Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Supplementary Information

Facile synthesis of accordion-like Ni-MOF superstructure for high-performance flexible supercapacitors

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Calculations:

The specific capacitance of the electrode material can be calculated from the charge-discharge curves according to the equation:

$C=Q / (m\times\Delta V)=\int Idt / (m\times\Delta V)= I\times t_{discharge} / (m\times\Delta V)$ (1)

Where m is the weight of the electrode materials, I is the discharge current, tdischarge is discharge time, ΔV is the potential drop during discharge (excluding the IR drop).

The area-specific capacitance (C) of the device can be calculated using

$C=Q / (A\times\Delta V)=\int Idt / (A\times\Delta V)= I\times t_{discharge} / (A\times\Delta V)$ (2)

Where A is the surface area of the device, I is the discharge current, $t_{discharge}$ is discharge time, ΔV is the potential drop during discharge (excluding the IR drop).

The energy density and power density of the device can be obtained from：

$E=0.5C\times V^2$ (3)

$P=E/t_{discharge}$ (4)

Where V represents the operating voltage.

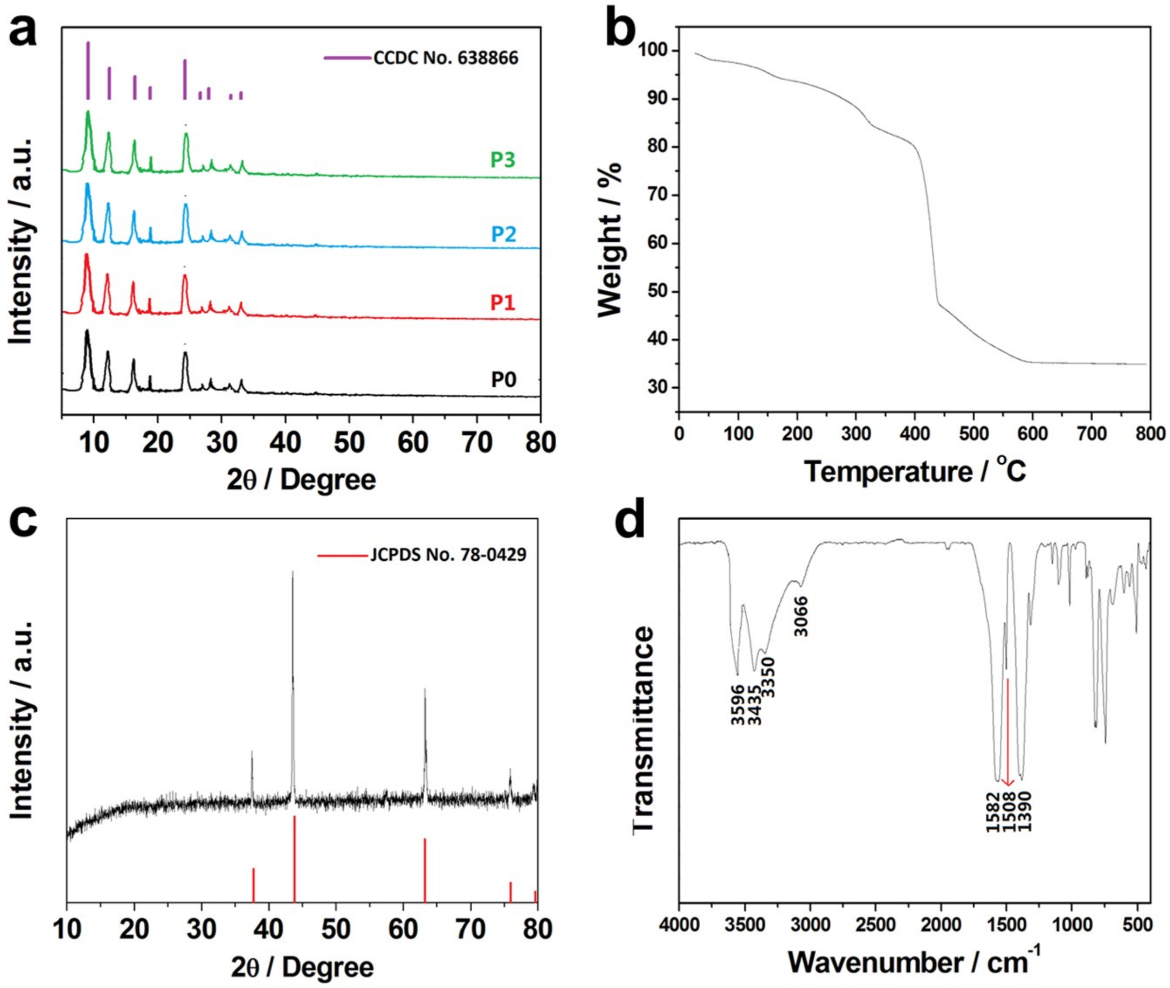

Figure S1. (a) XRD patterns of the products (P0–P3) obtained from different ultrasonic time (0min, 20min, 40min and 1h) of the bulk Ni-MOF, (b) TG curve of accordion-like Ni-MOF (P3); (c) XRD pattern of the samples obtained after the calcination at 800 °C for 2h in air, and (d) IR spectrum of as-prepared accordion-like Ni-MOF (P3).

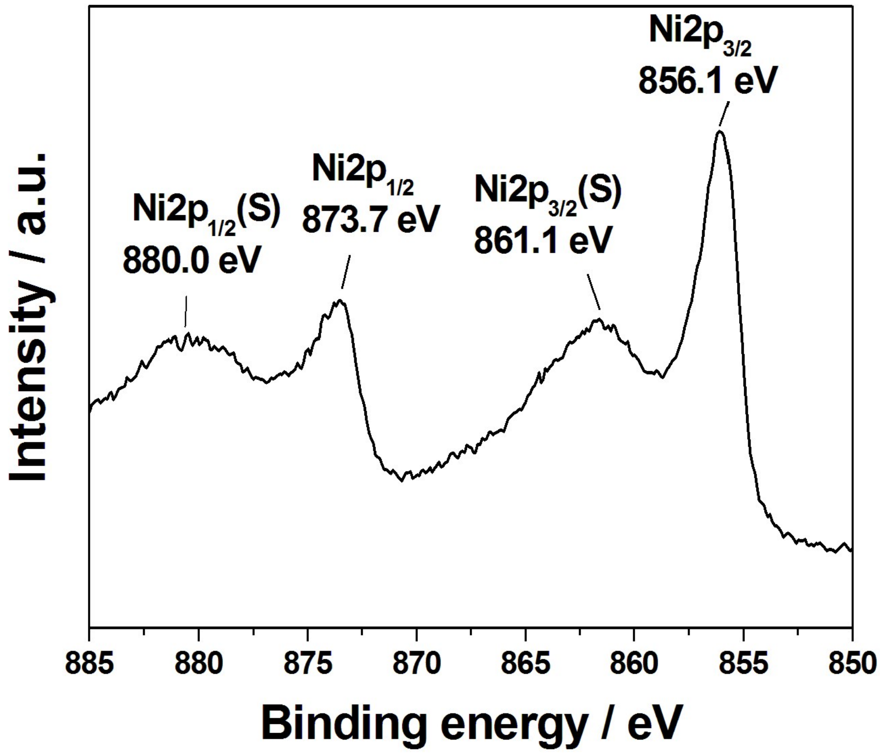

Figure S2. Ni 2p XPS spectra of as-prepared accordion-like Ni-MOF (P3).

