Surfactant-Assisted Synthesis of Nanoporous Nickel Sulfide Flakes and Their Hybridization with Reduced Graphene Oxides for Supercapacitor Applications

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Figure S1.

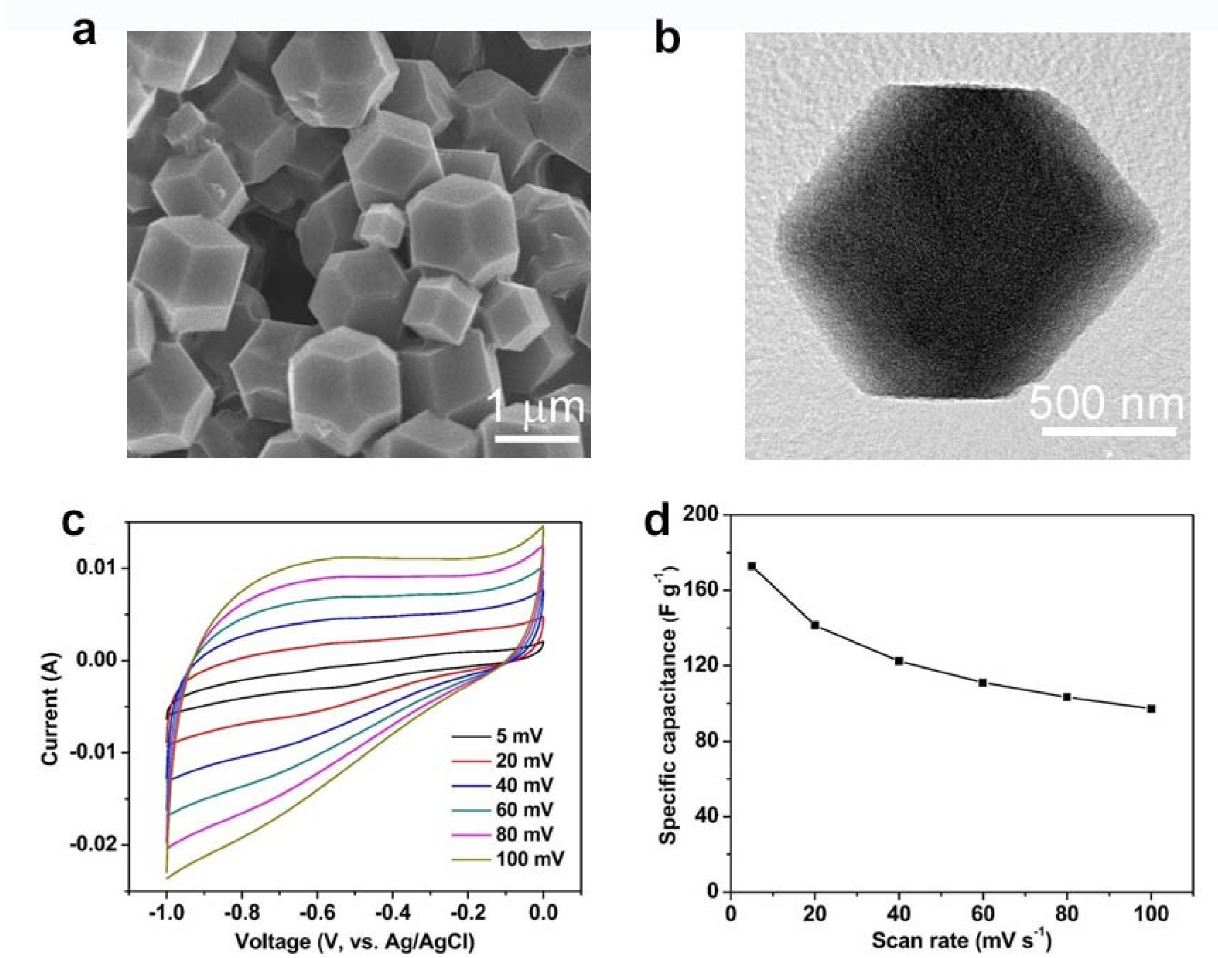

Figure S1 (a) SEM image and **(b)** TEM image of ZIF-8-derived carbon material. **(c)** Cyclic voltammograms (CVs) and **(d)** specific capacitances measured at various scan rate curves of ZIF-8-derived carbon. The CVs are measured in a KOH (3M) electrolyte using a three-electrode system.

