Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Immobilization of Sulfur by Constructing Three-dimensional Nitrogen-Rich Carbons for Long Life Lithium-Sulfur Batteries

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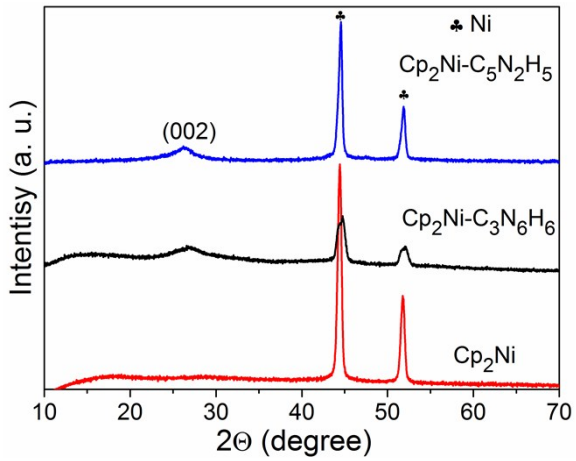

Fig. S1 Powder XRD patterns of the calcined products by using nickelocene, nickelocene (Cp_2Ni) and 2-methylimidazole ($C_5N_2H_5$), nickelocene and melamine ($C_3N_6H_6$).

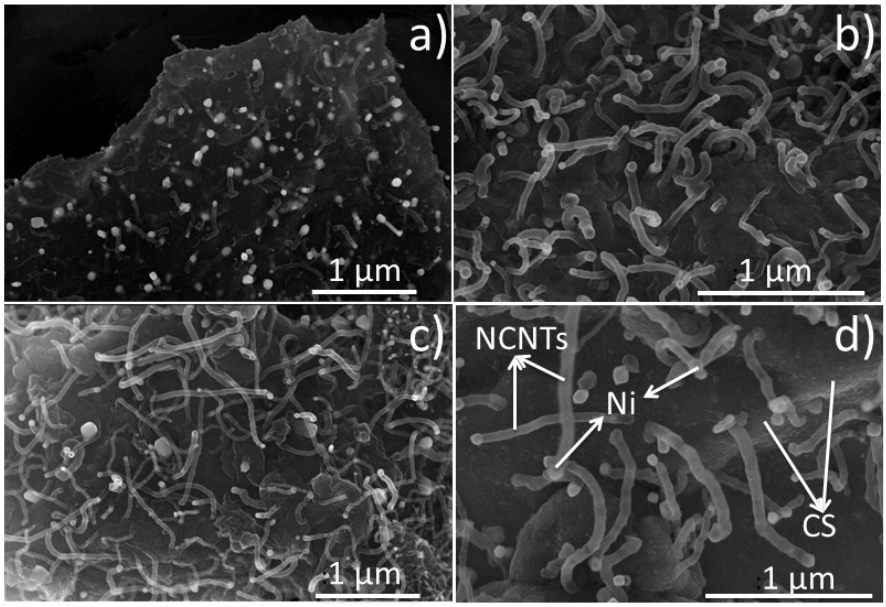

Fig. S2 SEM images of the obtained Ni@NCNTs-CS by using different mass ratios between nickelocene and melamine: a) 1:2.5, b) 1:5 and c) 1:10. d) SEM images of the obtained NCNTs-CS at Ar-H_2 atomsphere using 1:10 ratios between nickelocene and melamine.

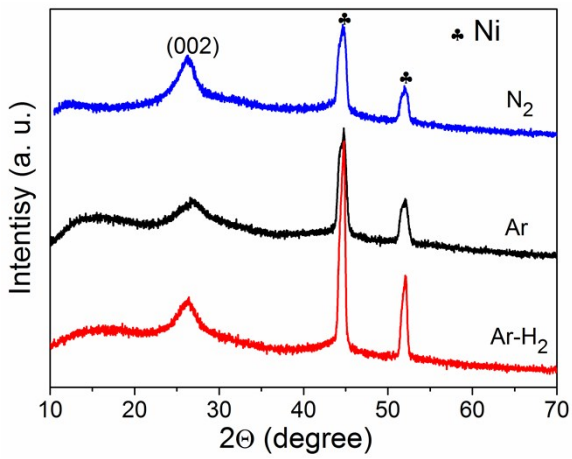

Fig. S3 Powder XRD patterns of as-prepared Ni@NCNTs-CS at N_2, Ar and Ar-H_2 atmosphere.

