Support imformation

Facile synthesis of $Co_{3-x}Mn_xO_4$/C nanocages as an efficient sulfur host for lithium-sulfur batteries with enhanced rate performance

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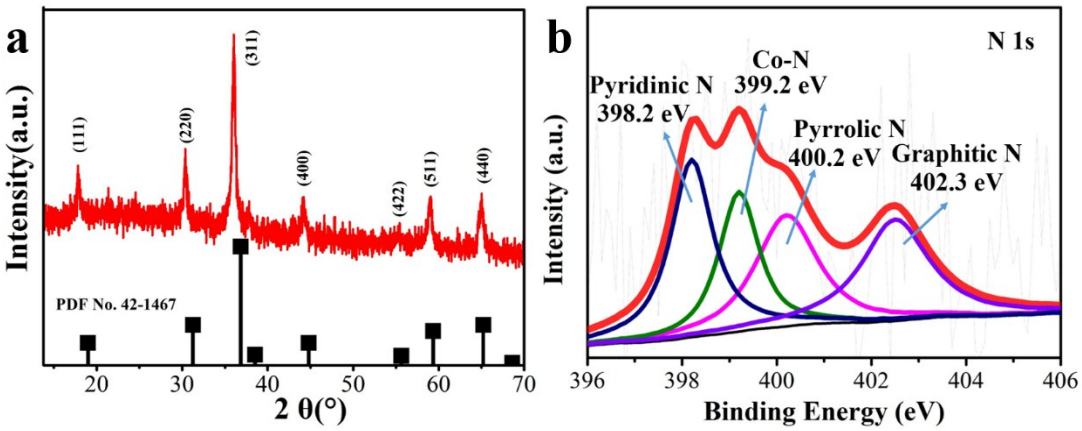

Fig. S1 (a) XRD pattern of $Co_{3-x}Mn_xO_4$/C nanocages. (b) The XPS pattern of N in $Co_{3-x}Mn_xO_4$/C/S.

Element	Mass percent (wt%)	Atomic percentage (%)
O	38.9	47.1
Co	30.0	9.9
C	20.2	32.6
N	6.4	8.9
Mn	4.5	1.6

Table. S1 EDS of a single $Co_{3-x}Mn_xO_4$/C nanocage.

