Supporting Information

Advanced carbon based materials for fabrications of sodium ion hybrid capacitors with high electrochemical performance

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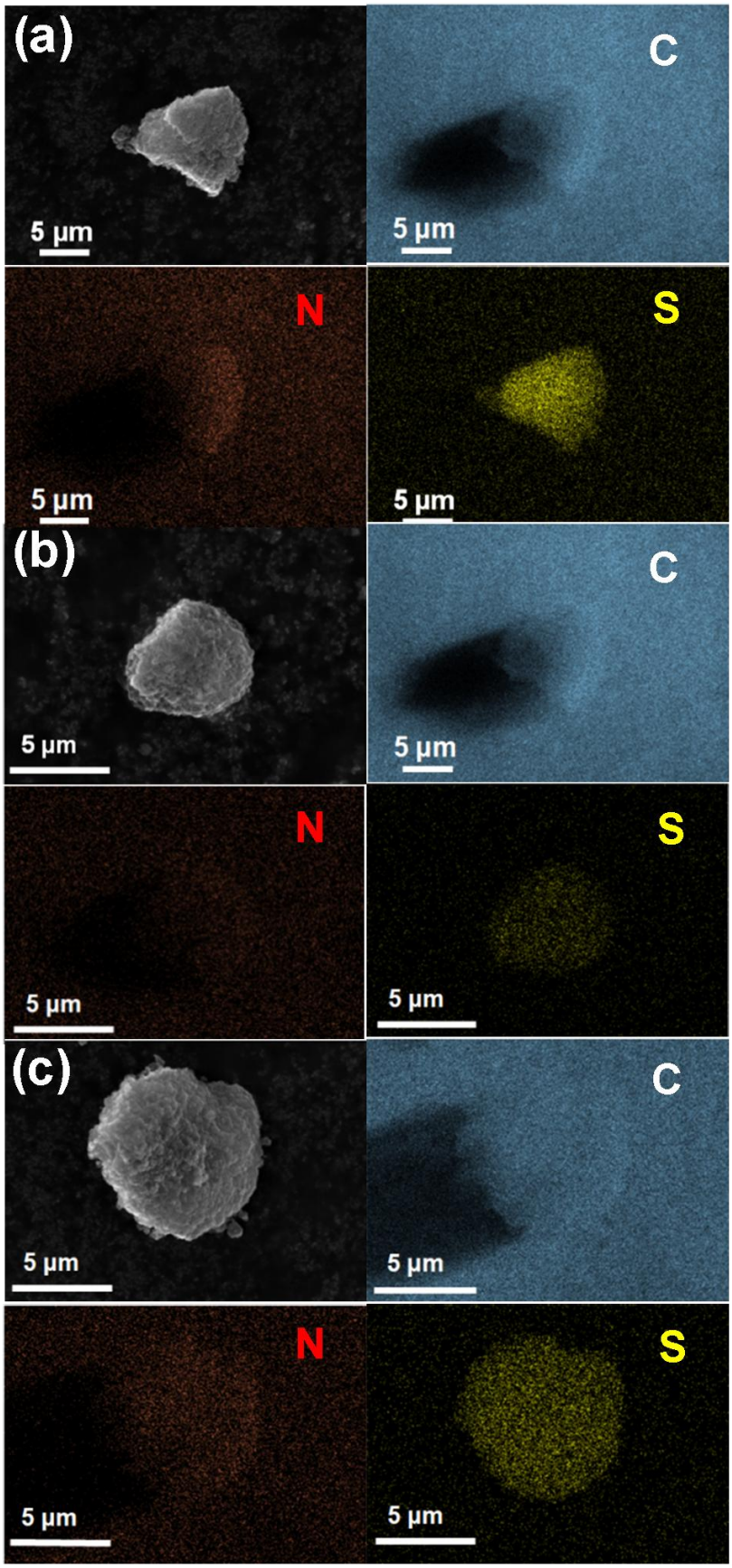

Figure S1. SEM-EDS images of NSMCC-650 (a), NSMCC-750 (b) and NSMCC-850 (c), respectively.

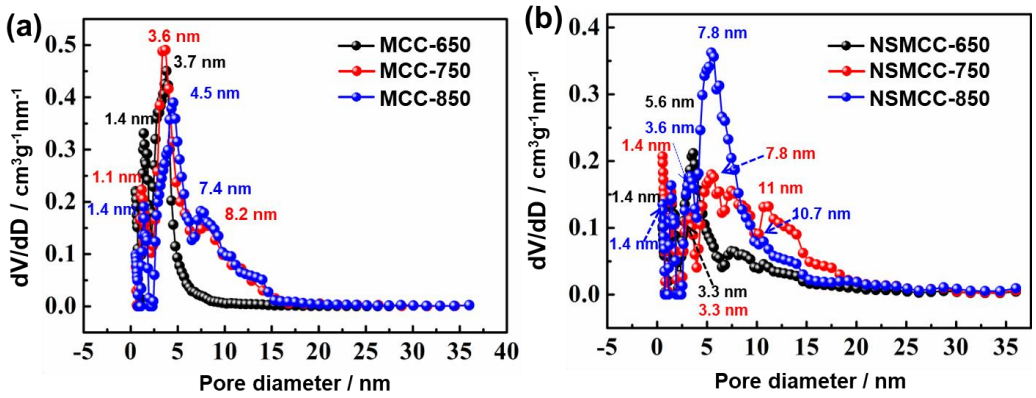

Figure S2. Pore size distribution curves of MCC (a) and NSMCC (b) materials.

Table S1 Specific surface area and pore volume data of MCC and NSMCC materials.