Figure S2

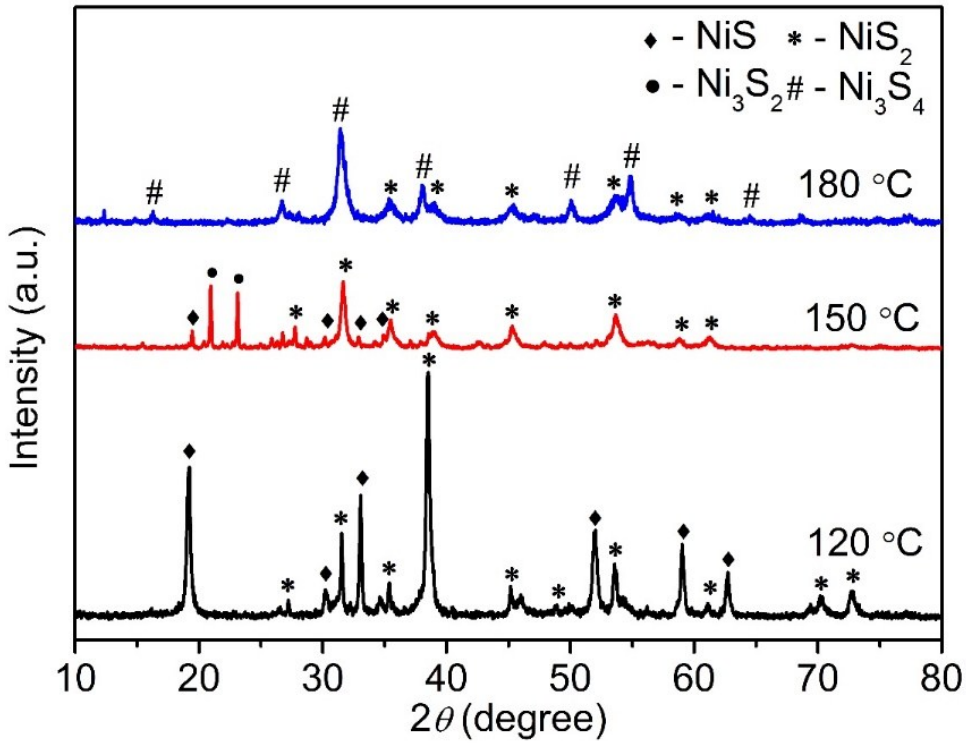

Figure S2 Wide-angle XRD patterns of nickel sulfide samples prepared at different temperatures.

Figure S3

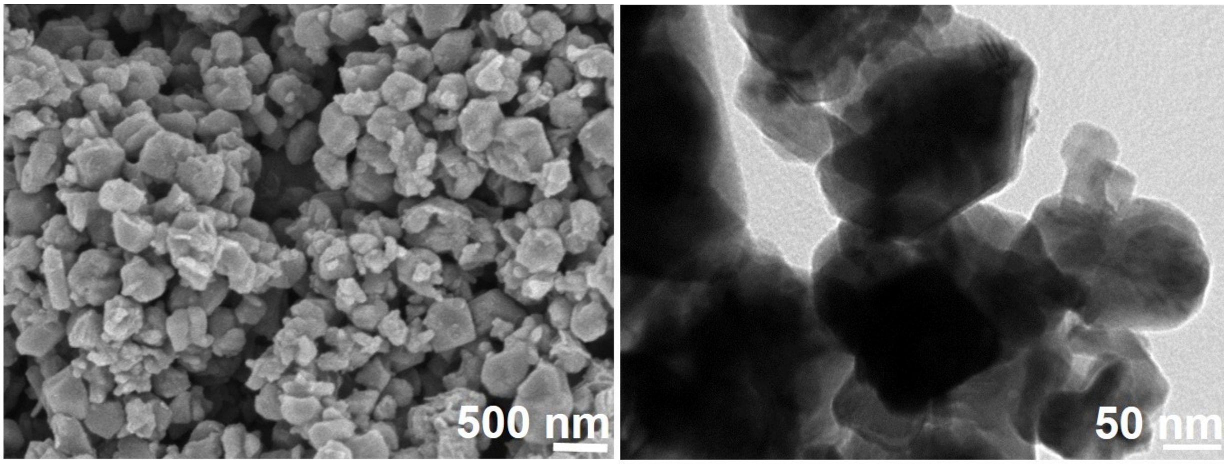

Figure S3 SEM and TEM images of a BNS sample prepared without surfactants.

