Electronic Supplementary Information

Three-dimensional honeycomb-like hierarchical structured carbon for High-performance supercapacitors derived from high-ash-content sewage sludge

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Table S1 Proximate and ultimate analyses of sewage sludge (SS) and HSC-3

Content (wt. %)	Moisture	Ash	Volatile matter	Fixed carbon	C	H	N	O	Si
SS	2.39	69.33	27.30	0.98	11.59	2.52	1.96	12.21	24.48
FSC	0.00	9.24	21.02	66.74	50.61	2.01	1.52	28.62	0.24
HSC-3	0.00	0.32	12.22	87.46	84.61	1.71	1.39	11.97	0.00

The proximate analysis was conducted according to ASTM E1755-01, ASTM E871-82 and ASTM E872-82 standards. For moisture determination, 1.0 g sample was taken in a crucible and placed in a muffle furnace at 105 °C for 2 h. The loss in weigh after drying was given as the moisture. In the same way, the conditions for ash and volatile matter determination were 575±10 °C for 4 h and 950±10 °C for 7 min, respectively. After each analysis, the crucible was removed from the furnace and placed in the desiccator until room temperature and weighed. Fixed carbon was calculated from: 100 % - moisture % - ash % - volatile matter %. Common organic elements such as C, H and N present in samples were determined through an EA2400 II elemental analyzer. The content of O was calculated from: 100 % - ash % – C % -H % - N %. The content of Si was measured by X-ray fluorescence (JSX-3400R, JEOL).

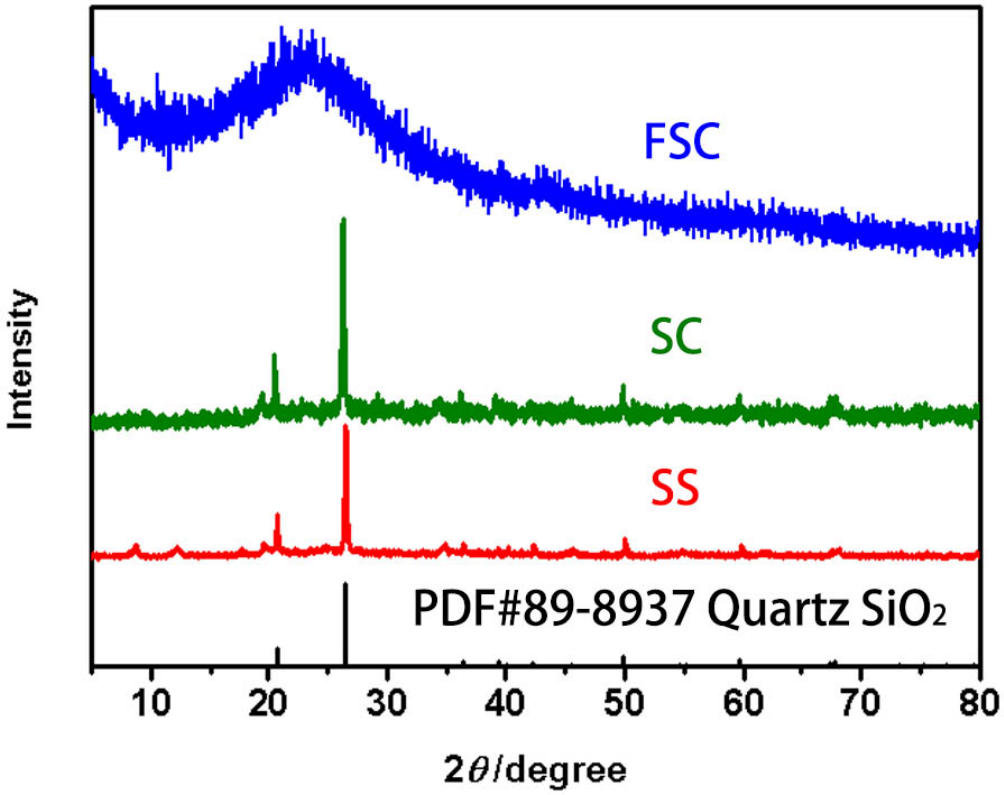

Fig. S1 XRD pattern of SS, SC and FSC.

