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Supporting Information

Supercapacitor electrode materials with hierarchically structured pores from carbonization of MWCNTs and ZIF-8 composites

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Table S1. Parameters used in the preparation of MWCNT/ZIF-8 with different sizes.

Sample	Size of ZIF-8 (nm)	$Zn(NO_3)_2 \cdot 6H_2O$ (mg)	2-MeIM (mg)	Methanol (mL)
MWCNT/ZIF-8-S	50	595	656	96
MWCNT/ZIF-8-M	200	298	656	96
MWCNT/ZIF-8-L	500	1190	656	96

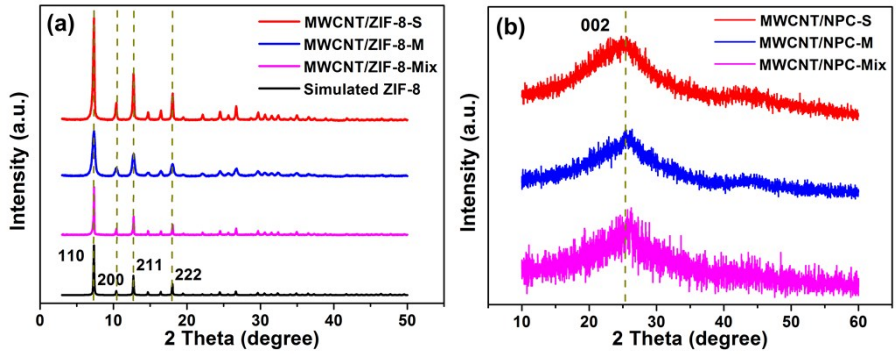

Fig. S1 The XRD results of MWCNT/ZIF-8-M/S, MWCNT/ZIF-8-Mix and the derived MWCNT/NPC-M/S composites, MWCNT/NPC-Mix.

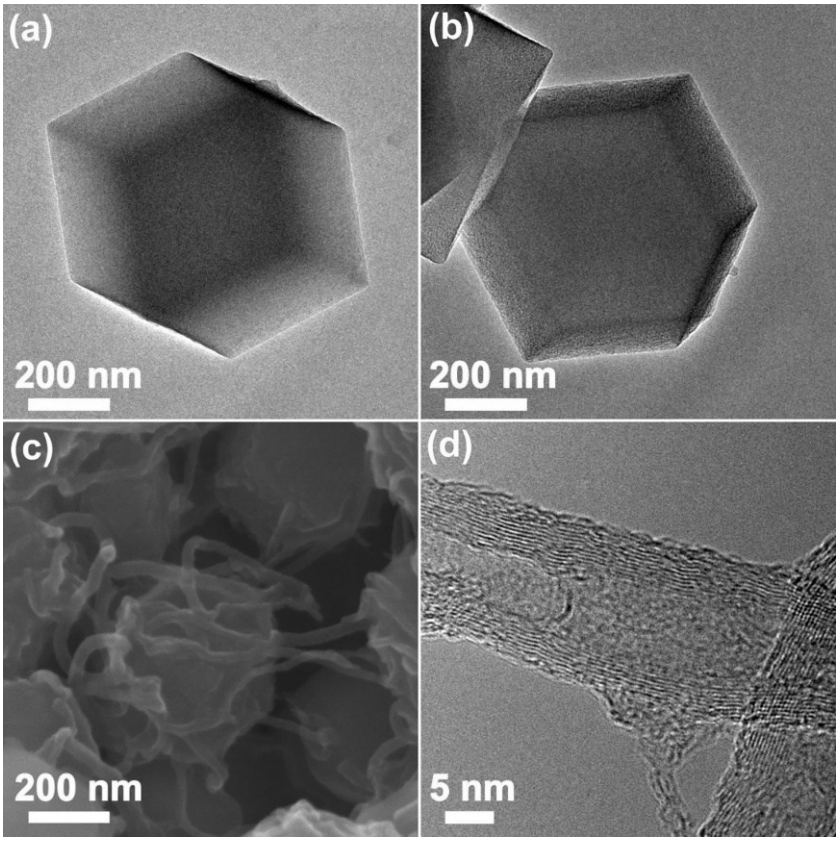

Fig. S2 TEM images of (a) ZIF-8, (b) NPC-L. (c) SEM image of the MWCNT/NPC-Mix. (d) HRTEM image of MWCNTs.