Figure S4

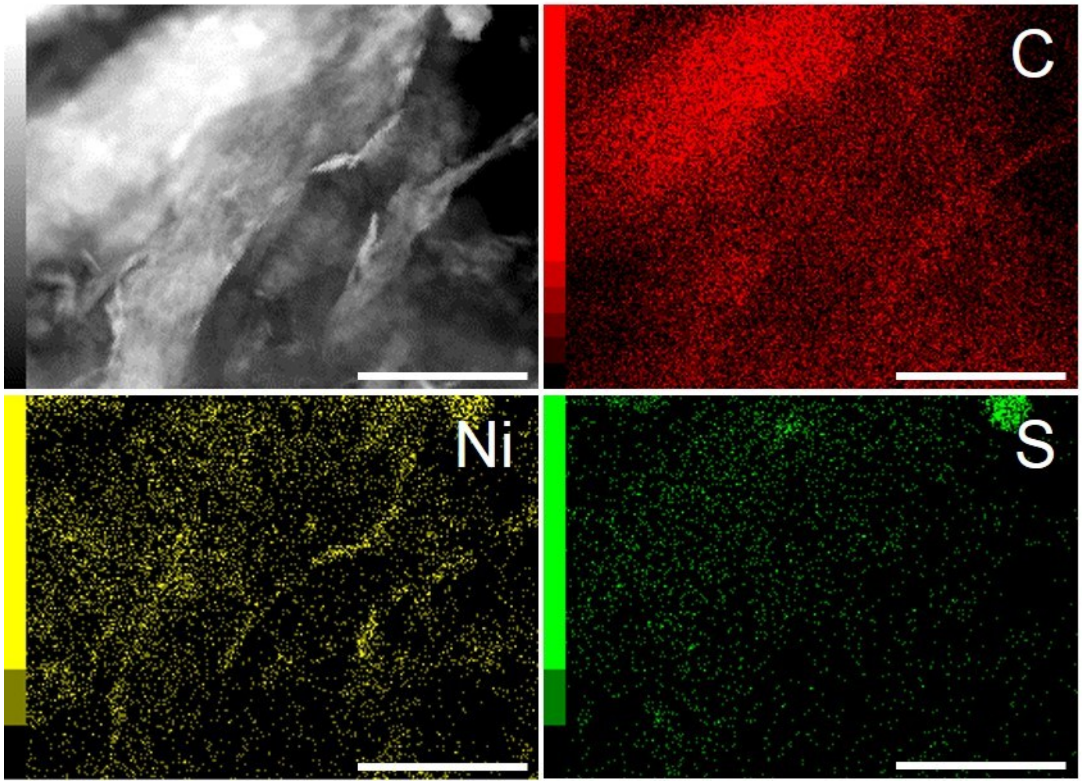

Figure S4 HAADF-STEM image and elemental mapping for the detection of carbon, nickel, and sulfur in PNS/rGO40 composites. The scale bars are 500 nm in length.

