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Supporting Information for

Expanded biomass-derived hard carbon with ultra-stable performance for sodium-ion batteries

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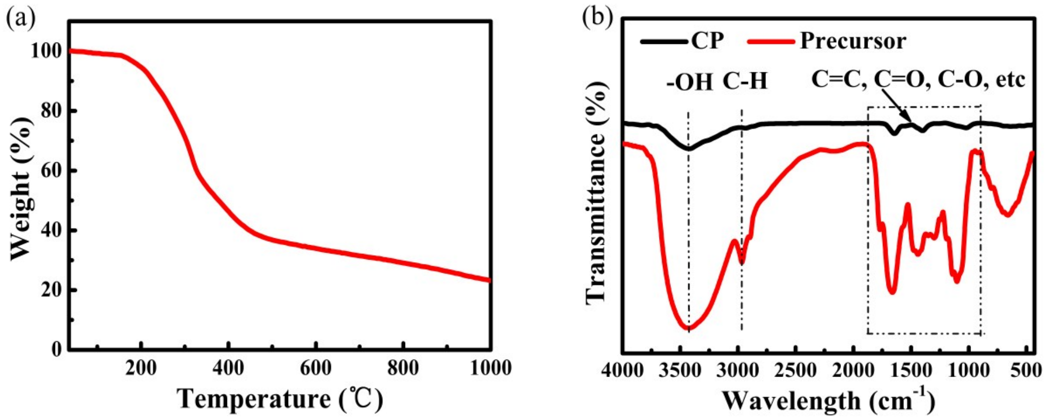

Fig. S1 (a) TGA analysis of CP; (b) FTIR analysis of CP.

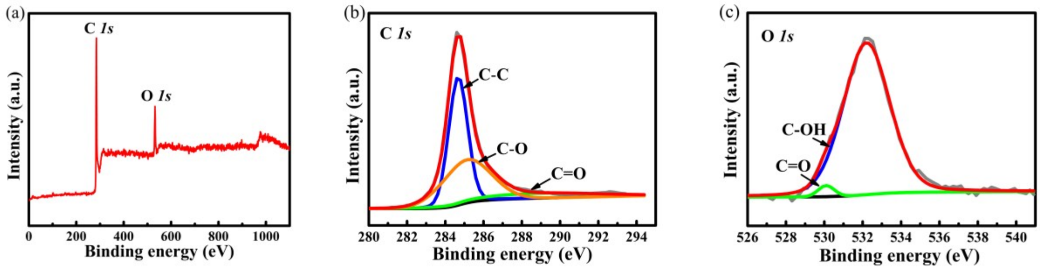

Fig. S2 (a) XPS spectra of CP specimens; (b) High-resolution C 1s XPS spectra of CP; (c) High-resolution O 1s XPS spectra of CP.

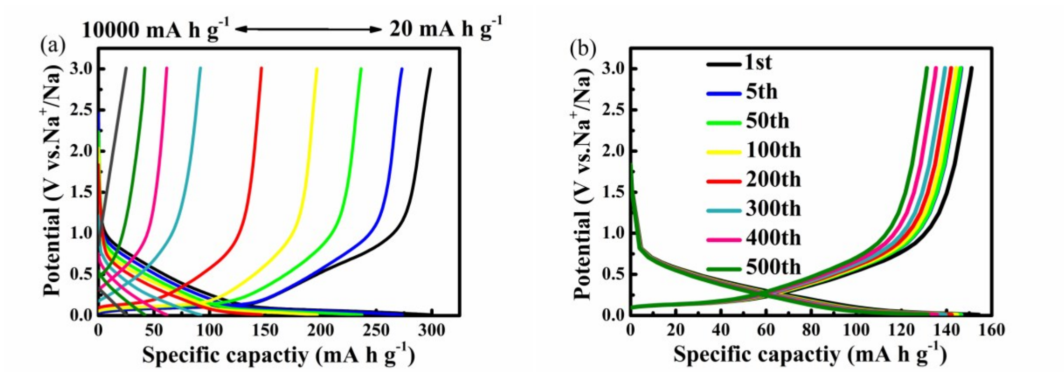

Fig. S3 (a) Galvanostatic charge/discharge cycling profiles at different current rates; (b) Galvanostatic charge/discharge cycling profiles at the high current density of 500 mA g^{-1}.

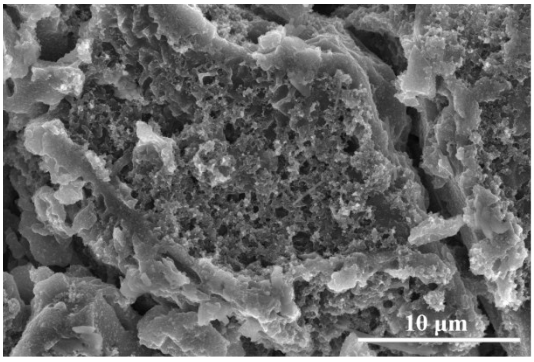

Fig. S4 SEM image of the CP electrode after 100 cycles at the current density of 20 mA g^{-1}.

