Electronic Supplementary Information

Binary Metal Organic Frameworks Derived Hierarchical Hollow Ni_3S_2/Co_9S_8/N-doped Carbon Composite with Superior Sodium Storage Performance

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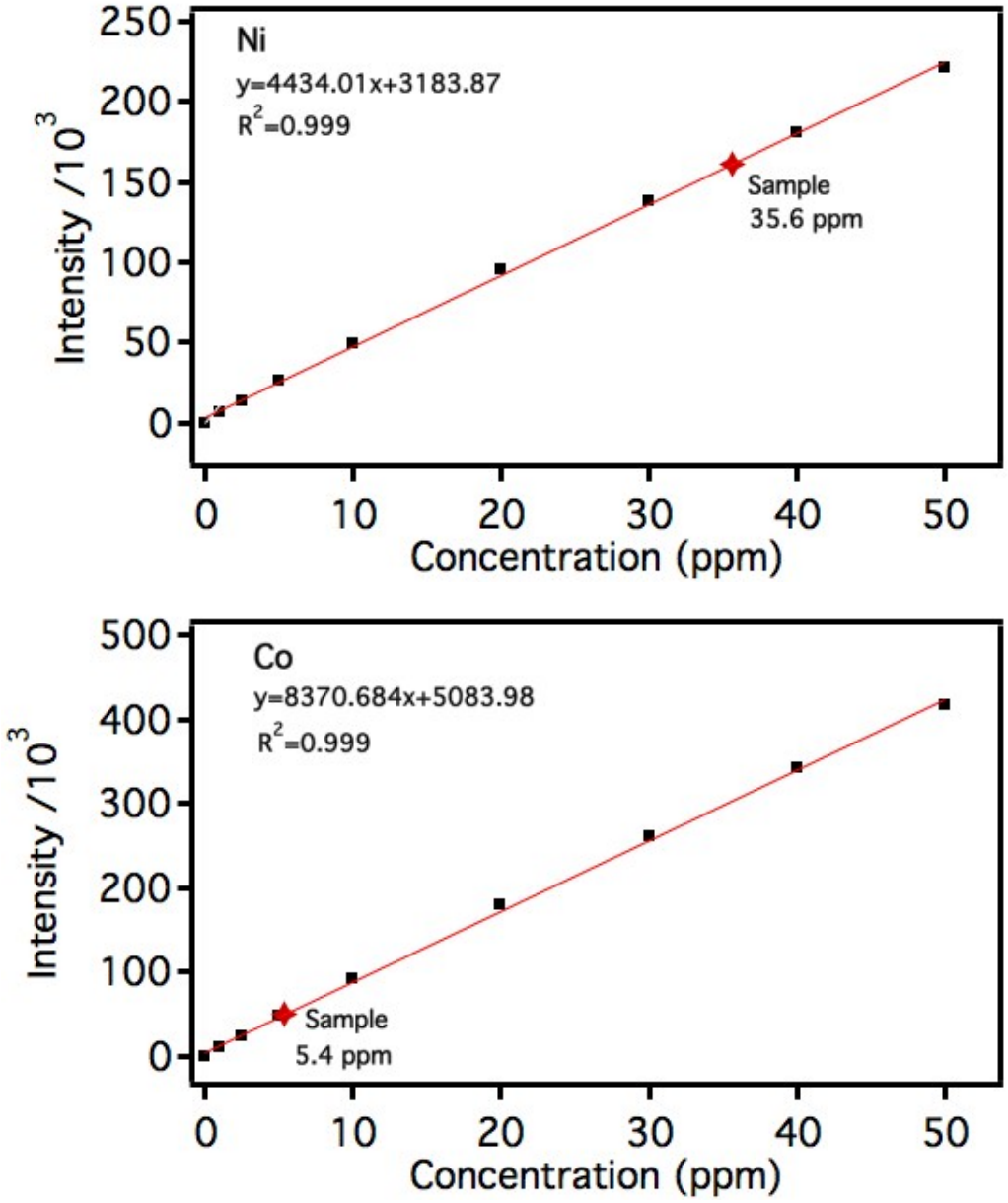


Figure S1. ICP test results for Ni and Co elements. The sample was prepared by dissolving 50 mg MOF precursor in 500 ml 4 wt% HNO_3 (100 ppm).

