Supporting Information

Binder-free Ni_3S_2@PANI Core-Shell Nanosheets as Durable and High-Energy Cathode for Aqueous Rechargeable Nickel-Zinc battery

Lijun Zhou,[a] Xiyue Zhang,[b] Dezhou Zheng,[a,] Wei Xu,[a*] Jie Liu,[c] and Xihong Lu [a,b,*]

[a]*School of Applied Physics and Materials, Wuyi University, Jiangmen 529020, PR China E-mail addresses: weixugreat@126.com (W. Xu), luxh6@mail.sysu.edu.cn (X. Lu).†*

[b]*MOE of the Key Laboratory of Bioinorganic and Synthetic Chemistry, The Key Lab of Low-carbon Chem & Energy Conservation of Guangdong Province, Chemistry, School of Chemistry, Sun Yat-Sen University, Guangzhou 510275, PR China*

[c]*College of Chemistry and Chemical Engineering, Yantai University, Yantai 264005, PR China*

Calculations:

The loading mass m (mg cm^{-2}) of the Ni_3S_2 on nickel foam was evaluated by a method that a piece of Ni_3S_2 sample (cut into 0.5 cm ⌀ 2 cm) was calcined in the H_2/Ar (or H_2/N_2) atmosphere (10 : 90 by volume) at 500 ˚C for 4 h, then weighed the loss mass and calculated the weigh of Ni_3S_2 from the following equation [1-3]:

$$m = \frac{\Delta m \times M_{Ni_3S_2}}{2M_s} \qquad (1)$$

Where Δm is the weight loss after calcining obtained by electronic scales (BT25S, 0.01 mg), $M_{Ni_3S_2}$ and M_s are the molecular weight of Ni_3S_2 and S, respectively.

The specific capacity C (mA h g^{-1}) of the battery was calculated from the discharge curve with the equations as followed:

$$C = \frac{\int_0^{\Delta t} I \times dt}{m} \qquad (2)$$

Where *I* (mA cm^{-2}) is the applied discharging current density, *Δt* (h) is the discharging time and *m* (mg cm^{-2}) is the mass loading of the electrodes (3.5 mg cm^{-2}).

The mass energy density *E* and mass power density *P* of the battery were obtained from the following equations:

$$E = C \times \Delta V \qquad (3)$$

$$P = \frac{C \times \Delta V}{1000 \times \Delta t} \qquad (4)$$

Where *E* (Wh kg^{-1}) is the energy density, *C* is the mass capacity obtained from Equation (1), (2) and *ΔV* (V) is the discharging voltage. *P* (kW kg^{-1}) is the specific power density and *Δt* (h) is the discharging time.

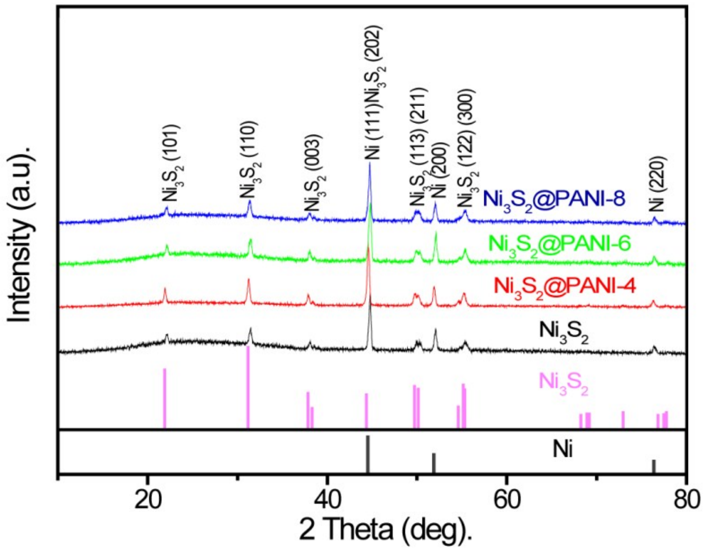

Figure S1. XRD patterns of pristine Ni_3S_2, Ni_3S_2@PANI-4, Ni_3S_2@PANI-6 and Ni_3S_2@PANI-8 electrodes.

