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Electronic supplementary information

A High-Power Lithium-Ion Hybrid Capacitor based on the Hollow N-Doped Carbon Nanobox Anode and its Porous Analogue cathode

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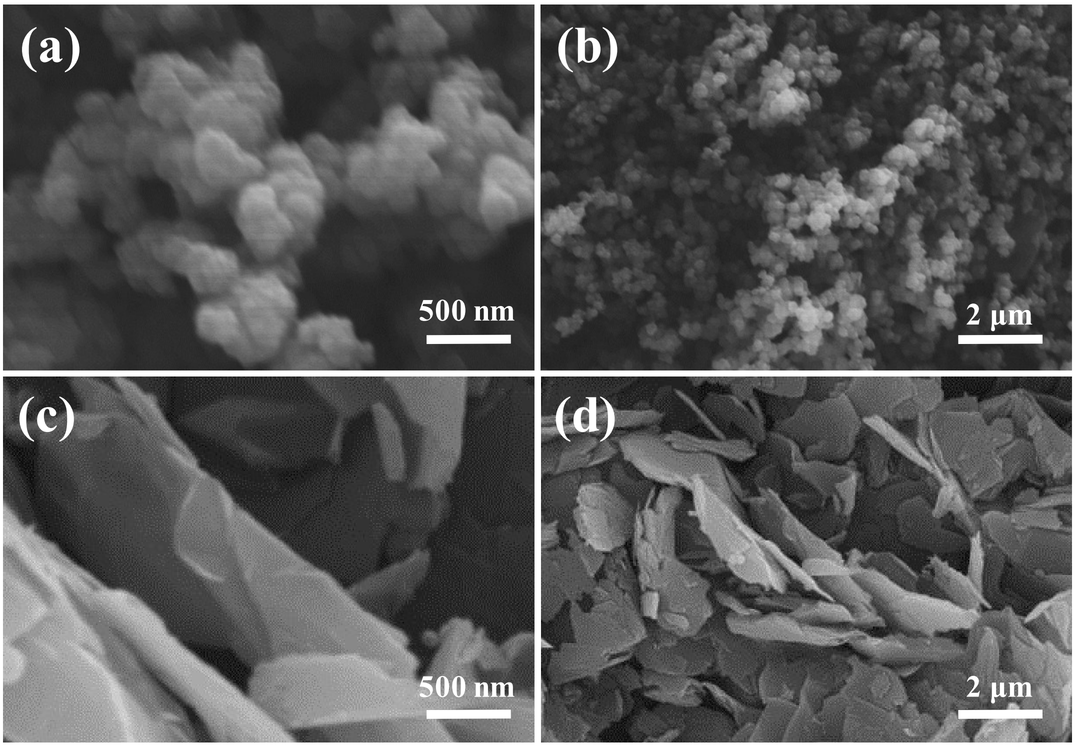

Fig. S1 SEM images of (a, b) NCBK and (c, d) flake graphite.

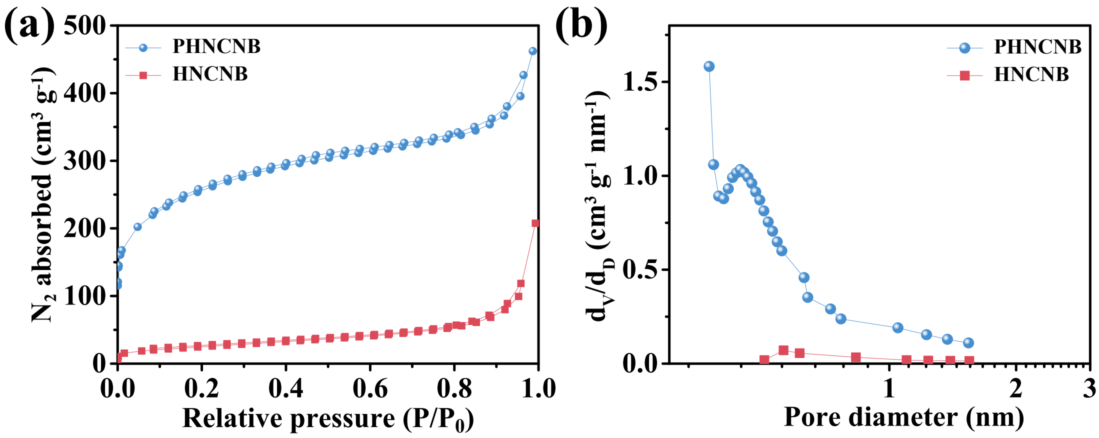

Fig. S2 (a) Nitrogen adsorption/desorption isotherms and (b) pore-size distribution curve of HNCNB and PHNCNB.

