Support information

Cobalt doped JUC-160 Derived Functional Carbon Superstructures with Synergetic Catalyst Effect for Li-SeS_2 Batteries

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Keywords: Cobalt-doped, ZIF, Self-assembled, Crystal-shape engineering, Li-SeS_2

Table S1. List of abbreviations	
ZIF	Zeolitic imidazolate frame-work (ZIF), a subfamily of metal organic framework (MOF) generated from an assembly of transition metal ions (i.e., Zn(II), Co(II)) and N-rich imidazolate linkers
JUC-160	A ZIF material with zinc ion as the central ion
CJ-n	Cobalt doped ZIF prepared by adding $CoCl_2.6H_2O$ in the synthesis of JUC-160, and based on the addition amount of $CoCl_2.6H_2O$ (0.03,0.05 and 0.07g), the cobalt doped JUC-160 is named as CJ-n (n=0.03,0.05 and 0.07)
PCJ-m	Cobalt doped JUC-160 was prepared by mixing 0.06g $CoCl_2.6H_2O$ and a certain amount of JUC-160, and based on the addition amount of JUC-160 (0.5,0.8 and 1.1 g), the cobalt doped JUC-160 is named as PCJ-m (m=0.5,0.8 and 1.1)
CNC-n	The carbonization products of CJ-n
PCNC-m	The carbonization products of PCJ-m
CNC-n/SeS_2	Selenium sulfide-impregnated CNC-n
PCNC-m/SeS_2	Selenium sulfide-impregnated PCNC-m

In order to better show the relationship between MOF, JUC-160, mixed linker ZIF and Zn-based ZIF, the following figure is drawn with the concept of aggregate in mathematics.

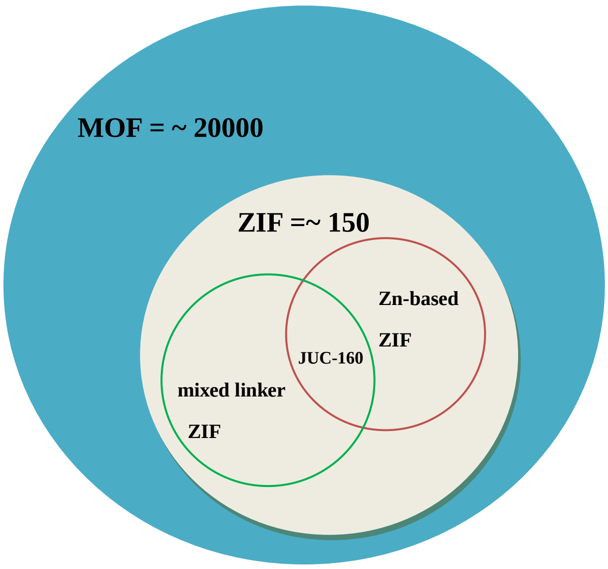

Fig.S1. the relationship between MOF, JUC-160, mixed linker ZIF and Zn-based ZIF.

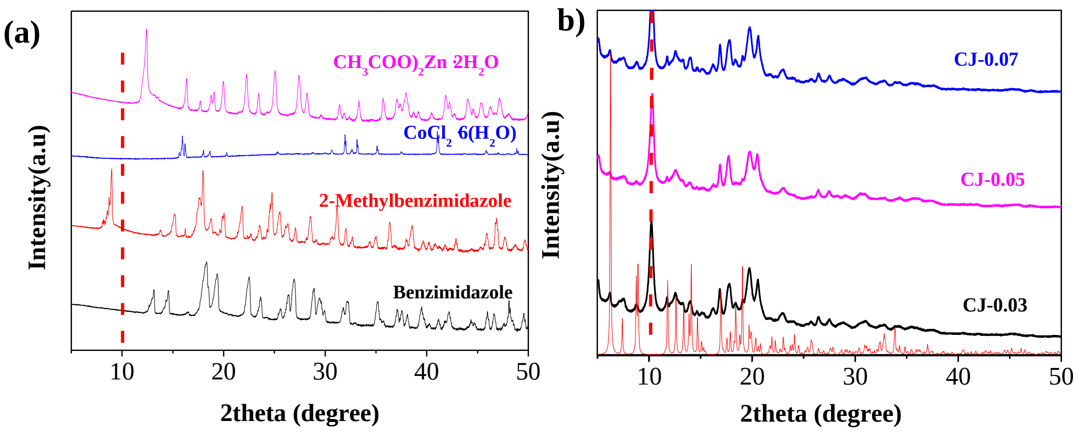

Fig.S2.(a)The chemical used in the experiment and its XRD characteristic peak; (b) X-ray diffraction (XRD) patterns of calculated the JUC-160 and CJ-n.

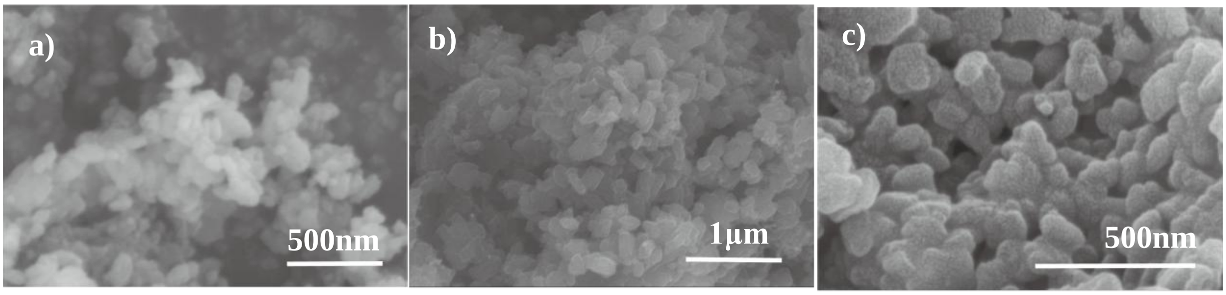

Fig.S3. JUC-160 (a) and their derived carbon materials (b,c).

