Supporting Information

Structural and Chemical Synergistic Effect of CoS Nanoparticles and Porous Carbon Nanorods for High-Performance Sodium Storage

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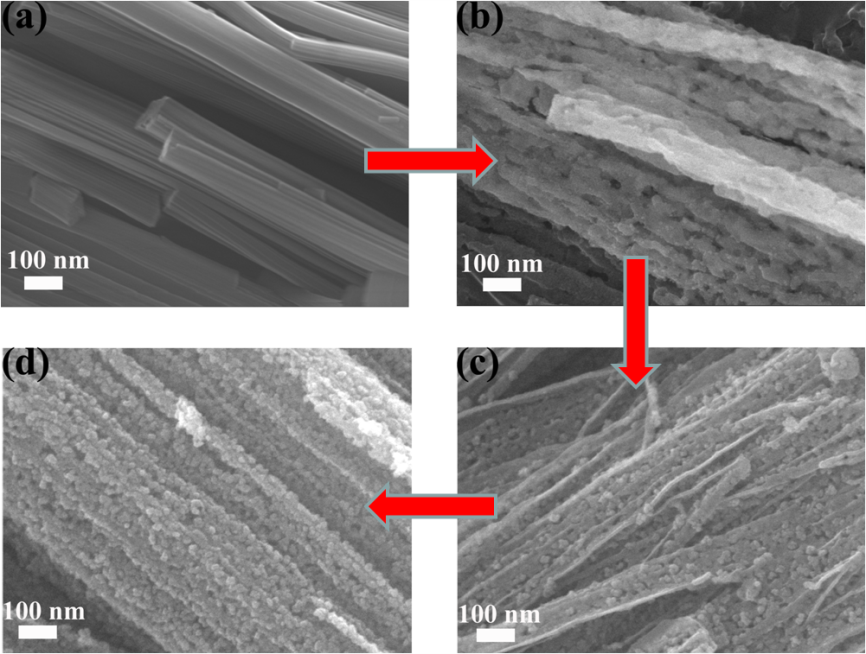
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**Fig. S1.** TGA curve for the 7-CoS/C between room temperature and 800˚C measured with a heating rate of 5 ˚C /min under air atmosphere.

With the increasing of temperature, the final obtained-product calcinated in air condition is Co3O4. Considering the existence of adsorbed water, the difference value of mass is calculated from 93.5 % to 71 % between 100 and 600 ˚C, including the oxidization of carbon and CoS. Then, we translate 93.5 % and 71 % into hundred-mark system, that is 100 % and 75.9 %. According to the proportion of Co in Co3O4, it comes to the conclusion that the mass content of Co, S, and C is 55.7, 30.2, and 14.1 wt%, respectively.

