Supporting Information for

A Ternary Hybrid Material for High Performance Lithium-Sulfur Battery

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Preparation of mildly oxidized CNTs. CNTs were oxidized by a modified Hummers method. Multi-wall CNTs (CNano Tech. Ltd.) were purified by calcinations at 400 °C for 1 h and washed with 10 wt% HCl to remove metal residues. 1g of purified CNTs were dispersed into 23 ml of concentrated H_2SO_4 and the mixture was stirred at room temperature overnight. Next, the solution was heated to 40 °C in an oil bath. 350 mg of $NaNO_3$ was added, followed by the slow addition of 1 g of $KMnO_4$ while keeping the reaction temperature below 45°C. The solution was kept at 40°C under stirring for 30 min. 3 ml of water was added into the flask, followed by another 3 ml after 5 minutes. After another 5 minutes, 40 ml of water was added. 15 minutes later, the flask was removed from the oil bath and 140 ml of water and 10 ml of 30% H_2O_2 were added to end the reaction. Oxidized CNTs were collected, repetitively washed with 5 wt% HCl solution and then water, and finally lyophilized to acquire the mildly oxidized CNTs (Fig. S8).

Preparation of Li_2S_6 solution. Polysulfide solution was prepared by dissolving stoichiometric amounts of Li_2S and sulfur in DOL at 80 °C for 10 hours.

Polysulfide adsorption study. Test solutions were prepared by mixing 20 μl of 0.3 M Li_2S_6 in DOL, 1 ml of DOL and 1 ml of DME. 5 mg of CNT/$NiFe_2O_4$, CNT/$NiFe_2O_4$-2 or CNTs was added to each solution. The solutions were vigorously stirred for 20 min. All procedures were completed in an Ar-filled glove box. To further test whether the host materials can still effectively trap polysulfides after the long-term cycling tests, the cycled cathodes of CNT/$NiFe_2O_4$-S, CNT/$NiFe_2O_4$-S-2 and CNT-S with absorbed electrolyte were each directly soaked in 4 mL of DOL/DME (1:1, vol) mixed solvent for 24 hours. All procedures were completed in an Ar-filled glove box.

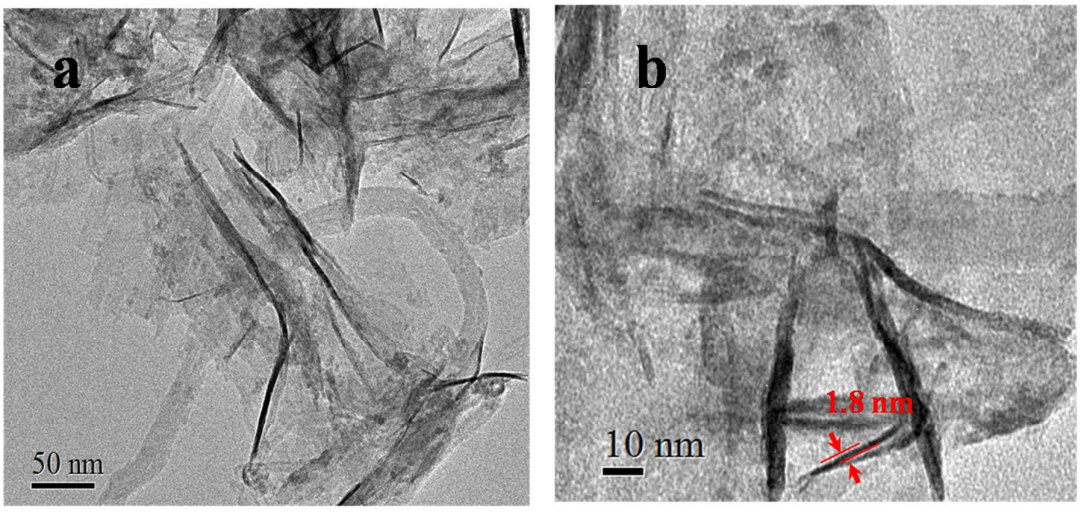

Fig. S1 TEM images of $NiFe_2O_4$ nanosheets grown on CNTs.