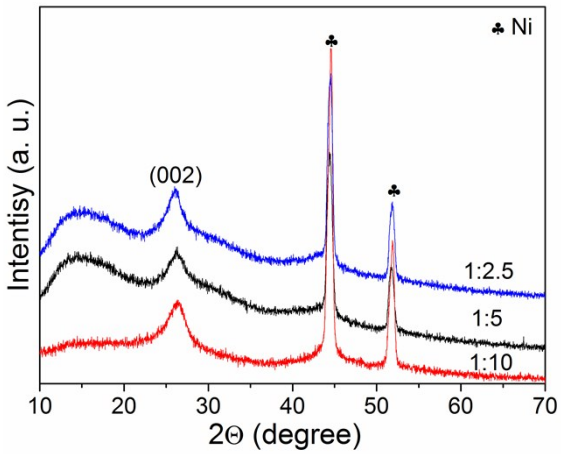

Fig. S4 Powder XRD patterns of the obtained Ni@NCNTs-CS by using different mass ratios between nickelocene and melamine: 1:2.5, 1:5 and 1:10.

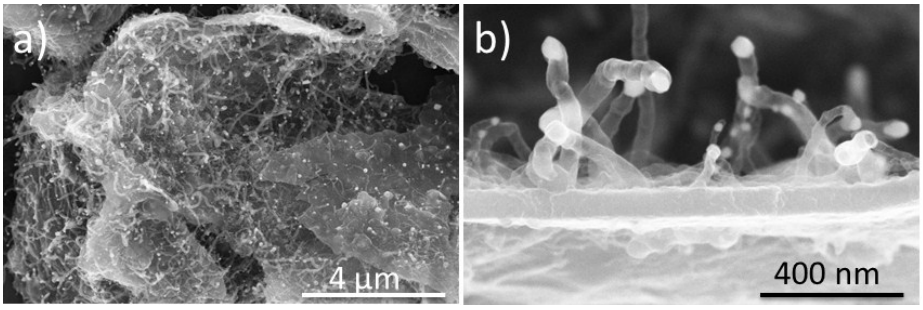

Fig. S5 SEM images of the obtained Ni@NCNTs-CS at N_2 atomsphere using 1:10 ratios between nickelocene and melamine.

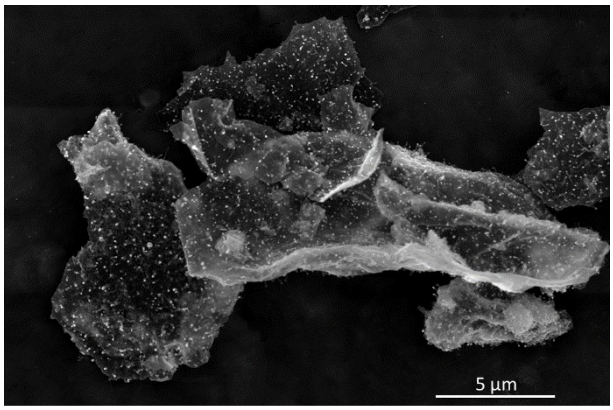

Fig. S6 SEM images of the obtained Ni@NCNTs-CS at Ar atomsphere using 1:5 ratios between nickelocene and melamine.

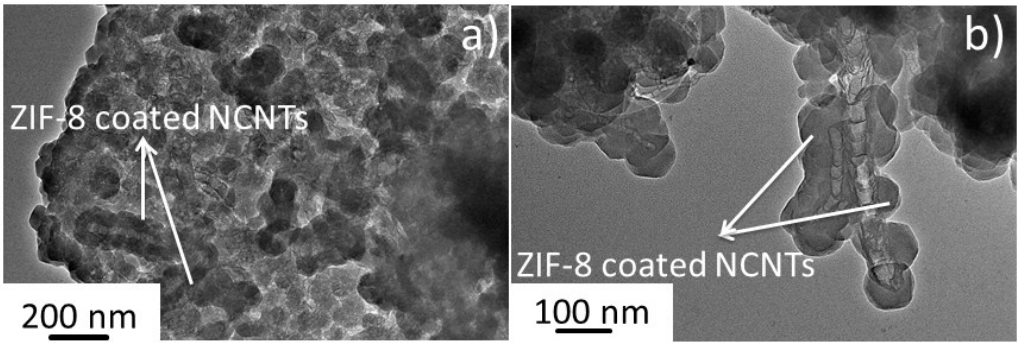

Fig. S7 TEM images of the obtained NCNTs-CS-ZIF-8 composite.

