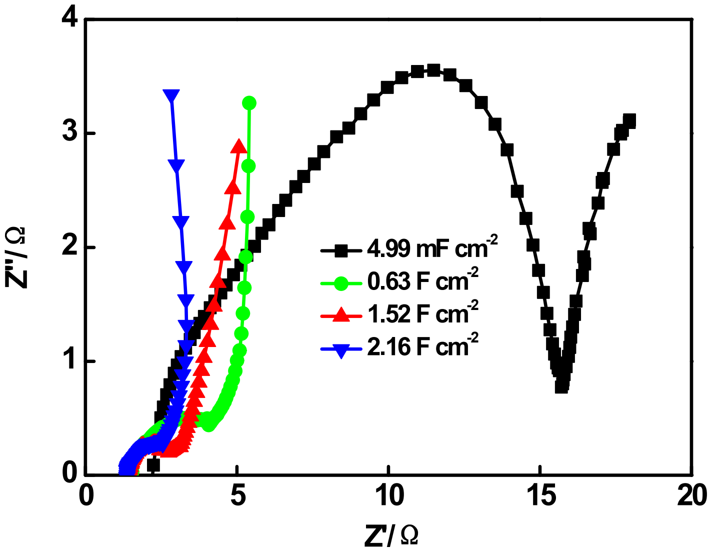

Fig. S6 Nyquist plots of inoculated anodes with different modifications.