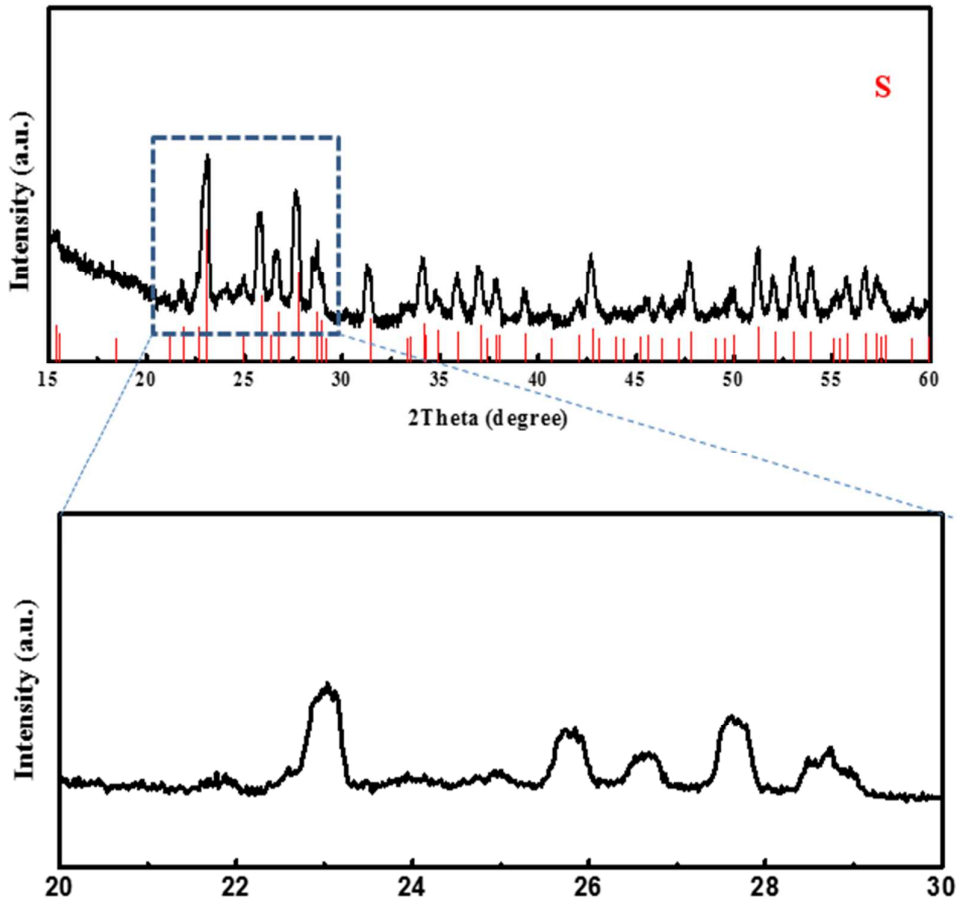

Fig. S2 XRD pattern of the CNT/$NiFe_2O_4$-S ternary hybrid material.

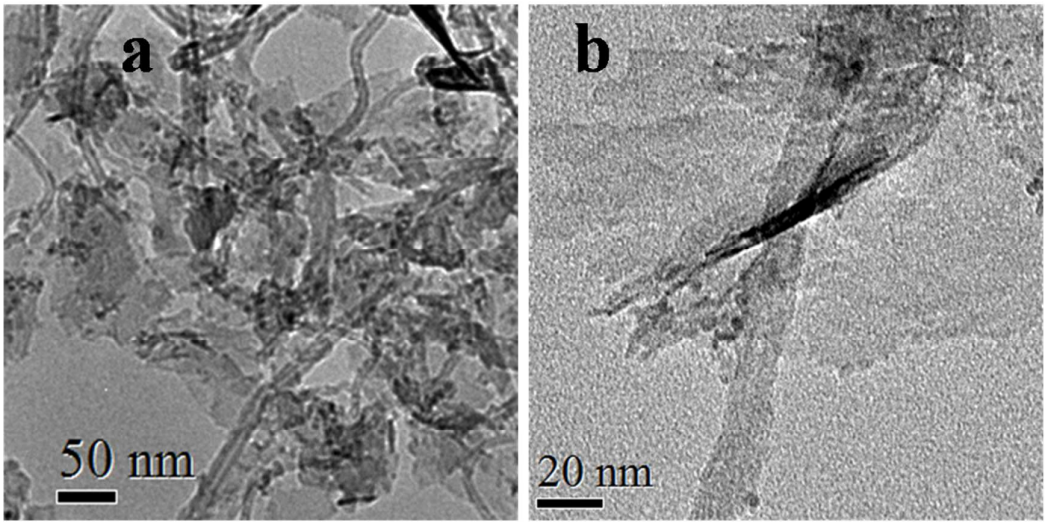

Fig. S3 TEM images of CNT/$NiFe_2O_4$-S after long-term cycling.