Figure S5

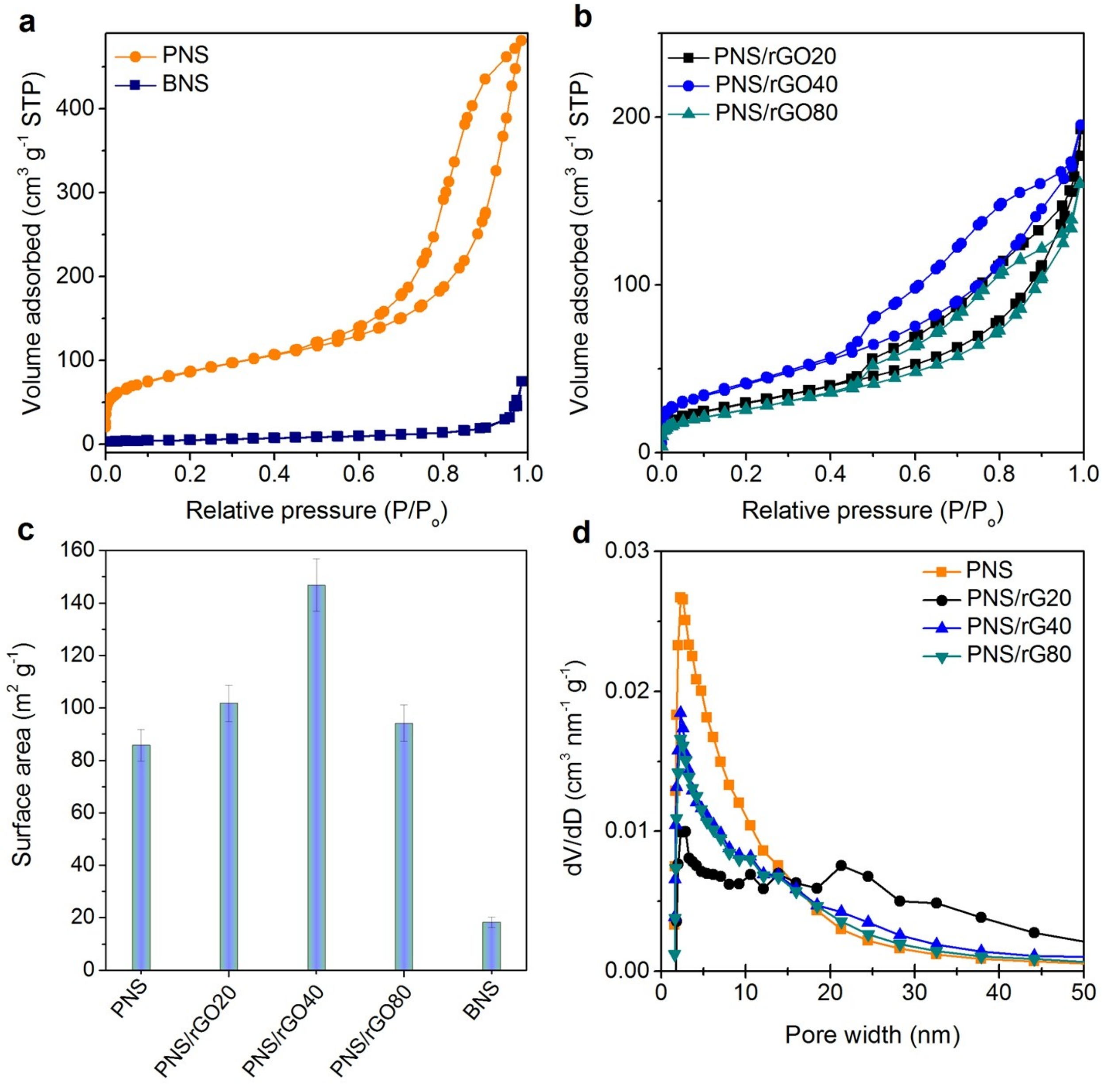

Figure S5 Nitrogen adsorption-desorption isotherms of (a) PNS and BNS samples, and (b) different PNS/rGO composites. (c) Comparison of BET surface areas, and (d) pore size distribution of the PNS and PNS/rGO composites. (Please note that for data clarity, the isotherm and pore-size distribution curves for PNS are offset vertically by 40 $cm^3 \cdot g^{-1}$ and 0.015 $cm^3 \cdot nm^{-1} \cdot g^{-1}$, respectively)

Figure S6

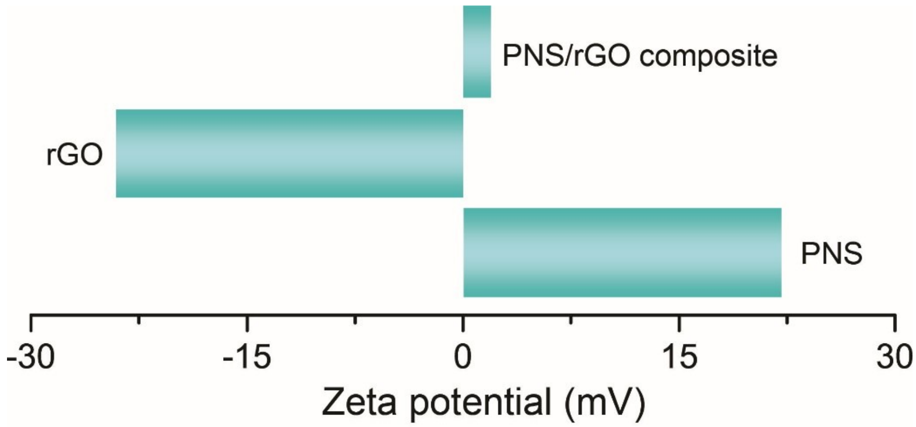

Figure S6 Zeta potentials for PNS, rGO, and PNS/rGO composite samples.

