Supporting information

Facile synthesis of $NiMoO_4 \cdot xH_2O$ nanorods as positive electrode material for supercapacitors

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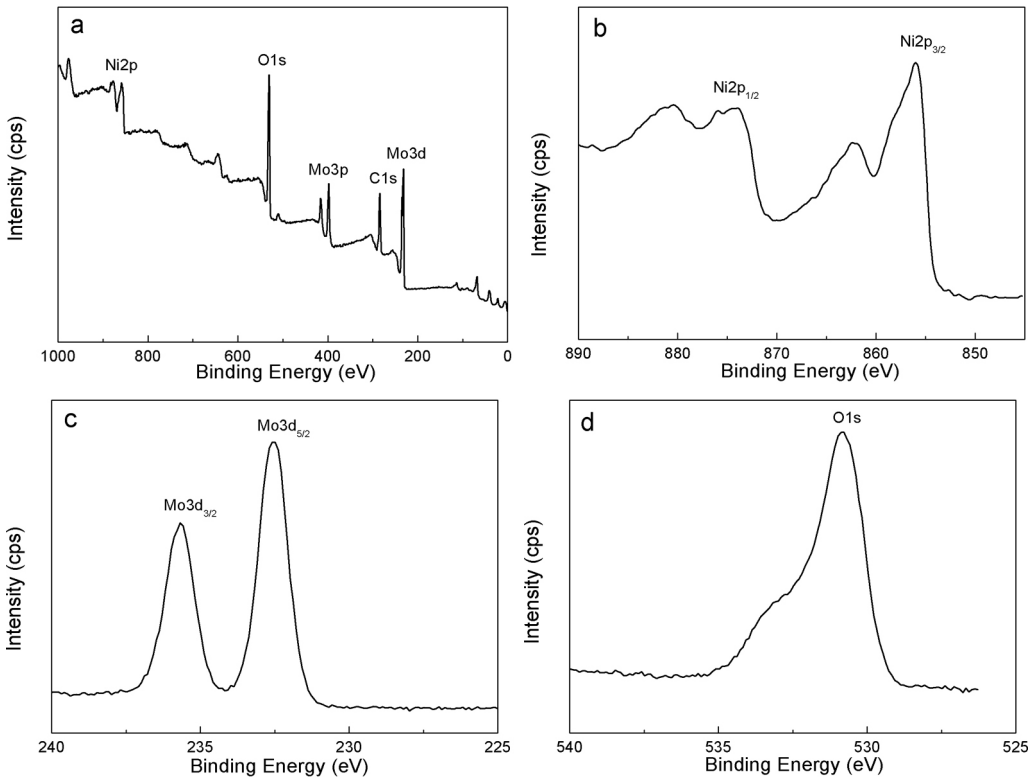

Figure S1. (a) Overall XPS, (b) Ni 2p, (c) Mo 3d and (d) O 1s XPS spectra of $NiMoO_4 \cdot xH_2O$.

The overall XPS spectrum (Fig. S1a) shows that the surface of $NiMoO_4 \cdot xH_2O$ consists of Ni, Mo, and O elements. The Ni 2p XPS spectra shows two peaks at 874.5 and 856.1 eV, corresponding to the Ni $2p_{1/2}$ and Ni $2p_{3/2}$, respectively (Fig. S1b). A spin-energy separation of 18.4 eV is the characteristic of Ni^{2+} in $NiMoO_4 \cdot xH_2O$.[1] The Mo 3d XPS spectra of the $NiMoO_4 \cdot xH_2O$ displays two peaks at 235.6 and 232.6 eV, agreeing well with Mo $3d_{3/2}$ and Mo $3d_{5/2}$ assigned to Mo^{6+} in $NiMoO_4 \cdot xH_2O$ (Fig. S1c).[2] O 1s XPS shows a strong peak around 530.8 eV which can be regarded as characteristic peak of O 1s in NiMoO4·xH2O.

Figure S2 shows the specific capacitances of the $NiMoO_4 \cdot xH_2O$ fabricated at different conditions. The sample fabricated at 70 °C exhibits higher specific capacitance than one at 60 °C. We also found that 60 °C is not the optimum temperature to fabricate $NiMoO_4 \cdot xH_2O$ due to the low yield at this temperature. Fig.

S2a indicates that the specific capacitance of the sample fabricated at 80 °C is close to that of the material prepared at 70 °C at a low current density of 5 mA cm^{-2}. But it quickly decreased with the increment of the discharge current density. When the current density is 50 mA cm^{-2}, only 30.1 % of the specific capacitance is remained. Obviously, it is lower than 60.6 % of the sample fabricated at 70 °C. We consider that the sample fabricated at 70 °C shows lower crystallinity due to mild fabrication temperature, which results in an excellent rate capability. Because of the highest specific capacitance and excellent rate capability, 70 °C is employed as the optimum temperature to synthesize $NiMoO_4 \cdot xH_2O$. Fig. S2b shows the specific capacitance of the samples synthesized through various reaction times. The specific capacitance of samples prepared through 4 and 6 h are almost equality and higher than that of 2 and 8 h, suggesting that 4 and 6 h are the better temperature to synthesize $NiMoO_4 \cdot xH_2O$. Take into above considerations, 70 °C and 4 h were chosen as optimum conditions to synthesize $NiMoO_4 \cdot xH_2O$ nanorods.