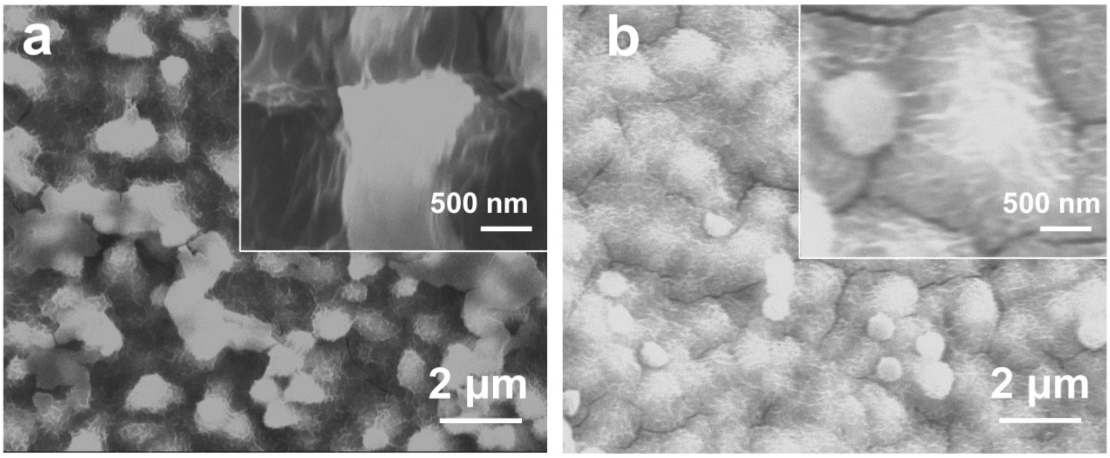

Figure S2. SEM images of the (a) Ni_3S_2@PANI-4 and (b) Ni_3S_2@PANI-8 electrodes (lower insets).

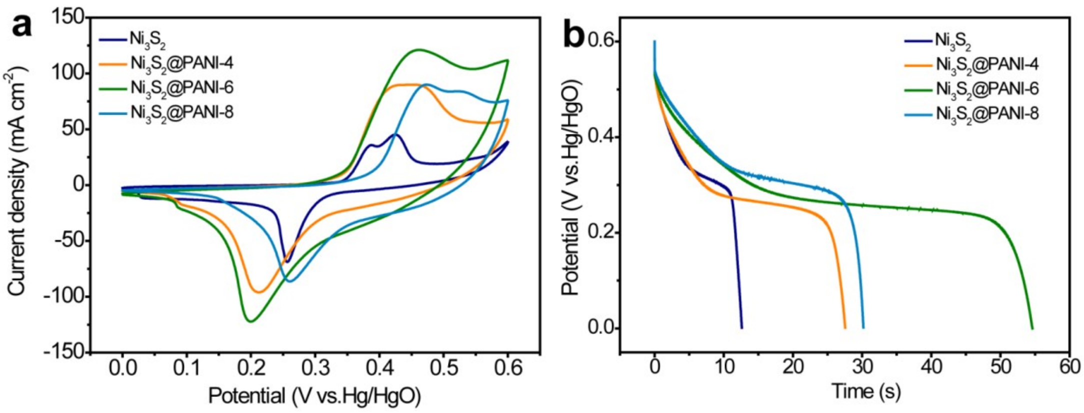

Figure S3. (a) CV curves at scaning rate of 10 mV s^{-1}, (b) GCD curves at 14.2 A g^{-1} of the Ni_3S_2, Ni_3S_2@PANI-4, Ni_3S_2@PANI-6 and Ni_3S_2@PANI-8 electrodes.

