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

Hierarchical electrodes of $NiCo_2S_4$ nanosheets anchored sulfur-doped Co_3O_4 nanoneedles with advanced performance for battery-supercapacitor hybrid devices

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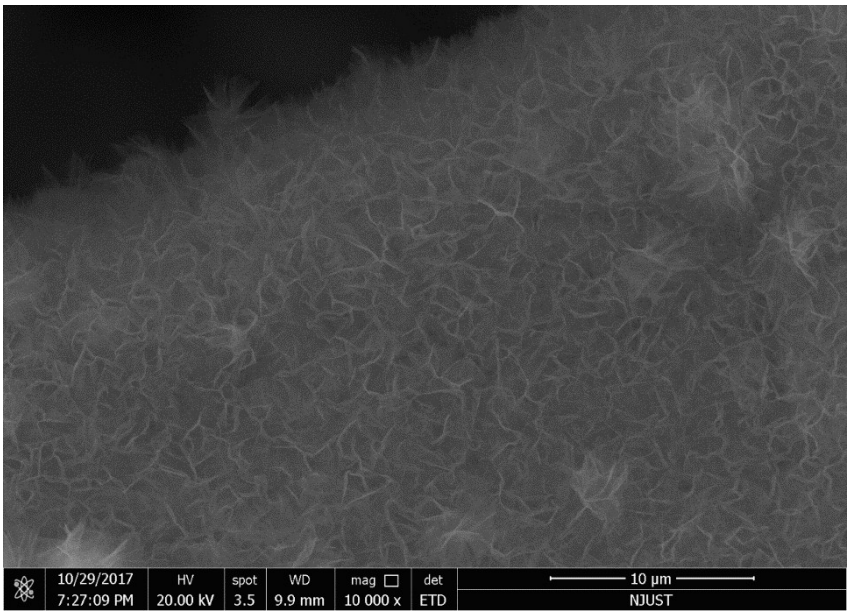

Fig. S1 SEM image of NF/$NiCo_2S_4$.

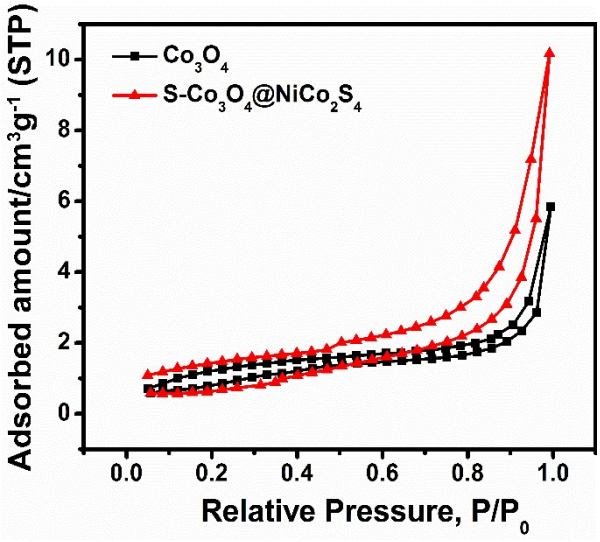

Fig. S2 Nitrogen adsorption/desorption of the NF/S-Co_3O_4 and NF/S-Co_3O_4@$NiCo_2S_4$.

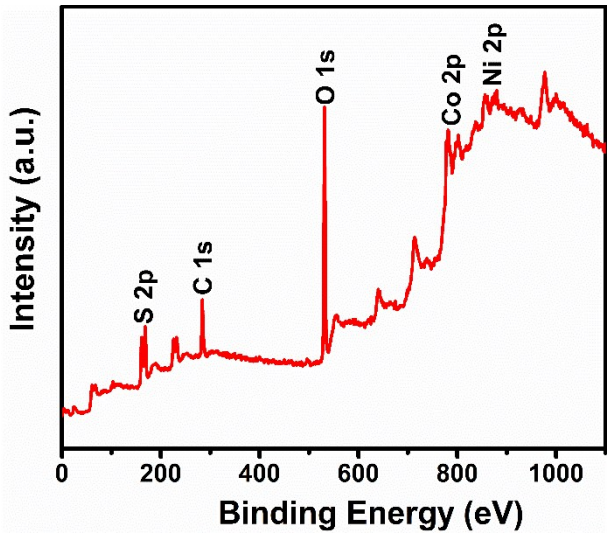

Fig. S3 XPS wide-scan spectra of S-Co_3O_4@$NiCo_2S_4$.