Samples	S_{BET} ($m^2\ g^{-1}$)	S_{micro} ($m^2\ g^{-1}$)	S_{meso} ($m^2\ g^{-1}$)	Micro/mesoporous ratio (%)	V_{total} ($cm^3\ g^{-1}$)
MCC-650	1529.1	1108.6	420.5	72.5 /27.5	1.449
MCC-750	1210.2	1175.8	34.4	97.2 /2.8	2.355
MCC-850	1169.5	890.7	278.8	76.2 /23.8	2.122
NSMCC-650	745.8	568.6	177.2	76.2 /23.8	1.197
NSMCC-750	917.3	796.7	120.6	86.9/13.1	2.050
NSMCC-850	1074.6	868.6	206.0	80.8 /19.2	2.364

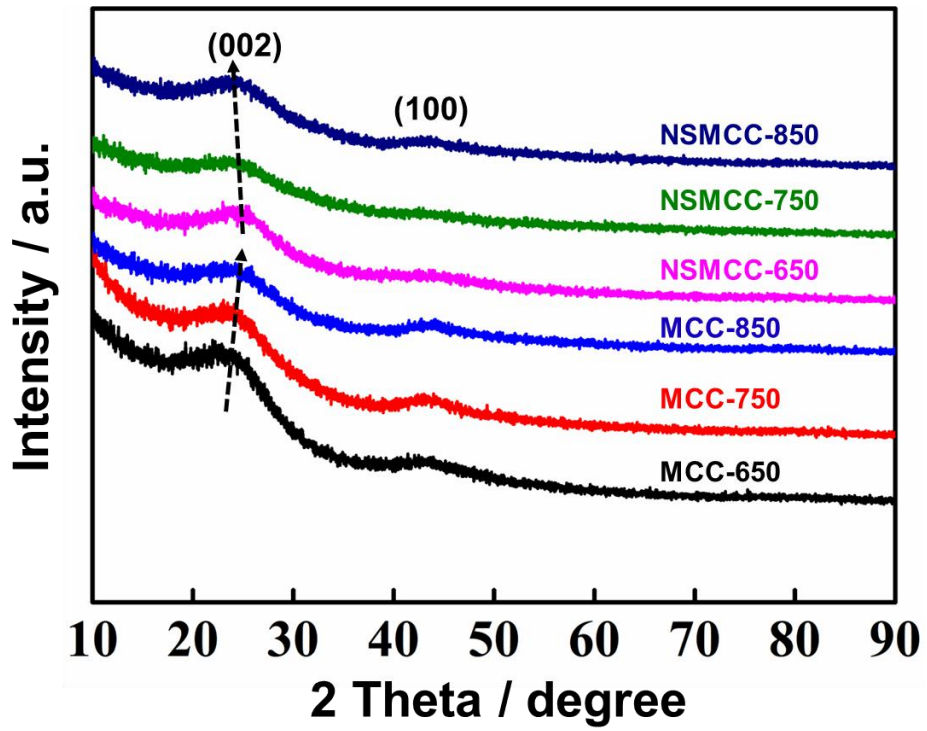

Figure S3. XRD patterns of MCC and NSMCC materials.

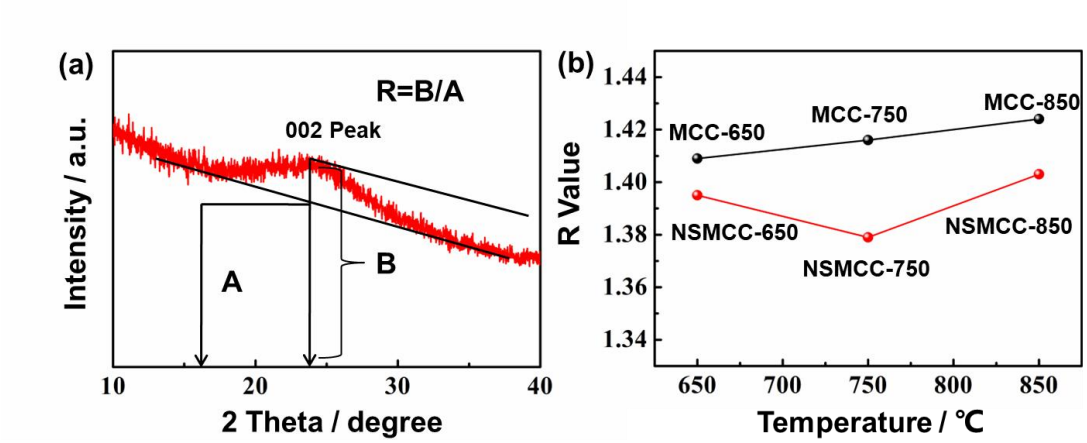

Figure S4. (a) Illustration of a calculation method for empirical R values. (b) Empirical R values of MCC and NSMCC materials prepared from different temperatures.

Table S2 The calculation results of R values.

Samples	R values	Samples	R values
MCC-650	1.409	NSMCC-650	1.395
MCC-750	1.416	NSMCC-750	1.379
MCC-850	1.424	NSMCC-850	1.403