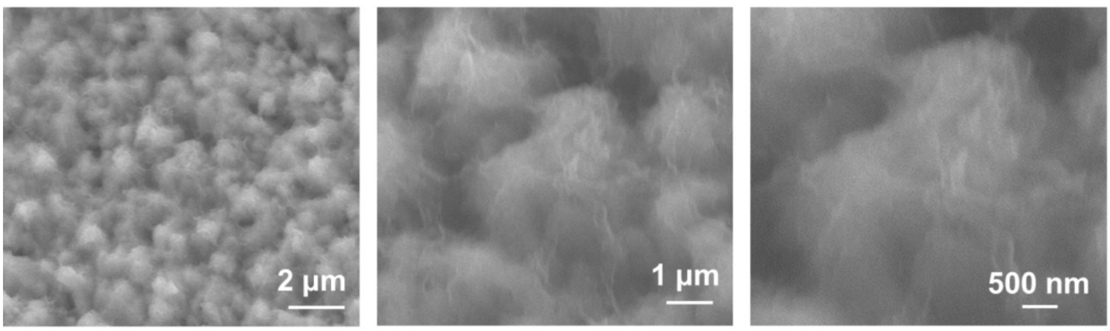

Figure S4. SEM images of Ni_3S_2@PANI-6 electrode after 10000 cycles.

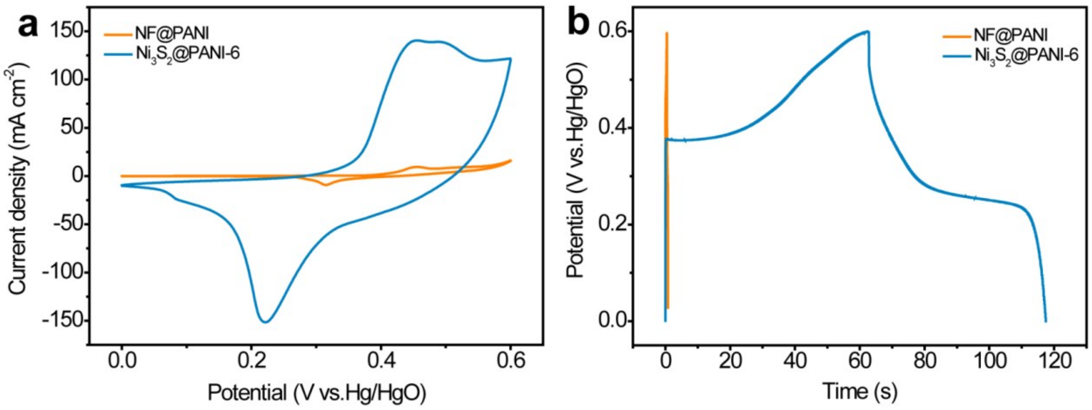

Figure S5. (a) CV curves at a scan rate of 10 mV s^{-1}, (b) GCD curves at 14.2 A g^{-1} of NF@PANI and Ni_3S_2@PANI-6 electrodes.

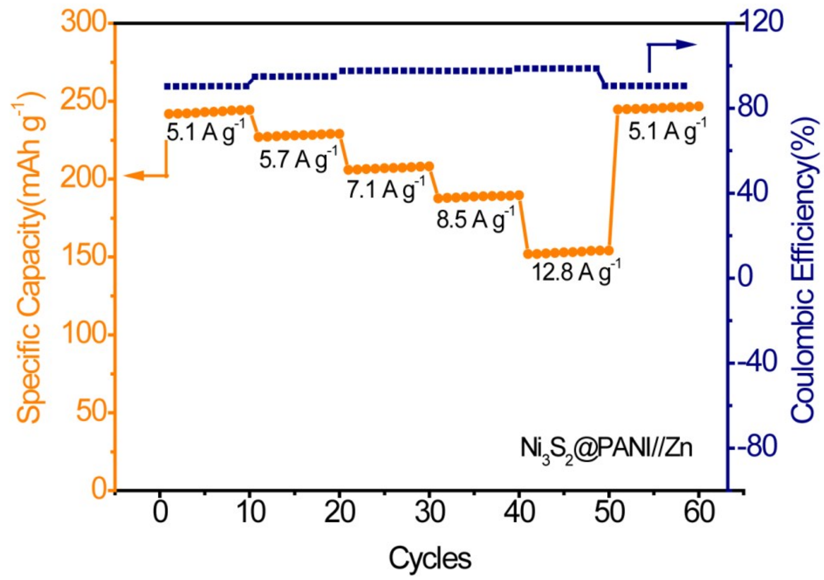

Figure S6. The rate performance of Ni_3S_2@PANI//Zn battery.