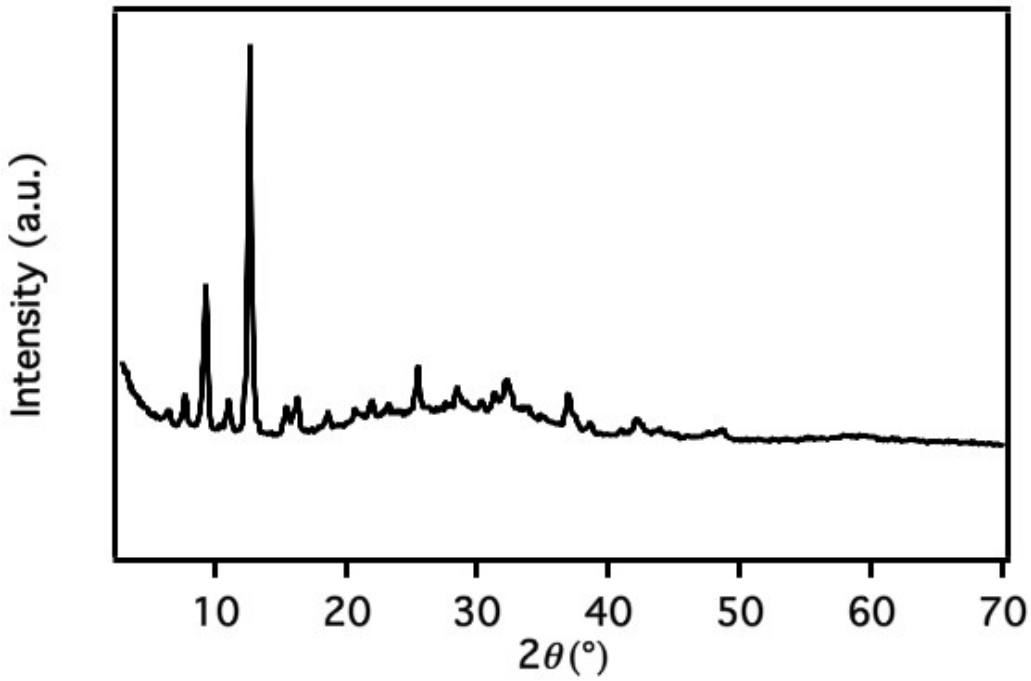


Figure S2. XRD pattern of Ni-Co-MOF.