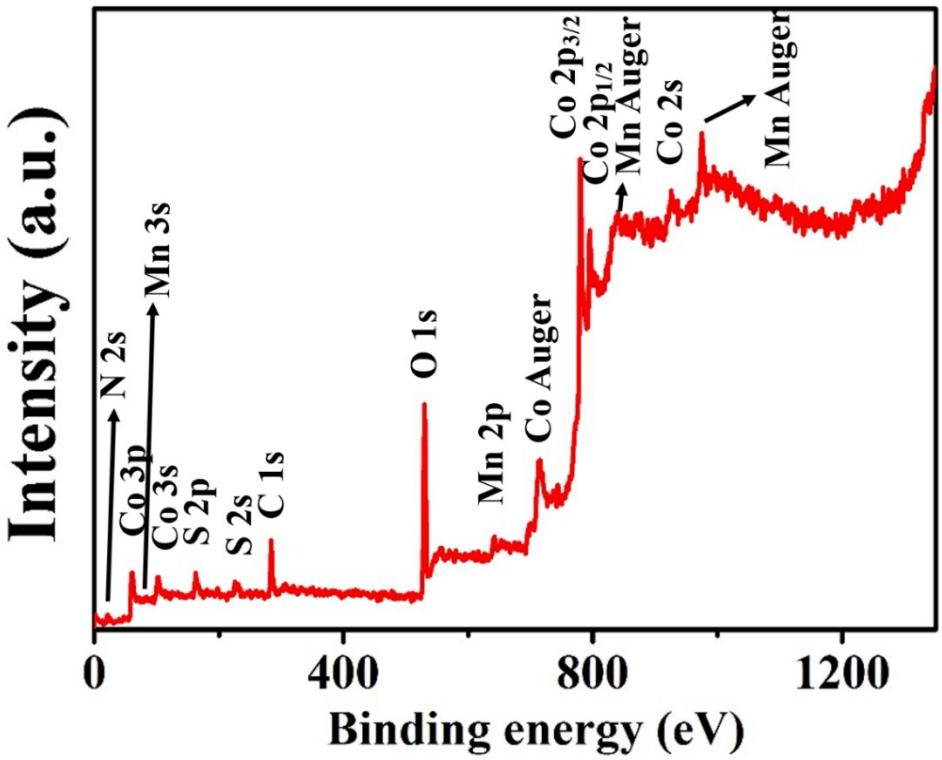

Fig. S2 XPS pattern of $Co_{3-x}Mn_xO_4$/C nanocages.

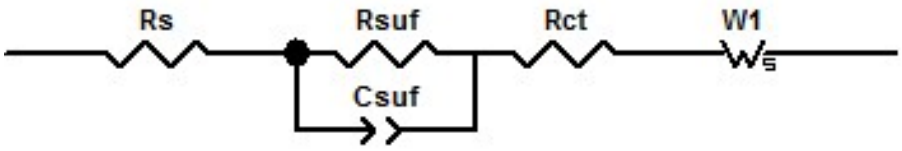

Fig. S3 Equivalent circuit of battery contained $Co_{3-x}Mn_xO_4$/C/S electrodes at 5 C.

Cycle Number	Rs	Rsuf	Rct
1 st	4.9	72.7	71.3
10 th	10.2	95.8	82.6
100 th	13.3	256.3	266.3
500 th	15.1	357.0	370.3

Table. S2 Parameters of the every part of an analog circuit of $Co_{3-x}Mn_xO_4$/C/S.

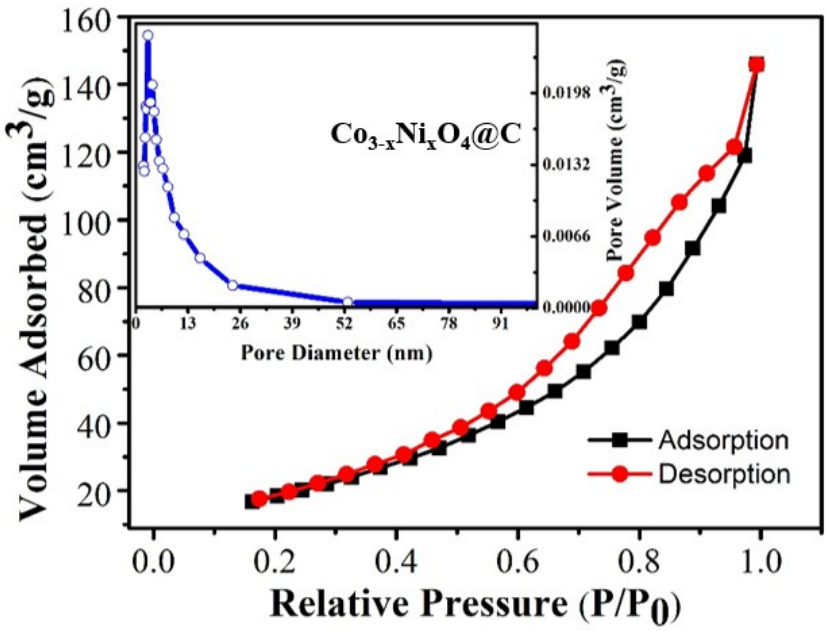

Fig.S4 N_2 adsorption-desorption isotherm curves of $Co_{3-x}Ni_xO_4$/C nanocages.