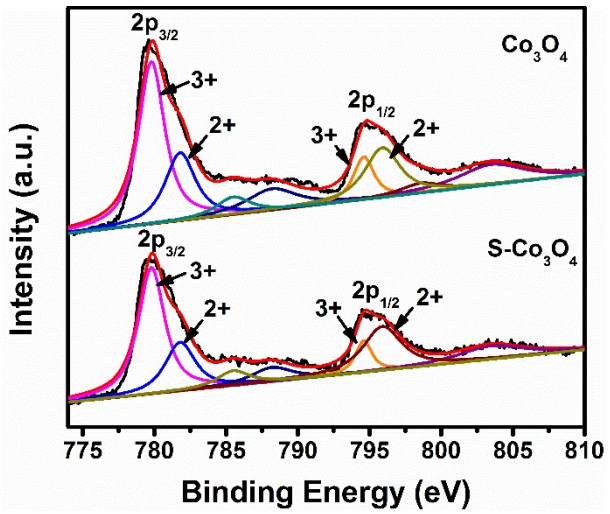

Fig. S4 High-resolution XPS spectra for Co of S-Co_3O_4.

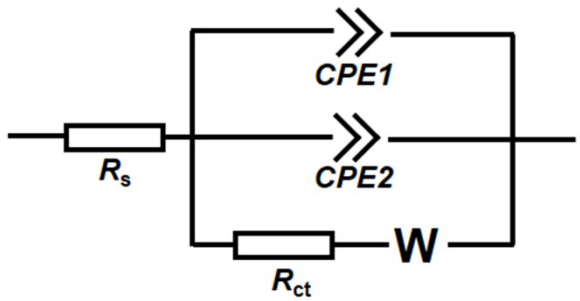

Figure S5. The equivalent electrical circuit in NF/S-Co_3O_4@$NiCo_2S_4$, NF/S-Co_3O_4, NF/Co_3O_4, and NF/$NiCo_2S_4$.

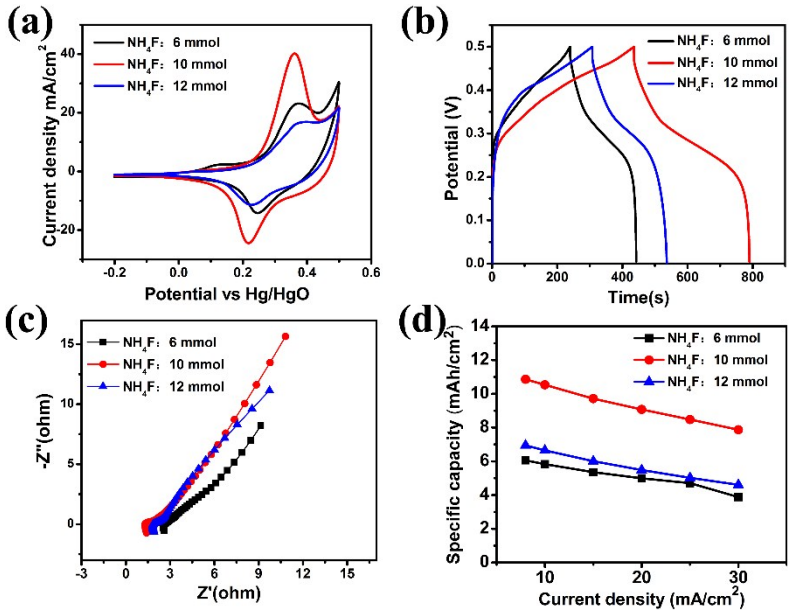

Fig. S6 Electrochemical performance of S-Co_3O_4@$NiCo_2S_4$ with different molar weight (6, 10, 12 mmol) of NH_4F. (a) EIS curves; (b) CV curves; (c) GCD curves; and (d) Specific capacity at different current densities from 8 to 30 mA/cm^2.

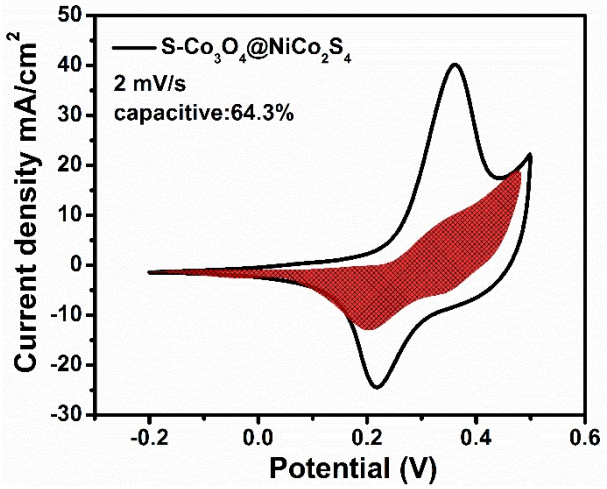

Fig. S7 Capacitive contribution of the NF/S-Co_3O_4@$NiCo_2S_4$.