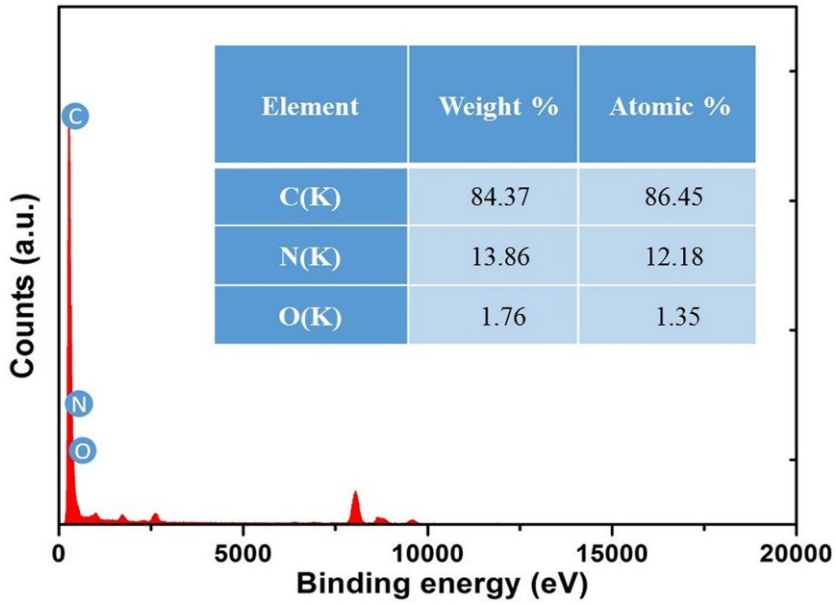

Fig. S3 The corresponding EDS spectra for MWCNT/NPC-L, the insert table is for the weight and atomic ratio of C, N and O elements.

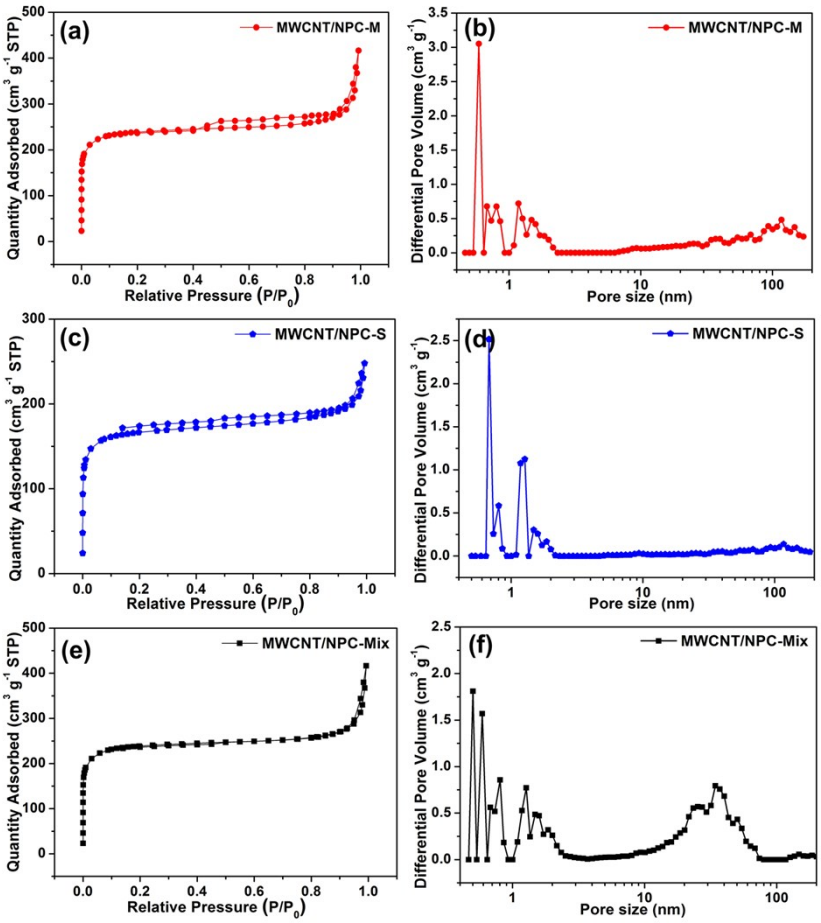

Fig. S4 Nitrogen adsorption–desorption isotherm and pore size distribution, (a) and (b) MWCNT/NPC-M, (c) and (d) MWCNT/NPC-S, (e) and (f) MWCNT/NPC-Mix.

