Biomass-derived Binderless Fibrous Carbon Electrodes for Ultrafast Energy Storage

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Electronic Supplementary information

Details on electrochemical characterization

The electrochemical behavior of the binderless electrodes have been analyzed using cyclic voltammetry (CV) at scan rates between 10 and 8000 mV s^{-1}, with capacitance being measured from the area enclosed by the CV. They have been plotted in terms of diferential gravimetric capacitance by dividing the measured intensity between the scan rate and the weight of single electrode (three-electrode cell) or the sum of both electrodes (two-electrode cell). Gravimetric capacitances have been determined from the charge enclosed by the CV curves and dividing the resulting value by the potential window and the weight of single (3E-cell) or both electrodes (2E-cell).

Galvanostatic charge-discharge experiments (GCD) at different specific currents have been utilized for the determination of the capacitance and the rate performance of the materials in the role of positive and negative electrodes. The gravimetric capacitance (C_g, F g^{-1}) of the electrodes have been determined from the discharge process using the following expression:

$$C_g = \frac{I \cdot t}{w \cdot (\Delta V - IR_{drop})}$$

Where I stands for the current (A), w is the weight of the electrode (g), t is the discharge time (s) and ΔV (V) is the potential window the electrode has been submitted to after discounting the ohmic drop (IR$_{drop}$). Similarly, the capacitance of the supercapacitor cells have been measured using the same equation, but considering the weight of the two electrodes as w. The specific energy (Eg, Wh kg^{-1}) is obtained from the integration of the discharge curve:

$$E_g = \left(\int_0^{Q_{dis}} V(t) \cdot dQ \right)/w = \left(\int_0^{t_{dis}} V(t) \cdot d(I \cdot t) \right)/w = I \cdot \left(\int_0^{t_{dis}} V(t) \cdot d(t) \right)/w$$

In this equation, w is the weight of both electrodes (kg), and the time, t, is in expressed in hours. The specific power (P$_g$, kW kg^{-1}) reported in the Ragone plots has been determined by dividing the specific energy by the discharge time expressed in hours. The cell resistance has been determined at different specific currents from the ohmic drop registered at the beginning of the discharge of the cell and the corresponding current intensity value. Coulombic and Energy efficiencies (C$_{eff}$ and E$_{eff}$, respectively) of the GCD measurements are defined as the ratio between the discharge time and charge time in the former case, and the charge energy and discharge energy for the latter one. The electrical resistances present in the 2-electrode cells have been analyzed using the Nyquist plots obtained from Electrochemical

Impedance Spectroscopy (EIS) technique at 50 mV. For these measurements, the frequency ranged from 100 kHz to 10 mHz, with and amplitude of the sine wave of 10 mV.

In order to assess the durability of the carbon films as supercapacitors, two-electrode cells have been built using a Teflon Swagelock fitting equipped with stainless steel collectors and submitted to 4 of 25000 cycles at 1.3V and 5 Ag^{-1} that were conducted with relaxing time of 3-9 hours between them. The cyclibility test was then followed by a floating test at 1.3V for 24 hours. The durability of the cell, defined as the retained capacitance, power and energy, was evaluated during the cyclability test and after the floating test.
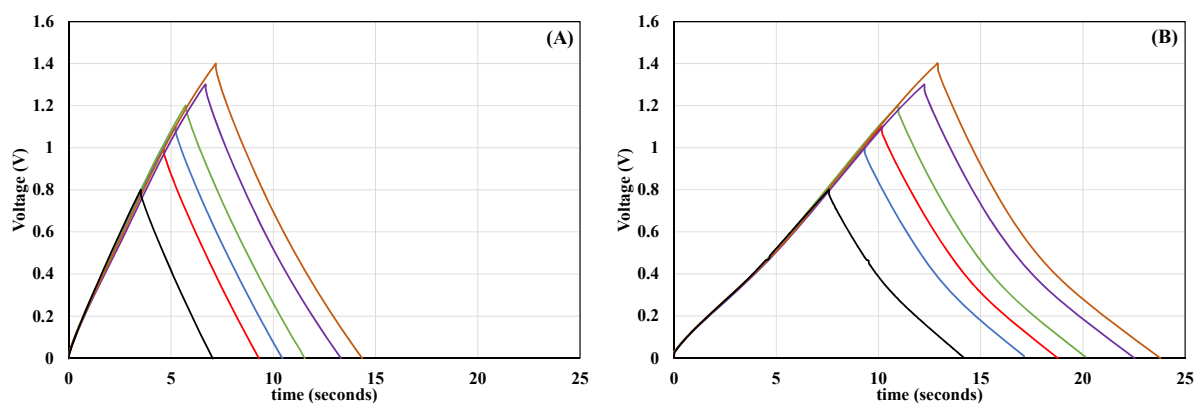