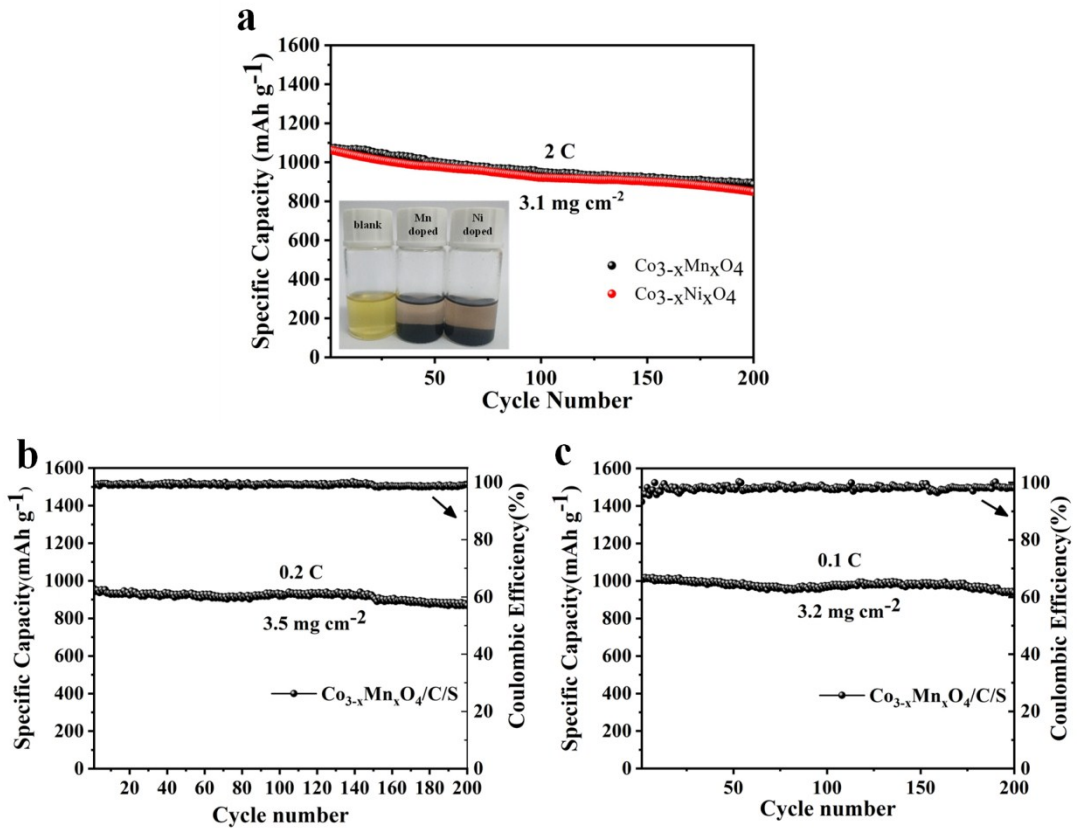

Fig. S5 (a) Discharge capacity of the $Co_{3-x}Mn_xO_4$/C nanocages/S and Discharge capacity of the $Co_{3-x}Ni_xO_4$/C nanocages/S electrodes electrodes cycled at rate of 2 C, and the corresponding photos (inset). (b) Discharge capacity of the $Co_{3-x}Mn_xO_4$/C nanocages/S electrodes cycled with S loading of 3.5 mg cm^{-2}. (c) Discharge capacity of the $Co_{3-x}Mn_xO_4$/C nanocages/S with S loading of 3.2 mg cm^{-2}.