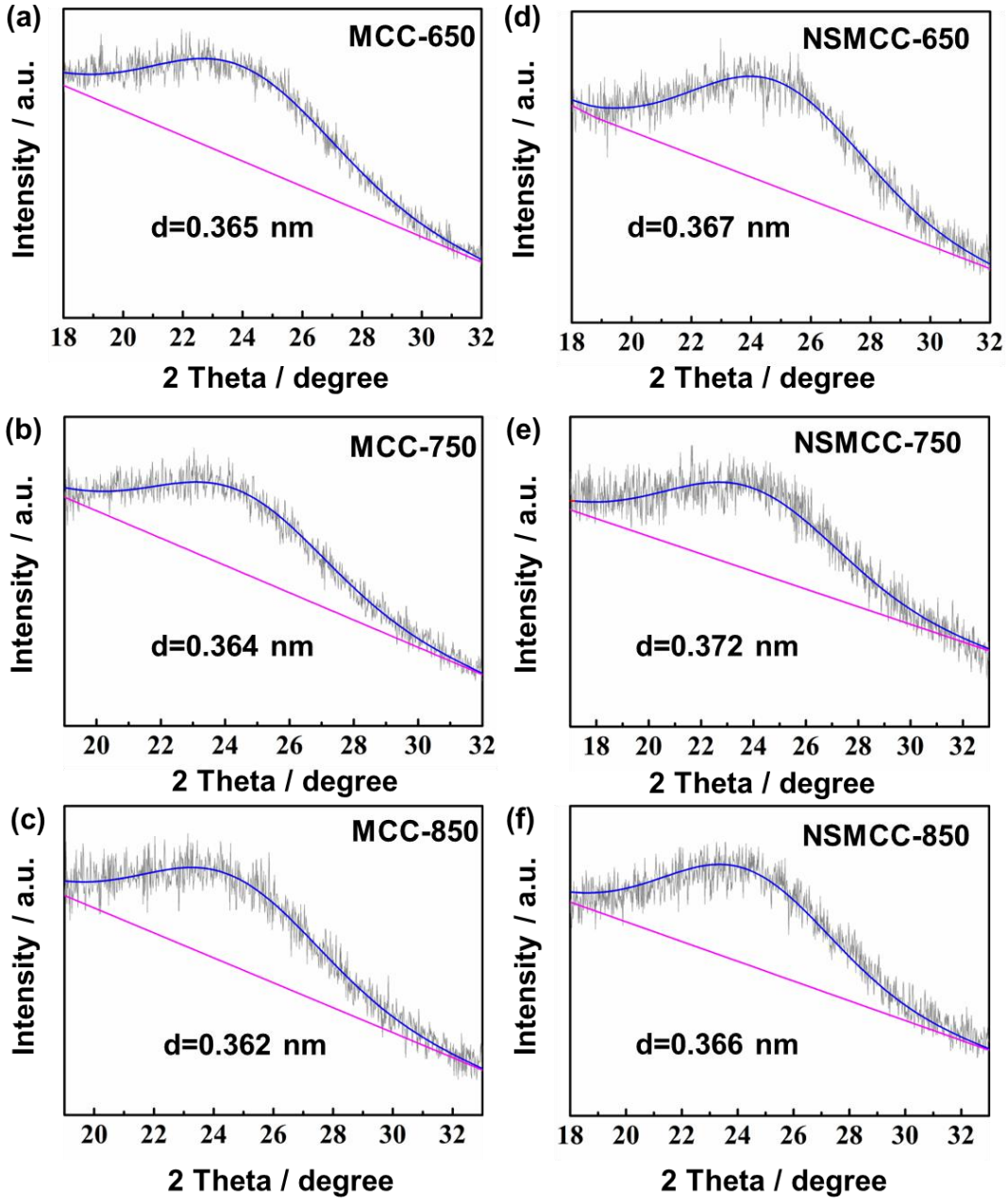

Figure S5. Fitting results of XRD measurements of MCC and NSMCC materials.

Table S3 Fitted data from XRD and Raman results of MCC and NSMCC materials.

Samples	d_{002}	I_D/I_G
MCC-650	0.365	2.18
MCC-750	0.364	2.31
MCC-850	0.362	2.64
NSMCC-650	0.367	2.13
NSMCC-750	0.372	2.07
NSMCC-850	0.366	2.49

Table S4a Fitted S 2p XPS results for NSMCC samples.

	$S\ 2p_{3/2}$ (at.%)	Position (eV)	$S\ 2p_{1/2}$ (at.%)	Position (eV)	Oxidized sulfur(at.%)	Position (eV)
NSMCC-650	0.71	164.0	0.75	165.1	0.47	167.7
NSMCC-750	1.72	164.1	1.96	165.2	1.38	167.4
NSMCC-850	1.03	164.0	1.22	165.1	1.1	167.8

Table S4b Fitted N 1s XPS results for NSMCC samples.

	N-6 (at.%)	Position (eV)	N-5 (at.%)	Position (eV)	N-Q (at.%)	Position (eV)
NSMCC-650	0.67	398.6	0.75	400.6	0.47	402.1
NSMCC-750	1.72	398.6	1.96	400.8	1.38	402.6
NSMCC-850	1.03	398.6	1.22	400.9	1.10	403.0

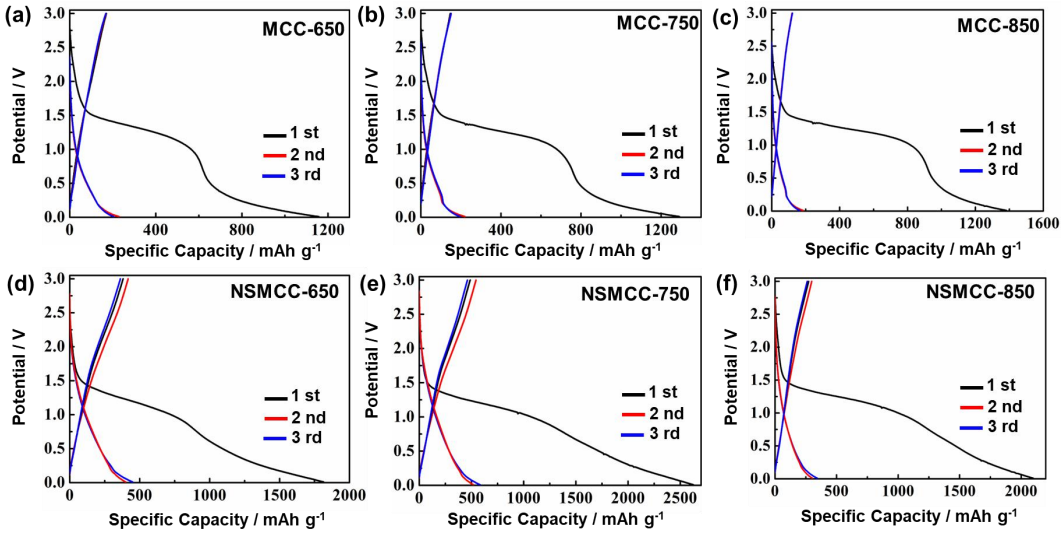

Figure S6. Charge-discharge curves of MCC and NSMCC materials.

