Electronic Supplementary Information (ESI) for

Biomass-derived carbon materials for high-performance supercapacitor electrodes

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Samples	BET-SSA ^{a)} m ² g ⁻¹	DFT-SSA ^{b)} m ² g ⁻¹	TPV ^{c)} cm ³ g ⁻¹	MPV ^{d)} cm ³ g ⁻¹	Average PD ^{e)} nm
BD-700-A0	396	413	0.466	0.443 (95.0%)	4.702
BD-700-A1	1517	1646	0.914	0.495 (54.1%)	2.410
BD-700-A2	2593	2157	1.429	0.948 (66.3%)	2.205
BD-700-A3	2876	2185	1.538	0.981 (63.8%)	2.139
BD-700-A4	3398	2769	1.972	1.335 (67.7%)	2.322
BD-600-A3	1329	1427	0.630	0.459 (72.9%)	1.897
BD-800-A3	2555	1851	1.543	0.594 (38.5%)	2.415
BP2000	1680	1368	3.618	0.368 (10.2%)	8.613
control A	3157	2415	1.716	1.046 (61.0%)	2.174
control B	2974	2499	1.737	1.050 (60.4%)	2.336

Table S1: Porosity properties of carbon materials based on N₂ physisorption.

(a) BET specific surface area (P/P₀ = 0.05–0.20); (b) NL-DFT method cumulative specific surface area; (c) Total pore volume calculated at P/P₀ = 0.99; (d) t-method micro pore volume and the percentage of micro pore volume (in the parentheses); (e) Average pore diameter. Although there are some differences in the absolute values between BET and NL-DFT results, which are commonly observed due to the distinct assumptions between the two types of calculations,¹ these two results have the similar trends with the increasing amount of KOH and temperature.

Increasing the amount of KOH, the BET-SSA and the total pore volume (TPV) of the samples activated at 700°C increase from 1517 m² g⁻¹ and 0.914 cm³ g⁻¹ for BD-700-A1 to 3398 m² g⁻¹ and 1.972 cm³ g⁻¹ for BD-700-A4 progressively. Furthermore, sample obtained by using a larger amount of activating agent possesses a wider PSD, as revealed in Fig. S10c. Higher temperature will also lead to the broadening of the PSD and the enlargement of the pore size (Fig. S10d). That is

probably ascribed to higher reactivity of KOH and stronger gas bubbling at the elevated temperature.²

Table S2: Elemental compositions (wt %) of carbon materials based on CHN

Samples	BD-700-A0	BD-700-A1	BD-700-A2	BD-700-A3	BD-700-A4	BD-600-A3	BD-800-A3	control	control
								Α	В
С	83.24	87.12	86.93	85.71	83.00	83.14	84.16	89.11	89.78
Ν	3.59	1.83	1.74	1.64	1.44	2.59	0.39	1.65	1.93
O ^{a)}	11.20	8.59	7.95	9.93	11.65	11.14	11.39	6.88	6.61
N/C	3.70	1.80	1.72	1.64	1.49	2.67	0.40	1.58	1.84
O/C	10.09	7.39	6.86	8.69	10.53	10.05	10.15	5.79	5.52

elemental analysis method and corresponding elemental atomic ratios (at %).

(a) The oxygen contents were obtained by extracting the amount of C, N and H (data

not shown) from the total mass.

Compared with the non-activated sample BD-700-A0, the nitrogen content in the activated samples is greatly reduced, since the activation will decrease the N content.³ Additionally, for the activated samples, the N content is reduced with the increase in the amount of KOH or the activation temperature.



Fig. S1 SEM micrographs of (a) BD-700-A0, (b) BD-700-A1, (c) BD-700-A2, (d)

BD-700-A4. The scale bar is 5 μ m.



Fig. S2 Raman spectra of carbon materials activated at various conditions.



Fig. S3 XRD of carbon materials activated at various conditions.



Fig. S4 Electrochemical performance of BP2000 based on the three-electrode system: (a) CVs at various scan rates; (b-d) galvanostatic charge/discharge curves at various current densities.



Fig. S5 Electrochemical performance of BP2000 based on the two-electrode system and compared with BD-700-A3 .(a) CVs of BP2000 at various scan rates; (b) CVs at $5mV s^{-1}$, (c) CVs at 40 mV s⁻¹, (d) galvanostatic charge/discharge curves at 0.5 A g⁻¹.

The mass loading of the electrode in the two-electrode system (Fig. 5) was an order of magnitude higher than that of the three-electrode system using GCE as working electrode (Fig. 4). As illustrated by previous work, a high correlation existed between the measured C_s and mass loading. With increasing the mass loading, the C_s of the electrode decreased.⁴ In order to evaluate the electrochemical performance in the two systems more precisely and reliably, we also tested the as-prepared materials in three-electrode system but used the same electrode as the in the symmetrical two-electrode system (carbon composite pasted on a titanium foil was worked as working electrode) and the result were presented in Fig. S6. As expected, the obtained

capacitive values are higher than that of the values in the symmetrical two-electrode system (Fig. 5c). Such observation indicates that the faradaic reaction is the main reason of the different capacitive responses between the two systems and confirms the analysis in the main text. In addition, although the C_s obtained here are lower than the values obtained by using GCE as work electrode, due to the much higher mass loading, the capacitive performance is still impressive and demonstrates the good capacitive performance of the as-prepared sample.



Fig. S6 The electrochemical behaviors of BD-700-A3 in the three-electrode configuration (Carbon composite sheet pasted on the titanium foil was used as working electrode. Ag/AgCl (3 mol L⁻¹ KCl) and Pt foil were used as the reference electrode and the counter electrode, respectively.). (a, b) Galvanostatic charge/discharge curves and (c) C_s at various current densities.



Fig. S7 IR_{drops} collected at various current densities (I_s), revealing that low equivalent series resistance is obtained in all these cases.



Fig. S8 CVs of (a) BD-600-A3 and (b) BD-800-A3 at various scan rates.



Fig. S9 Electrochemical performance of control A and B compared with BD-700-A3 in the three-electrode system: galvanostatic charge/discharge curves at (a) 1 A g^{-1} ; (b) 5 A g^{-1} ; (c) 10 A g^{-1} ; (d) 50 A g^{-1} .



Fig. S10 (a, b) N_2 physisorption isotherms (77 K) and (c, d) NL-DFT pore size distributions of carbon materials. The PSD was calculated via the NL-DFT method based on nitrogen adsorption data, and assuming a slit pore model.



Fig. S11 (a) N_2 physisorption isotherms (77 K) and (b) NL-DFT pore size distributions of control A and B compared with BD-700-A3. The PSD was calculated via the NL-DFT method based on nitrogen adsorption data, and assuming a slit pore model.



Fig. S12 SEM micrographs of control B, showing a cracked and irregular shape without interconnected cavities present in the overall texture. The scale bar in (a), (b), (c), and (d) is 50 μm, 20 μm, 10 μm, and 10 μm, respectively.

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