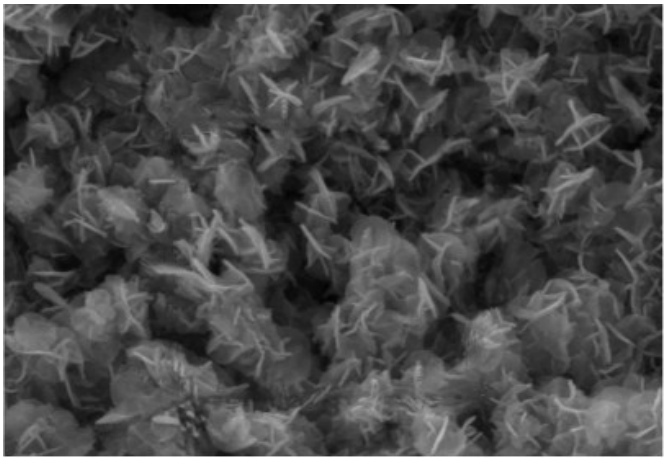

Fig. S8 SEM of NF/S-Co_3O_4@$NiCo_2S_4$ after 5,000 cycles.

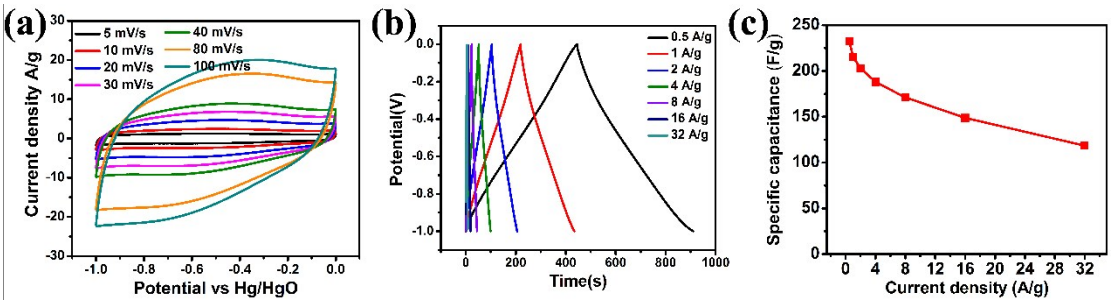

Fig. S9 (a) CV curves of AC at different scan rates. (b) GCD curves of AC at different current densities. (c) Specific capacity at different current densities from 0.5 to 30 A/g.

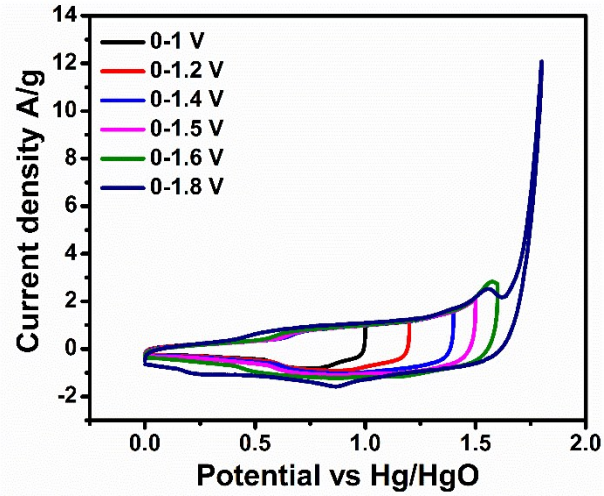

Fig. S10. CV curves of BSH device with different window voltages at 5 mV/s.

Table S1. Comparison of electrochemical performance between the NF/S-Co_3O_4@$NiCo_2S_4$ and the reported sulfides-based electrode materials.

Electrode material	Specific capacitance (capacity)	Cycling performance	Ref
hollow ellipsoid Ni–Mn sulfides	1636.8 F/g at 2 A/g	95.1% (4000 cycles)	[1]
$NiCo_2S_4$/NCF	1231 F/g at 2 A/g	90.4% (2000 cycles)	[2]
$NiCo_2S_4$ @Ni−Mn LDH arrays/GS	1.48 F/cm^2 at 5 mA/cm^2	88.3% (1000 cycles)	[3]
porous NiCo2S4 aerogel	1268 F/g at 1 A/g	--	[4]
P-Doped $NiCo_2S_4$ nanotubes	8.03 F/cm^2 at 2 mA/cm^2	87.5% (5000 cycles)	[5]
$NiCo_2O_4$@$NiCo_2S_4$ Nanocomposite	1872 F/g at 1 A/g	65% (4000 cycles)	[6]
Onion-like $NiCo_2S_4$ particles	1016 F/g at 2 A/g	87% (10000 cycles)	[7]
$FeCo_2S_4$-$NiCo_2S_4$ composite	1519 F/g at 5 mA/cm^2	--	[8]
NF/S-Co_3O_4@$NiCo_2S_4$	1886 F/g at 2.5 A/g or (6 F/cm^2 at 8 mA/cm^2)	97.3% (5000 cycles)	This work

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