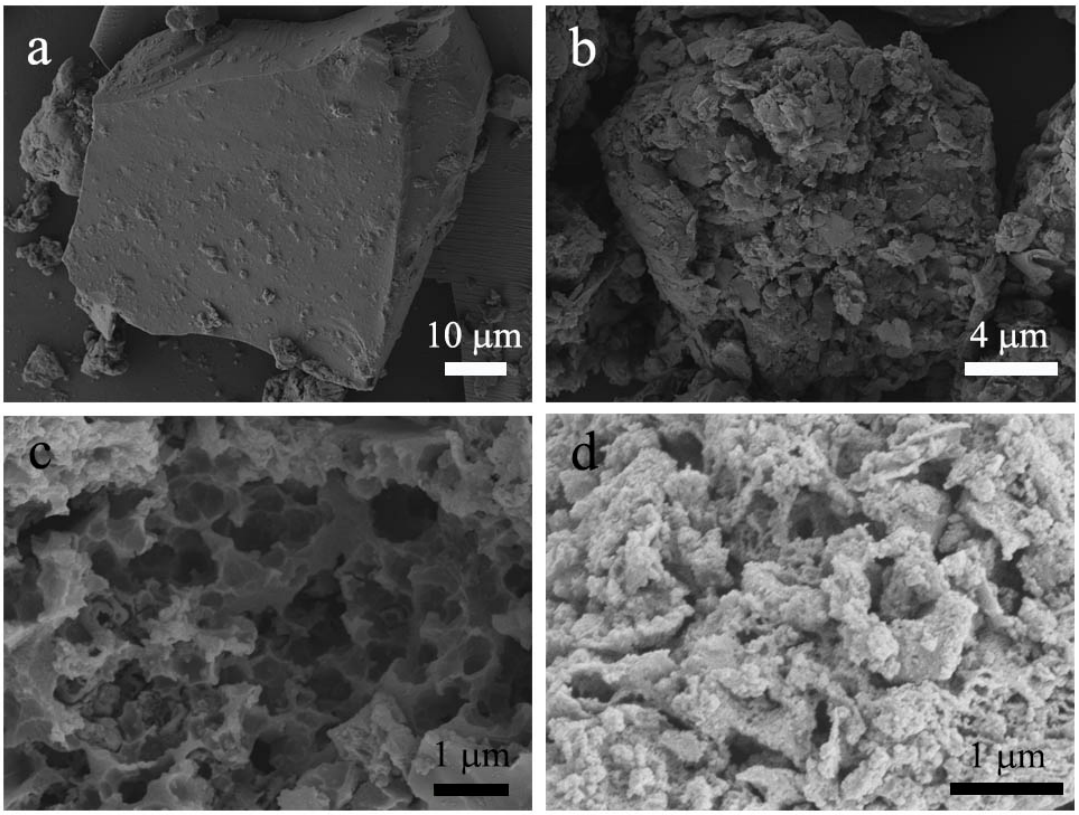

Fig. S2 FESEM images of SS (a), SC (b), FSC (c), and ASC (d).