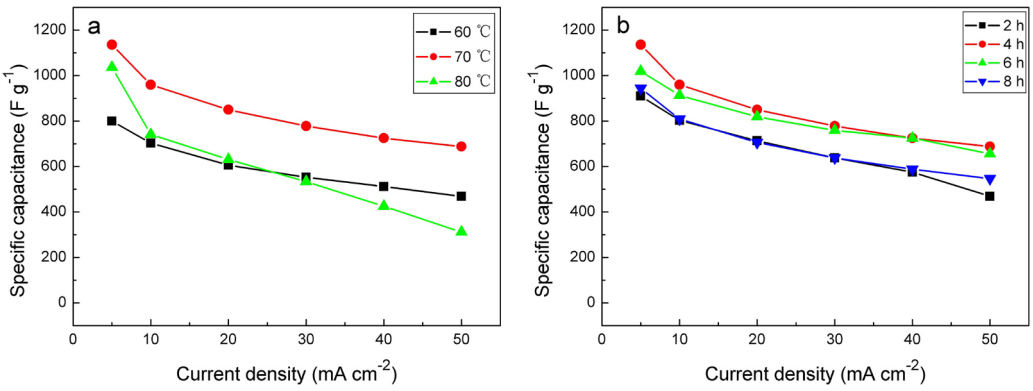

Figure S2. Specific capacitances of $NiMoO_4 \cdot xH_2O$ fabricated at: (a) various temperatures and (b) various reaction times.

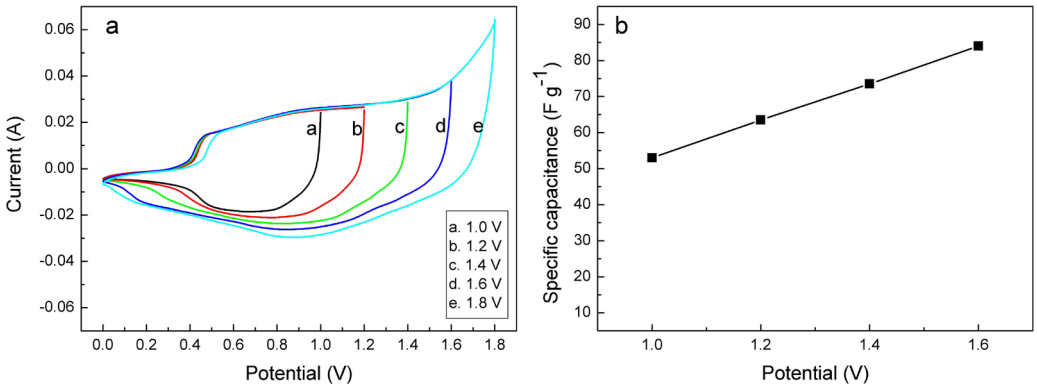

Figure S3. (a) CV curves of the AC//$NiMoO_4 \cdot xH_2O$ asymmetric supercapacitor measured at different potential windows at a scan rate of 10 mV s^{-1}. (b) Specific capacitances of the asymmetric supercapacitor with the increases of potential window.

It is very important to chose an appropriate potential window for asymmetric supercapacitor, otherwise there is a risk of damaging the cell when charge it in the high potential. Fig. S3a exhibits the CV curves with different potential windows for an assembled asymmetric supercapacitor in 2 M KOH aqueous electrolyte at a scan rate of 10 mV s^{-1}. The current quickly increased when the scan potential exceed 1.6 V, indicating that the O_2 evolution was taken place because of the water decomposition from electrolyte. Results suggest that the potential window of the cell should not exceed 0-1.6 V. Fig. S3b exhibits the variation of the specific capacitance with the increase of potential window for the cell. As shown, the specific capacitance increases significantly from 53 to 84 F g^{-1} with the operation potential from 1.0 to 1.6 V, the stored energy can be improved at least by 405 % according to Equation 1. Given the above considerations, we chose an operation voltage window of 1.6 V in 2 M KOH aqueous electrolyte to further investigate the supercapacitive performance of the asymmetric supercapacitor.

References

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2 Z. W. Xu, Z. Li, X. H. Tan, C. M. B. Holt, L. Zhang, B. S. Amirkhiz and D. Mitlin, *RSC Adv.*, 2012, **2**, 2753.