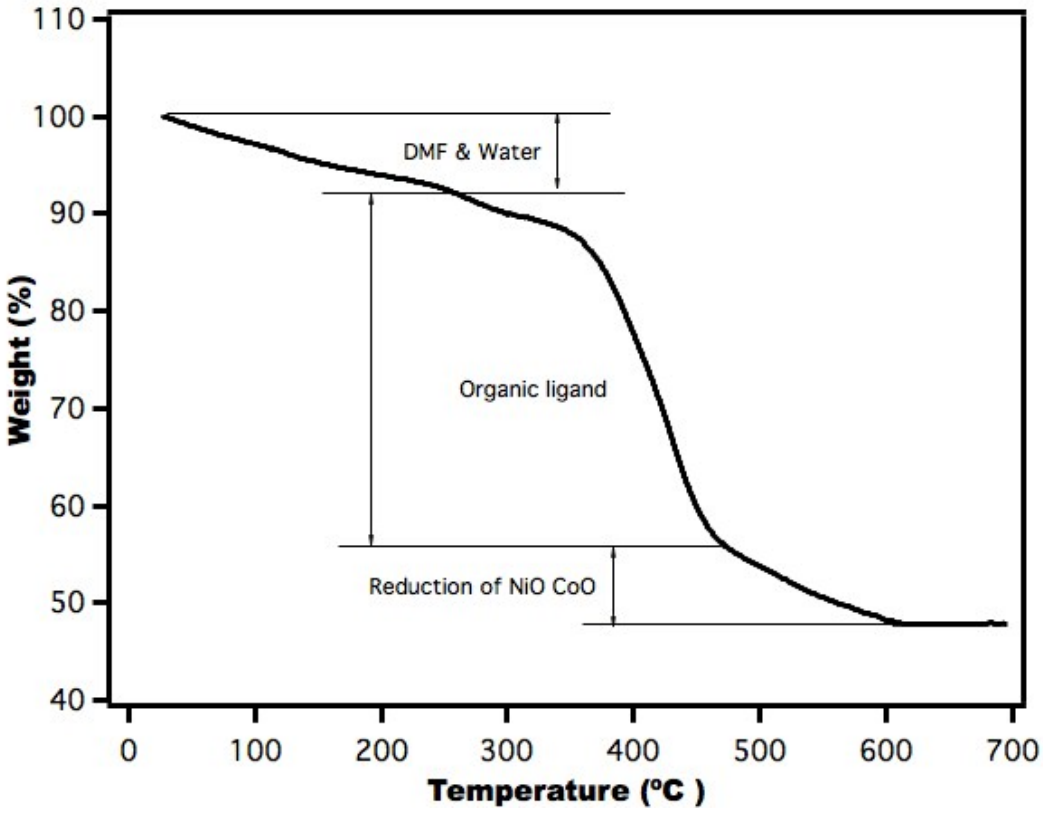
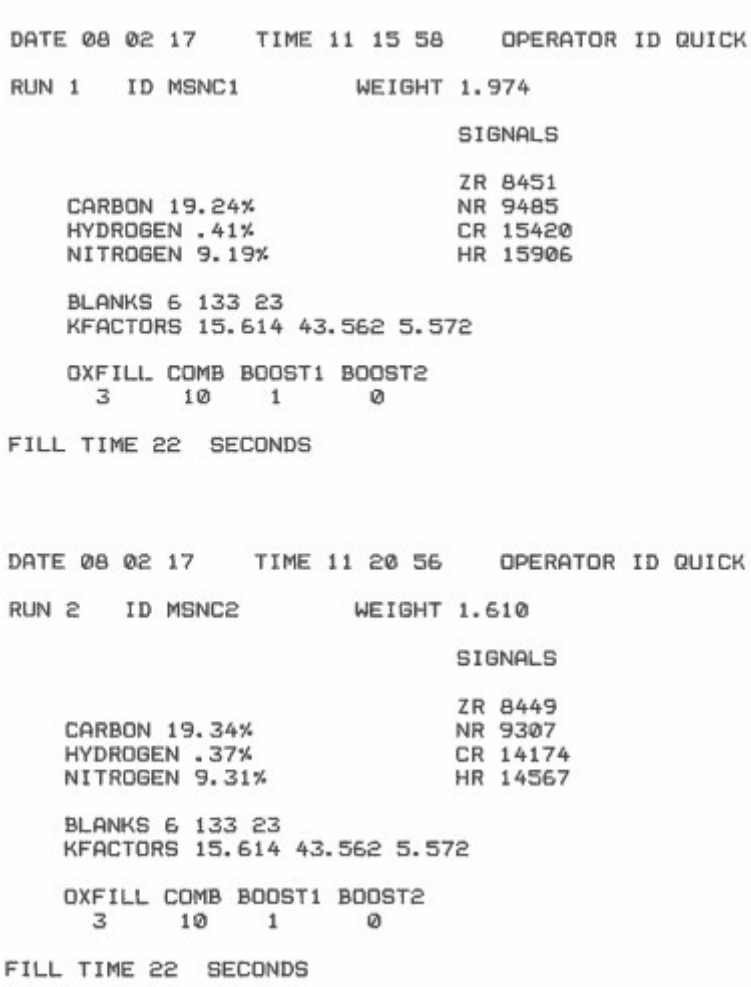


Figure S3. TGA of Ni-Co-MOF under N_2 with a temperature ramp rate of 5 ºC/min.