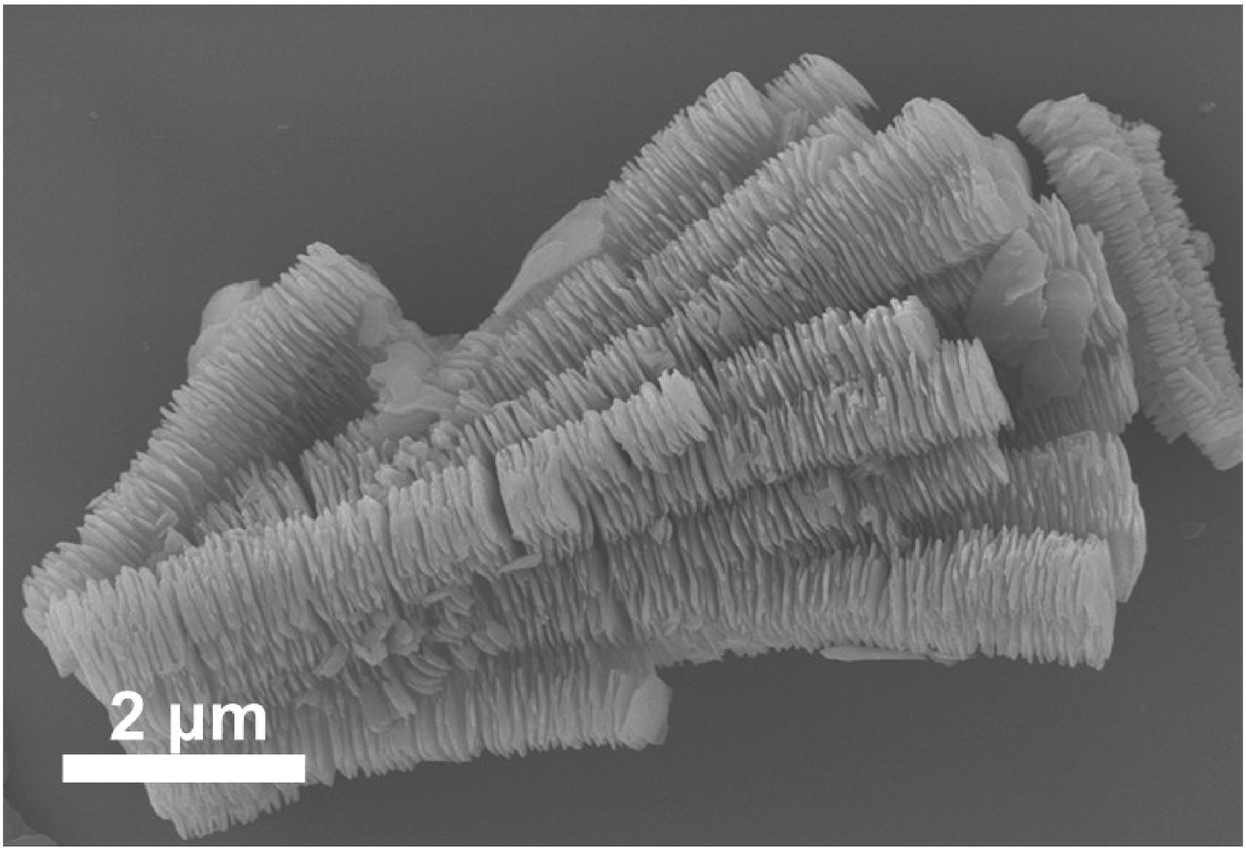

Figure S3. Large scale FESEM image of the accordion-like Ni-MOF (P3).