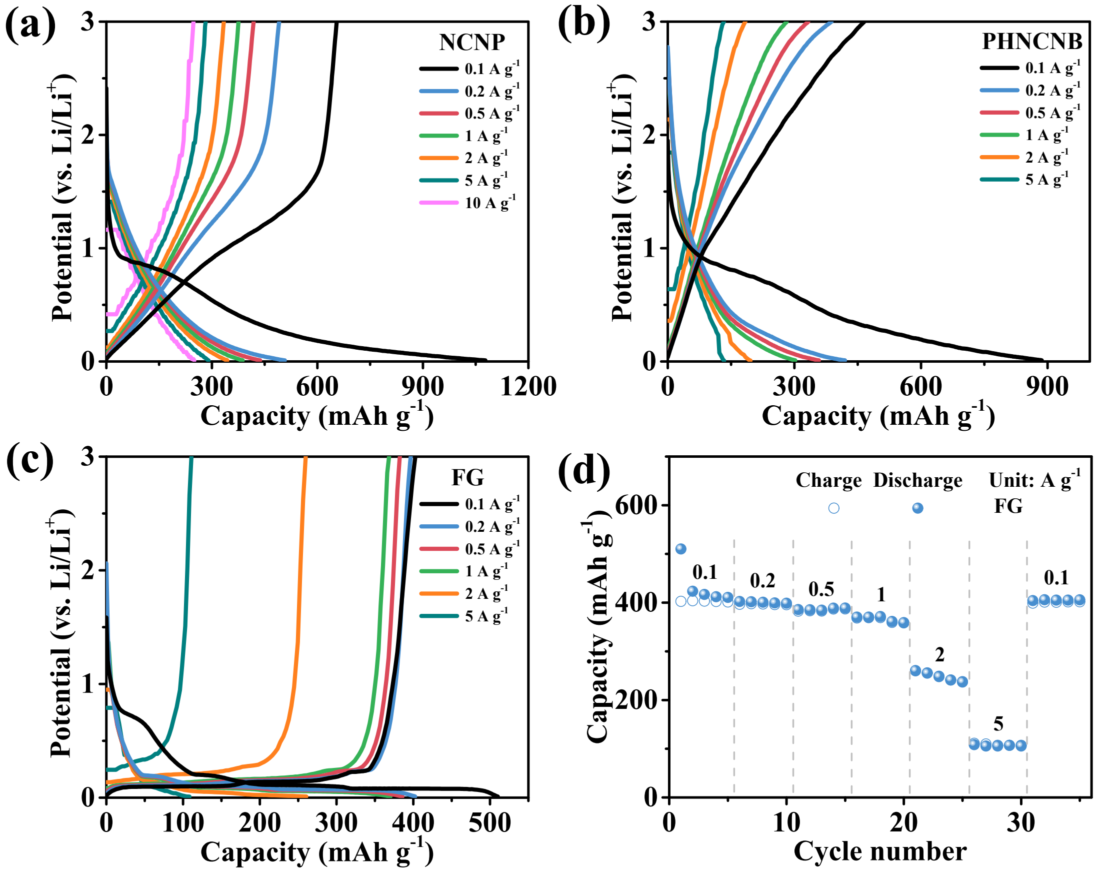

Fig. S3. GCD curves of (a) NCNP, (b) PHNCNB and (c) FG, (d) rate performance of FG.