Figure S1. Comparison between GCD profiles for the LCF-I (A) and LCF-IA (B) electrodes at 5 Ag^{-1}, upon increasing the cut-off voltage from 0.8 to 1.4V
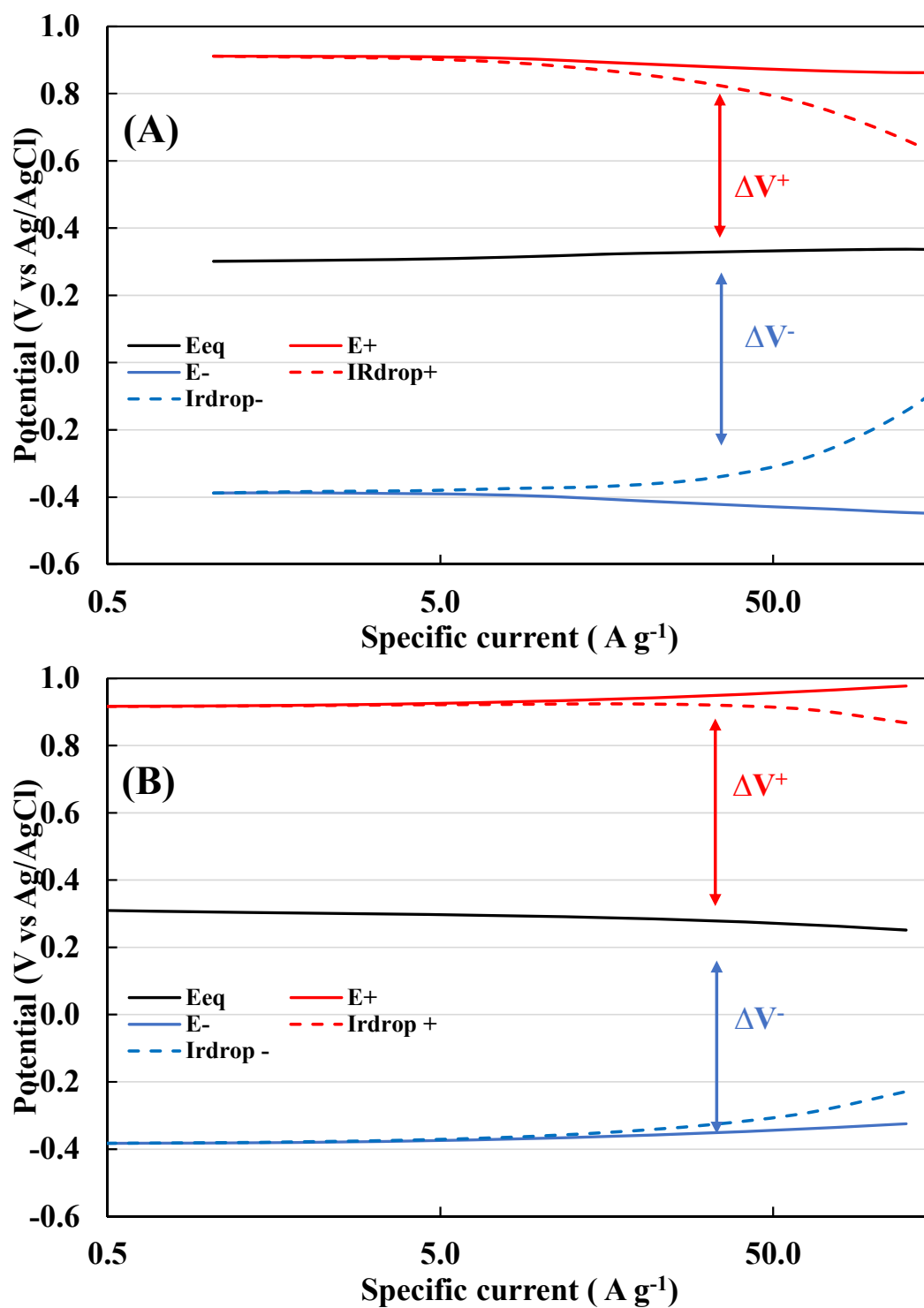
Figure S2. Equilibrium potential of the electrodes, potential limits and the respective IRdrop values reached by each electrode during GCD experiments for (A) LCF-IA and (b) LCF-I cells working at 1.3V under different specific currents.
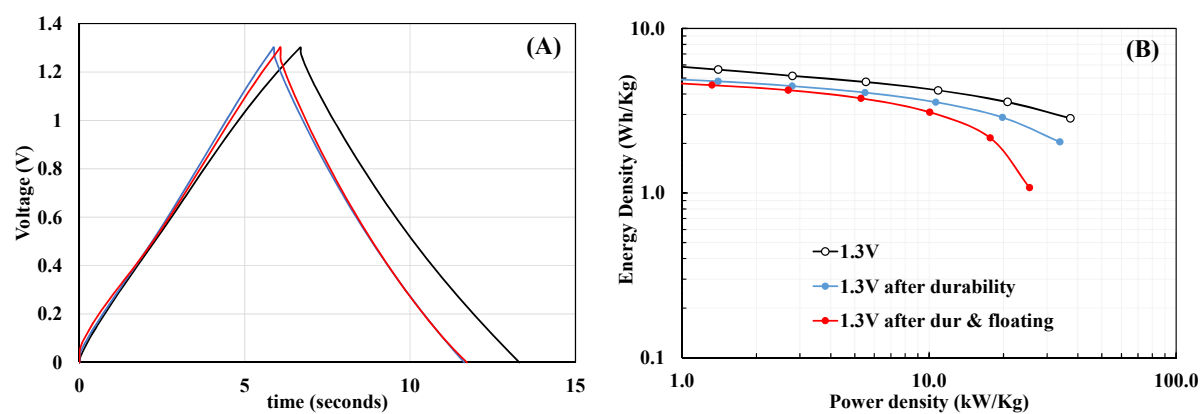
Figure S3. (A) GCD profiles and (B) Ragone plots of LCF-I before (black line) and after the cycling (blue line) and floating (red line) tests.