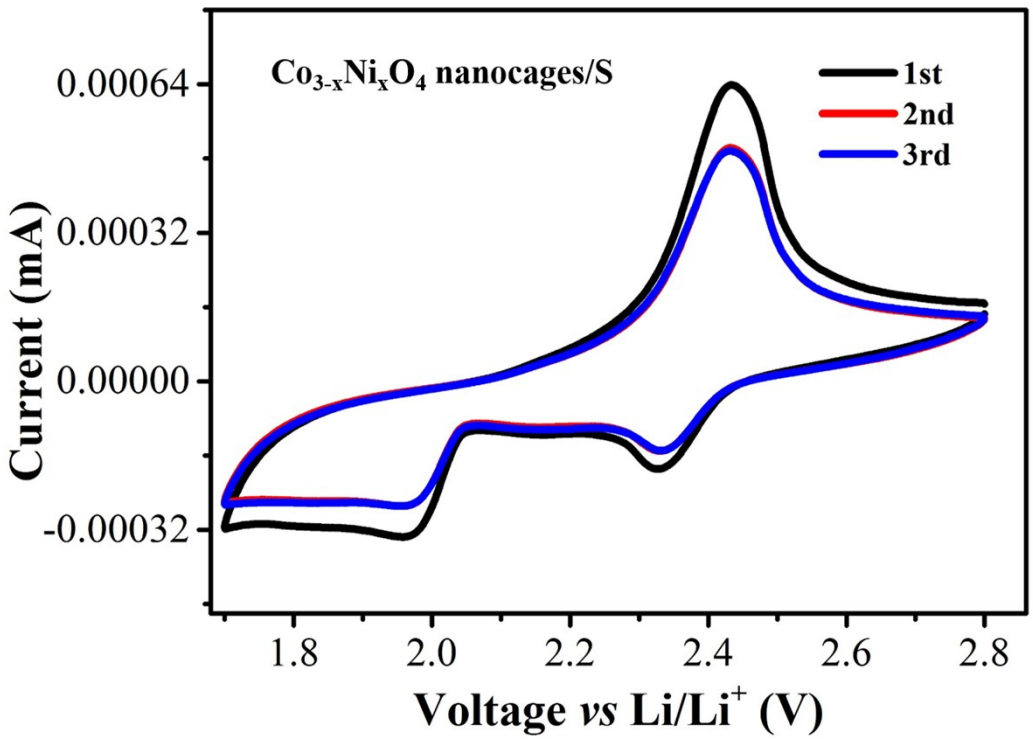

Fig. S6 CV tested between 1.7 and 2.8 V at a sweep rate of 0.1 mV s^{-1} for $Co_{3-x}Ni_xO_4$/C/S.

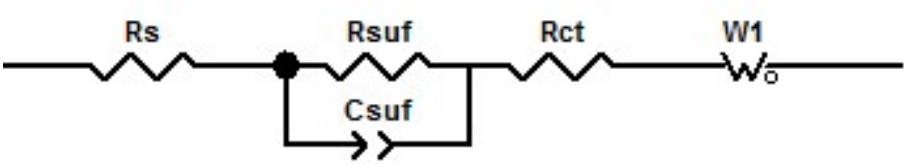

Fig. S7 Aquivalent circuit of battery contained $Co_{3-x}Ni_xO_4$/C/S electrodes at 2 C.

Cycle Number	Rs	Rsuf	Rct
1 st	10.5	97.0	66.7
200 th	25.8	515.3	520.5

Table. S3 Parameters of the every part of an analog circuit of $Co_{3-x}Ni_xO_4$/C/S.

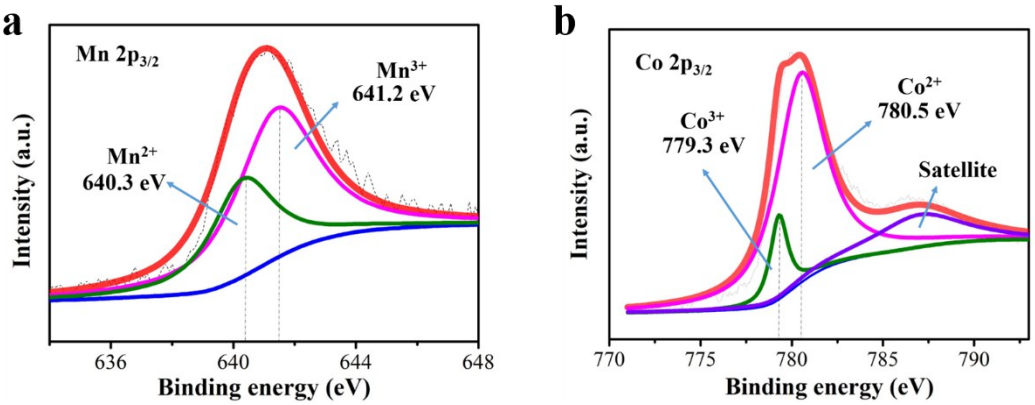

Fig. S8 The XPS pattern of $Co_{3-x}Mn_xO_4$/C nanocages after absorbing Li_2S_4: (a) Mn2p; (b) Co2p.