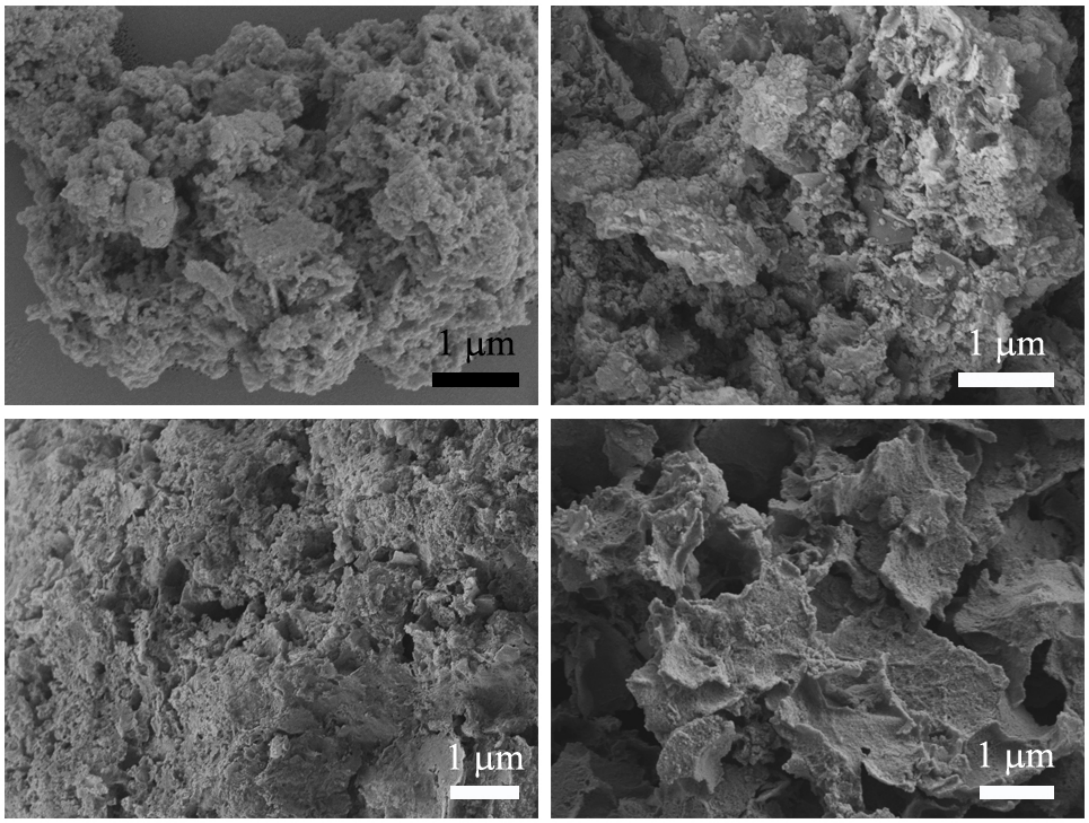

Fig. S3 SEM image of the as-resulted ASC samples from different pre-treatment process (similar to fly-silicon) of SC before KOH activation: (a) hydrochloric acid, (b) nitric acid, (c) sulfuric acid, and (d) KOH.

Table S2 Pore characteristics of SC, FSC, ASC, and HSC samples

Sample	S_{BET}[a] [m^2 g^{-1}]	S_{micro}[b] [m^2 g^{-1}]	V_{pore}[c] [cm^3 g^{-1}]	V_{micro}[d] [cm^3 g^{-1}]	D_{aver}[e] [nm]
SC	31	0	0.008	0	110.44
FSC	111	24	0.269	0.016	9.67
ASC	1272	788	0.903	0.406	2.93
HSC-1	550	382	0.509	0.189	3.81
HSC-2	2125	1306	1.827	0.647	3.53
HSC-3	2839	1218	2.652	0.681	3.73
HSC-4	1001	406	1.308	0.213	5.16

a BET surface area.
b Surface area of micropores, NLDFT method.
c Volume of pores at $p/p^0 = 0.98$.
d Volume of micropores, NLDFT method.
e Average pore diameter, 4V/A by BET.