Table S5 Simulated impedance of MCC and NSMCC materials.

Samples	R_1(ohm)	R_2 (ohm)	R_3 (ohm)
MCC-650	5.396	6.258	684.1
MCC-750	4.728	5.941	1163.0
MCC-850	4.605	5.306	1386.0
NSMCC-650	5.491	5.210	184.5
NSMCC-750	4.970	5.070	144.4
NSMCC-850	5.029	6.080	228.2

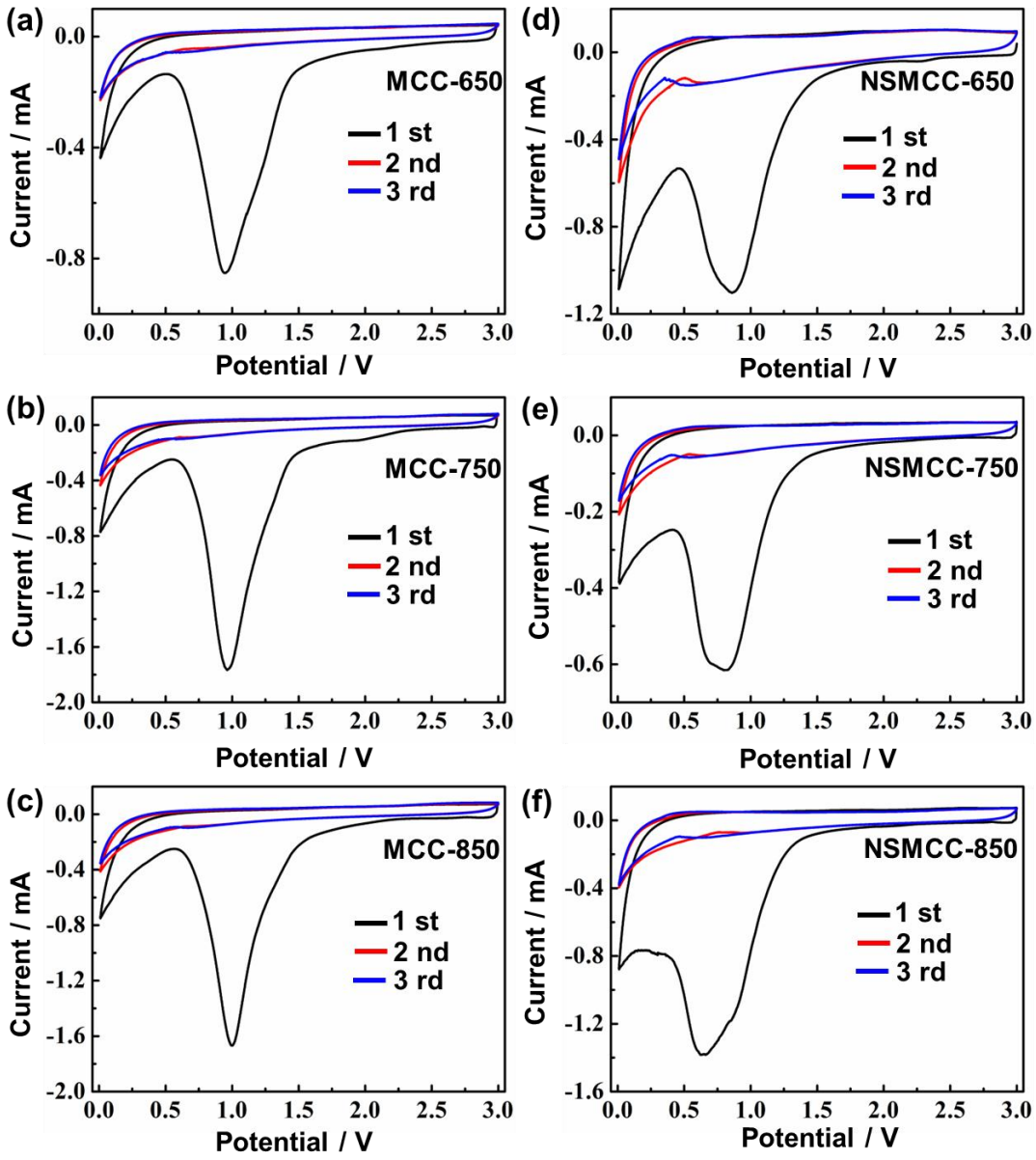

Figure S7. CV measurement results of MCC (a-c) and NSMCC (d-f) materials.