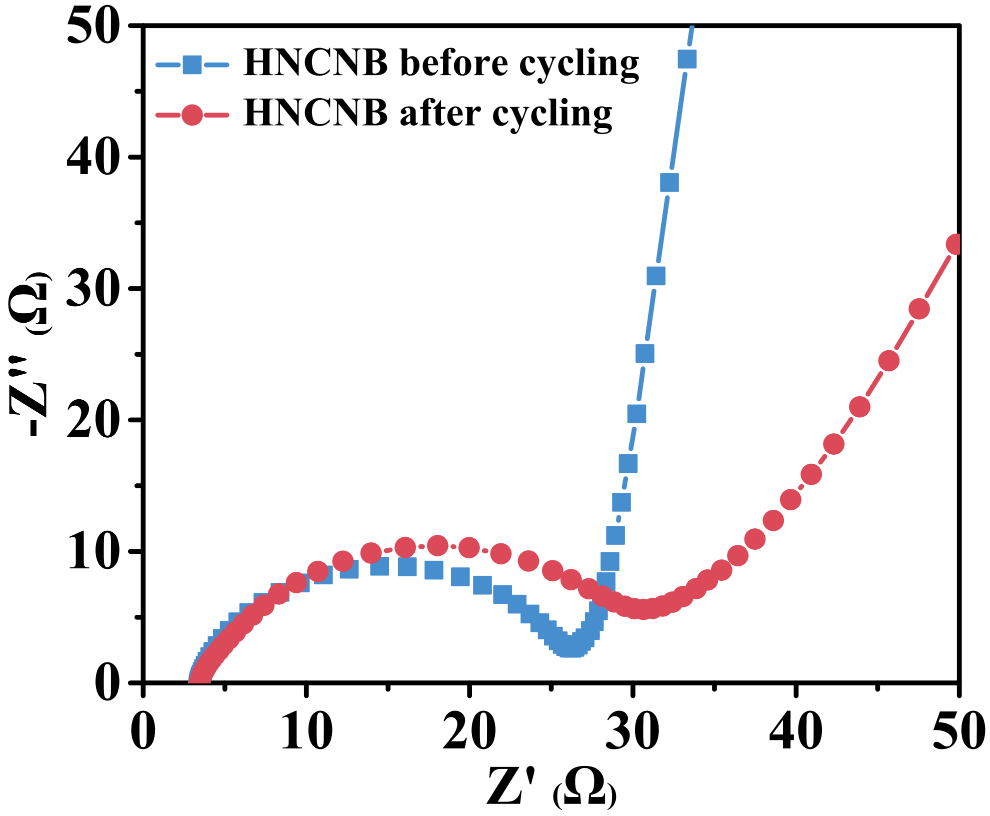

Fig. S4. EIS spectra of HNCNB before and after cycling.

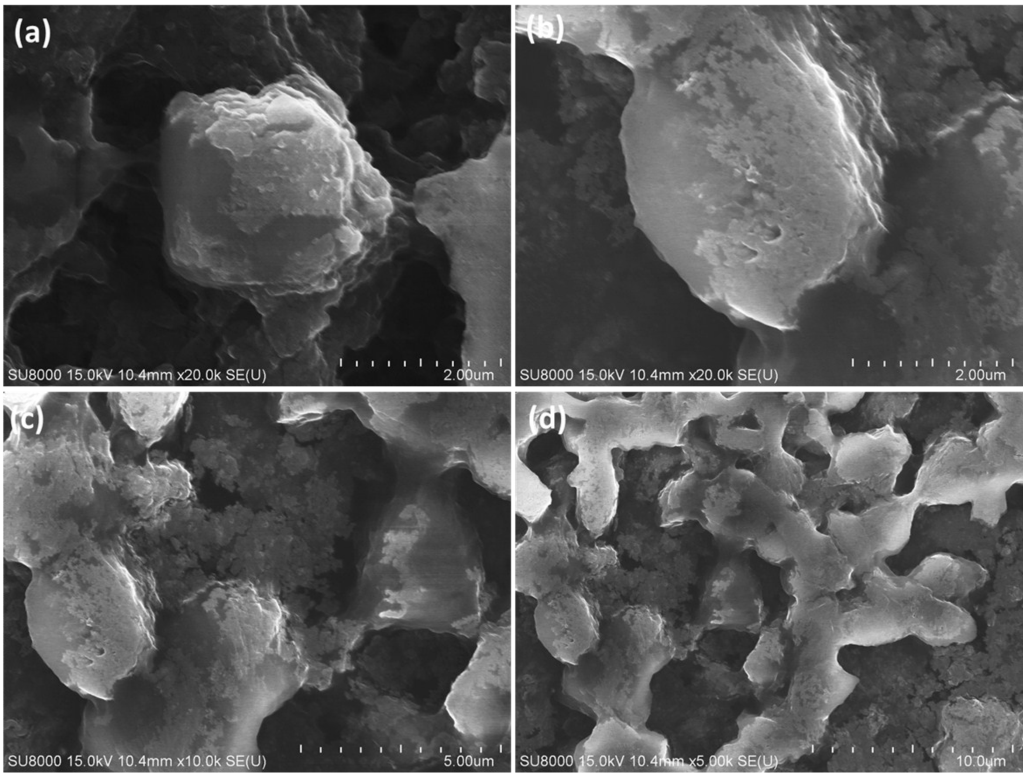

Fig. S5 SEM images of the HNCNB anode after 2000 cycles at 5.0 A g^{-1}.