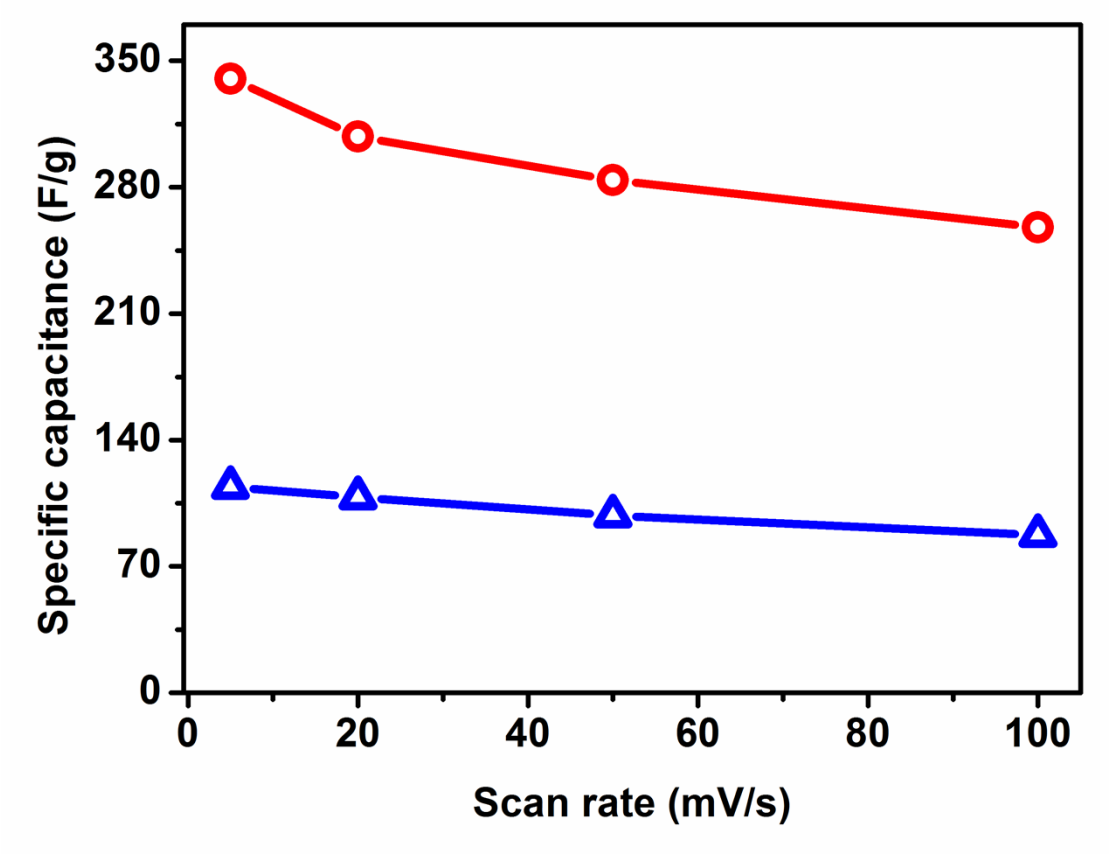

Fig. S4 Specific capacitance of HSC-3 and ASC at different scan rate.

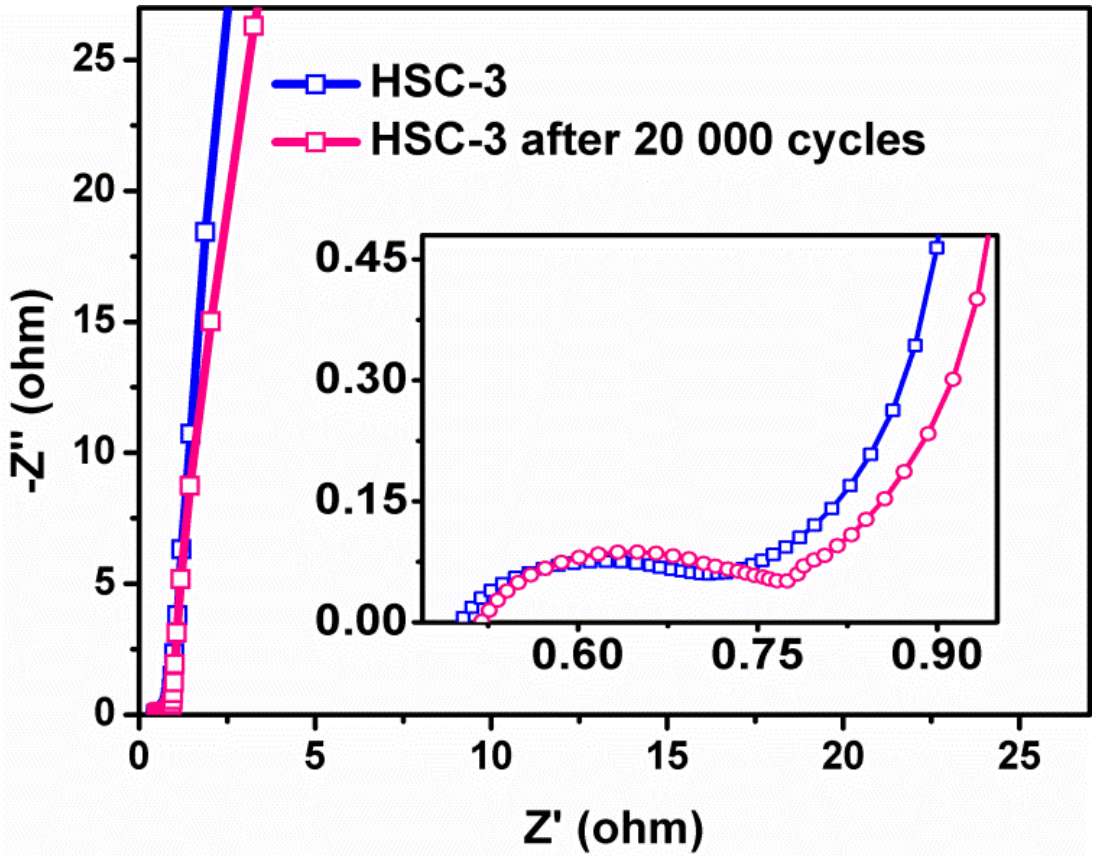

Fig. S5 Nyquist plots of HSC-3 electrode before and after 20 000 cycles.