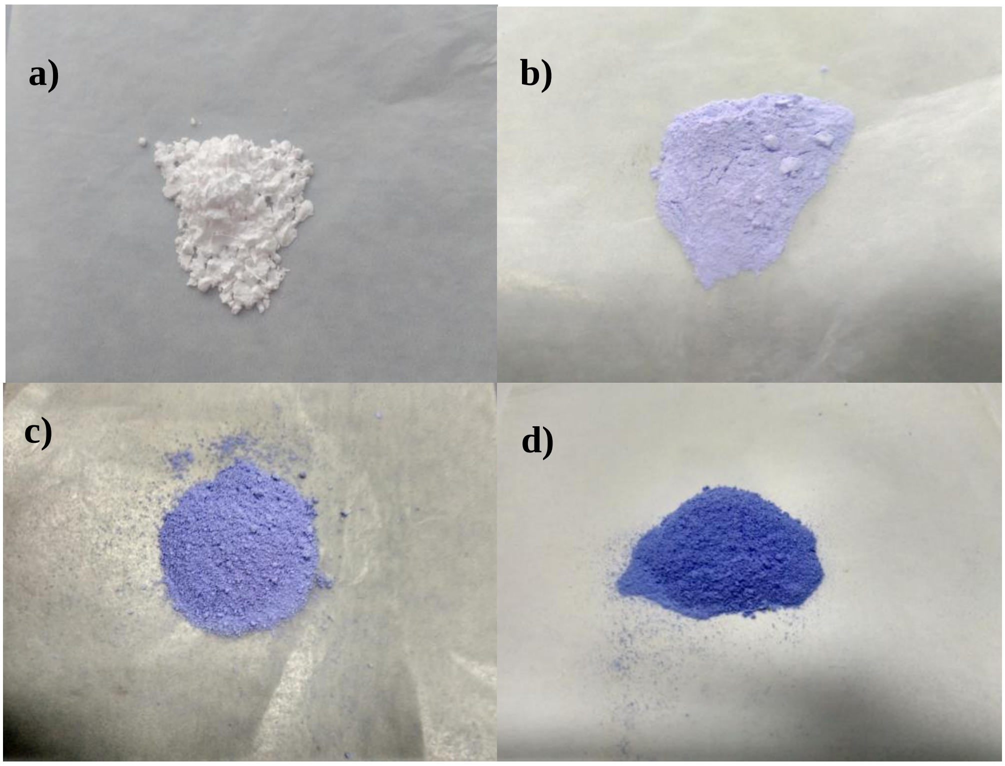

Fig.S4. The photographs of (a) JUC-160, (b) CJ-0.03, (c) CJ-0.05 and (d) CJ-0.07.

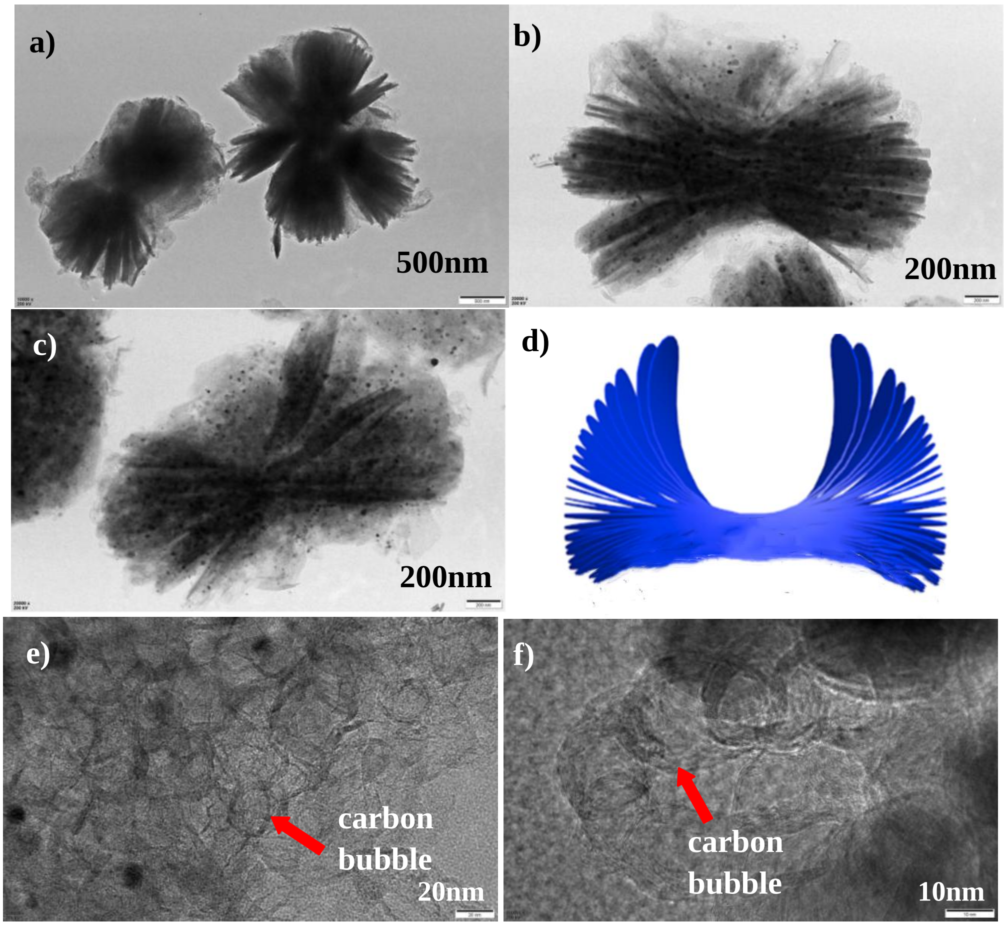

Fig.S5. TEM images of the CNC-0.05 (a-c) and the open-book-like model (d); The hollow carbon bubble structures of CNC-0.05(e-f).