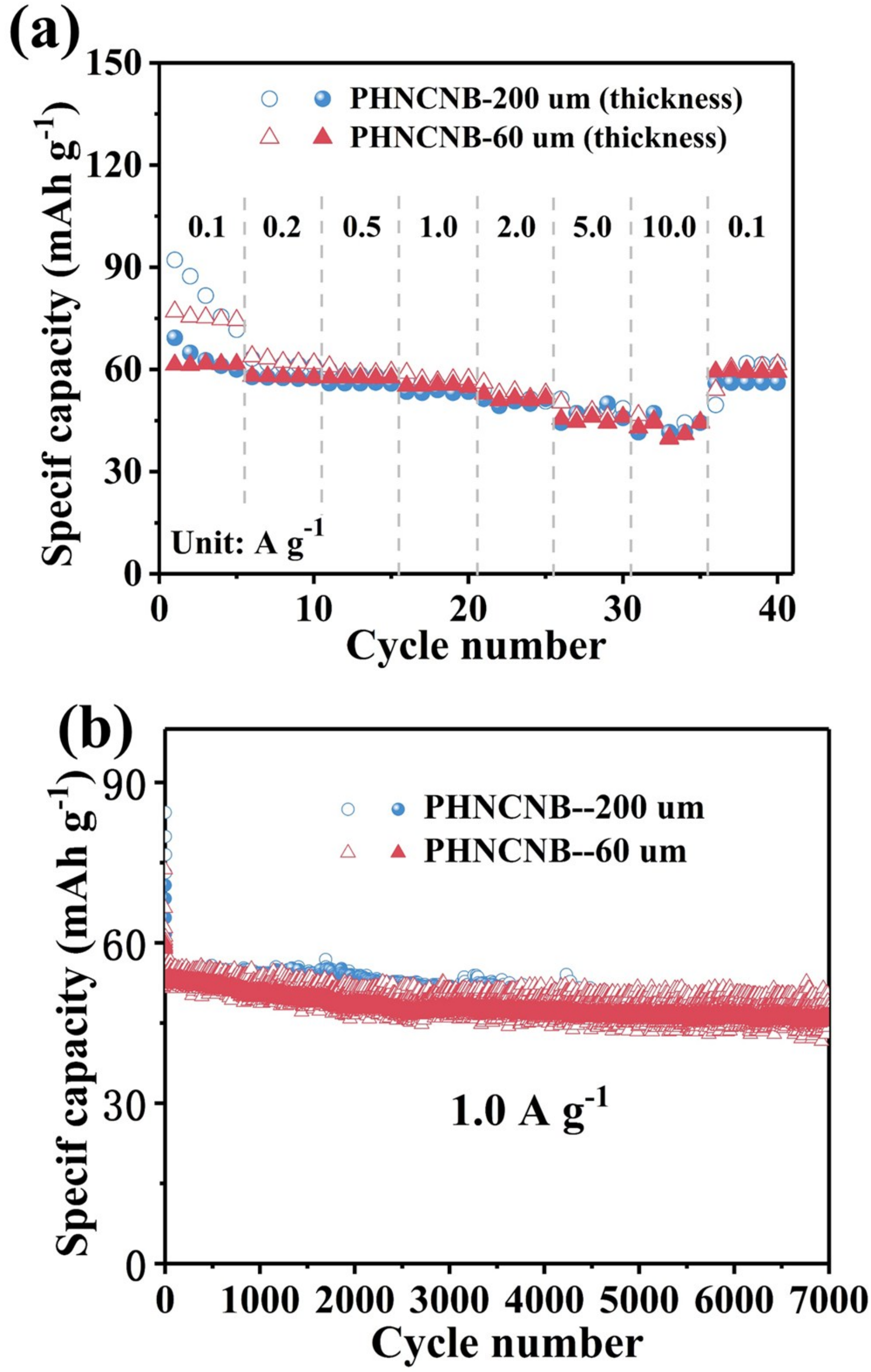

Fig. S6. (a) Rate capability and (b) cycling performance of the PHNCNB cathode with two different electrode thicknesses (60 and 200 μm) in half-cells.