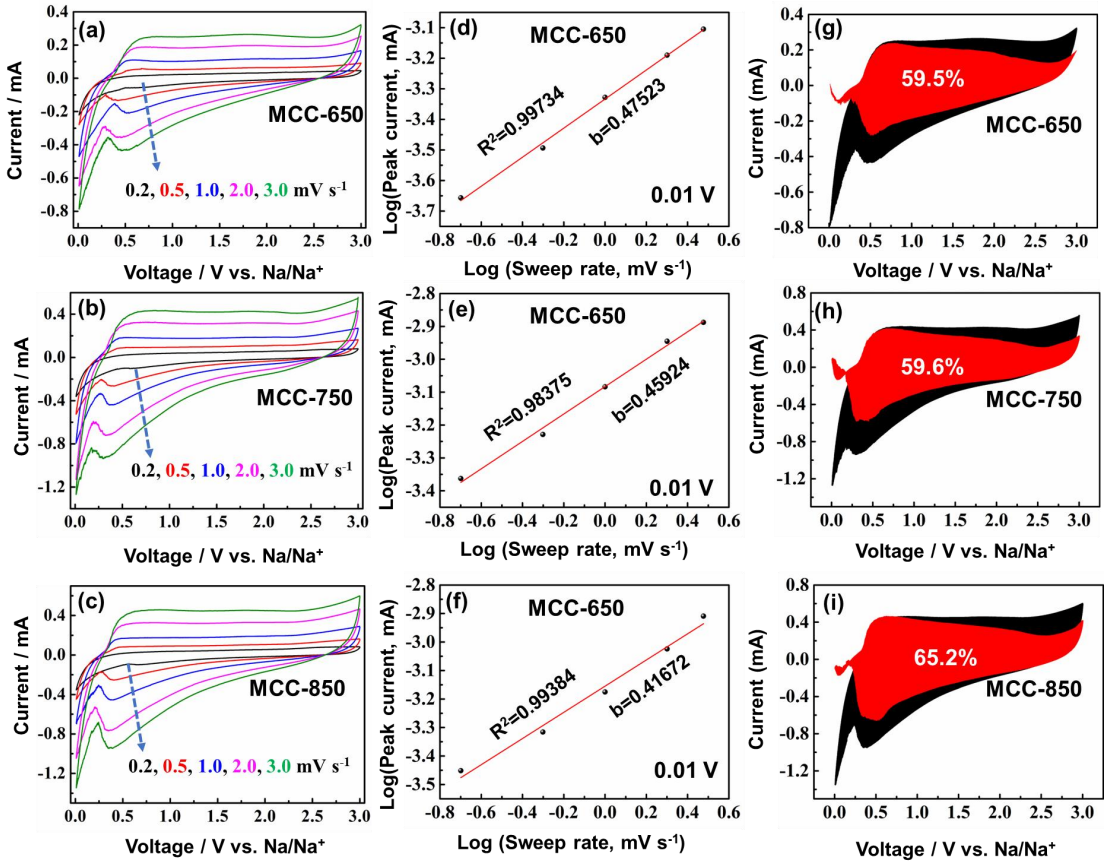

Figure S8. CV measurements of MCC materials at different rate scans (a-c). (d-f) are the b values of MCC materials. Capacitive contribution calculation results of MCC materials at a rate scan of 3.0 mV/s (g-i).

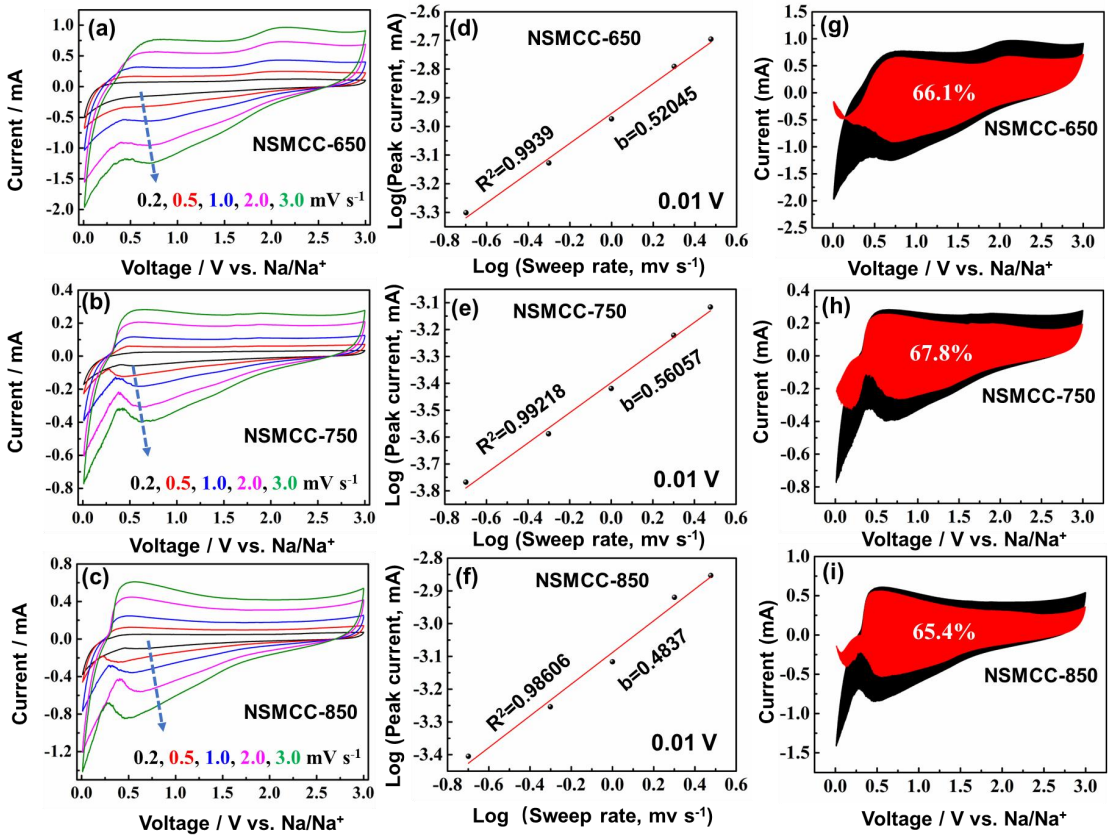

Figure S9. CV measurements of NSMCC materials at different rate scans (a-c). (d-f) are the b values of NSMCC materials. Capacitive contribution calculation results of NSMCC materials at a rate scan of 3.0 mV/s (g-i).