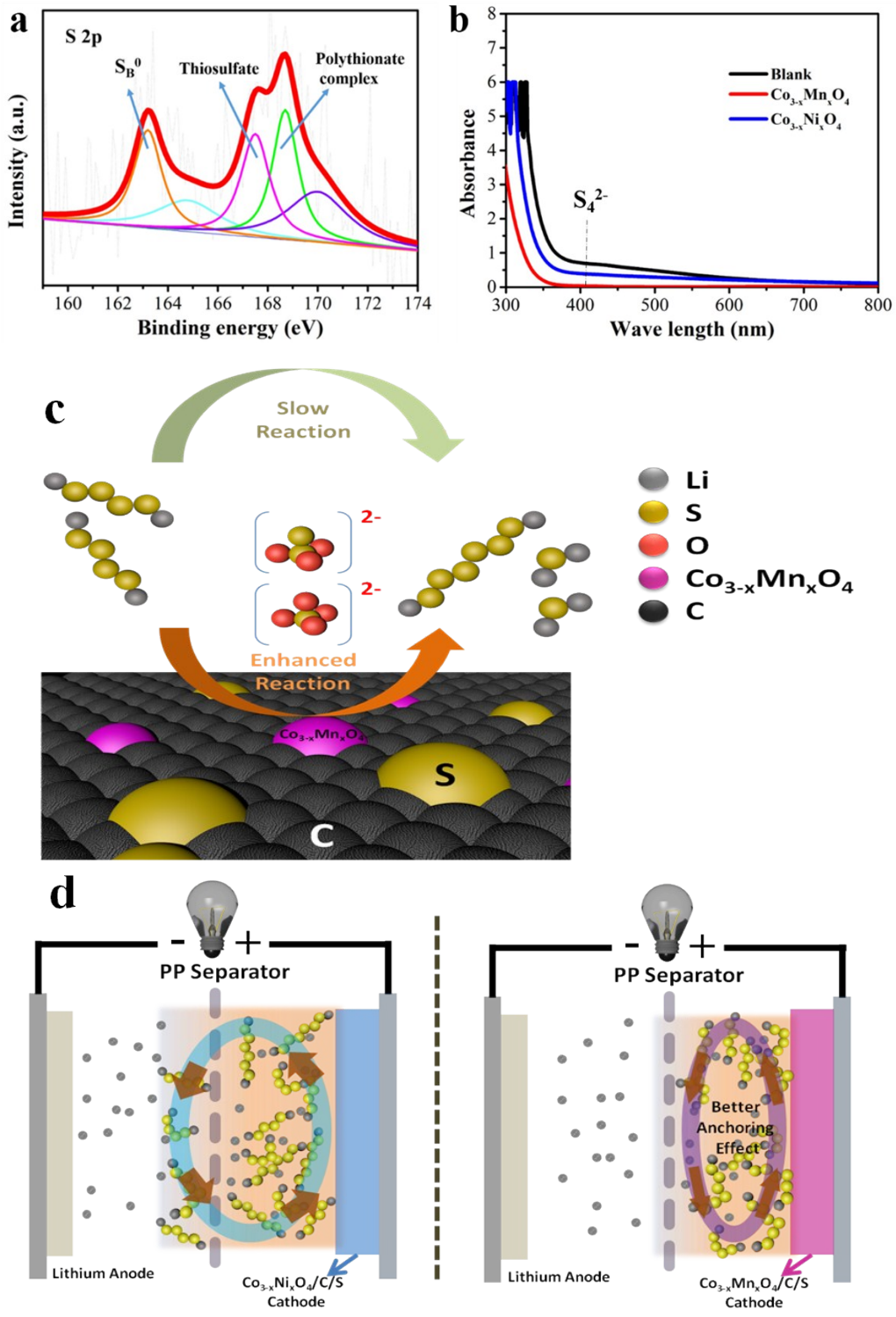

Fig. S9 (a) The XPS pattern of S after absorbing test. (b) UV-vis spectra of supernatant of Li_2S_4 solution after the adsorption test. (c) Schematic illustration of $Co_{3-x}Mn_xO_4$ promoting the conversion of lithium polysulfides (LiPSs). (d) Schematic illustration of anchoring effect comparison.

