Supporting information

Simple synthesis of $CoMoS_4$ based nanostructure and its application for high-performance supercapacitors

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This supporting information includes: Reagents, Preparation of CoS, MoS_2, and $CoMoO_4$, preparation of working electrodes, Figure S1, Figure S2, Figure S3, Figure S4, Figure S5, and Figure S6, Table S1.

Reagents

Analytical grade $CoCl_2 \cdot 6H_2O$, $NaMoO_4 \cdot 2H_2O$, $(NH_4)_2Mo_7O_{24} \cdot 4H_2O$, $(NH_4)_2S$, $Na_2S \cdot 9H_2O$, and KOH were purchased from Sinopharm Chemical Reagent Co. Ltd. and used as received without any further purification. Nickel foam was purchased from ChangSha Lyrun New Material Co. Ltd, and was washed with acetone and double-distilled water for several times and dried at 60 ºC before using.

Preparation of CoS

In the preparation of CoS, 1 g of $CoCl_2 \cdot 6H_2O$ was dissolved in 30 ml distilled water and stirred at 70 ºC, then 1.2 g of $Na_2S \cdot 9H_2O$ in 30 ml of distilled water under constant magnetic stirring and then the reaction mixture was kept at 70 ºC for 2 h. Then the precipitate was collected and washed with distilled water and absolute ethanol for several times, and dried at 60 ºC.

Preparation of MoS_2

For the formation of MoS_2, 0.120 g of $(NH_4)_2Mo_7O_{24} \cdot 4H_2O$ and 0.240 g of thioacetamide were dissolved in 80 ml of distilled water with continuous stirring. [1] The as-obtained mixture was loaded into a Teflon-lined stainless steel autoclave and heated at 200 °C for 24 h. After heating, the Teflon reactor was cooled to room temperature naturally and then the mixture was washed with distilled water and absolute ethanol for several times, and dried at 60 ºC.

Preparation of $CoMoO_4$

$CoMoO_4$ were fabricated as follows: 1 g of $CoCl_2 \cdot 6H_2O$ was dissolved in 30 ml distilled water and stirred at 70 ºC, then 30 ml distilled water containing 1.02 g of $NaMoO_4 \cdot 2H_2O$ was added dropwise and stirred for 2 h. The pink solid was filtered, washed and dried at 60 ºC.

Working electrode preparation

The working electrodes were prepared by mixing 80 wt% electro-active material, 7.5 wt%acetylene black and 7.5 wt% conducting graphite in an agate mortar until a homogeneous black powder was obtained. Then, 5 wt% poly(tetrafluoroethylene) was added into this mixture together with a few drops of ethanol. After briefly allowing the solvent to evaporate, the resulting slurry was pressed to nickel foam with a nickel wire for an electric connection. Subsequently, the electrode was dried for 10 h at 60 °C in air. Each electrode contained approximately 4 mg of electrode material and had a geometric surface area of 1 cm^2.

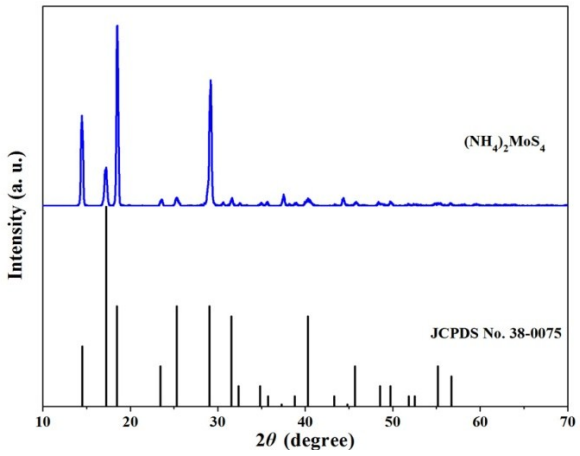

Figure S1 XRD pattern of the $(NH_4)_2MoS_4$ sample.

Figure S1 shows the XRD patterns of the as−prepared $(NH_4)_2MoS_4$ samples. The XRD patterns of $(NH_4)_2MoS_4$ are in good agreement with the standard patterns for $(NH_4)_2MoS_4$ (JCPDS card no. 38−0075), indicating the formation of $(NH_4)_2MoS_4$ phase. While the intensities of the peaks for the experimental sample of $(NH_4)_2MoS_4$ do not match those of the JCPDS file perfectly, this may be due to preferred orientation effects.