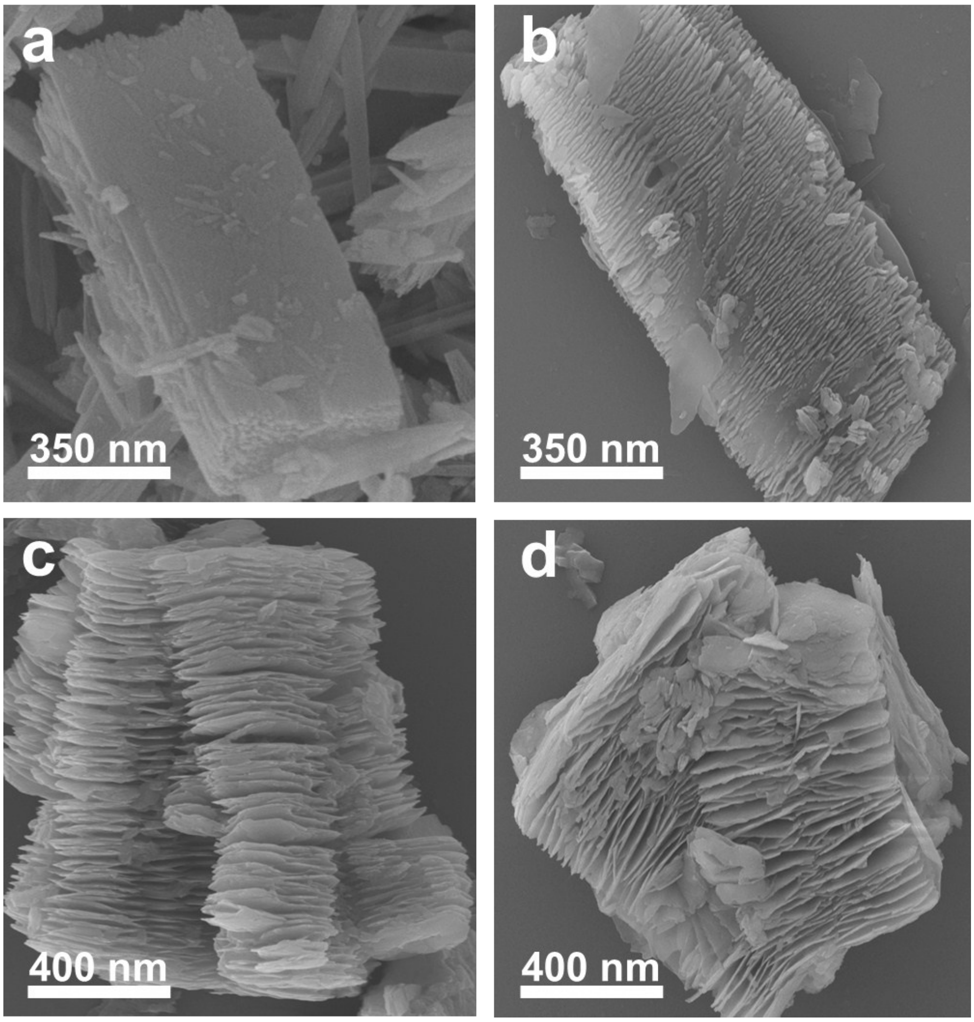

Figure S4. FESEM image of the products (P0–P3) obtained from different ultrasonic time (0min, 20min, 40min and 1h) of the bulk Ni-MOF.