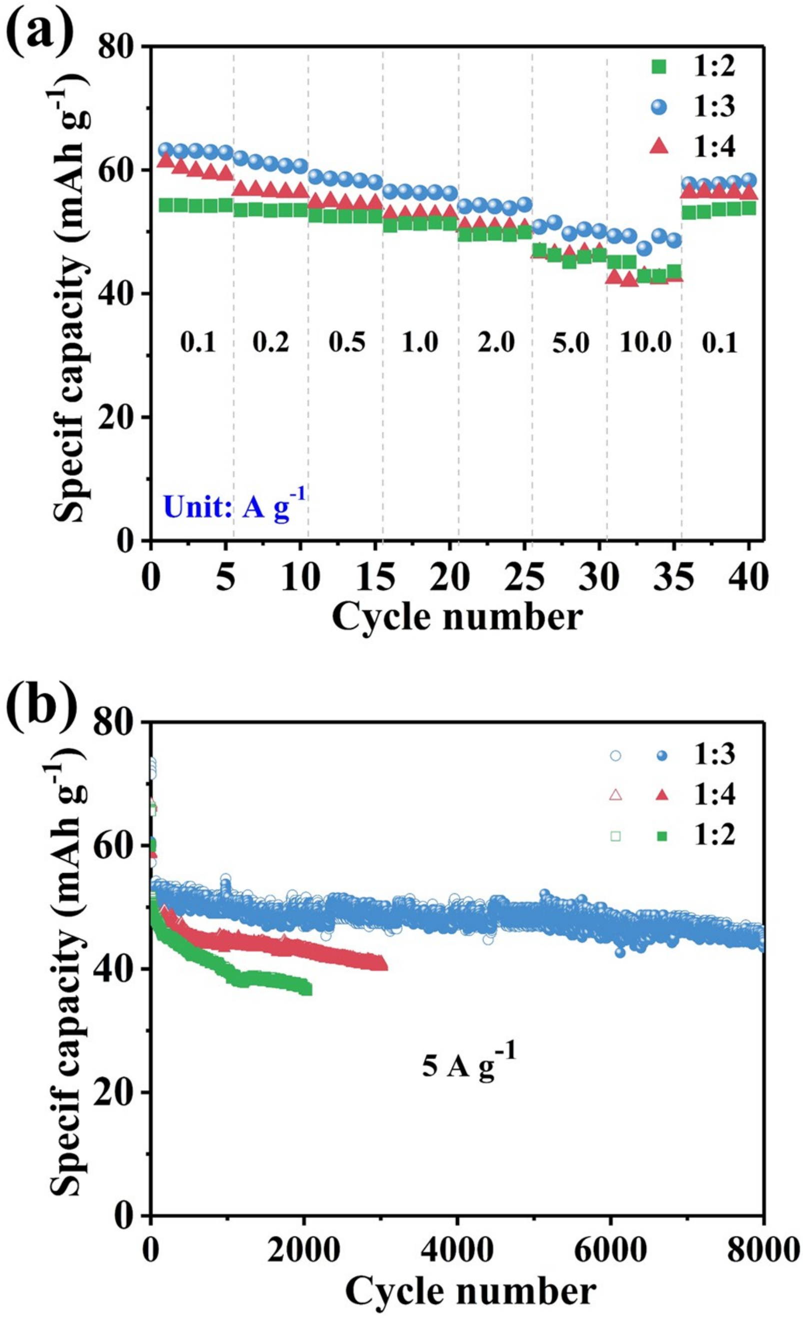

Fig. S7. (a) Rate capability and (b) cycling performance of the HNCNB//PHNCNB hybrid capacitors with different anode to cathode mass ratios.