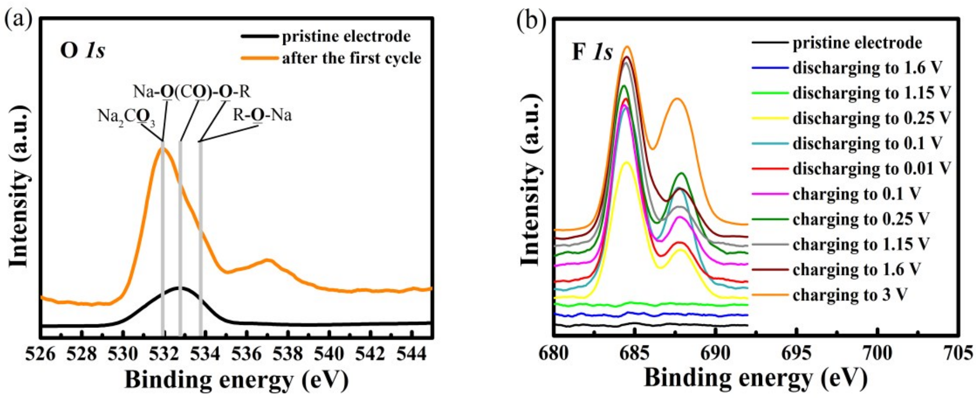

Fig. S5 (a) O1s XPS spectra for the CP electrodes tests after the first cycle and the pristine electrode; (b) F 1s XPS spectra for the CP electrodes tests under different cut-off voltages.

Table S1 Element ratio on the surface of CP

Sample	Element analysis (at%)								
	C	O	N	Al	Cl	Ca	K	P	Mg
CP	85.8	12.0	1.4	0.4	0.2	0.1	<0.1	<0.1	<0.1

Table S2 A comparison with literatures of the reversible capacities for carbon materials, tested in standard half-cell configuration vs. Na.

Sample	Initial	Rate performance	Cyclability

	coulombic efficiency (%)		
Cherry petals (This work)	67.3	300.2 mA h g^{-1} at 20 mA g^{-1} 273.1 mA h g^{-1} at 50 mA g^{-1} 236.5 mA h g^{-1} at 100 mA g^{-1} 146.5 mA h g^{-1} at 500 mA g^{-1} 91.9 mA h g^{-1} at 1000 mA g^{-1}	298.1 mA h g^{-1} at 100th cycle and 20 mA g^{-1} (99.3% capacity retention), 131.5 mA h g^{-1} at 500th cycle and 500 mA g^{-1} (89.8% capacity retention)
Carbon nanofiber (ref 44)	58.2	233 mA h g^{-1} at 50 mA g^{-1} 173 mA h g^{-1} at 200 mA g^{-1} 82 mA h g^{-1} at 2000 mA g^{-1}	217 mA h g^{-1} at 50th cycle and 50 mA g^{-1}, 169 mA h g^{-1} at 200th cycle and 200 mA g^{-1} (97.7% capacity retention)
Hollow carbon nanowire (ref 25)	50.5	251 mA h g^{-1} at 50 mA g^{-1} 149 mA h g^{-1} at 500 mA g^{-1}	206.3 mA h g^{-1} at 400th cycle and 50 mA g^{-1} (82.2% capacity retention)
Expanded graphite (ref 27)	49.53	284 mA h g^{-1} at 20 mA g^{-1} 91 mA h g^{-1} at 200 mA g^{-1}	184 mA h g^{-1} at 2000th cycle and 100 mA g^{-1} (73.92% capacity retention)
Highly disordered carbon (ref 45)	57.6	231 mA h g^{-1} at 100 mA g^{-1} 40 mA h g^{-1} at 5000 mA g^{-1}	225 mA h g^{-1} at 180th cycle and 100 mA g^{-1} (92% capacity retention)
Biomass derived hierarchical porous carbons (ref 21)	33.8	226 mA h g^{-1} at 100 mA g^{-1} 47 mA h g^{-1} at 10000 mA g^{-1}	144 mA h g^{-1} at 200th cycle and 500 mA g^{-1} (~86% capacity retention)
Pitch-derived amorphous carbon (ref 46)	88	284 mA h g^{-1} at 30 mA g^{-1}	~99.2% capacity retention after 100th cycles at 30 mA g^{-1}
Sucrose-based hard carbon	not reported	307 mA h g^{-1} at 20 mA g^{-1}	288 mA h g^{-1} at 100th cycle and 20 mA g^{-1}