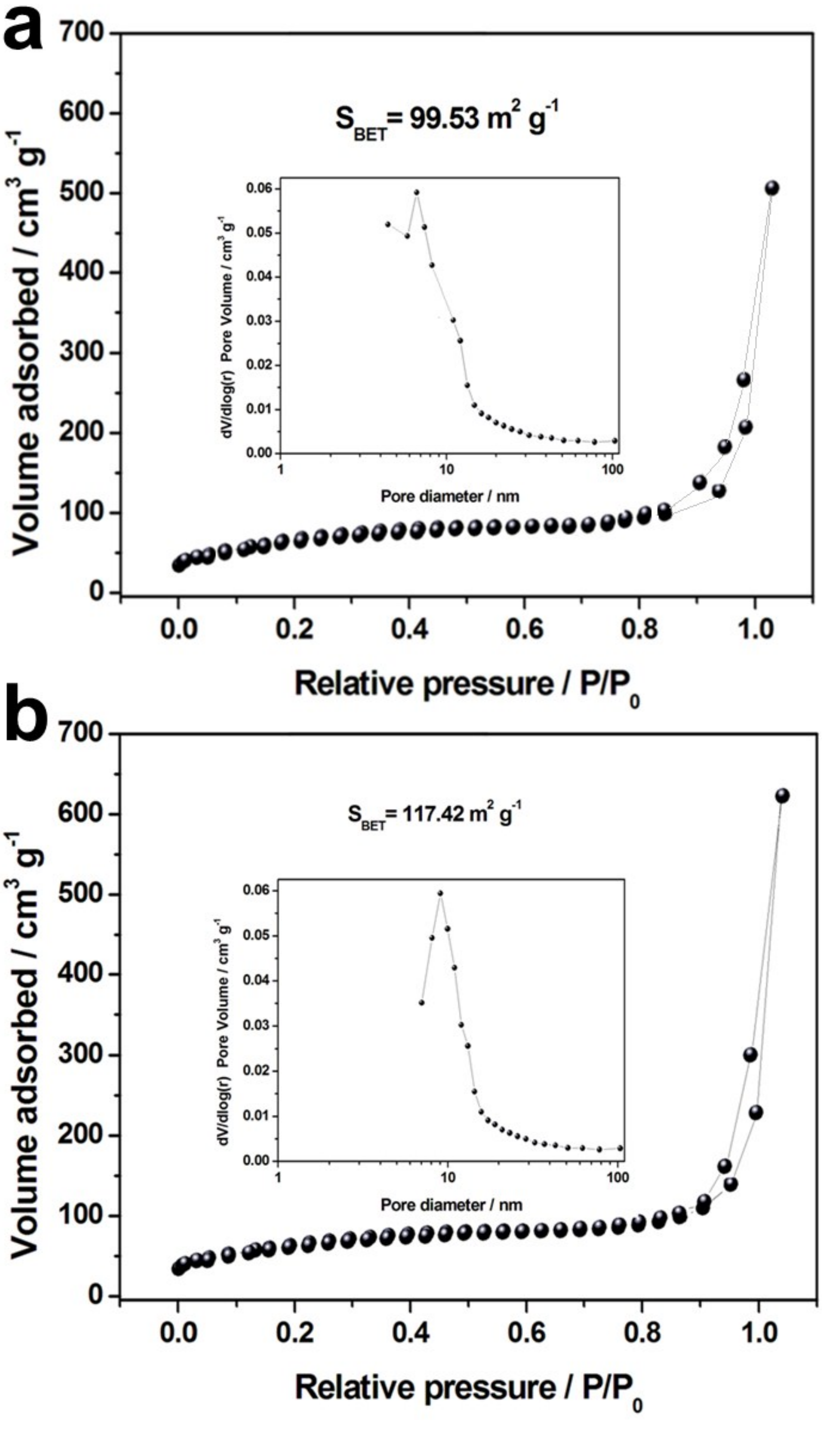

Figure S5. N_2 adsorption-desorption isotherms and the pore size distribution curves for (a) bulk Ni-MOF (P0) and (b) accordion-like Ni-MOF (P3).