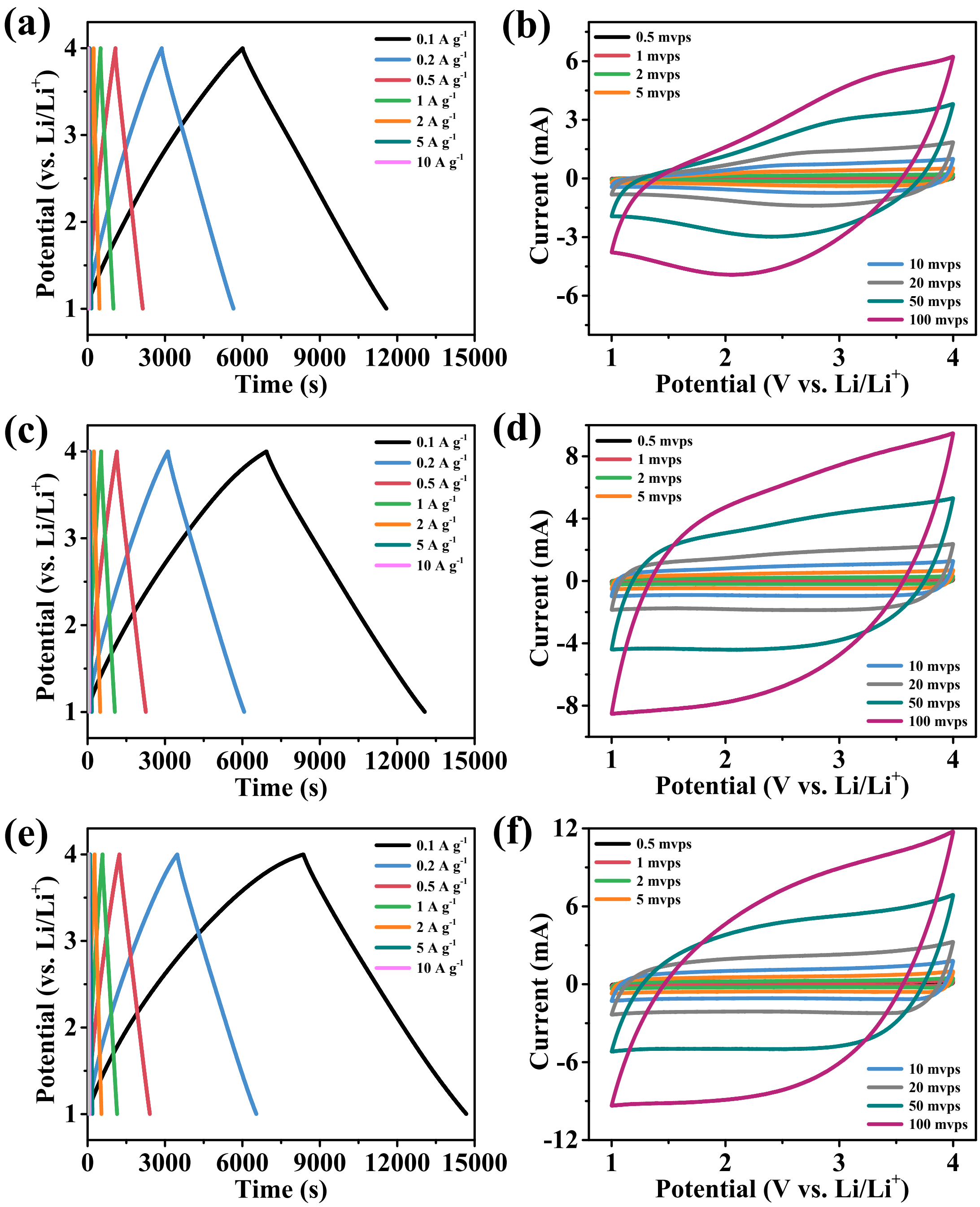

Fig. S8. GCD and CV curves of LIHC measured at (a, b) 0 ˚C, (c, d) 25 ˚C, (e, f) 60 ˚C.

Table S1. Percentage (Atomic %) of various element and functional groups in HNCNB and PHNCNB.

	HNCNB	PHNCNB
C1s %	84.18	92.75
N1s %	13.19	2.61
O1s %	2.63	4.64
C-C %	54.96	67.32
C-N %	30.20	19.77
C-O %	14.84	12.91
Pyridinic-N %	31.86	17.31
Pyrrolic-N %	19.69	22.31
Quarternary-N %	42.32	42.92
Oxidize-N %	6.13	17.46

Table S2. Cycling and rate performance of various carbon materials as anode in Li half cells.