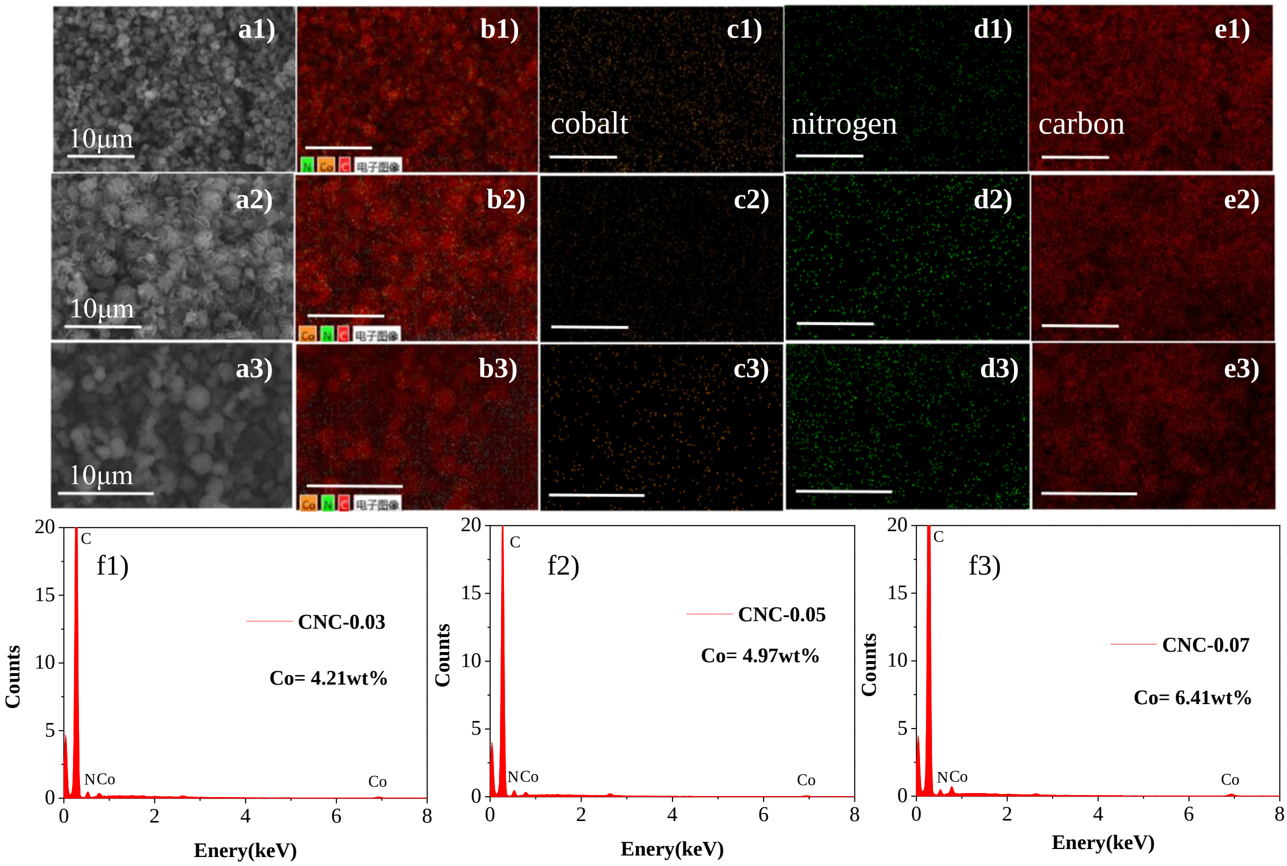

Fig.S6. SEM image of (a1~a3) CNC-n and the corresponding EDS elemental maps for cobalt(c1~c3), nitrogen (d1~d3), carbon(e1~e3) and all elements combined (b1~b3). The scale bar is 10μm; elemental spectrum(f1~f3).

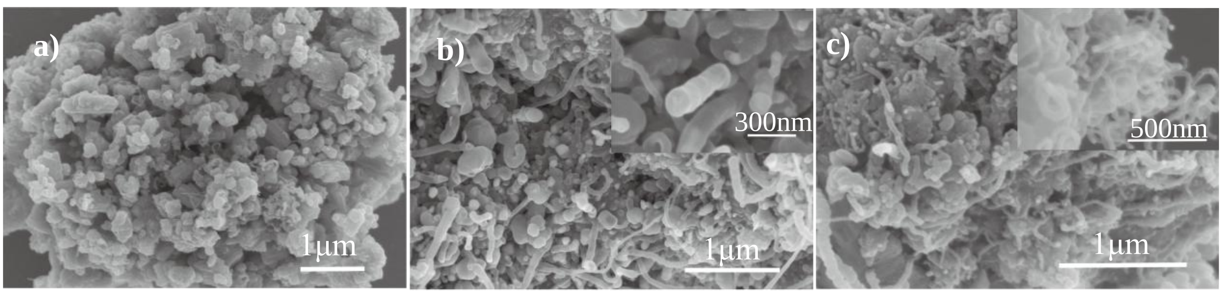

Fig.S7. SEM image of (a) PCNC-1.1, (b) PCNC-0.8 and (c) PCNC-0.5.

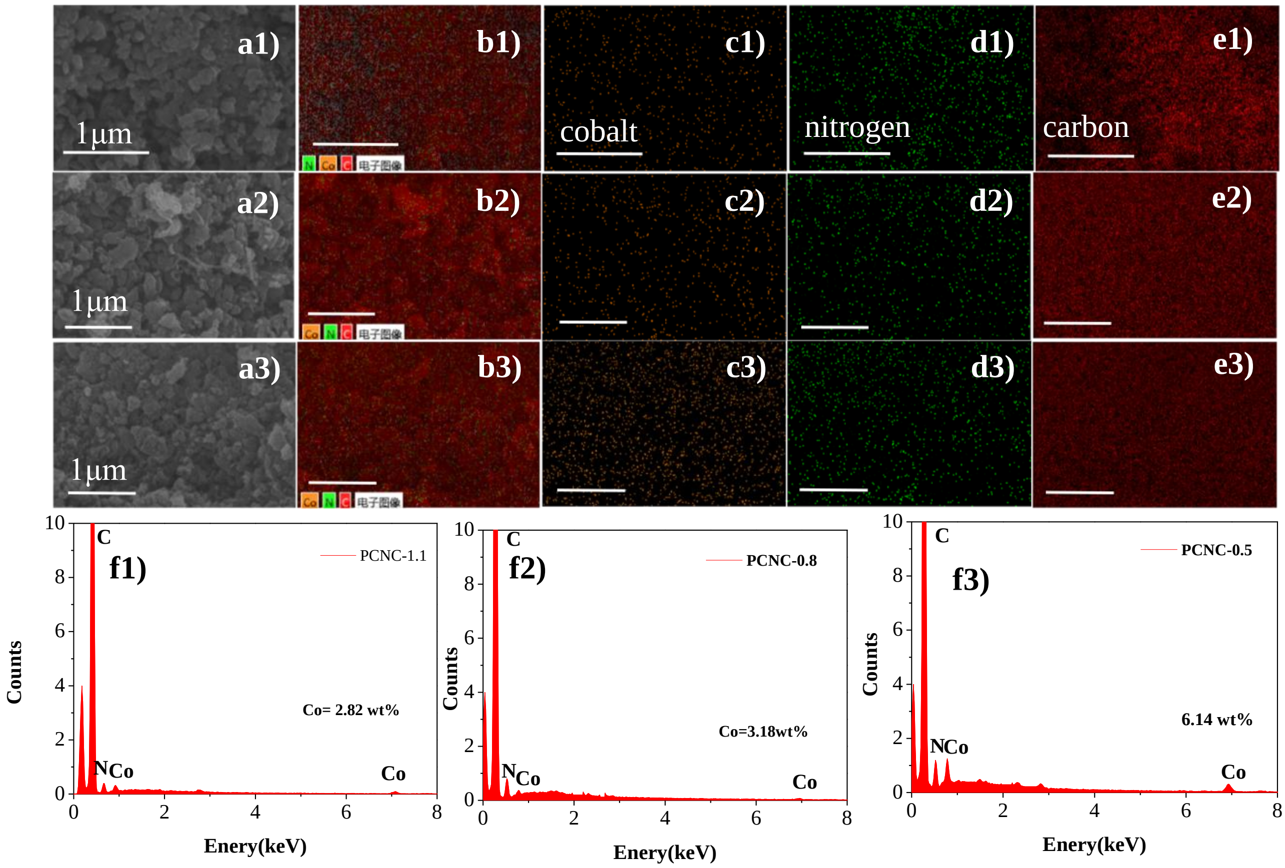

Fig.S8. SEM image of (a1~a3) PCNC-m and the corresponding EDS elemental maps for cobalt(c1~c3), nitrogen (d1~d3), carbon(e1~e3) and all elements combined (b1~b3). The scale bar is 1μm; elemental spectrum(f1~f3).