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DATE 08 02 17    TIME 11 15 58    OPERATOR ID QUICK

RUN 1   ID MSNC1         WEIGHT 1.974

                                  SIGNALS

                                  ZR 8451
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    HYDROGEN .41%                 CR 15420
    NITROGEN 9.19%                HR 15906

    BLANKS 6 133 23
    KFACTORS 15.614 43.562 5.572

    OXFILL COMB BOOST1 BOOST2
      3     10    1      0

FILL TIME 22  SECONDS



DATE 08 02 17    TIME 11 20 56    OPERATOR ID QUICK

RUN 2   ID MSNC2         WEIGHT 1.610

                                  SIGNALS

                                  ZR 8449
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    HYDROGEN .37%                 CR 14174
    NITROGEN 9.31%                HR 14567

    BLANKS 6 133 23
    KFACTORS 15.614 43.562 5.572

    OXFILL COMB BOOST1 BOOST2
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FILL TIME 22  SECONDS
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Figure S4. CHN analysis results for the Ni_3S_2/Co_9S_8/N-doped carbon composite

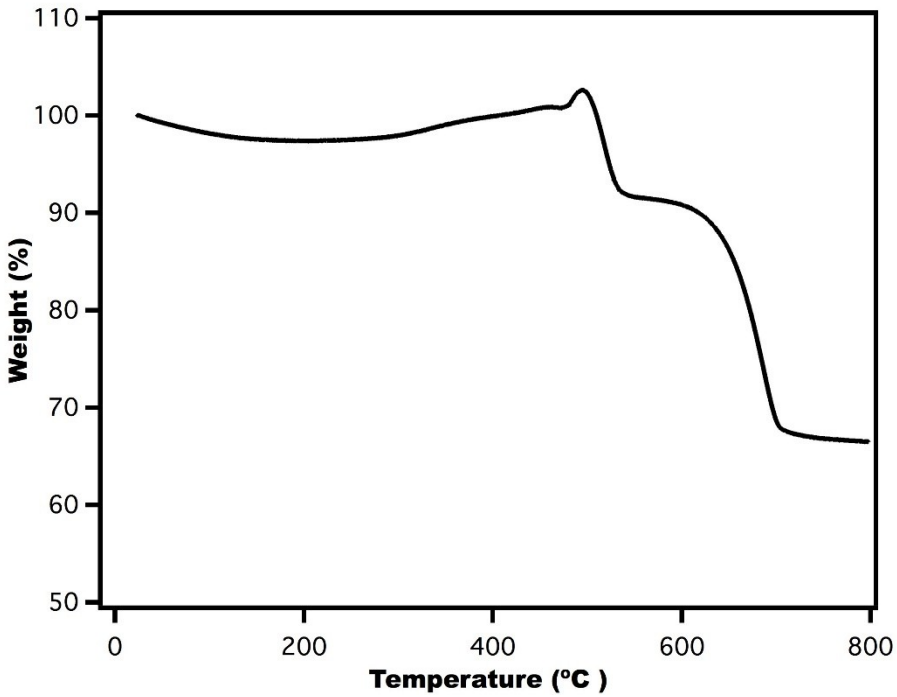

Figure S5. TGA of Ni_3S_2/Co_9S_8/N-doped carbon composite under air with a temperature ramp rate of 5 ºC/min.