Materials	Cycling stability	Rate performance	Ref.
NSPCs	1150 mAh g^{-1} at 0.39 A g^{-1} after 100 cycles	390 mAh g^{-1} at 7.8 A g^{-1} 353 mAh g^{-1} at 11.72 A g^{-1} 325 mAh g^{-1} at 15.62 A g^{-1}	1
N-PCS	538 mAh g^{-1} at 0.5 A g^{-1} after 100 cycles	410 mAh g^{-1} at 1 A g^{-1} 293 mAh g^{-1} at 2 A g^{-1} 215 mAh g^{-1} at 3 A g^{-1}	2
PNG	2244 mAh g^{-1} at 0.15 A g^{-1} after 50 cycles 438 mAh g^{-1} at 5 A g^{-1} after 1500 cycles	1040 mAh g^{-1} at 0.5 A g^{-1} 745 mAh g^{-1} at 1 A g^{-1}	3
AMC	429 mAh g^{-1} at 1 A g^{-1} after 200 cycles	326 mAh g^{-1} at 1 A g^{-1} 275 mAh g^{-1} at 2 A g^{-1} 203 mAh g^{-1} at 5 A g^{-1}	4
ANCS	1367 mAh g^{-1} at 0.1 A g^{-1} after 100 cycles 638 mAh g^{-1} at 2 A g^{-1} after 2000 cycles	467 mAh g^{-1} at 2 A g^{-1} 330 mAh g^{-1} at 4 A g^{-1} 301 mAh g^{-1} at 5 A g^{-1}	5
NB-PCNFs	816 mAh g^{-1} at 0.1 A g^{-1} after 50 cycles 636 mAh g^{-1} at 2 A g^{-1} after 200 cycles	581 mAh g^{-1} at 0.5 A g^{-1} 459 mAh g^{-1} at 1 A g^{-1} 376 mAh g^{-1} at 3 A g^{-1}	6
BNC	444 mAh g^{-1} at 2 A g^{-1} after 5000 cycles	521 mAh g^{-1} at 2 A g^{-1} 371 mAh g^{-1} at 5 A g^{-1} 270 mAh g^{-1} at 10 A g^{-1}	7
NHCS-O	616 mAh g^{-1} at 0.5 A g^{-1} after 250 cycles	503 mAh g^{-1} at 1.5 A g^{-1}	8
G-graphitic HCS	935 mAh g^{-1} at 0.1 A g^{-1} after 100 cycles 595 mAh g^{-1} at 1 A g^{-1} after 1000 cycles	410 mAh g^{-1} at 5 A g^{-1}	9
graphene hollow spheres	424 mAh g^{-1} at 1 A g^{-1} after 100 cycles	382.1 mAh g^{-1} at 1 A g^{-1} 316.9 mAh g^{-1} at 2 A g^{-1} 249.3 mAh g^{-1} at 5 A g^{-1}	10
NCSs	660 mAh g^{-1} at 0.05 A g^{-1} after 50 cycles	341 mAh g^{-1} at 0.5 A g^{-1} 255 mAh g^{-1} at 1 A g^{-1}	11

N-MCHSs	485 mAh g^{-1} at 0.5 A g^{-1} after 1100 cycles	214 mAh g^{-1} at 4 A g^{-1}	[12]
hN-CCs	750 mAh g^{-1} at 2 A g^{-1} after 600 cycles	285 mAh g^{-1} at 20 A g^{-1}	[13]
	669 mAh g^{-1} at 0.2 A g^{-1} after 200 cycles	440 mAh g^{-1} at 5 A g^{-1}	Our
HNCNB	537.3 mAh g^{-1} at 1 A g^{-1} after 500 cycles	392 mAh g^{-1} at 10 A g^{-1}	wor
	344.5 mAh g^{-1} at 5 A g^{-1} after 2000 cycles	322 mAh g^{-1} at 20 A g^{-1}	k

Table S3. Electrochemical performance of various LICs.