Figure S7

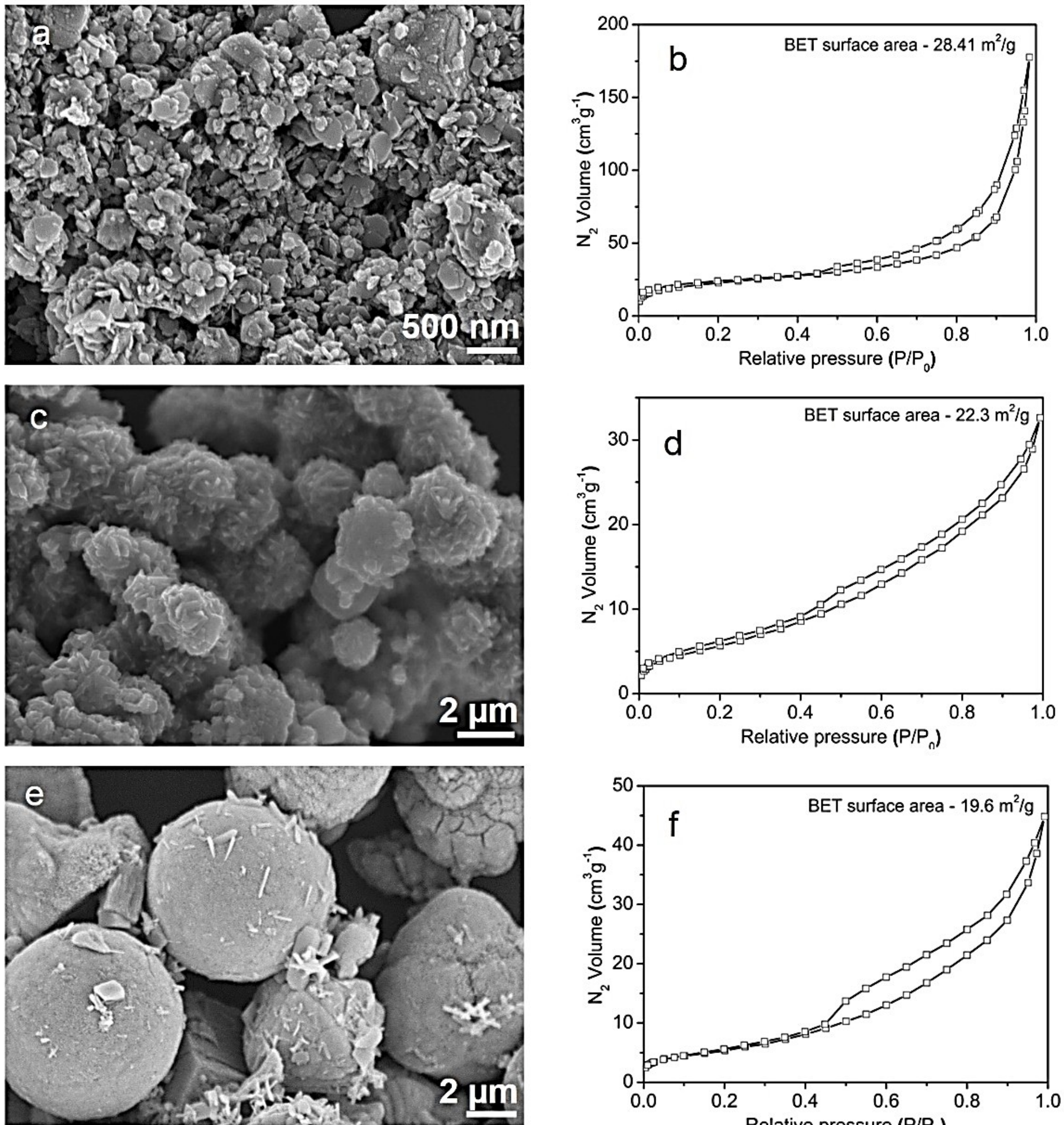

Figure S7 SEM images and the nitrogen adsorption-desorption isotherms of nickel sulfide samples at different temperatures [(a–b) 120 °C, (c–d) 150 °C, and (e–f) 180 °C].

Table S1 Comparison of the BET surface areas of our samples with those of previous reports.