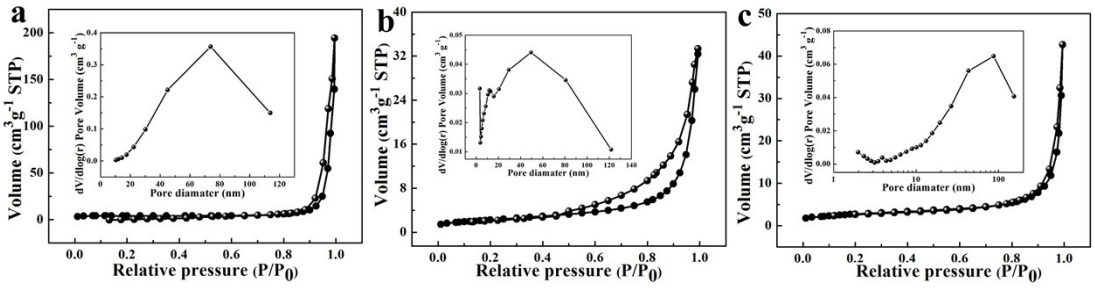

Figure S2 The nitrogen adsorption–desorption isotherms of (a) CoS, (b) MoS_2, (c) $CoMoO_4$, and the corresponding pore size distributions (inset) calculated from the adsorption branches of the isotherms at -196 °C using the Barrett-Joyner-Halenda (BJH) theory model.

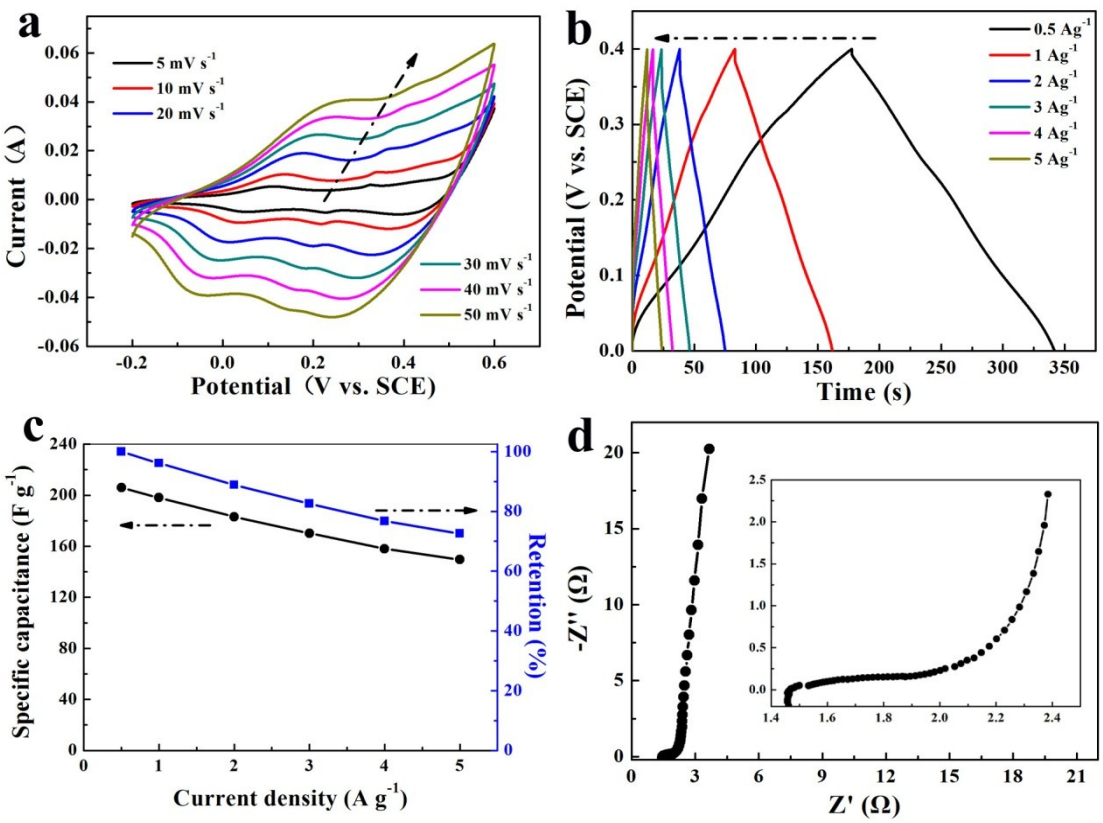

Figure S3 Electrochemical performance of CoS in 6 M KOH aqueous electrolyte: (a) CV curves at various scan rates, (b) Charge–discharge curves at various current densities, (c) The specific capacitance as a function of discharge current density, (d) EIS curve measured in the frequency range from 10^5 Hz to 10^{-2} Hz at the open circuit voltage with an alternate current amplitude of 5 mV.