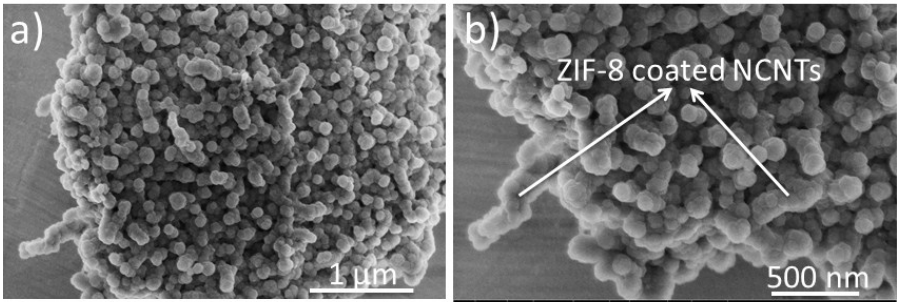

Fig. S8 SEM images of the obtained NCNTs-CS-ZIF-8 composite.

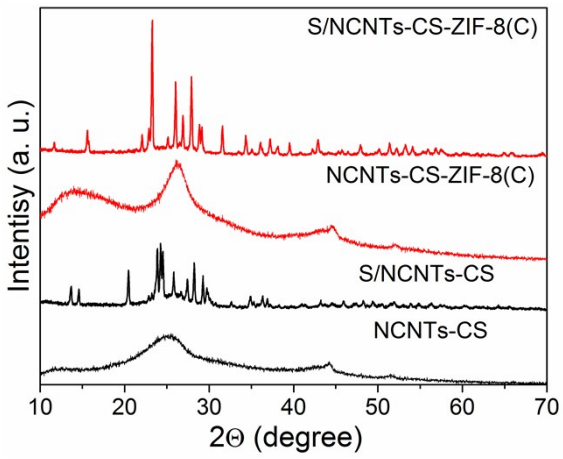

Fig. S9 Powder XRD patterns of as-prepared NCNTs-CS, ZIF-8, NCNTs-CS-ZIF-8 and NCNTs-CS-ZIF-8(C).

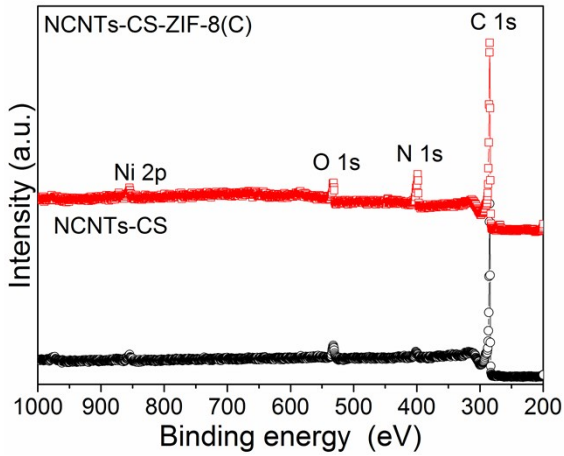

Fig. S10 XPS spectrum of a) NCNTs-CS and b) NCNTs-CS-ZIF-8(C).

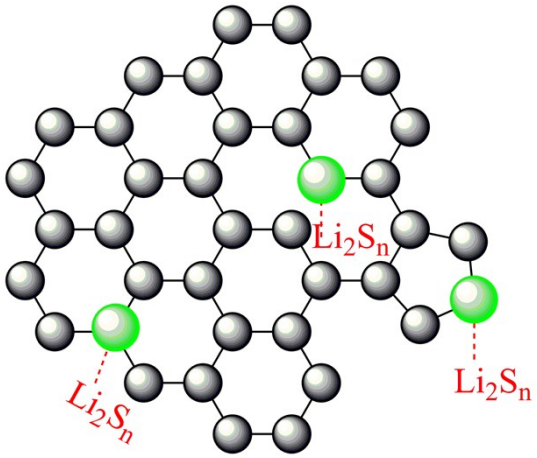

Fig. S11 The bonding interface between Li_2S_n and nitrogen atom.

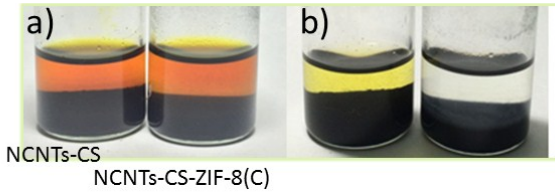

Fig. S12 Sealed vials of a lithium polysulfides solution (Li_2S_6 dissolved in DOL/DME solvents) containing NCNTs-CS and NCNTs-CS-ZIF-8(C) powder: (a) after 0 h, (b) after 0.5 h.

