Flexible Wire-like All-Carbon Supercapacitors Based on Porous Core-shell Carbon Fibers

Weijia Zhou\textsuperscript{a*}, Kai Zhou\textsuperscript{a}, Xiaojun Liu\textsuperscript{a}, Renzong Hu\textsuperscript{b}, Hong Liu\textsuperscript{c}, and Shaowei Chen\textsuperscript{a,d,*}

\textsuperscript{a} New Energy Research Center, School of Environment and Energy, South China University of Technology, University Town, Guangzhou 510006, China
\textsuperscript{b} New Energy Research Center, School of Materials Science and Engineering, South China University of Technology, University Town, Guangzhou 510006, China
\textsuperscript{c} State Key Laboratory of Crystal Materials, Center of Bio & Micro/Nano Functional Materials, Shandong University, 27 South Shanda Road, Jinan 250100, China
\textsuperscript{d} Department of Chemistry and Biochemistry, University of California, 1156 High Street, Santa Cruz, California 95064, United States

* Corresponding authors. E-mail: eszhouwj@scut.edu.cn (W. J. Zhou), shaowei@ucsc.edu (S. W. Chen)

Calculations
Specific capacitance $C_m$ (F/g) was calculated from the CV and charge-discharge curves by the equations (1) and (2), respectively, where $I_1$ (A) is the response current, $\Delta V$ (V) is the voltage window, $\nu$ (V/s) is the scan rate, $I_2$ (A) is the constant discharge current, $\Delta t$ (s) is the discharging time and $m$ (g) is the weight used for the capacitance calculations. For three-electrode cell, $m$ is the weight of electrode, which is about 0.06 g. For the two-electrode cell, it is the weight of the entire device, which is about 0.2 g.

$$C_m = \frac{\int I_1 \, dV}{\nu m \Delta V} \quad (1)$$

$$C_m = \frac{I_2 \Delta t}{m \Delta V} \quad (2)$$

Length capacitance $C_L$ (F/cm) was calculated from CV and charge-discharge curves by the equations (3) and (4), respectively. Compared with Specific capacitance $C_m$ (F/g), $m$ (g) was replaced into $L$ (cm).

$$C_L = \frac{\int I_1 \, dV}{\nu L \Delta V} \quad (3)$$

$$C_L = \frac{I_2 \Delta t}{L \Delta V} \quad (4)$$

Energy density ($E$) and Power density ($P$) were calculated by equations (5) and (6), respectively.

$$E = \frac{1}{2} C_m (\Delta V)^2 \quad (5)$$

$$P = E / \Delta t \quad (6)$$
Figure S1. Size distribution of carbon nanoparticles from carbon shell.

Figure S2. (a) specific surface area and (b) pore size distribution of the porous core-shell carbon fibers.

Figure S3. FT-IR spectra of the original carbon fibers and porous core-shell carbon fibers.
Figure S4. Calculated specific capacitance as a function of (a) scan rate and (b) current density for porous core-shell carbon fibers electrode.

Figure S5. Calculated specific capacitance as a function of (a) scan rate and (b) current density for the wire-like all-carbon supercapacitor.

Figure S6. Impedance comparison curves for the original carbon fibers, porous core-shell carbon fibers and wire-like all-carbon supercapacitor.
Figure S7. Length capacitance of wire-like all-carbon supercapacitor obtained from CV curves at a scan rate of 10 mV/s (a), galvanostatic charge/discharge curves at a constant current of 5 mA (b), and specific capacitance as a function of the length based on CV results (c,d). The diameters of wire-like all-carbon supercapacitor are about 0.53 mm, H₃PO₄/PVA as solid-state electrolyte. The supercapacitor fiber was cut off 1 cm every time to test the corresponding CV and galvanostatic charge/discharge result.

Figure S8. Ragone plot for the porous core-shell carbon fiber electrode in 1 M H₂SO₄ aqueous electrolyte and H₂SO₄/PVA solid electrolyte, respectively. The data were calculated by (a) the weight and (b) volume of the supercapacitor.