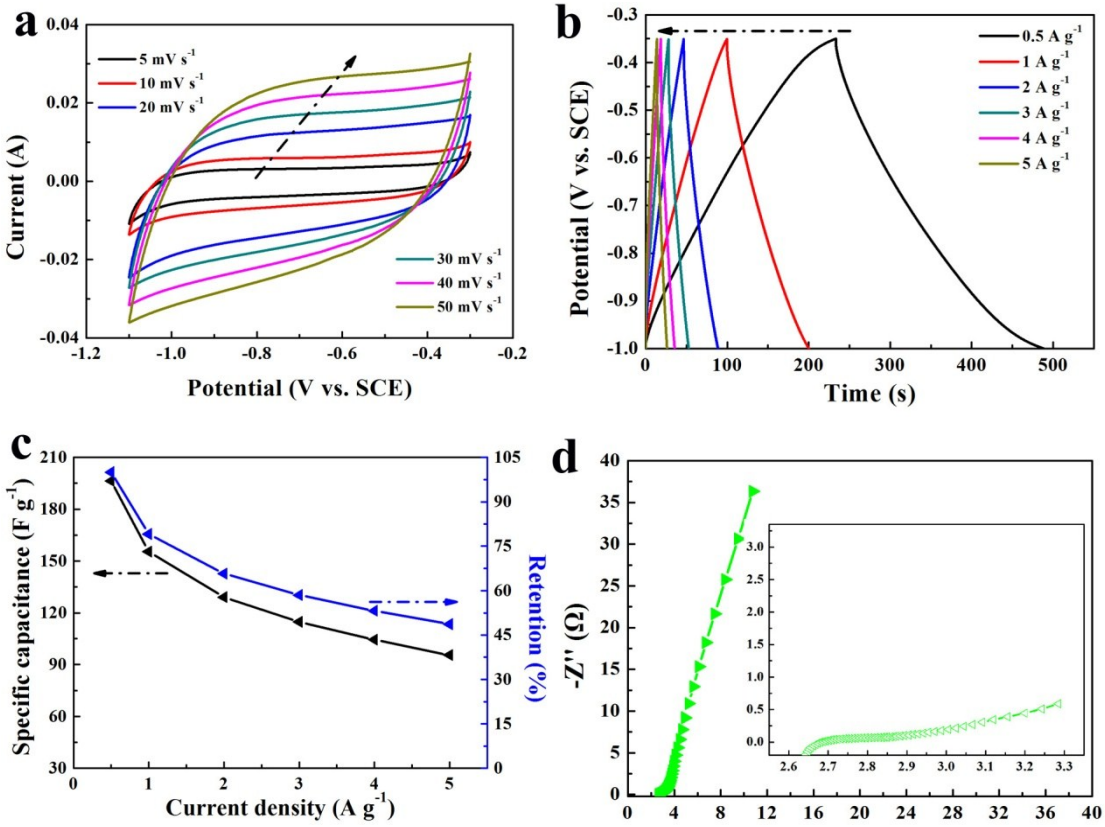

Figure S4 Electrochemical performance of MoS_2 in 1 M Na_2SO_4 neutral electrolyte: (a) CV curves at various scan rates, (b) Charge–discharge curves at various current densities, (c) The specific capacitance as a function of discharge current density, (d) EIS curve measured in the frequency range from 10^5 Hz to 10^{-2} Hz at the open circuit voltage with an alternate current amplitude of 5 mV.