Hybrid systems (anode//cathode)	Voltage window (V)	Energy density and corresponding power density	Cycling stability	Ref.
$Li_4Ti_5O_{12}$-graphene//AC	1.0-2.5	30 Wh kg^{-1} at 1000 W kg^{-1} 4 Wh kg^{-1} at 15000 W kg^{-1}	84% after 10000 cycles	14
Graphene-$Li_4Ti_5O_{12}$//Graphene	0.8-2.5	95 Wh kg^{-1} at 45 W kg^{-1} 32 Wh kg^{-1} at 3000 W kg^{-1}	87% after 500 cycles	15
TiO_2-rGO//AC	1.0-4.5	42 Wh kg^{-1} at 800 W kg^{-1} 8.9 Wh kg^{-1} at 8000 W kg^{-1}	80% after100 cycles	16
TiO_2 NBA//graphene	0-3.8	82 Wh kg^{-1} at 570 W kg^{-1} 21 Wh kg^{-1} at 19000 W kg^{-1}	73% after 600 cycles	17
TiP_2O_7//AC	0-3	13 Wh kg^{-1} at 46 W kg^{-1}	Stable for 100–500 cycles	18
CNT-V_2O_5//AC	1.8-4.0	25.5 Wh kg^{-1} at 40 W kg^{-1} 6.9 Wh kg^{-1} at 6300 W kg^{-1}	80% after 10000 cycles	19
Graphite//URGO	2.0-4.0	106 Wh kg^{-1} at 84 W kg^{-1} 85 Wh kg^{-1} at 4200 W kg^{-1}	100% after 1000 cycles	20
Graphite//AC	1.5-4.5	103.8 Wh kg^{-1} at 10000 W kg^{-1}	85% after 10000 cycles	21
Fe_3O_4-graphene//graphene	1.0-4.0	147 Wh kg^{-1} at 150 W kg^{-1} 86 Wh kg^{-1} at 2587 W kg^{-1}	70% after 1000 cycles	22
Si-C//AC	2.0-4.5	230 Wh kg^{-1} at 1747 W kg^{-1}, 141 Wh kg^{-1} at 30127 W kg^{-1}	76.3% after 8000 cycles	23
B-Si-SiO_2-C//PSC	2.0-4.5	128 Wh kg^{-1} at 1229 W kg^{-1} 89 Wh kg^{-1} at 9704 W kg^{-1}	70% after 6000 cycles	24
3D-MnO-CNS//CNS	1.0-4.5	184 Wh kg^{-1} at 83 W kg^{-1} 90 Wh kg^{-1} at 15000 W kg^{-1}	76% after 5000 cycles	25

Nb_2O_5-C//AC	1.0-3.5	63 Wh kg^{-1} at 70 W kg^{-1} 5 Wh kg^{-1} at 16528 W kg^{-1}	nearly no fading after 1000 cycles	[26]
Nb_2O_5-graphene paper//AC	0.01-3.0	47 Wh kg^{-1} at 393 W kg^{-1} 15 Wh kg^{-1} at 18000 W kg^{-1}	93% after 2000 cycles	[27]
Graphene-VN//carbon nanorods	0-4.0	162 Wh kg^{-1} at 200 W kg^{-1} 64 Wh kg^{-1} at 10000 W kg^{-1}	86% after 1000 cycles	[28]
TiC//PHPNC	0-4.5	101.5 Wh kg^{-1} at 450 W kg^{-1} 23.4 Wh kg^{-1} at 67500 W kg^{-1}	83% after 5000 cycles	[29]
SnO_2-C//C	0.5-4.5	110 Wh kg^{-1} at 190 W kg^{-1} 45 Wh kg^{-1} at 2960 W kg^{-1}	80% after 5000 cycles	[30]
$H_2Ti_6O_{13}$//CMK-3	1-3.5	90 Wh kg^{-1} at 11000 W kg^{-1}	80% after 1000 cycles	[31]
$MnFe_2O_4$//3DaC	0-4.0	157 Wh kg^{-1} at 200 W kg^{-1} 58 Wh kg^{-1} at 22000 W kg^{-1}	86.5% after 6000 cycles	[32]
BNC//BNC	0-4.5	220 Wh kg^{-1} at 225 W kg^{-1} 104 Wh kg^{-1} at 22500 W kg^{-1}	81% after 5000 cycle	[7]
ANCS//ANCS	0-4.5	207.6 Wh kg^{-1} at 225 W kg^{-1} 115.4 Wh kg^{-1} at 22500 W kg^{-1}	86% after 10000 cycles	[5]
Hard carbon//AC	2.0-4.2	85.7 Wh kg^{-1} at 7600 W kg^{-1}	96% after 5000 cycles	[33]
HC//AC	2.0-4.0	73.6 Wh kg^{-1} at 69.2 W kg^{-1} 36.6 Wh kg^{-1} at 11900 W kg^{-1}	83% after 10000 cycles	[34]
AMC//PdCS	0.5-4	133 Wh kg^{-1} at 210 W kg^{-1} 42 Wh kg^{-1} at 11200 W kg^{-1}	81.8% after 5000 cycles	[4]
MCMB//AC	2-4	92.3 Wh kg^{-1} at 55 W kg^{-1} 22.6 Wh kg^{-1} at 5500 W kg^{-1}	97 % after 1000 cycles	[35]
HNCNB//PHNCNB	1.0-4.0	148.5 Wh kg^{-1} at 250 W kg^{-1} 112.1 Wh kg^{-1} at 25000 W kg^{-1}	90% after 8000 cycles	Our work

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