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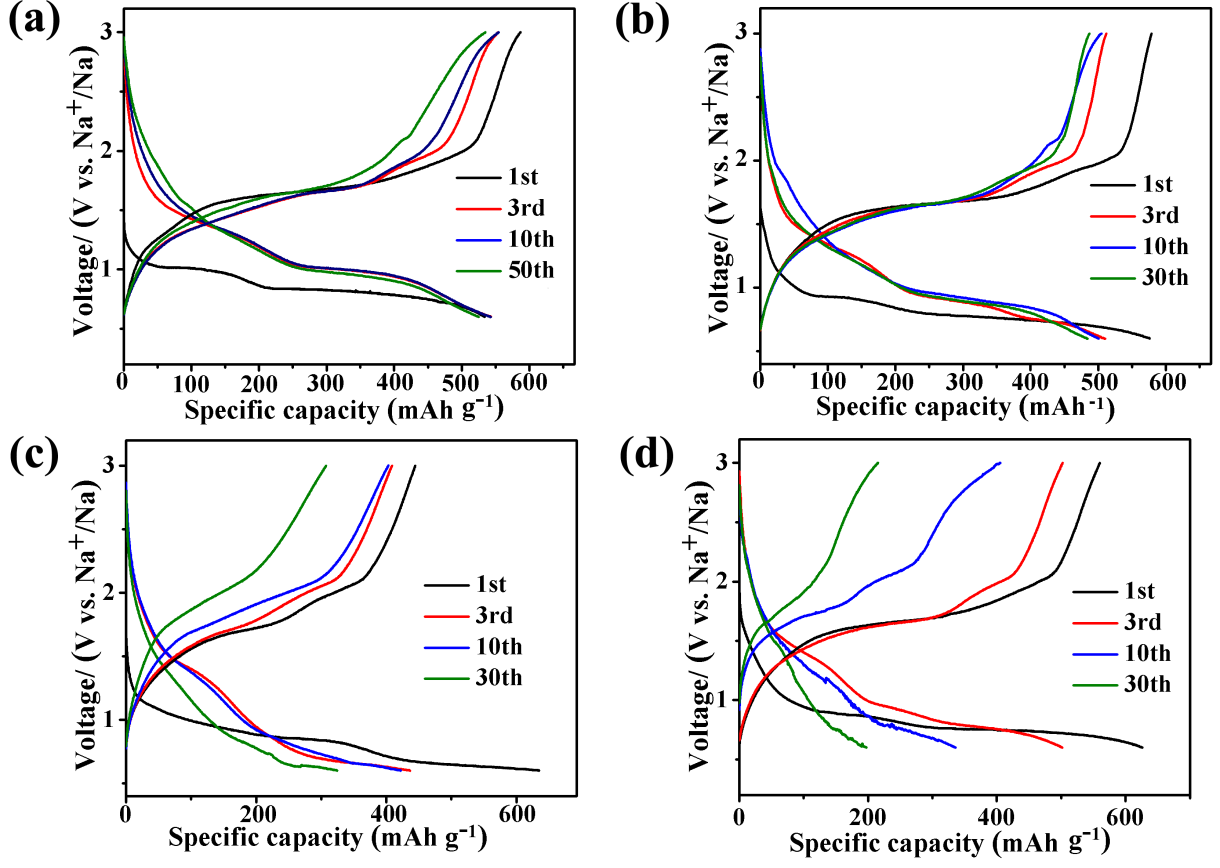
**Fig. S2.**SEM image (a), TEM image (b) (inset: CoS particle size distribution diagram) of the as-prepared 18.5-CoS/C.



**Fig. S3.** SEM images of the 7-CoS/C with different calcination temperature and heating time (a. Co-MOF precursor; b. 400 ˚C, 0 h; c. 600 ˚C, 0 h; and d. 600 ˚C, 2 h).

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**Fig. S4**. N2 adsorption-desorption isotherm (a) and pore size distribution curve (b) of the 18.5-CoS/C.



**Fig. S5.** Electrolyte optimization of 7-CoS/C-Na batteries. Discharge–charge curves at the current density of 1 A g-1 in (a) NaSO3CF3/DGM, (b) NaClO4/DGM, (c) NaClO4/EC-DMC, and (d) NaClO4/PC.

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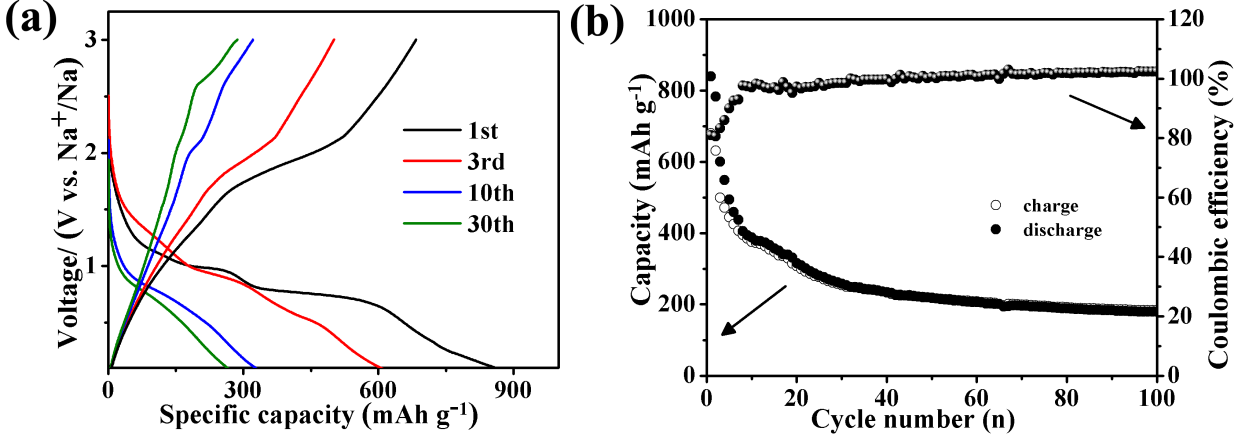
**Fig. S6.** The Nyquist plots of 7-CoS/C-Na cell in (a) NaSO3CF3/DGM, (b) NaClO4/DGM, (c) NaClO4/EC-DMC, and (d) NaClO4/PC. The equivalent circuit is put inside each image.