Table S3 Comparison of the supercapacitive properties of carbonaceous materials derived from waste biomass

Materials	BET surface area ($m^2 g^{-1}$)	Capacitance ($F g^{-1}$)	Current density ($A g^{-1}$)	Electrolyte	Reference no.
Fermented rice	2106	250	2	6 M KOH	[1]
Waste tea-leaves	2841	270	2	2 M KOH	[2]
Human hair	1104	220	2	6 M KOH	[3]
Human hair	1306	280	2	6 M KOH	[4]
Carrageenan	2502	210	2	6 M KOH	[5]
Waste wood	3223	250	2	1 M H_2SO_4	[6]
Enteromorpha prolifera	2405	260	2	30 % KOH	[7]
Chitosan	1579	280	2	6 M KOH	[8]
Willow catkins	1586	275	2	6 M KOH	[9]
Pomelo peel	2725	260	2	6 M KOH	[10]
Sewage Sludge	2839	340	2	6 M KOH	This work

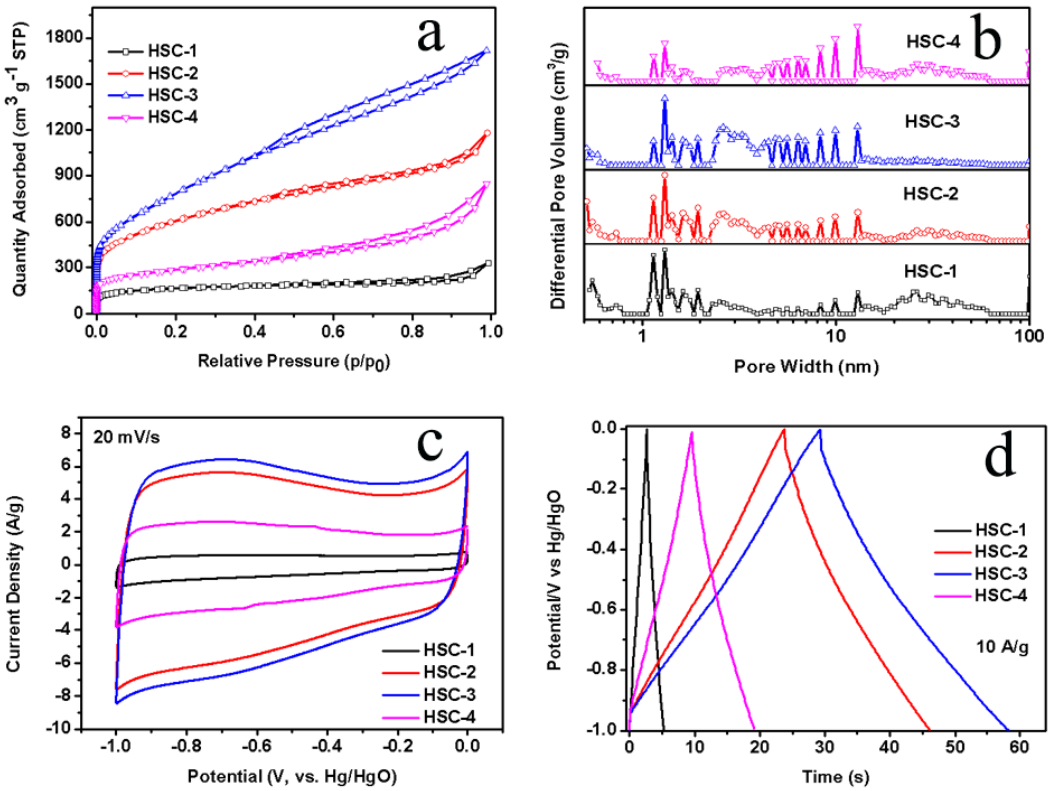

Fig. S6 N_2 adsorption-desorption isothermal (a) and pore size distribution calculated from the adsorption branch of the isotherm by NLDFT method (b) of HSC-1, HSC-2, HSC-3 and HSC-4. CV measurements (c) and GCD curves (d) of HSC samples.