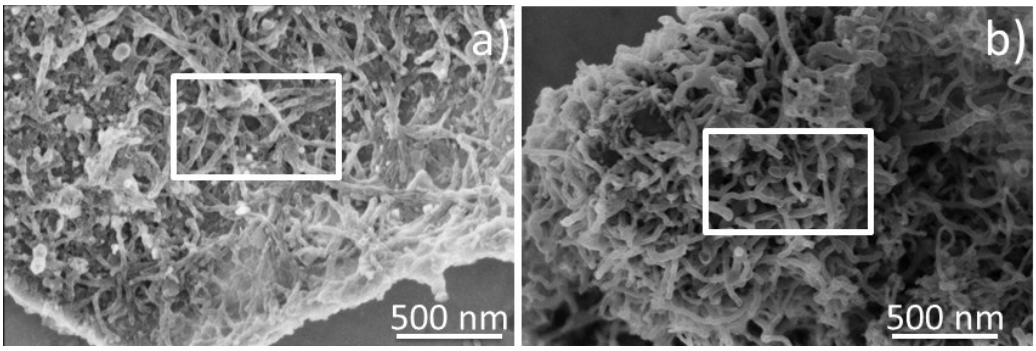

Fig. S13 SEM images of a) S/NCNTs-CS and b) S/NCNTs-CS-ZIF-8(C).

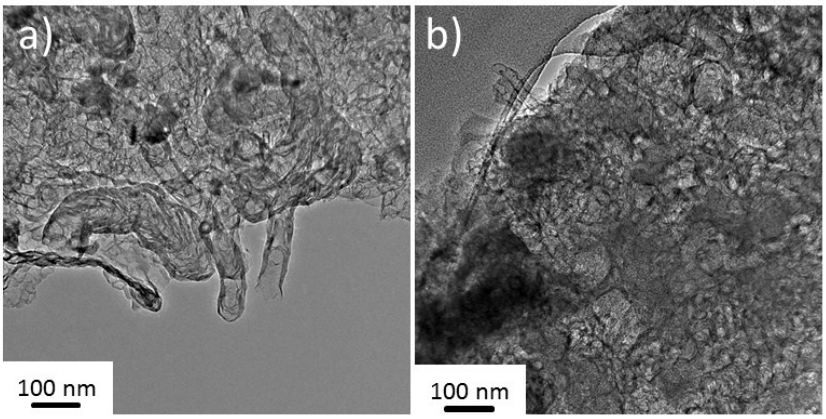

Fig. S14 TEM images of a) S/NCNTs-CS and b) S/NCNTs-CS-ZIF-8(C).

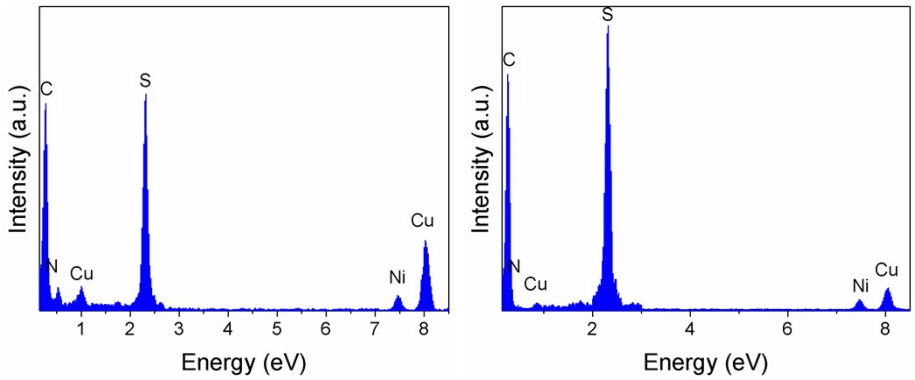

Fig. S15 EDX spectrum of the area in the white square of **Fig. S13**.