The EIS plot is charateristic of a compressed semicircle at high-frequency range and a line at low-frequency range, which reveals the charge transfer and electrolyte diffusion process. The EIS analysis of the 7-CoS/C-Na system with various electrolyte was taken under different temperature from 298.15 K to 323.15 K shown in Figure S6. We can obviously observe that the 7-CoS/C-Na cell has the lowest charge tranfer impedance in NaSO3CF3/DGM electrolyte.

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**Fig. S7.** (a) Apparent activation energy calculation: the relationship between ln(T/Rct) and 1000/T.

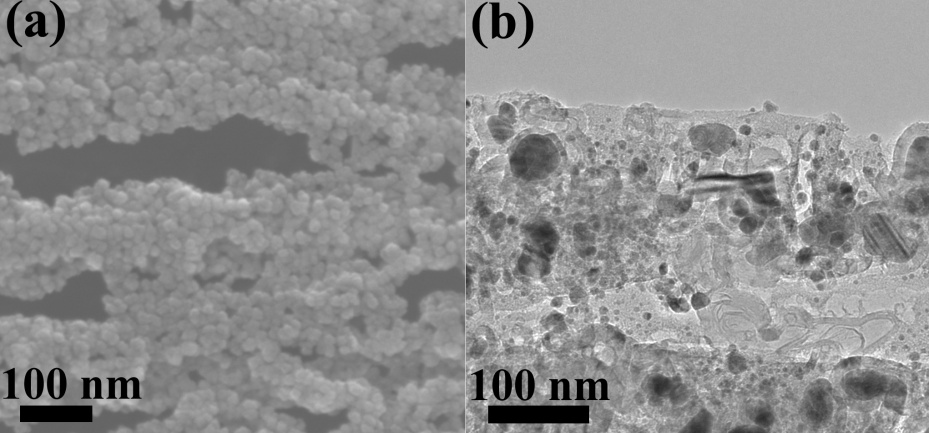
The activiation energy (Ea) was calculated from the EIS data at differnet temperature according to the equations: *i*0=RT/nFRct (Equation S1) and *i*0=Aexp(-Ea/RT) (Equation S2), where R is the gas constant, T is the absolute temperature, n is the number of transferred electrons, and F is the Faraday constant.[1,2] NaSO3CF3/DGM displays the lowest Ea, proving that electrons are easy to transport in the 7-CoS/C-Na system with NaSO3CF3/DGM electrolyte than the other three electrolytes.



**Fig. S8.** (a) galvanostatic discharge/charge profiles and (b) cycling performance of the 7-CoS/C electrode tested at a current density of 0.5 A g−1 in the voltage range of 0.01–3 V vs Na+/Na.

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**Fig. S9.** The Nyquist plots of the 7-CoS/C-Na and 18.5-CoS/C-Na electrodes before and after 50 cycles in NaSO3CF3/DGM.



**Fig. S10.** SEM and TEM images of the 18.5-CoS/C electrode after 200 cycles at a current density of 1 A g−1.

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**Fig. S11.** CollectedXRD profiles of the 7-CoS/C electrode at different charge and discharge states after 200 cycles.

**Table S1. The average voltage of 7-CoS/C and 18.5-CoS/C**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Current density (mA cm-2) | 7-CoS/C average voltage (V) | | | 18.5-CoS/C average voltage (V) | | |
| charge | discharge | difference | charge | discharge | difference |
| 0.64 | 1.71 | 1.12 | 0.59 | 1.72 | 1.11 | 0.62 |
| 3.19 | 1.74 | 1.11 | 0.63 | 1.78 | 1.10 | 0.67 |
| 6.37 | 1.76 | 1.10 | 0.66 | 1.85 | 1.10 | 0.75 |
| 31.85 | 1.86 | 1.08 | 0.78 | 1.98 | 1.05 | 0.94 |
| 63.70 | 1.93 | 1.05 | 0.88 | 2.12 | 1.01 | 1.12 |

**References:**

1. H. Ma, S. Zhang, W. Ji, Z. Tao, J. Chen, J. Am. Chem. Soc. 130 (2008) 5361-5367.

2. H. Gao, Z. Hu, K. Zhang, F. Cheng, J. Chen, Chem. Commun. 49 (2013) 3040-3042.