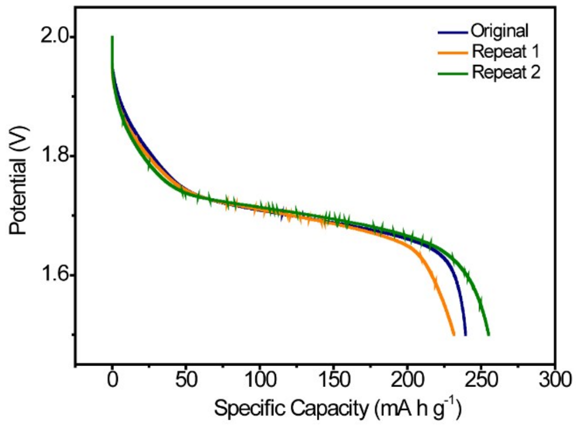

Figure S7. GCD curves at 5.1 A g^{-1} of Ni_3S_2@PANI//Zn battery in repeated experiments.

Table S1. The average value of capacities from three experiments (Figure S7).

No.	Original	Repeat 1	Repeat 2	Average
Capacity (mAh g^{-1})	241.8	232.5	254.1	242.8 $\pm$ 8.8

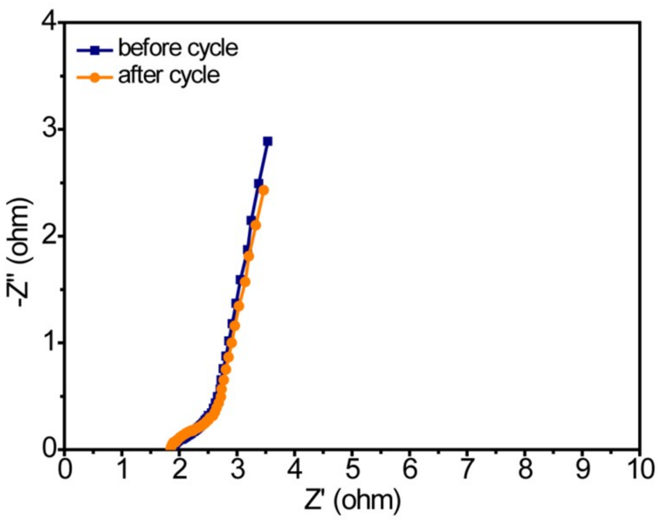

Figure S8. EIS spectra of Ni_3S_2@PANI//Zn battery before and after 5000 cycles.

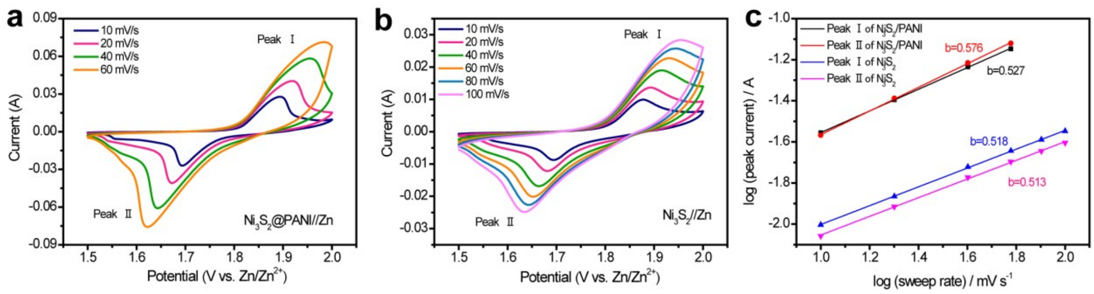

Figure S9. CV curves at various scan rates of (a) Ni_3S_2@PANI//Zn, (b) Ni_3S_2//Zn, and log (i) versus log (v) plots at specific peak currents.

References

1. S. Ni, X. Yang and L. Tao, *Mater. Chem. Phys.s*, 2012, **132**, 1103-1107.
2. T. K. Kim, W. Chen and C. Wang, *J.Power Sources*, 2011, **196**, 8742-8746.
3. X. Li, A. Dhanabalan, K. Bechtold and C. Wang, *Electrochem. Commun.*, 2010, **12**, 1222-1225.