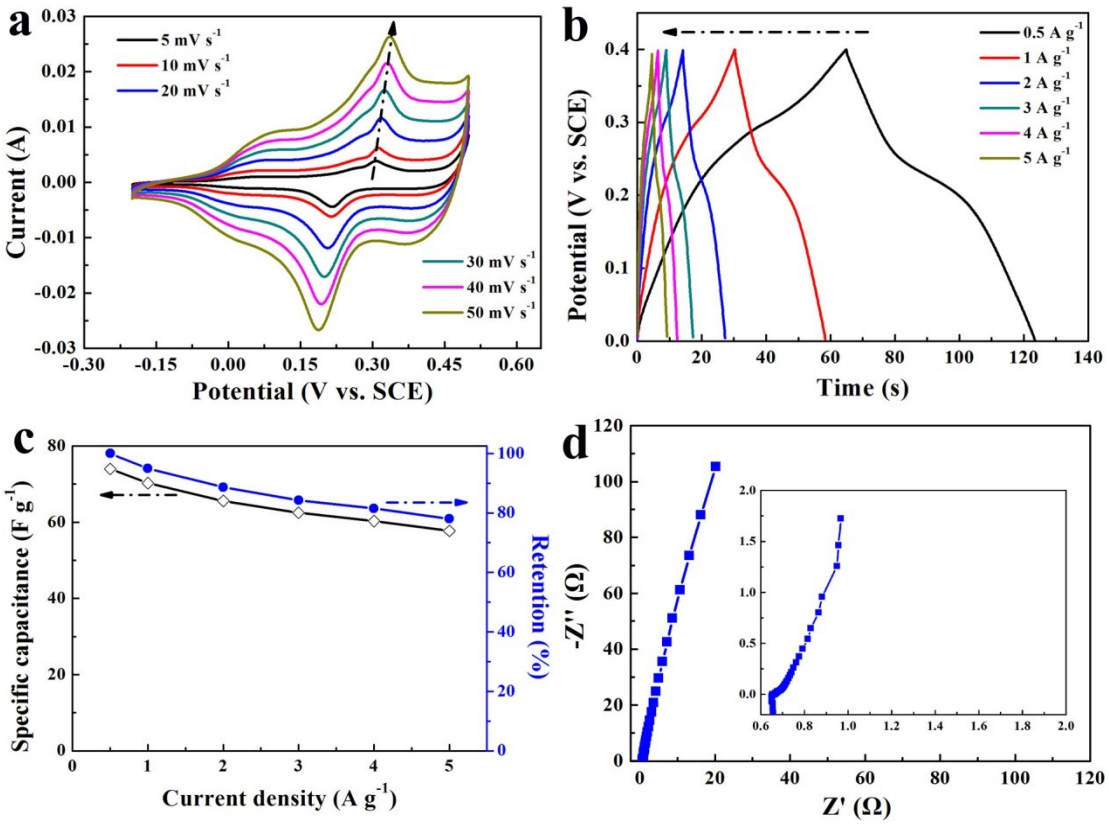

Figure S5 Electrochemical performance of $CoMoO_4$ in 6 M KOH aqueous electrolyte: (a) CV curves at various scan rates, (b) Charge–discharge curves at various current densities, (c) The specific capacitance as a function of discharge current density, (d) EIS curve measured in the frequency range from 10^5 Hz to 10^{-2} Hz at the open circuit voltage with an alternate current amplitude of 5 mV.

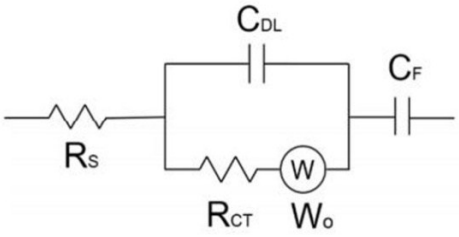

Figure S6. An equilibrium circuit used to fit the Nyquist plot using the software Zsimpwin. (R_S: Cell internal resistance, R_{CT}: Charge transfer resistance, C_{DL}: Double layer capacitance, W_O: Warbug diffusion element, C_F: Faradic capacitance.)

Table S1. Equivalent circuit parameters obtained by using fitting program.

Samples	R_S (Ω)	C_{DL} (μF)	R_{CT} (Ω)	W_O (Ω.$^{-1/2}$)	C_F (F)
MoS_2	2.711	2050	0.1272	0.6216	0.4906
CoS	1.534	6392	0.0594	1.5910	0.7368
$CoMoO_4$	0.717	83710	0.0355	0.0163	1.324E18
$CoMoS_4$	0.620	531	0.0100	3.0910	0.9942

References

1 A. Ramadoss, T. Kim, G. S. Kima and S. J. Kim, *New J. Chem.*, 2014, **38**, 2379.