(ref 43)		95 mA h g^{-1} at 500 mA g^{-1}	
Graphene template carbon (ref 47)	43.1	192 mA h g^{-1} at 200 mA g^{-1} 45 mA h g^{-1} at 10000 mA g^{-1}	190 mA h g^{-1} at 2000th cycle and 200 mA g^{-1} (92% capacity retention)
Carbon nanofibrous webs (ref 48)	70.5	292.6 mA h g^{-1} at 20 mA g^{-1} 210 mA h g^{-1} at 400 mA g^{-1} 80 mA h g^{-1} at 1000 mA g^{-1}	247 mA h g^{-1} at 200th cycle and 100 mA g^{-1} (90.2% capacity retention)
Reduced graphene oxide (ref 49)	not reported	271.2 mA h g^{-1} at 40 mA g^{-1} 150.9 mA h g^{-1} at 200 mA g^{-1} 95.6 mA h g^{-1} at 1000 mA g^{-1}	93.3 mA h g^{-1} at 250th cycle and 400 mA g^{-1}, 141 mA h g^{-1} at 1000th cycle and 40 mA g^{-1} (45% capacity retention)
Hard carbon (ref 42)	83	~220 mA h g^{-1} at 20 mA g^{-1} ~50 mA h g^{-1} at 500 mA g^{-1}	~213 mA h g^{-1} at 300th cycle and 20 mA g^{-1}
Carbon nanospheres (ref 50)	41.5	~200 mA h g^{-1} at 50 mA g^{-1} ~137 mA h g^{-1} at 100 mA g^{-1} ~50 mA h g^{-1} at 10000 mA g^{-1}	~160 mA h g^{-1} at 100th cycle and 50 mA g^{-1}
N-doped interconnected carbon nanofibers (ref 51)	41.8	87 mA h g^{-1} at 10000 mA g^{-1} 37 mA h g^{-1} at 20000 mA g^{-1}	134.2 mA h g^{-1} at 200th cycle and 200 mA g^{-1} (88.7% capacity retention)
Sulfur covalently bonded graphene (ref 52)	57.36	291 mA h g^{-1} at 50 mA g^{-1} 262 mA h g^{-1} at 100 mA g^{-1} 161 mA h g^{-1} at 1000 mA g^{-1}	127 mA h g^{-1} at 200th cycle and 2000 mA g^{-1}, 83 mA h g^{-1} at 200th cycle and 5000 mA g^{-1} (~30% capacity retention)
Rape seed shuck derived-lamellar hard carbon (ref 19)	not reported	196 mA h g^{-1} at 25 mA g^{-1} 92 mA h g^{-1} at 500 mA g^{-1} 32 mA h g^{-1} at 5000 mA g^{-1}	143 mA h g^{-1} at 200th cycle and 100 mA g^{-1}
Graphene	not reported	220 mA h g^{-1} at 30 mA g^{-1}	~80% capacity retention after 300th cycles at

nanosheets (ref 53)		202 mA h g^{-1} at 50 mA g^{-1} 189 mA h g^{-1} at 100 mA g^{-1} 159 mA h g^{-1} at 500 mA g^{-1} 146 mA h g^{-1} at 1000 mA g^{-1} 105 mA h g^{-1} at 5000 mA g^{-1} 73 mA h g^{-1} at 10000 mA g^{-1} 46 mA h g^{-1} at 20000 mA g^{-1}	100 mA g^{-1}
Biomass derived hard carbon (ref 20)	27	287.8 mA h g^{-1} at 50 mA g^{-1} 182.3 mA h g^{-1} at 200 mA g^{-1} 151.2 mA h g^{-1} at 500 mA g^{-1} 71 mA h g^{-1} at 5000 mA g^{-1}	181 mA h g^{-1} at 220th cycle and 200 mA g^{-1} (84.6% capacity retention)
Carbon nanobubbles (ref 54)	not reported	175 mA h g^{-1} at 50 mA g^{-1} 25 mA h g^{-1} at 5000 mA g^{-1}	>120 mA h g^{-1} at 30th cycle and 100 mA g^{-1} >60 mA h g^{-1} at 30th cycle and 200 mA g^{-1}

Table S3 Impedance parameters of CP electrodes.

Sample	R_s (Ω)	Error%	R_{ct}+R_{SEI}(Ω)	Error%
Before test	11.6	1.29	82.3	1.61
After 10th	23.1	1.04	138.7	0.73
After 100th	38.5	0.83	261.4	0.45
After 200th	45.1	0.54	283.5	0.41