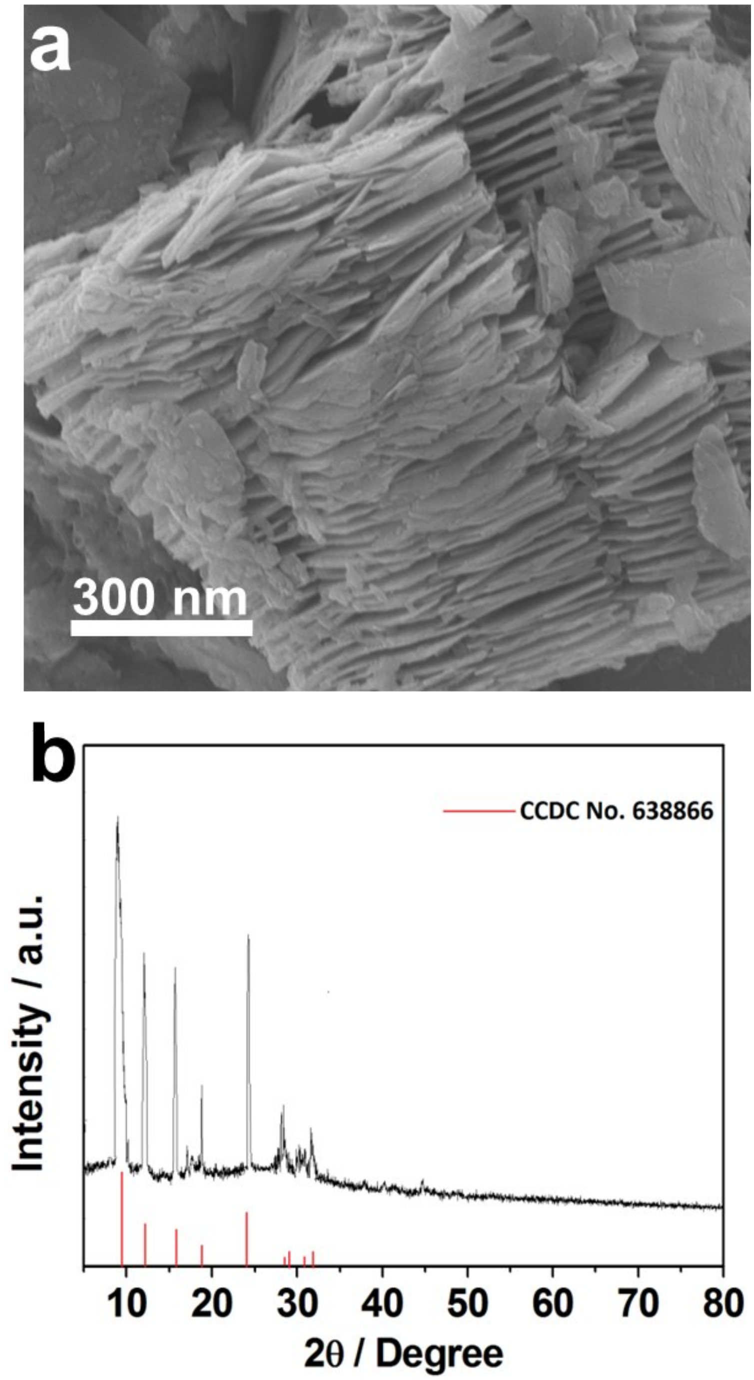

Figure S6. The SEM image (a) and XRD pattern (b) of the samples (P3) obtained after the 5000 cycle life testing.