Table S6 The b values and capacitance ratios data of MCC and NSMCC samples.

Samples	b values	capacitance ratios (%)
MCC-650	0.475	59.5
MCC-750	0.459	59.6
MCC-850	0.417	65.2
NSMCC-650	0.520	66.1
NSMCC-750	0.561	67.8
NSMCC-850	0.484	65.4

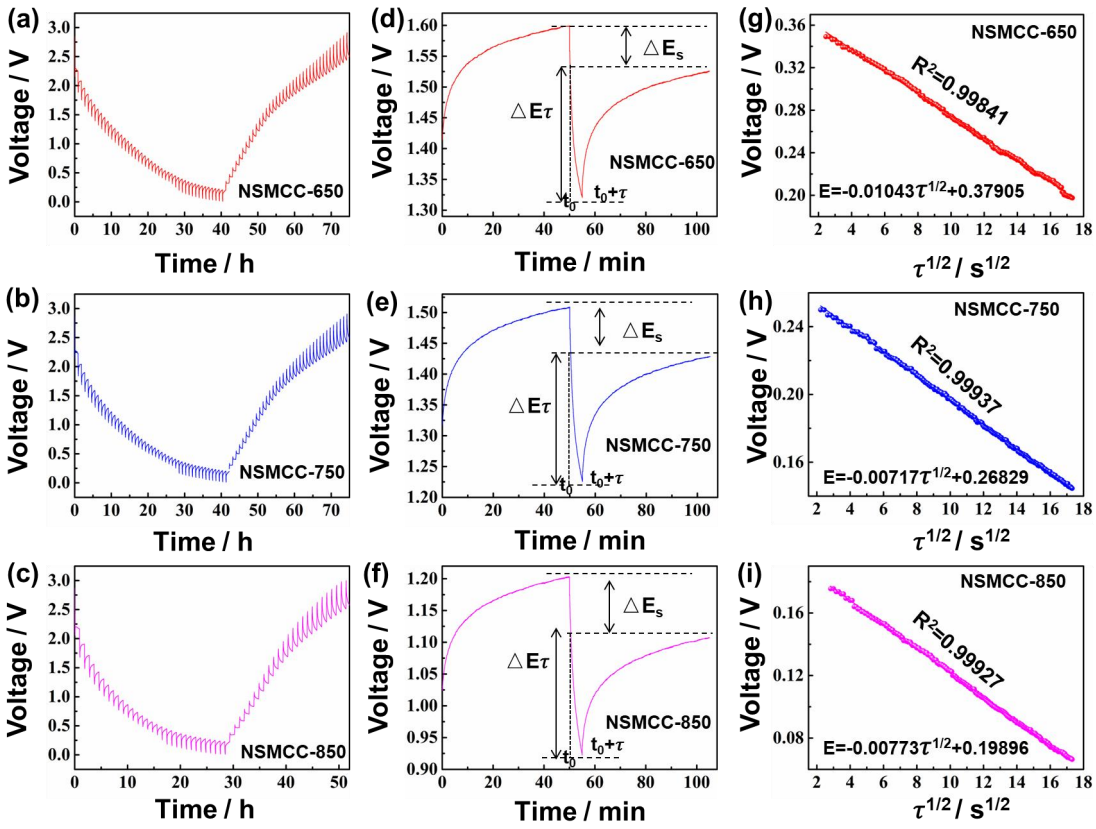

Figure S10. GITT titration curves (a-c) of MCC materials, titration curve of single GITT (d-f) and the relation of discharge voltage E vs $\tau^{1/2}$ (g-i).

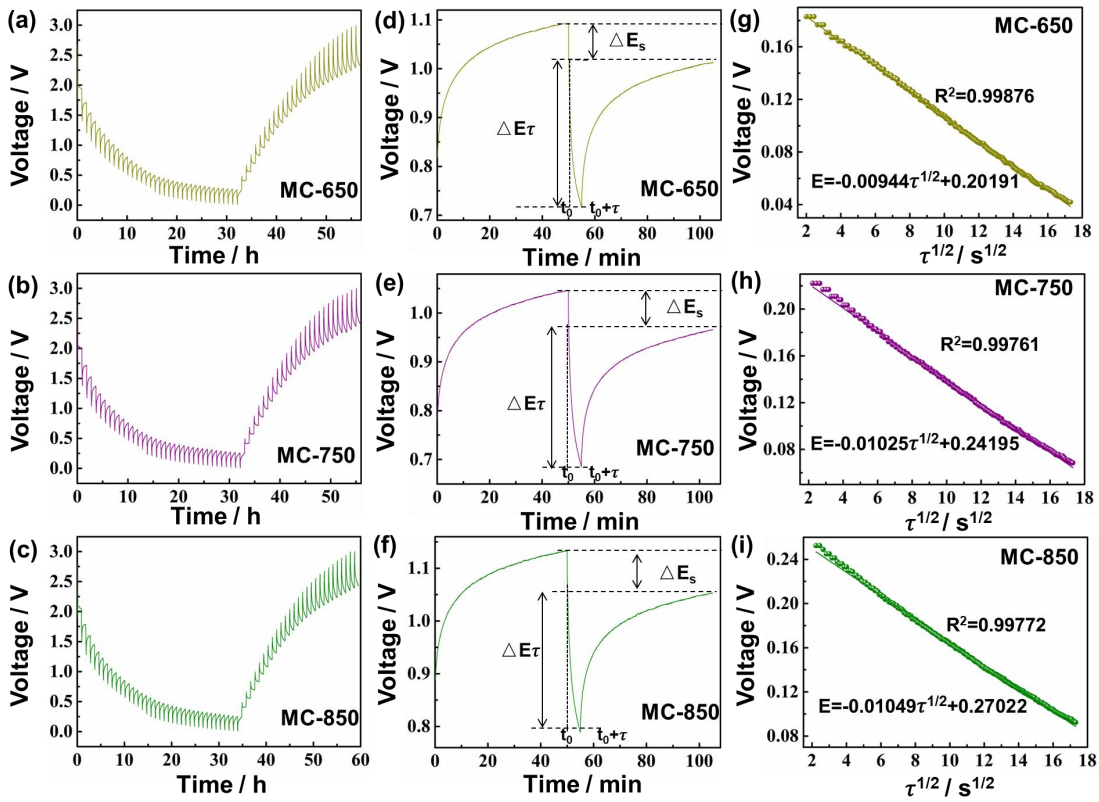

Figure S11. GITT titration curves (a-c) of NSMCC, titration curve of single GITT (d-f) and the relation of discharge voltage E vs $\tau^{1/2}$ (g-i).