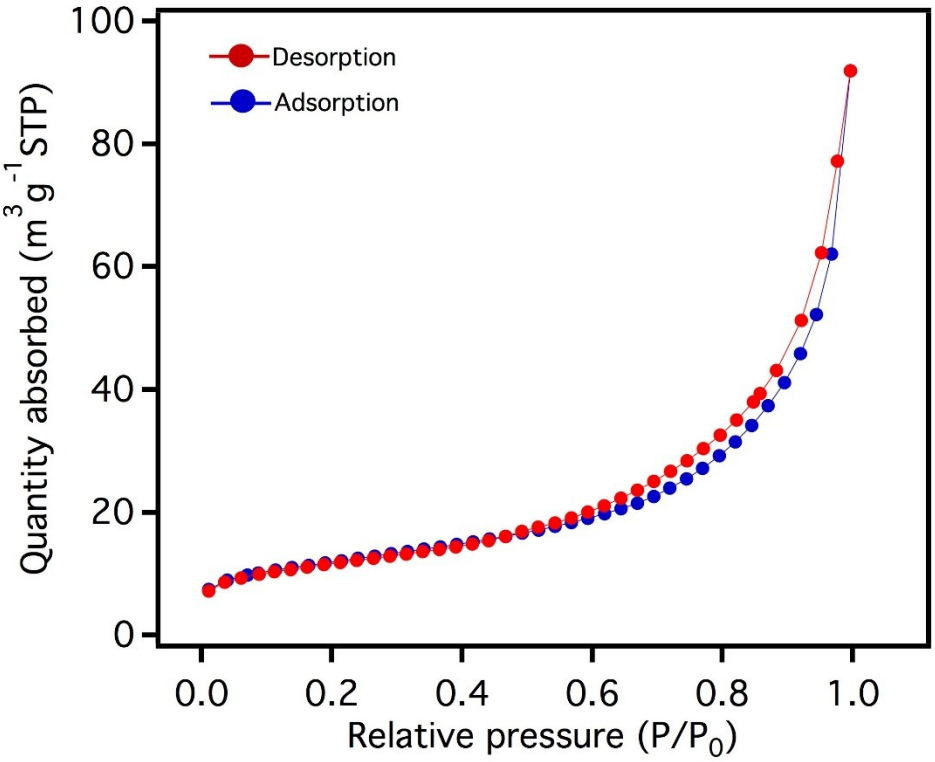

Figure S6. Nitrogen adsorption-desorption isotherm of the Ni_3S_2/Co_9S_8/N-doped carbon composite (BET surface area: 41.5 m^2g^{-1})

Calculation of crystal sizes based on the Scherrer equation

$$D = \frac{K\lambda}{\beta \cos\theta}$$

D: grain size
K: shape factor, (0.9)
λ: X-ray wavelength (nm)
β: full width at half the maximum intensity (FWHM)
θ: Bragg angle

The XRD pattern is shown in Figure 2b. The X-ray wavelength is 1.541 Å. Peak (1-10) of Ni_3S_2 (2θ=31.245º) and peak (440) of Co_9S_8 (2θ=52.104º) are used for calculation. The FWHMs are 0.232º and 0.269º, respectively.

For calculation, the FWHMs were converted into radian. The value of β for Ni_3S_2 and Co_9S_8 are 0.0040 and 0.0047, respectively.

Based on the Scherrer equation

$$D(Ni_3S_2) = \frac{0.9 * 0.154}{0.0040 \cos(15.625)} \text{ nm} = 35.5 \text{ nm}$$

$$D(Co_9S_8) = \frac{0.9 * 0.154}{0.0047 \cos(26.052)} \text{ nm} = 32.4 \text{ nm}$$

Table S1 Sodium storage performance comparison between our work and previous results.

Reference	Active Materials	Current Density (A/g)	Capacity (mAh/g)	Cycles	Retention
Wang et al. [1]	NiS_2-GNS	0.08 1.6	314 168	200	77%

Shang et al. [2]	Ni_3S_2-PEDOT	0.6 1.2	280 310	30	88%
Pan et al. [3]	NiS-20rGO	Charge 0.2 Discharge 0.05	160	10	88%
Song et al. [4]	Rod-like Ni_3S_2/Ni	0.05 0.8	315.3 230	100	90.6%
Kim et al. [5]	Ni_3S_2	0.05	342	16	81%
Qin et al. [6]	NiS-rGO	0.1 1	391.6 346	50	77.1%
Zhang et al. [7]	Core-shell Co_xS_y	0.5	300	50	77%
Du et al. [8]	Co_3S_4-PNS/GS	0.5 2	329 307	50	71
Zhou et al. [9]	Co_3S_4@PANI	0.2 2	252.5 189.3	100	44%
Ko et al. [10]	Co_9S_8@carbon	0.5 1.5	404 326	50	80%
Zhang et al. [11]	CuO/Cu_2O	0.05 1	415 217.3	50	/
Feng et al.[12]	NiO/Ni/Graphene	1 2	248 207	190	60%
This work	Ni_3S_2/Co_9S_8/N-doped carbon composite	0.1 2	419.9 323.2	100	98.6%
* GNS: graphene nanosheets; PEDOT: poly(3,4-ethylenedioxythiophene); rGO: reduced graphene oxide; Co_3S_4-PNS/GS: Co_3S_4 porous nanosheets/graphene sheets; PANI: polyaniline					

References

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