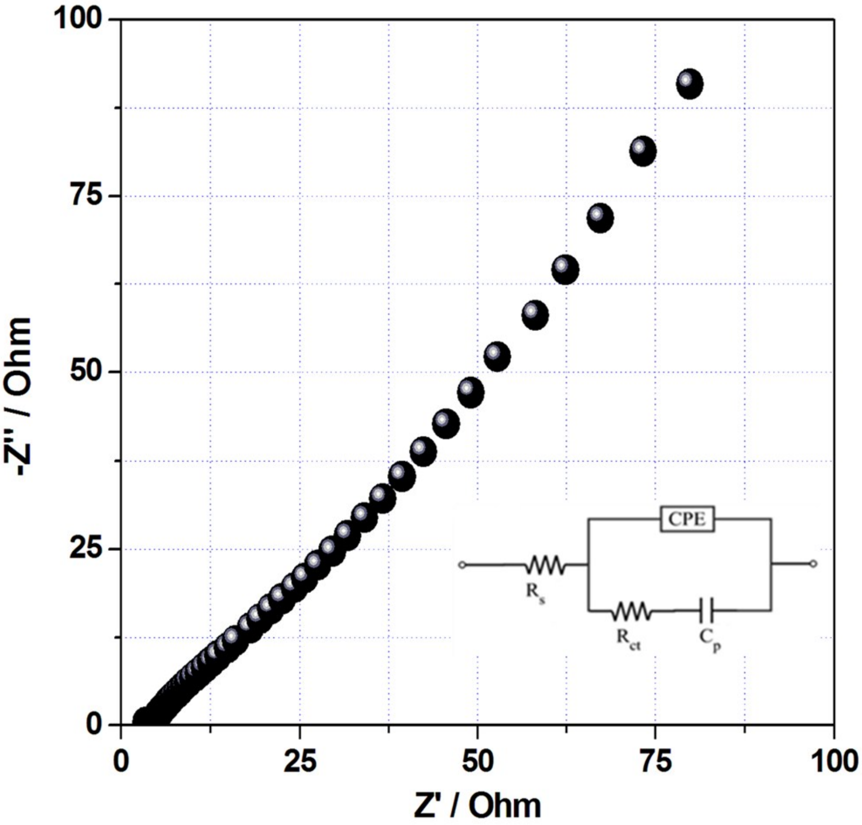

Figure S7. The electrochemical impedance spectra (EIS) of the as-prepared accordion-like Ni-MOF (P3) electrode at room temperature, and the equivalent circuit for the electrochemical impedance spectrum (Inset).