Nickel sulfide materials			
Method	Nickel sulfide phase	Surface area ($m^2 \cdot g^{-1}$)	Ref.
Hard template (KIT-6)	NiS_2	77	**S1**
Hydrothermal method	Mixed phase NiS	34.3	**S2**
Solvothermal method	NiS	62	**S3**
Solvothermal method	β-NiS	24.0	**S4**
Solvothermal method	β -NiS	10.0	**S5**
Dodecanethiol complex	NiS nanorods	34.8	**S6**
	NiS nanowires	17.7	
Microwave irradiation	NiS_2 nanocubes	12.0	**S7**
	NiS_2 nanospheres	38.3	
	NiS_2 nanoparticles	25.1	
Soft template	NiS	85.7	**Our work**
Nickel sulfide-based composites			
Method	Nickel sulfide-based composites	Surface area ($m^2 \cdot g^{-1}$)	Ref.
MOF-74	Mixed-phase NiS with carbon	112	**S8**
Solvothermal method	Carbon-coated Ni_3S_2	4.2	**S9**
	Carbon-coated Ni_3S_2/RGO	12.3	
Chemical method	Nickel sulfide with carbon rods	30.8	**S10**
Hydrothermal method	NiS/CNT	16.4	**S11**
	NiS/rGO	18.9	
Biomolecule-assisted synthesis	NiS/rGO	46.3	**S12**
Soft template	NiS/rGO40	146.76	**Our work**

Table S2 Comparison of specific capacitance performance of our PNS and PNS/rGO composites with previous literature reports using a standard three-electrode system.

Bare nickel sulfide materials							
No.	Materials	Morphology	Electrolyte	Specific capacitance ($F \cdot g^{-1}$)	Scan rate ($mV \cdot s^{-1}$)	Current density ($A \cdot g^{-1}$)	Ref.
1.	Mesoporous NiS	nanoflakes	KOH (3M)	1205	5	-	**Our work**
2.	NiS	nanoflakes	KOH (1M)	664	-	4	**S13**
3.	NiS	hollow sphere	KOH (2M)	927	-	4.08	**S14**
4.	NiS	nanoparticle	KOH (2M)	893	-	5	**S15**
5.	β-NiS	flower-like	KOH (2M)	857	-	2	**S4**
6.	Co_9S_8	nanorods	KOH (3M)	783	5	-	**S16**
7.	Co_3S_4	hollow nanosphere	KOH (2M)	522	-	0.5	**S17**
8.	$NiCo_2S_4$	Urchin-like	KOH (6M)	1149	-	1	**S18**
9.	$NiCo_2S_4$	Porous nanotube	KOH (6M)	933	-	1	**S19**
Nickel sulfide-based composites							
10.	NiS/rGO40 composite	nanoflakes	KOH (3M)	1312	5	-	**Our work**
11.	Ni_3S_2/MWCNT composite	nanoparticle	KOH (2M)	1024	-	0.8	**S20**

12.	Ni_3S_2/CNT composite	nanoparticle	KOH (3M)	514	-	4	**S21**
13.	Nickel sulfide/rGO composites	nanosphere	KOH (2M)	1169	-	5	**S12**
14.	Graphene nanosheets/NiS	nanostructure	KOH (6M)	775	-	0.5	**S22**
15.	Graphene/NiS_2	nanostructure	KOH (6M)	478		0.5	**S23**
16.	Carbon/nickel sulfide/rGO	nanoparticle	KOH (3M)	860	5	-	**S9**

Table S3 Comparison of our ASC cell, consisting of PNS/rGO40 as a positive and ZIF-derived carbon as negative electrode, with those of previous reports.

No.	Working electrode	Counter electrode	Electrolyte	Operating voltage (V)	Specific energy ($W \cdot h \cdot kg^{-1}$)	Specific power ($W \cdot kg^{-1}$)	Ref.
1.	NiS/rGO40 composite	Nanoporous carbon	KOH (3M)	1.6	17.01	10283.51	**Our work**
2.	MWCNT/NiS	graphene	KOH (6M)	1.4	17.0	7000	**S24**
3.	Ni_3S_2/MWCNT	AC	KOH (2M)	1.6	15.4	6400	**S20**
4.	$NiCo_2S_4$	rGO	KOH (6M)	1.6	16.6	2348	**S25**
5.	$Ni(OH)_2$@Ni foam	a-MEGO	KOH (6M)	1.8	13.4	85000	**S26**
6.	$Co(OH)_2$ nanorods	GO	KOH (1M)	1.2	11.94	2540	**S27**
7.	MnO_2	AC	Na_2SO_4 (0.5M)	1.8	10.4	14700	**S28**
8.	$NiWO_4$	AC	KOH (2M)	1.6	15.1	4800	**S29**
9.	$NiMoO_4$	rGO	KOH (3M)	1.1	12.31	274.91	**S30**

(AC: activated carbon; rGO: reduced graphene oxide; a-MEGO: activated microwave exfoliated graphite oxide; GO: graphene oxide)

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