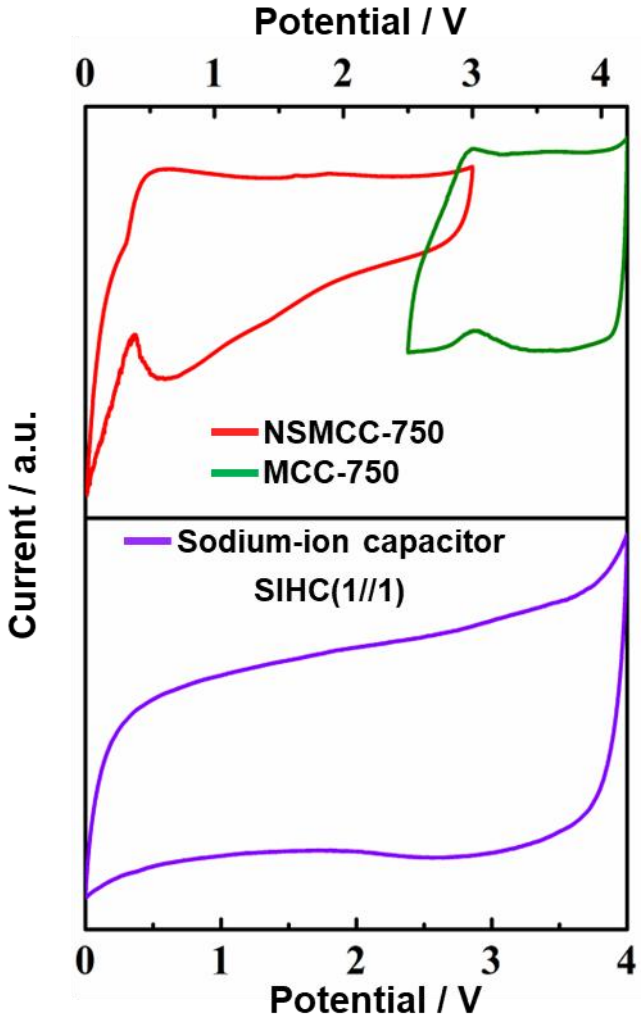

Figure S12. CV results of NSMCC-750, MCC-750 and SIHC(1//1).

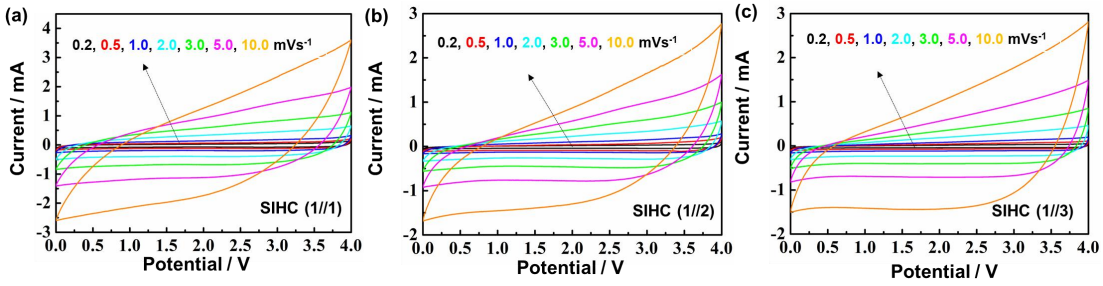

Figure S13. CV curves of SIHC(1//1) (a), SIHC(1//2) (b) and SIHC(1//3) (c) at various scan rates from 0.2 to 10.0 mV s^{-1}.

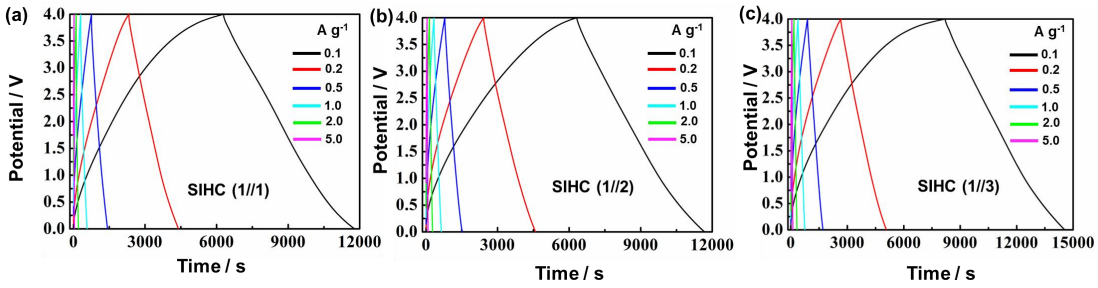

Figure S14. GCD curves of SIHC(1//1) (a), SIHC(1//2) (b) and SIHC(1//3) (c) are described at current densities from 0.1 A g^{-1} to 5.0 A g^{-1}.

Table S7 Specific capacities (F g^{-1}) of materials MCC and NSMCC materials at different current densities.