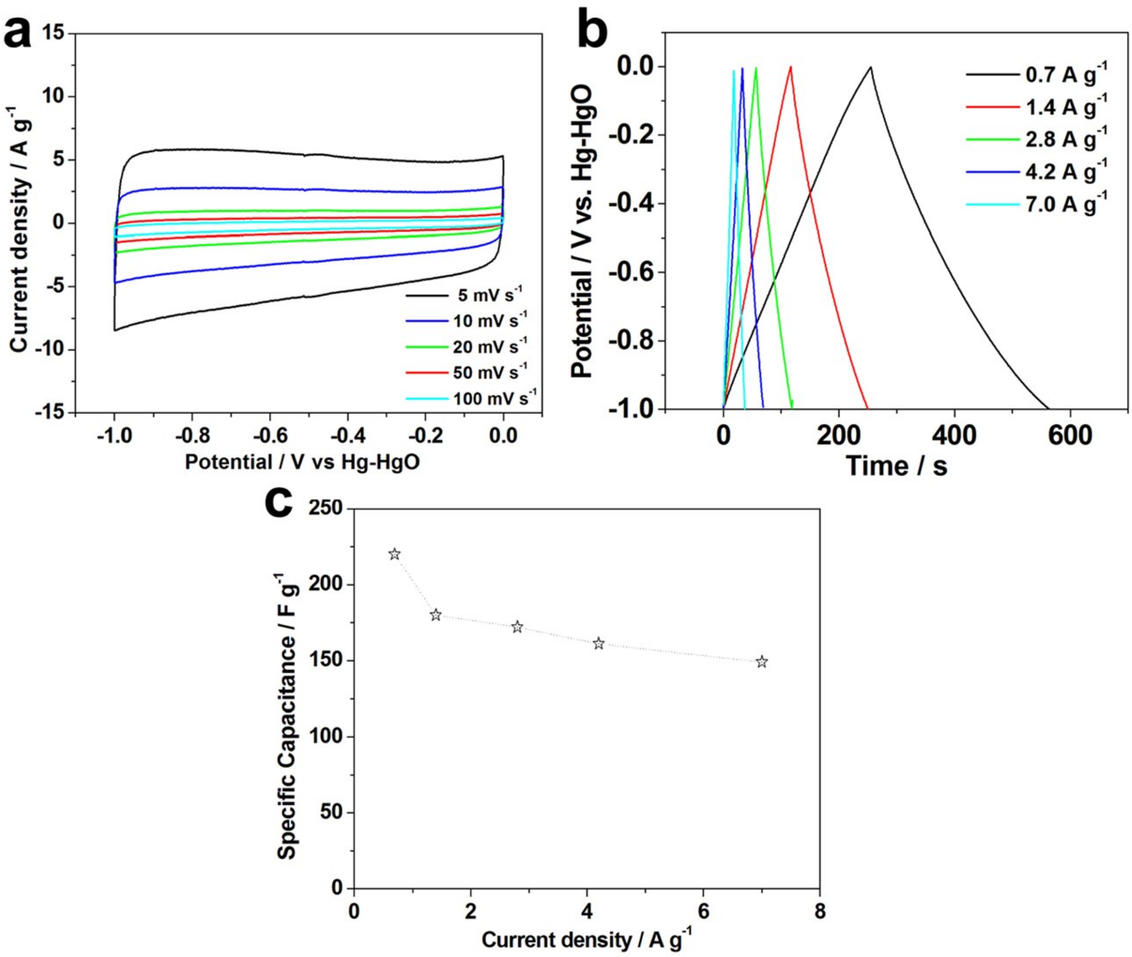

Figure S8. Activated carbon electrode in 3.0 M KOH solution: (a) CV curves with different scan rates; (b) CP curves with different current densities; (c) Specific capacitance calculated based on the discharge curve.