Table S2, Synthesis conditions of CJ-n

CJ-n	Derived carbon	Benzimidazole (g)	2-methylbenzimidazole (g)	$Zn(Ac)_2 \cdot 2H_2O$ (g)	$CoCl_2 \cdot 6H_2O$ (g)
CJ-0.03	CNC-0.03	0.29539	0.26432	0.49394	0.03399
CJ-0.05	CNC-0.05	0.29541	0.26439	0.49357	0.05558
CJ-0.07	CNC-0.07	0.29543	0.26435	0.494071	0.07131

Table S3, Synthesis conditions of PCJ-m

PCJ-(JUC-160(g)/ $CoCl_2.6H_2O$=0.06g)	Derived carbon	JUC-160 (g)	$CoCl_2.6H_2O$ (g)	ethanol (ml)
PCJ-0.5	PCNC-0.5	0.50722	0.06973	40ml
PCJ-0.8	PCNC-0.8	0.82162	0.06979	40ml
PCJ-1.1	PCNC-1.1	1.182	0.06970	40ml

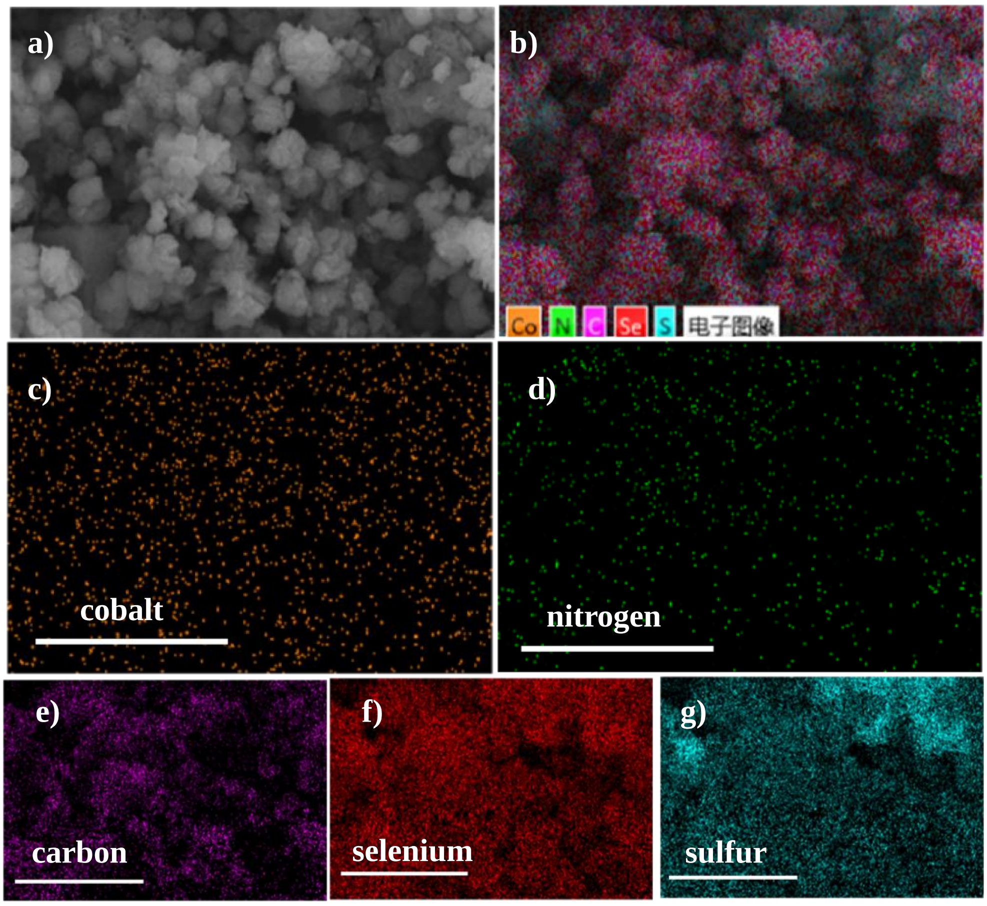

Fig. S9 . SEM image of (a) CNC-0.05/SeS_2 and the corresponding EDS elemental maps for cobalt(c), nitrogen (d), carbon (e), selenium (f) , sulfur (f) and all elements combined (b). The scale bar is 10μm.

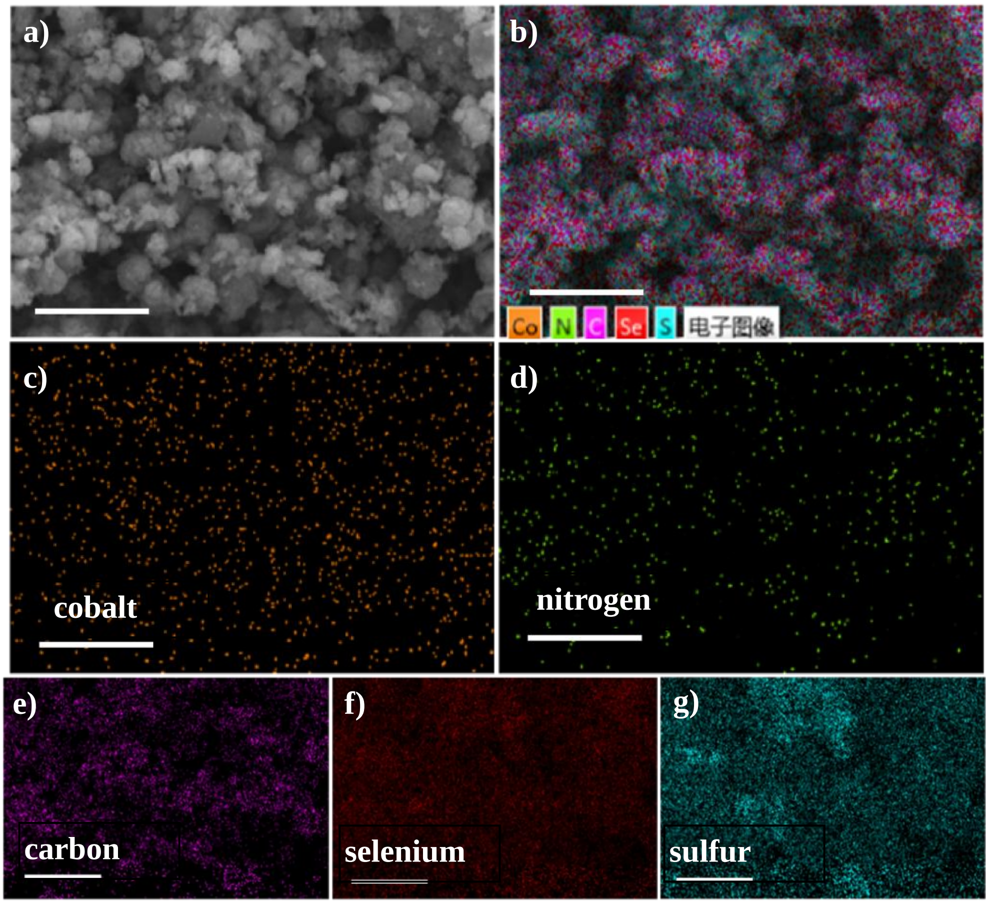

Fig. S10 . SEM image of (a) CNC-0.07/SeS_2 and the corresponding EDS elemental maps for cobalt(c), nitrogen (d), carbon (e), selenium (f) , sulfur (f) and all elements combined (b). The scale bar is 10μm.