Samples	0.1 A g^{-1}	0.2 A g^{-1}	0.5 A g^{-1}	1 A g^{-1}	2 A g^{-1}	5 A g^{-1}
MCC-650	87.5	78.2	67.6	46.3	37.4	28
MCC-750	103.7	98.2	94.5	90.6	85.3	78.8
MCC-850	98.3	95.2	91.3	86.7	81.2	73.6
NSMCC-650	98.6	88.2	72.4	56.3	44.2	32.6
NSMCC-750	96	92.6	88.8	82.4	77.1	68.4
NSMCC-850	99.4	97.9	93.1	92	87	79.4

Table S8 Specific capacities (F g^{-1}) of SIHCs at different current densities.

	0.1 A g^{-1}	0.2 A g^{-1}	0.5 A g^{-1}	1 A g^{-1}	2 A g^{-1}	5 A g^{-1}
SIHC(1//1)	80.2	52.8	43.8	36.8	28.0	21.1
SIHC(1//2)	52.2	37.0	30.5	26.5	22.9	18.0
SIHC(1//3)	48.25	33.5	27.3	23.5	20.4	16.5

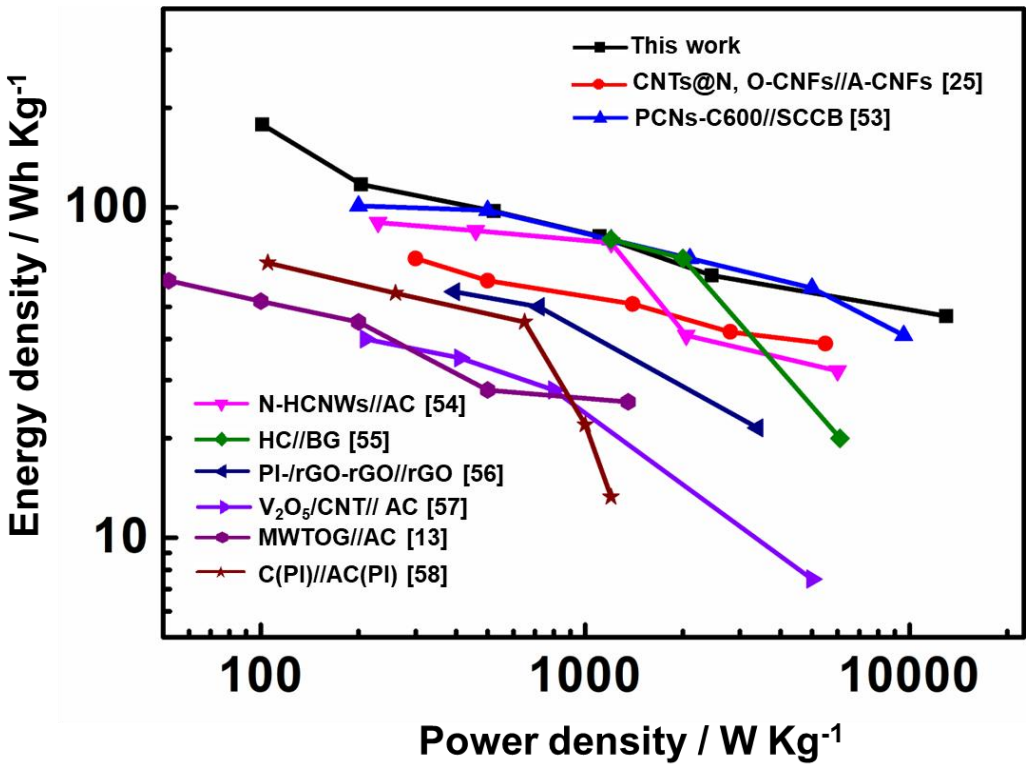

Figure S15. Ragone plots comparing SIHCs fabricated in our studies with other reported SIHCs.

Table S9 Specific capacitances of SIHC (1//1) and other reported materials at different current densities.

System (anode//cathode)	specific capacitances (F g^{-1}) at different current densities (A g^{-1})						Ref.
	0.1 (A g^{-1})	0.2 (A g^{-1})	0.5 (A g^{-1})	1.0 (A g^{-1})	2 (A g^{-1})	5 (A g^{-1})	
NSMCC-750//MCC-750 SIHC (1//1)	80.17 (F g^{-1})	52.81 (F g^{-1})	43.82 (F g^{-1})	36.84 (F g^{-1})	27.97 (F g^{-1})	21.12 (F g^{-1})	This work
PCNs-C600//SCCB	40.29 (F g^{-1})	36.95 (F g^{-1})	33.53 (F g^{-1})	29.64 (F g^{-1})	N/A	19.55 (F g^{-1})	53
CNTs@N, O-CNFs//A-CNFs	31 (F g^{-1})	N/A	N/A	N/A	20.2 (F g^{-1})	N/A	25

Table S10 Comparisons of the electrochemical performances of full-cell SIHCs.

System (anode//cathode)	Energy density (Wh Kg^{-1})	Power density (W Kg^{-1})	Capacity retention(%)/Cycle number/Current density(A/g)	Ref.
NSMCC-750//MCC-750 SIHC (1//1)	46.9	12957.6	64.5%/10000/2	This work
PCNs-C600//SCCB	41	9600	83%/8000/1	53
CNTs@N,O-CNFs//A-CNFs	38.7	5500	48.6%/5000/0.5	25
N-HCNWs//AC	37.5	9000	70%/2000/2	54
HC//BG	20	6100	97%/5000/1	55
PI-/rGO-rGO//rGO	21.5	3400	60%/1000/0.1	56
V_2O_5/CNT// AC	7.5	5000	N/A	57
MWTOG//AC	25.8	1357	90%/10000/3.4	13
C(PI)//AC(PI)	13.3	1200	82.4%/1000/0.4	58