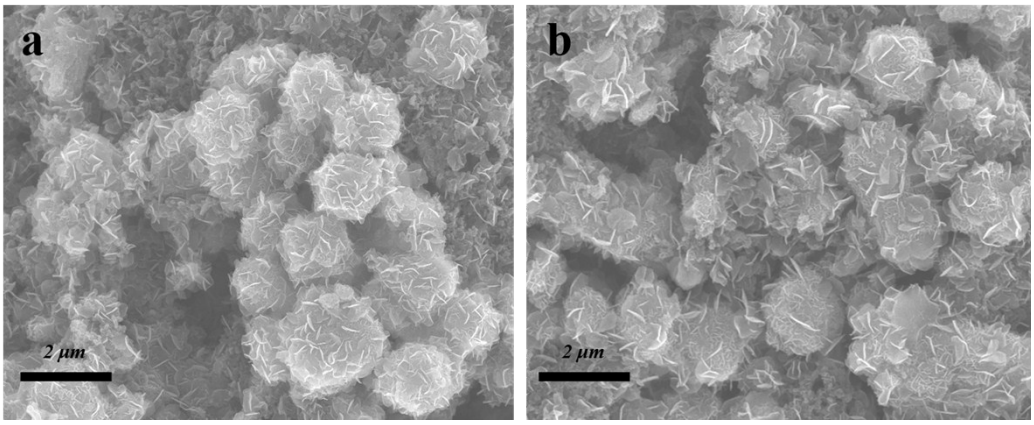

Fig. S10 The FESM images of $Co_{3-x}Ni_xO_4$/C/S after running for (a) 100 cycles and (d) 200 cycles at a rate of 2 C in coin cells.

Matrix	Areal sulfur loading (mg cm^{-2})	Sulfur content (wt%)	Final capacity (mAh g^{-1})	Rate /current density	Capacity retention (%)	Cycle numbers	Rate performance (mAh g^{-1})	Ref.
$Co_{3-x}Mn_xO_4$/C	1.3	66	893	1 C	82.5	500	700 (3 C) 628 (5 C) 405 (10 C)	This work
CNT@Co-N-C	2.0	71	970	0.2 C	79.8	500	620 (5 C)	1
N-Co_3O_4@N-C	5.8	—	568	0.2 C	46.4	500	611 (2 C)	2
Co_3O_4/C nanocage	1.4	70	817	0.2 C	75.9	100	807 (1 C) 682 (2 C)	3
Co_3O_4 polyhedron	2.5	—	630	0.1 C	55.6	200	620 (4 C)	4
Co@C	2.1	70	790	0.2 C	91.6	220	712 (1 C)	5
RGO/C-Co	1.0	59	949	0.3 A g^{-1}	91.7	300	479 (5 A g^{-1})	6
Cobalt-graphitic carbon nanocages	2.2-2.3	77	833	0.5 C	72.6	500	718 (1 C)	7
C-Co-N	2.0 (Li_2S)	52 (Li_2S)	929	0.2 C	80.4	300	898 (2 C) 604 (4 C)	8
Co_3O_4 nanofiber	1.3	72	726	0.5 C	79.3	200	796 (1 C)	9
Co_3O_4 nanoneedle	4.1	—	987	0.5 C	80.1	200	476 (2 C)	10
Co_3O_4 submicro-spheres	1.0	66	805	0.2 C	89.2	100	428 (3 C)	11
TiO_2/Co_3O_4 nanocrystal	1.5	54	968	0.1 C	85	100	684 (1 C)	12
Co_3O_4-T nanotube	1.0	78	1081	100	84.8	50	492.3 (1000 mA g^{-1})	13
Co_3O_4 embedded carbon	5.2	—	930	0.2 A g^{-1}	88.5	300	410 (3.2 A g^{-1})	14
Co_3O_{4-x} microsphere	2.0	—	1054	0.2 C	83.9	100	852 (2 C) 780 (3 C)	15
NiO-Co_3O_4 hollow shell	—	52	713	1 C	79.5	200	827 (2 C)	16

Table. S4. Summary of electrochemical performance of various ZIF-67 derived nanocages and Co_3O_4 in LSBs.

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