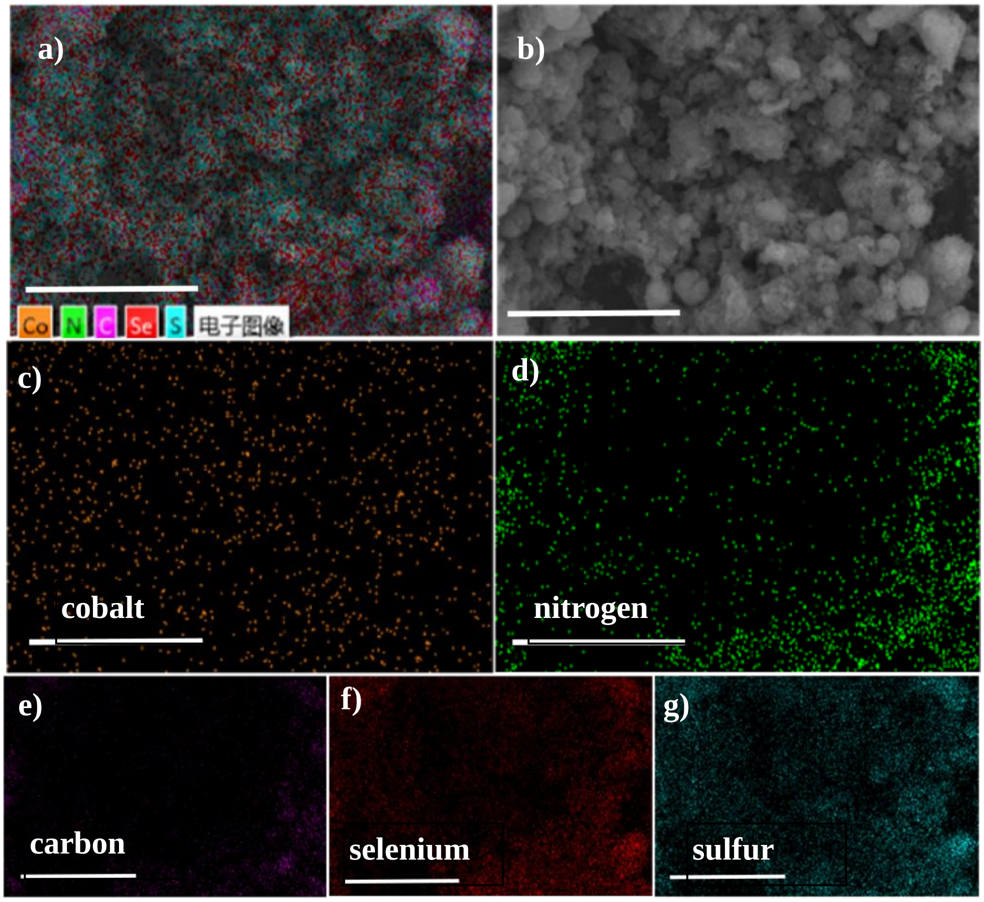

Fig. S11. SEM image of (a) CNC-0.03/SeS_2 and the corresponding EDS elemental maps for cobalt(c), nitrogen (d), carbon (e), selenium (f) , sulfur (f) and all elements combined (b). The scale bar is 10μm.

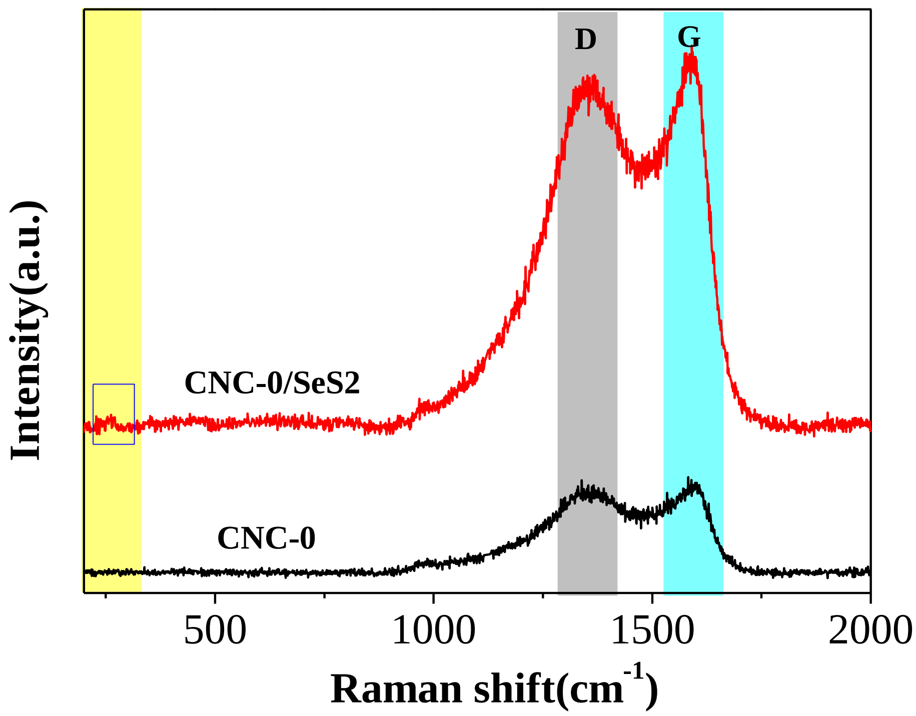

Fig.S12. Raman spectra of CNC-0 and CNC-0/SeS_2.

