Supplementary information

Elastic carbon foam via direct carbonization of polymer foam for flexible electrodes and organic chemical adsorption

Shuiliang Chen*, a,b Guanghua He, a Huan Hu, a Shaoqin Jin, a Yan Zhou, a Yunyun He, a Shuijian He, a Feng Zhao b and Haoqing Hou *a

Electrode preparation and electrochemical capacitance measurement

The electrodes for capacitive measurement were made by sandwiching the ECFs between two pieces of stainless steel mesh. All the electrochemical tests were carried out on a CHI 660D electrochemical workstation (CH Instruments Inc.). 1 M H₂SO₄ aqueous solution was used as electrolyte. The cyclic voltammetry (CV) were carried out in three-electrode cells with an Ag/AgCl electrode (saturated with KCl) used as reference electrode. Galvanostatic charge/discharge (chronopotentiometry, CP) tests were performed with the two-electrode cell in the cutoff potential range -0.2 to 0.6 V.

Calculation of porosity, density and carbon yield

The porosity is provided as a fraction of the void volume in the total volume, which follows our previous report [1].

\[ \Theta = \frac{V_{\text{void}}}{V_{\text{total}}} \times 100\% = 1 - \frac{V_{\text{solid}}}{V_{\text{total}}} \times 100\% \quad (1) \]

Here, the \( V_{\text{void}} \) is volume of pores, the \( V_{\text{solid}} \) is volume of solid and the \( V_{\text{total}} \) is total or bulk volume of foam material including the solid and pore volume. The \( V_{\text{total}} \) of the foam with cuboid shape can be expressed as \( V_{\text{total}} = a \times b \times c \). The \( a \), \( b \) and \( c \) represent the three dimensions of the foam, respectively. The \( V_{\text{solid}} \) can be expressed as \( V_{\text{solid}} = \frac{m}{\rho_m} \), the \( m \) is the weight of foam, and the \( \rho_m \) is the density of materials. The density of carbon (carbonized at low temperature of 800-1000 °C) is about 1.8 g cm⁻³, the density of melamine resin is about 1.51 g cm⁻³, which obtained from company.

For the a piece of elastic carbon foam with volume of 1.50 cm * 1.10 cm * 0.76 cm (1.254 cm³), its

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*a Department of Chemistry and Chemical Engineering, Jiangxi Normal University, Nanchang, 330022, China. E-mail: slchen2006@yahoo.com.cn and haoqing@jsnu.edu.cn

b Institute of Urban Environment, Chinese Academy of Sciences, Xiamen, 361021, China
weight is 0.0088 g. So, the porosity is calculated as

\[
1 - \frac{0.0088}{1.8 \, g \cdot cm^{-3} \times 1.254 \, cm^3} \times 100\% = 99.61\%
\]

The density of the foam materials (\( \rho_f \)) are calculated as ratio of foam weight (mc) to \( V_{total} \),

\[
\rho_f = \frac{m}{V_{total}} \quad (2)
\]

The carbonization rate (\( \xi_c \)) is means of char yield, which is calculated as,

\[
\xi_c = \frac{m_c}{m_{MF}} \times 100\% \quad (3)
\]

\( m_c \) is the weight of carbon foam, \( m_{MF} \) is the weight of melamine foam.

Table S1 Properties of ECFs with different slenderness ratio.

<table>
<thead>
<tr>
<th>Samples</th>
<th>Density of MF / mg cm(^{-3})</th>
<th>Density of ECF / mg cm(^{-3})</th>
<th>Porosity / %</th>
<th>( \bar{L}_f )/ ( \mu m )</th>
<th>( \bar{L}_m )/ ( \mu m )</th>
<th>Slenderness ratio ( \bar{L}_f / \bar{L}_m )</th>
<th>Plastic deformation/ %</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECF</td>
<td>7.2</td>
<td>5.0</td>
<td>99.68</td>
<td>61</td>
<td>2.9</td>
<td>26.7</td>
<td>0</td>
</tr>
<tr>
<td>ECF -1</td>
<td>11.1</td>
<td>7.93</td>
<td>99.56</td>
<td>63</td>
<td>3.8</td>
<td>16.6</td>
<td>5.3</td>
</tr>
<tr>
<td>ECF -2</td>
<td>12.0</td>
<td>8.64</td>
<td>99.52</td>
<td>47</td>
<td>4.1</td>
<td>11.5</td>
<td>21.5</td>
</tr>
<tr>
<td>RVC</td>
<td>—</td>
<td>54</td>
<td>97</td>
<td>354</td>
<td>48</td>
<td>7.2</td>
<td>100</td>
</tr>
</tbody>
</table>
Figure S1. Figure S1. (A) SEM image of MF, (B) the cross-sectional image of the network fiber in the MF, (C) macromolecular structure MF.

Figure S2. SEM images of RVC, (A) overview image and (B) cross-section image of the network.
Figure S3 Loading and unloading compressive stress-strain curves of *ECFs* prepared at temperature of 700, 800, 900, 1000 and 1800 °C.

Figure S4 Raman spectra of *ECFs* prepared at temperatures of 700, 800, 900, 1000, and 1800 °C
Figure S5 Capacitance performance of the ECFs preparing at different temperature in 1 M H$_2$SO$_4$. (A) Cyclic voltammograms at scan rate of 5 mV s$^{-1}$, (B) Charge/discharge curves at current density of 50 A g$^{-1}$ and (C) relationship between capacitance and charge/discharge current density, (D) Specific capacitance and capacitance retention curves of ECF prepared at 800 °C for 8000 cycles at 50A g$^{-1}$.

Fig. S6 (A) N$_2$ absorption and desorption isotherm linear plot and (B) pore size distribution of the ECF materials
Fig. S7 XPS spectra of ECF carbonized at 800 °C (left) survey, (right) high resolution spectra of N1s.

Fig. S8 Absorption properties of ECF towards ethanol for ten cycles.

Reference