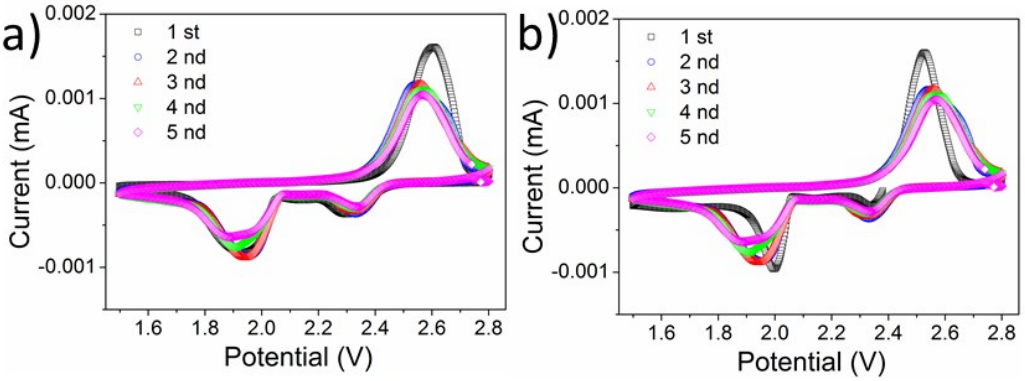

Fig. S16 CVs of a) S/NCNTs-CS and b) S/NCNTs-CS-ZIF-8(C) in the voltage range of 1.5-2.8 V versus Li^+/Li.

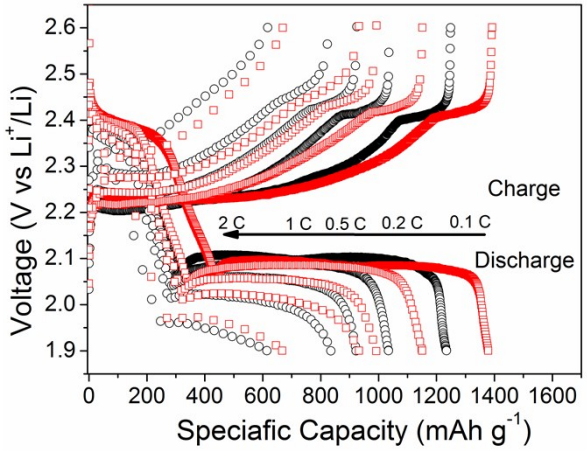

Fig. S17 The discharge-charge curves of the batteries with the S/NCNTs-CS and S/NCNTs-CS-ZIF-8(C) cathodes at different C rates.

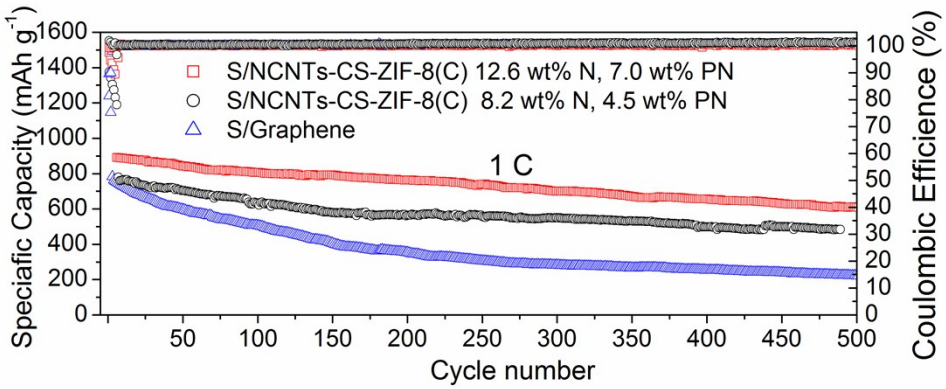

Fig. S18 The long-term cycling performance and Coulombic efficiencies of S/Graphene and S/NCNTs-CS-ZIF-8(C) with different nitrogen content at 1 C.

Table S1. The contents of carbon, nitrogen, oxygen in the resulting NCNTs-CS and NCNTs-CS-ZIF-8(C) via elemental analysis, and the content of nickel in the NCNTs-CS and NCNTs-CS-ZIF-8(C) by ICP measurement.

Samples	**C (wt%)**	**N (wt%)**	**O (wt%)**	**Ni (wt%)**	**graphitic-N (wt %)**	**pyrrolic-N (wt %)**	**pyidinic-N (wt %)**
NCNTs-CS	85.9	4.5	4.2	5.4	0.4	2.6	1.5
NCNTs-CS-ZIF-8(C)	80.7	12.6	4.5	4.2	1.5	4.1	7.0

It is inferred that these N-doped and O-doped sites in the carbon matrix can produce abundant active sites to promote the surface affinity for polysulfides and lithium sulfides.