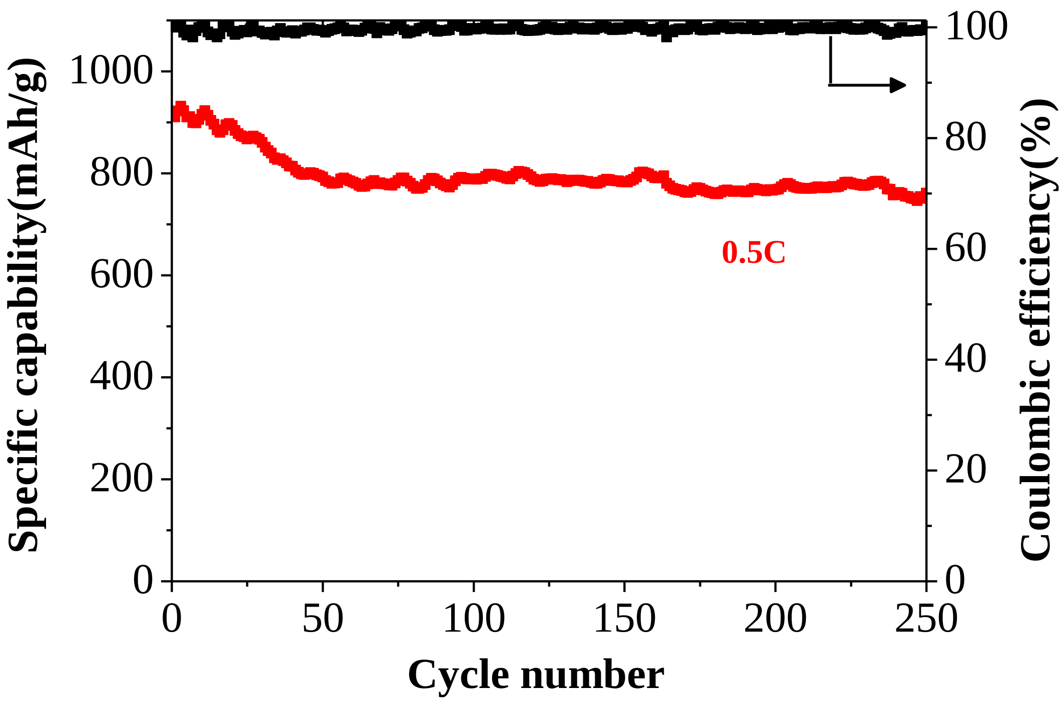

Fig.13. Cycle performance of the CNC-0.05/SeS_2 at 0.5C.

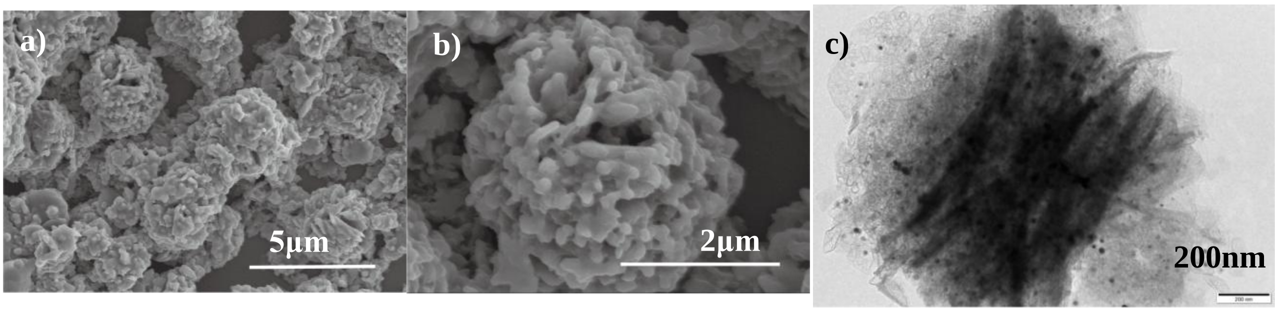

Fig.S14. (a-b) FESEM and (c) TEM images of the CNC-0.05/SeS_2 electrode after 100 cycles at a current density of 0.2C.

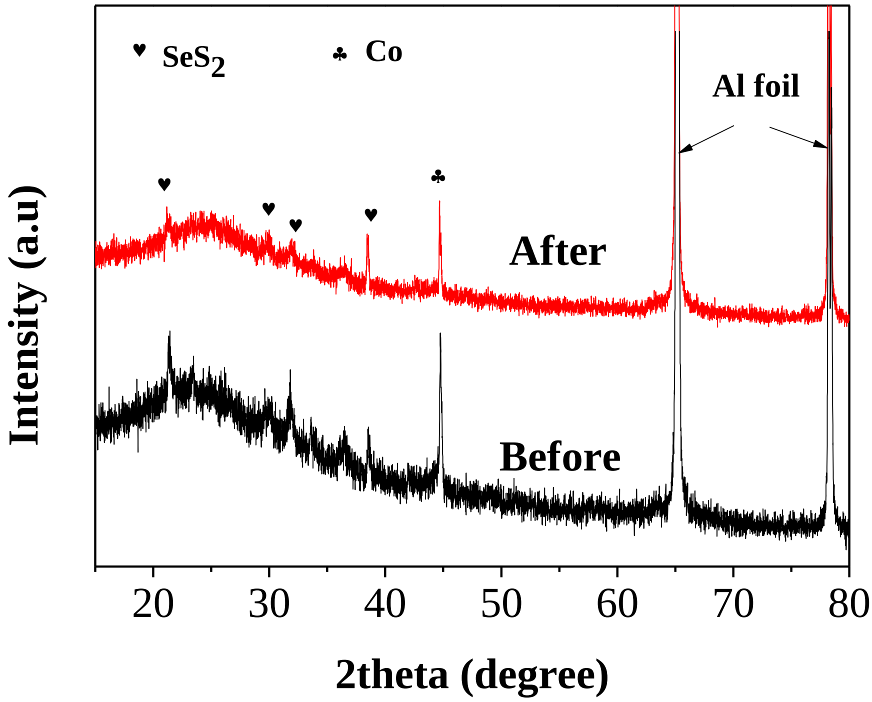

Fig.S15. XRD patterns of CNC-0.05/SeS_2 electrode on Al foil before and after 100 cycles at 0.2C.