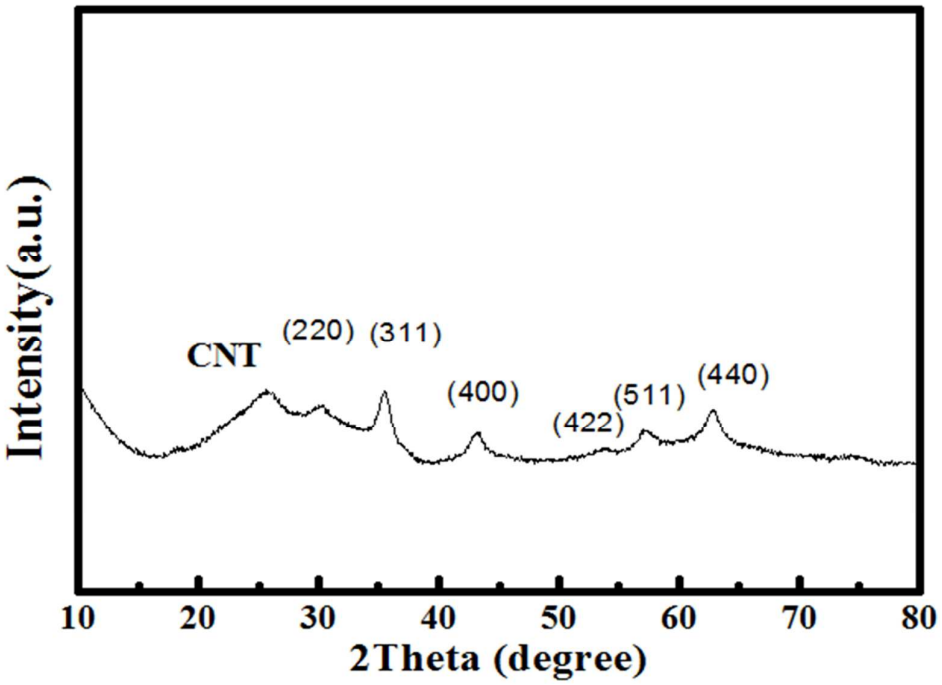

Fig. S4 XRD pattern of the discharged electrode material after hundreds of cycles.

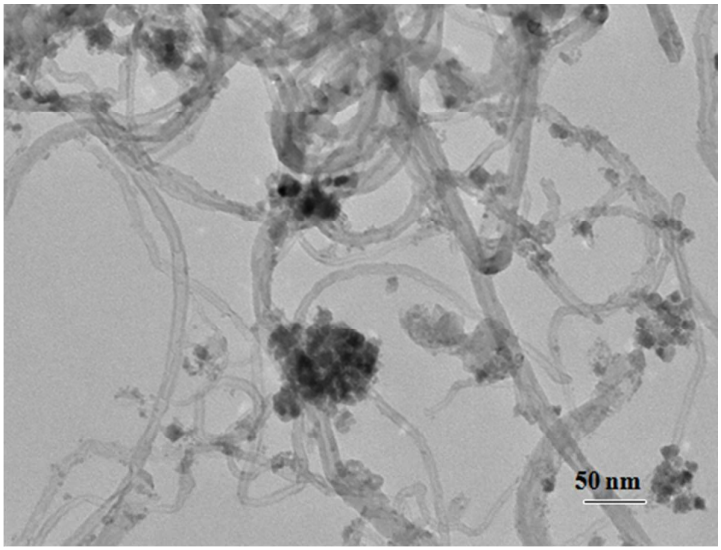

Fig. S5 TEM image of $NiFe_2O_4$ nanopartcles grown on CNTs.

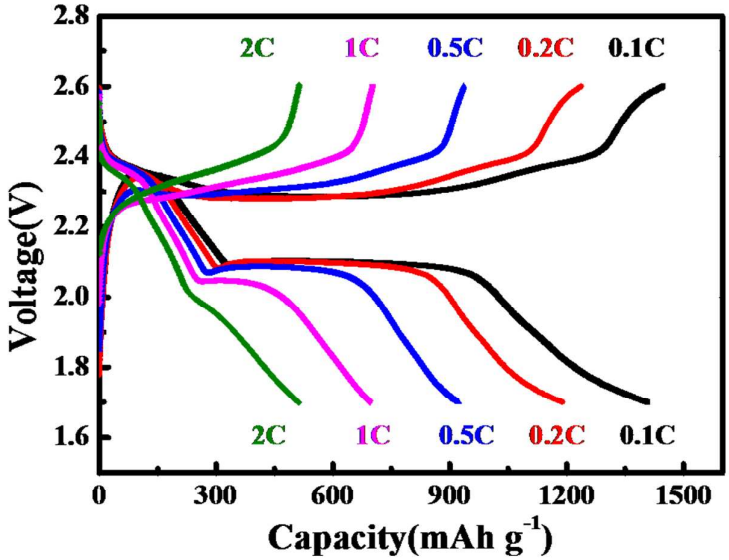

Fig. S6 Charging/discharging voltage profiles of the CNT-S at various C rates from 0.1 to 2 C.