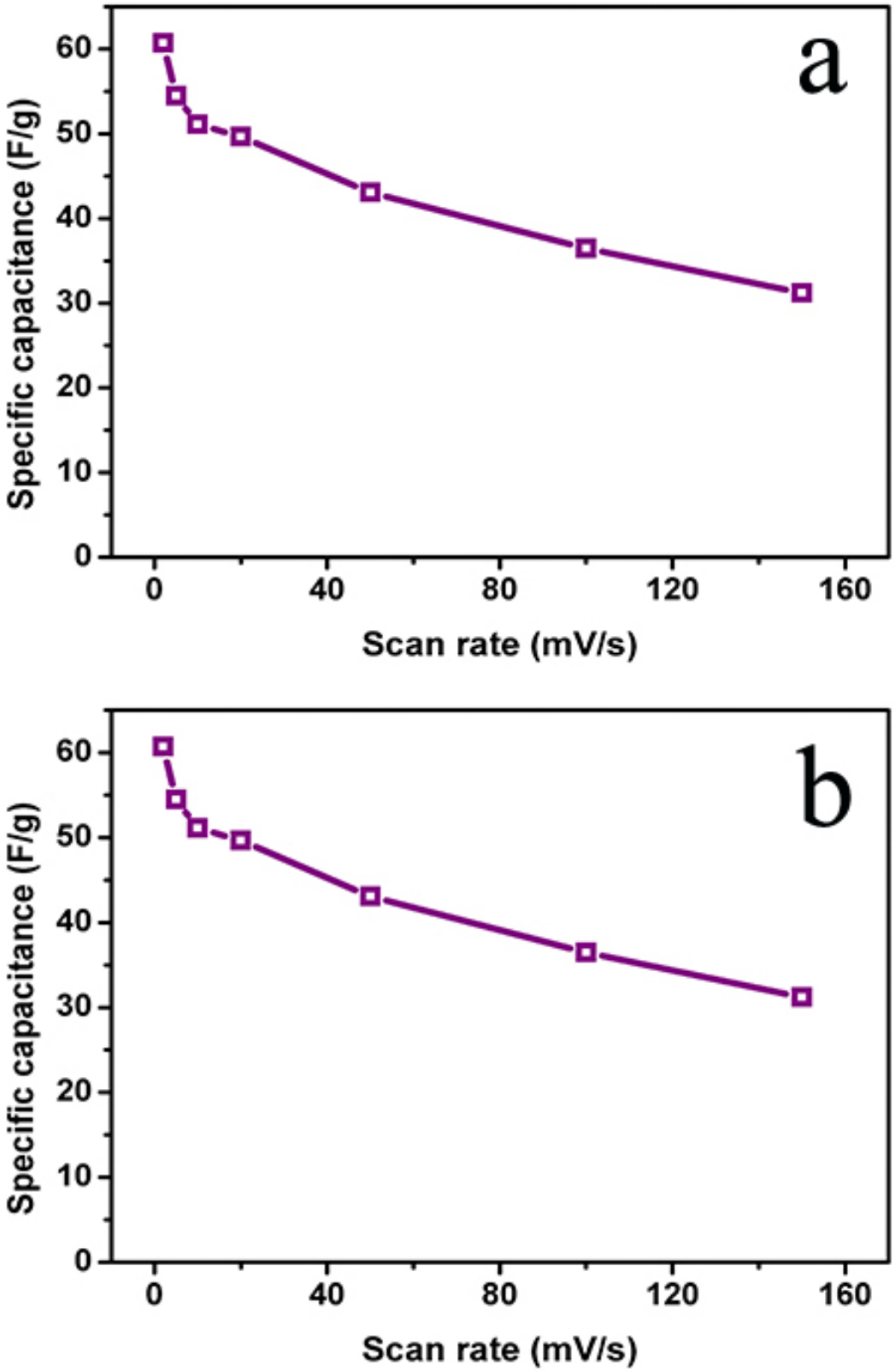

Fig. S7 Specific capacitance of HSC-3//HSC-3 symmetric supercapacitor calculated from cyclic curves (a) and galvanostatic charge/discharge curves (b).

References

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