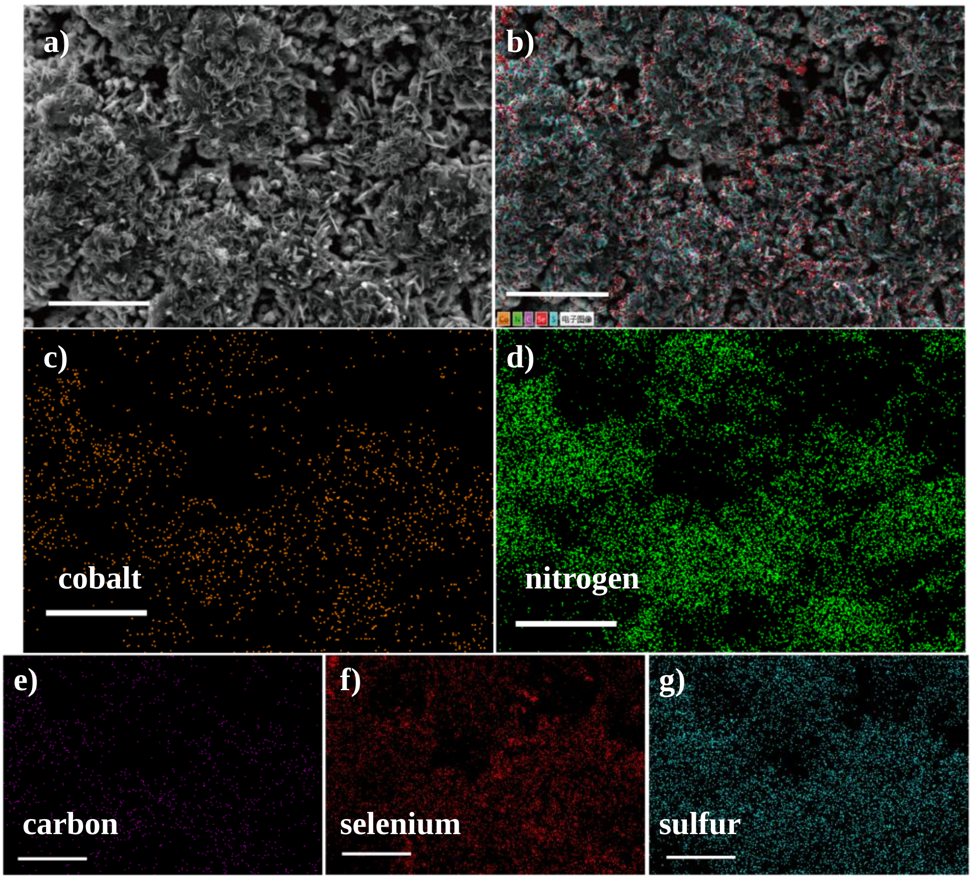

Fig. S16. SEM image of (a) CNC-0.03/SeS_2 and the corresponding EDS elemental maps for cobalt(c), nitrogen (d), carbon (e), selenium (f) , sulfur (f) and all elements combined (b). of CNC-0.05/SeS_2 electrode after 100 cycles at 0.2C. The scale bar is 25µm.

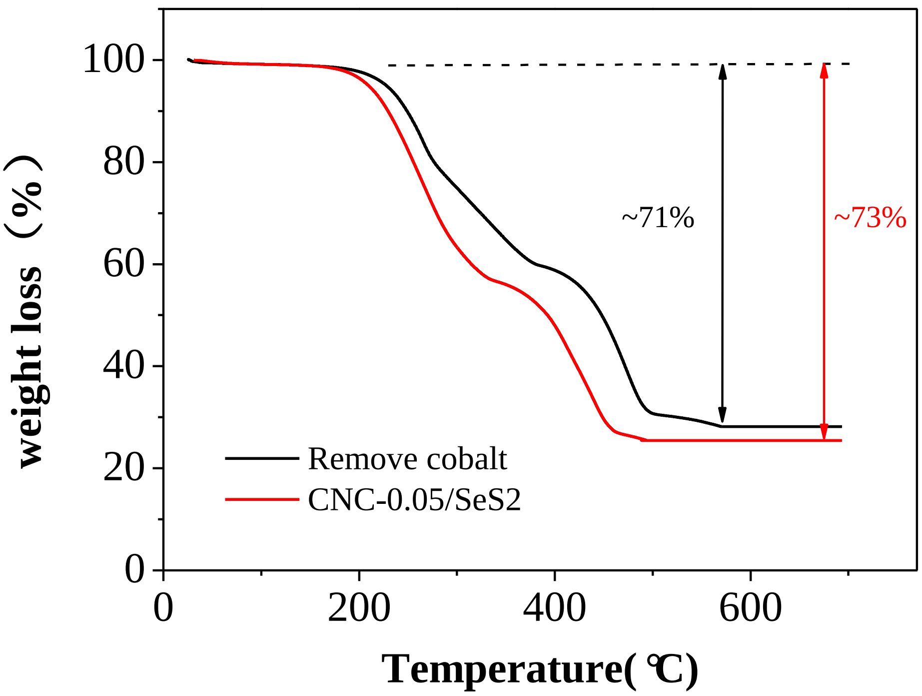

Fig.S17. TGA curves of the CNC-0.05/SeS_2 and the samples of remove cobalt.