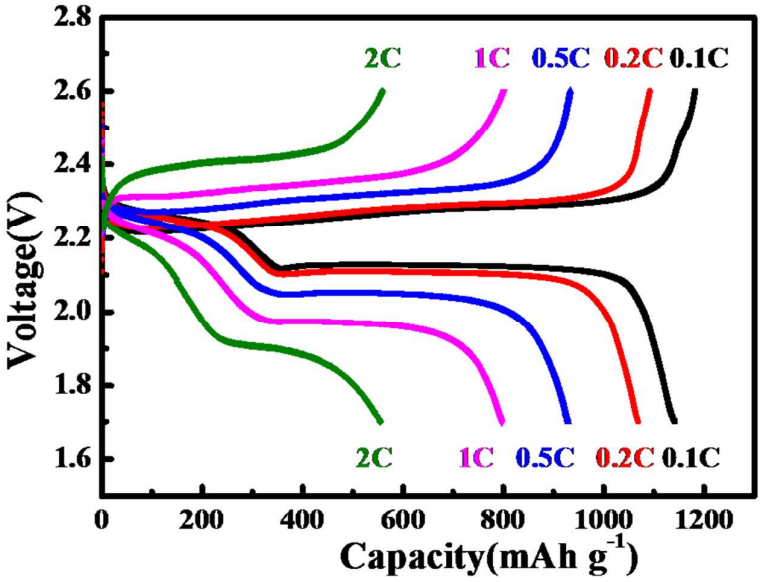

Fig. S7 Charging/discharging voltage profiles of the CNT/$NiFe_2O_4$-S-2 at various C rates from 0.1 to 2 C.

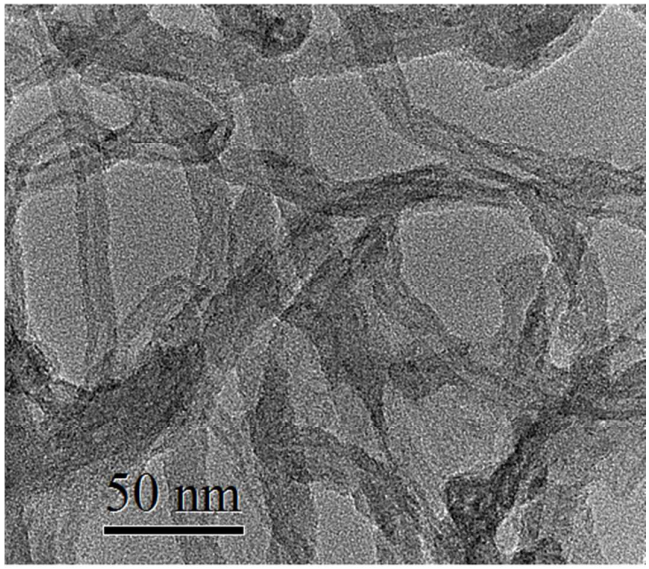

Fig. S8 TEM image of the mildly oxided CNTs.

Host Material	Sulfur Loading	Capacity loss per cycle	
		Cycles	Loss (%)
CNT/$NiFe_2O_4$ nanosheet *This work*	76 wt%	>500	0.009 (at 1C)
ITO-Carbon Fiber[1] *Ref.1*	57 wt%	500	0.036(at 0.2C)
MnO_2 nanosheet[2] *Ref. 2*	75 wt%	2000	0.036 (at 2C)
TiO_2 hollow sphere[3] *Ref.3*	71 wt%	1000	0.033 (at 0.5C)
Ti_4O_7[4] *Ref.4*	70 wt%	500	0.06 (at 2C)
Amino-functionalized reduced graphene oxide [5] *Ref.5*	60 wt%	350	0.057 (at 0.5C)
Covalently bonded CNT[6] *Ref.6*	83 wt%	500	0.021（at 0.5C）
Graphene[7] *Ref.7*	70 wt%	300	0.1（at 1C）
N-Doped Graphene[8] *Ref.8*	60 wt%	700	0.068 (at 1C)
CNT-interpenetrated mesoporous N-doped carbon sphere[9] *Ref.9*	70 wt%	200	0.05 (at 0.2C)
N-Doped Double-Shelled Hollow Carbon Sphere[10] *Ref.10*	78 wt%	200	0.19 (at 0.5C)
Ultra-high-surface-area hollow carbon nanosphere[11] *Ref.11*	67 wt%	500	0.053 (at 1C)
Porous trithiocyanuric acid[12] *Ref.12*	63 wt%	450	0.037 (at 0.5C)

Table S1 Comparison of cycling stability of representative S cathode material structures in the literature.

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