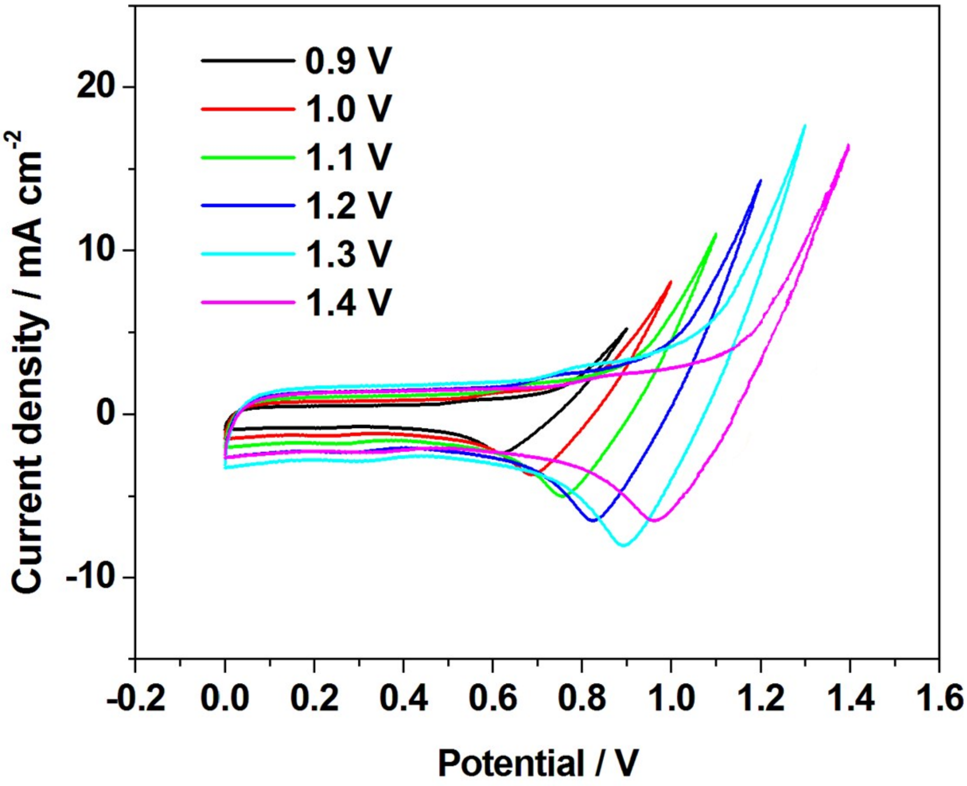

Figure S9. CV curves of the flexible solid-state asymmetric supercapacitors (accordion-like Ni-MOF (P3)//activated carbons) with the increase of the potential.

Table S1 Capacitance properties of some recently published Ni-based electrode materials

Material	Specific capacitance (F g^{-1}) (low current density/scan rate)	Specific capacitance (F g^{-1}) (high current density/scan rate)	Capacity retention (%)
NiO nanoflowers[1]	1678.4 (0.625 A g^{-1})	856 (6.25 A g^{-1})	99.7% (1000 cycles, 6.25 A g^{-1})
NiO nanowires[2]	180 (0.126 A g^{-1})	—	—
NiO nanofibers/Ni[3]	737 (2 A g^{-1})	570 (40 A g^{-1})	~100% (8000 cycles, 10 A g^{-1})
NiO/Ni[4]	905 (1 A g^{-1})	380 (28.6 A g^{-1})	—
NiO film[5]	441 (2 A g^{-1})	200 (20 A g^{-1})	—
NiO nanoparticles[6]	549 (1 mV s^{-1})	236 (20 mV s^{-1})	60.6% (1000 cycles, 2 A g^{-1})
$NiCo_2S_4$ ball in ball[7]	1036 (1 A g^{-1})	705 (20 A g^{-1})	87% (2000 cycles, 5 A g^{-1})
Ni-based pillared MOF[8]	552 (1 A g^{-1})	438 (20 A g^{-1})	>98% (16000 cycles, 10 A g^{-1})
$Ni_3(btc)_2\cdot 12H_2O$ MOF[9]	726 (1 A g^{-1})	313.8 (5 A g^{-1})	65% (5000 cycles, 1 A g^{-1})
Ni-based MOF nanorods[10]	1698 (1 A g^{-1})	838 (10 A g^{-1})	94.8% (1000 cycles, 1 A g^{-1})
Accordion-like Ni-MOF(This work)	1021 (0.7 A g^{-1})	823 (7 A g^{-1})	96.5% (5000 cycles, 1.4 A g^{-1})

References

1 H. Pang, Y. Shi, J. Du, Y. Ma, G. Li, J. Chen, J. Zhang, H. Zheng and B. Yuan, *Electrochim. Acta*, 2012, **85**, 256.
2 H. Pang, Q. Lu, Y. Li and F. Gao, *Chem. Commun.*, 2009, 7542.
3 M. Kundu and L. Liu, *Mater. Lett.*, 2015, **144**, 114.
4 Q. Lu, M. W. Lattanzi, Y. Chen, X. Kou, W. Li, X. Fan, K. M. Unruh, J. Chen and J. Q. Xiao, *Angew. Chem., Int. Ed.*, 2011, **50**, 6847.
5 Y. Zhang, X. Xia, J. Tu, Y. Mai, S. Shi, X. Wang and C. Gu, *J. Power Sources*, 2012, **199**, 413.
6 S. Jahromi, A. Pandikumar, B. Goh, Y. Lim, W. Basirun, H. Lim and N. Huang, *RSC Adv.*, 2015, **5**, 14010.
7 L. Shen, L. Yu, H. Wu, X. Yu, X. Zhang and X. W. Lou, *Nat. Commun.*, 2015, **6**, 6694.
8 C. Qu, Y. Jiao, B. Zhao, D. Chen, R. Zou, K. S. Walton and M. Liu, *Nano Energy,* 2016, **26**, 66.
9 L. Kang, S. Sun, L. Kong, J. Lang and Y. Luo, *Chin. Chem. Lett.*, 2014, **25**, 957.
10 J. Xu, C. Yang, Y. Xue, C. Wang, J. Cao and Z. Chen, *Electrochim. Acta,* 2016, **211**, 595.