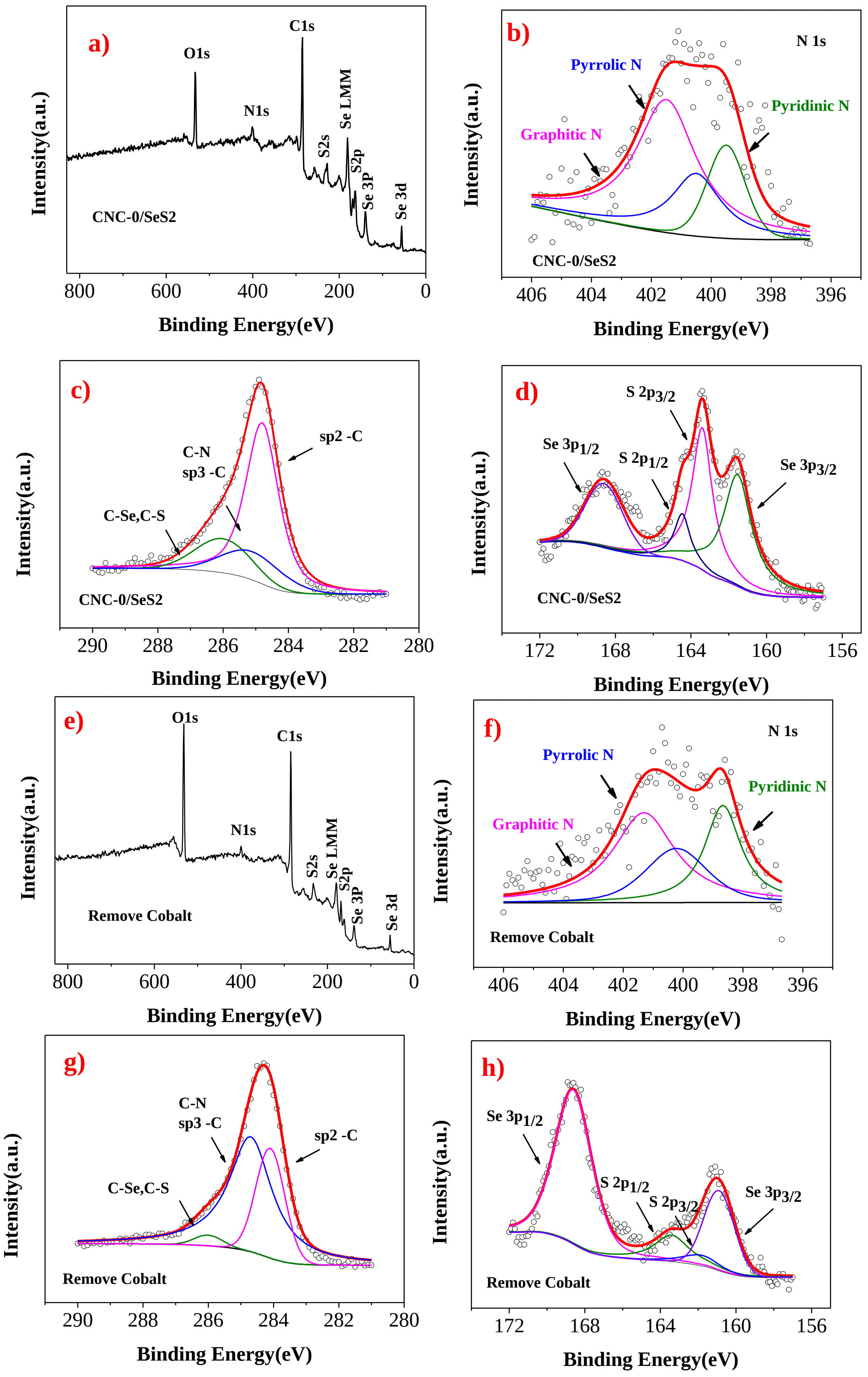

Fig.S18, (a) XPS survey spectrum of CNC-0/SeS_2, (b–d) the corresponding high-resolution XPS

spectra for N 1s and C 1s, S 2p/Se 3p, respectively; (e) XPS survey spectrum of the removing cobalt samples, (f–h) the corresponding high-resolution XPS spectra for N 1s and C 1s, S 2p/Se 3p, respectively.

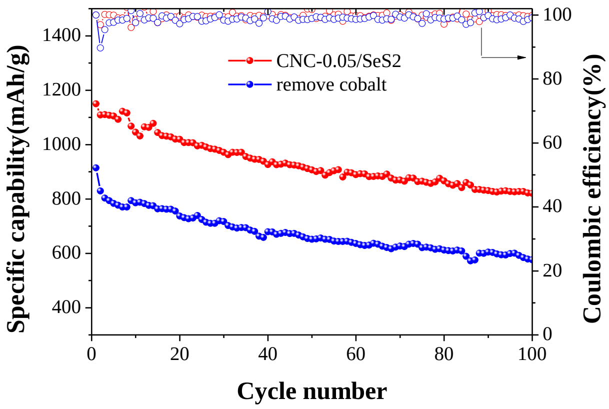

Fig.S19, Cycle performance of the CNC-0.05/SeS_2 and remove cobalt at 0.2 C.

Table S4. A survey of electrochemical properties of the comparisons of cathode materials for Li-SeS_2 batteries.

Category	**Carbon SSA* ($m^2 g^{-1}$)**	**Precursor**	**SeS_2 content**	**Cycling stability**	**C-Rate-performance**
CNC-0.05/SeS_2 (This work)	**416**	**Cobalt doped JUC-160 (Template-free)**	**~73%**	**820.87 mAh g^{-1} after 100 cycles at 0.2C/0.22 A g^{-1} 760.93 mAh g^{-1} after 250 cycles at 0.5C/0.56 A g^{-1}**	**1067 mAh g^{-1}（0.1C/0.11 A g^{-1}), 927 mAh g^{-1}（0.2C/0.22 A g^{-1}), 822mAh g^{-1}（0.5C/0.56 A g^{-1}), 733 mAh g^{-1}（1C/1.12 A g^{-1}), 634mAh g^{-1}（2C/2.24 A g^{-1}）, 262mAh g^{-1}（5C/5.61 A g^{-1}), 158 mAh g^{-1}（10C/11.23 A g^{-1}）**
MYS-Co_4 N@C/SeS_2 (Ref.[1])	142	ZIF-67 (Template-free)	70%	996 mA h.g $^{-1}$ after 100 cycles at 0.22 A g^{-1} 669 mA h.g $^{-1}$ after 300 cycles at 0.56 A g^{-1}	962 mAh g^{-1}（0.22 A g^{-1}）, 866 mAh g^{-1}（0.56 A g^{-1}）, 735 mAh g^{-1}（1.12 A g^{-1}）, 610mAh g^{-1}（2.24 A g^{-1}）, 460 mAh g^{-1}（3.36 A g^{-1}）

Co–N–C/SeS_2 (Ref.[2])	296	ZIF-67 (Template-free)	66.5%	970.2 mAh g^{-1} after 200 cycles at 0.26 A g^{-1}	1193.5 mAh g^{-1} (0.13 A g^{-1}), 1080.7 mAh g^{-1} (0.26 A g^{-1}), 928.2 mAh g^{-1} (0.67 A g^{-1}), 760 mAh g^{-1} (1.34 A g^{-1}), 604.1 mAh g^{-1} (2.69 A g^{-1}), 439.7mAh g^{-1} (5.38 A g^{-1}), 300.3 mAh g^{-1} (8.07 A g^{-1}), 138.1 mAh g^{-1} (10.76 A g^{-1})
$NiCo_2S_4$ @NC /SeS_2 (Ref.[3])	44.5	Dopamine hydrochloride (NiCo2S4 template)	66.7 %	556.45 mAh g^{-1} after 800 cycles at 1.34 A g^{-1}	1205.1 mAh g^{-1} (0.13 A g^{-1}), 1021.2 mAh g^{-1} (0.26 A g^{-1}), 871.6 mAh g^{-1} (0.67 A g^{-1}), 776.6 mAh g^{-1} (1.34 A g^{-1}), 673.5 mAh g^{-1} (2.69 A g^{-1}),
SeS_2 @MCA (Ref.[4])	—	mesoporous carbon aerogels (Template-free)	49.3 %	308 mAh g^{-1} after 130 cycles at 0.2 A g^{-1}	1074 mAh g^{-1} (0.25A g^{-1}), 731 mAh g^{-1} (0.5A g^{-1}), 371mAh g^{-1} (2A g^{-1}),
CMK-3/SeS_2 @PDA: (Ref.[5])	—	CMK-3/SeS 2 @PDA (Core-shell structure)	70%	783 mAh g^{-1} after 150 cycles at 0.2 A g^{-1}	1005 mAh g^{-1} (0.2A g^{-1}), 864 mAh g^{-1} (0.5A g^{-1}), 787mAh g^{-1} (1A g^{-1}), 702mAh g^{-1} (2A g^{-1}), 645mAh g^{-1} (3A g^{-1}), 584mAh g^{-1} (4A g^{-1}) 535mAh g^{-1} (5A g^{-1})
CoS_2 @LRC/SeS_2 (Ref.[6])	77.6	Co(Ac) 2 /PAN/PS paper	70%	745 mAh g^{-1} after 100 cycles at 0.2A g^{-1}	1096 mA hg $^{-1}$ (0.1A g^{-1}), 1038mA hg $^{-1}$ (0.2A g^{-1}), 846mA hg $^{-1}$ (0.5A g^{-1}), 686 mA hg $^{-1}$ (1A g^{-1}), 526mA hg $^{-1}$ (2A g^{-1}),

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