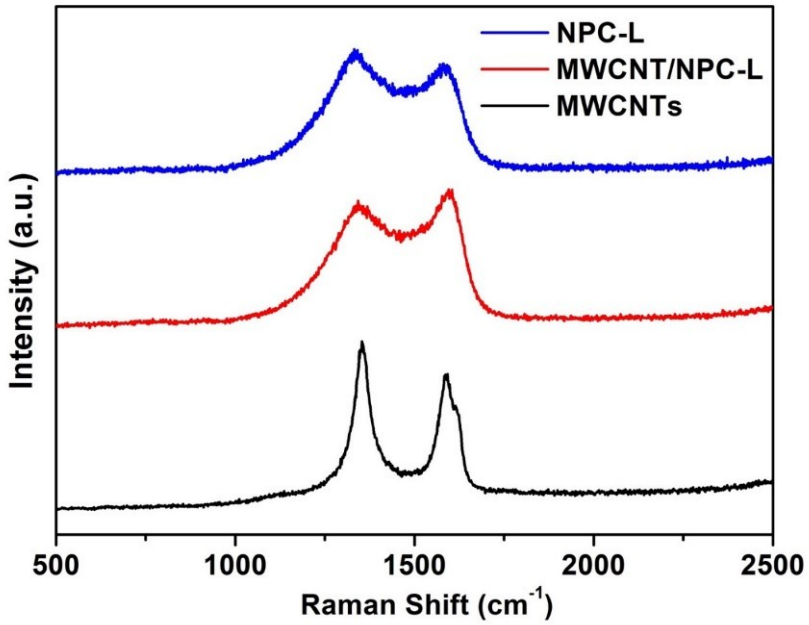

Fig. S5 Raman spectra of MWCNTs, NPC, and MWCNT/NPC recorded at 633 nm laser excitation.

Table S2. The content of C, N, O in the obtained samples from XPS analysis (at. %)

Sample	C	N	O	Pyridinic-N	Pyrrolic-N	Graphitic-N
NPC-L	85.473	10.193	4.335	65.5	14.9	19.6
MWCNT/NPC-S	84.296	10.969	4.735	56.4	19.6	24
MWCNT/NPC-M	86.399	10.081	3.52	65.9	18.8	15.3
MWCNT/NPC-L	87.054	10.454	2.492	68	9.9	22.1

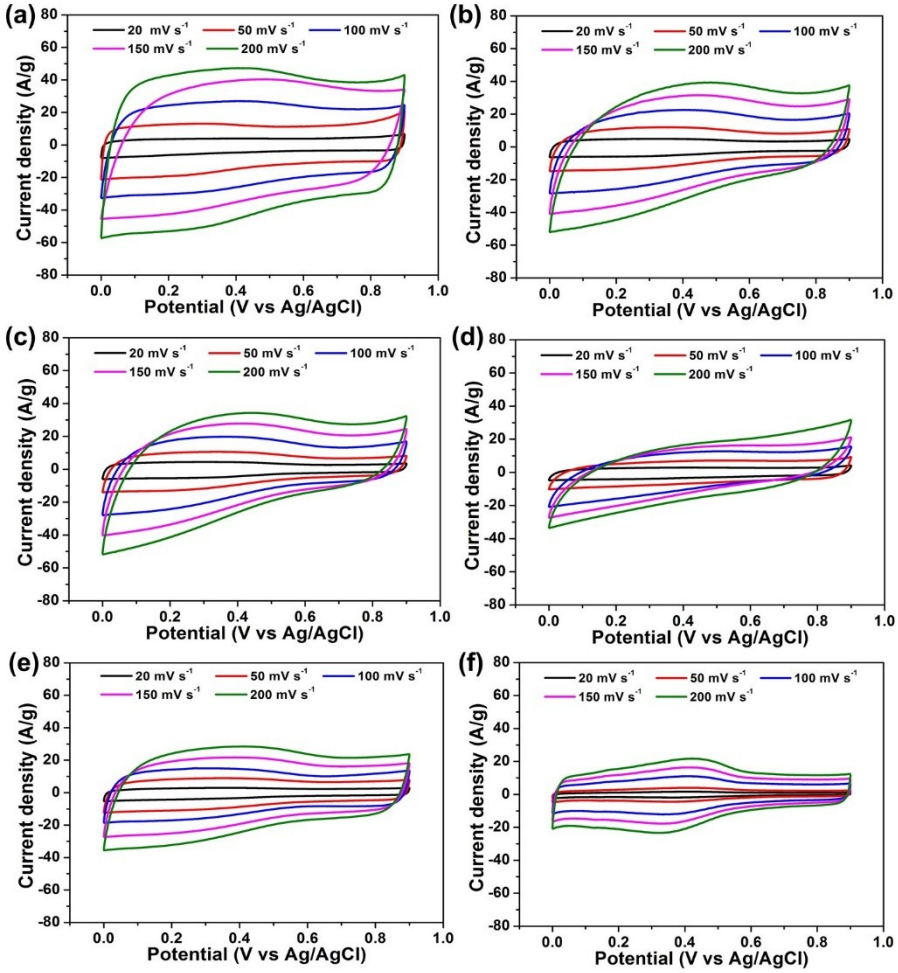

Fig. S6 Cyclic voltammograms of (a) MWCNT/NPC-L, (b) MWCNT/NPC-M, (c) MWCNT/NPC-S, (d) NPC-L, (e) MWCNT/NPC-Mix, and (f) MWCNTs electrodes at various scan rates in a range from 20 to 200 mV/s. All measurements were conducted in 1.0 M H_2SO_4.

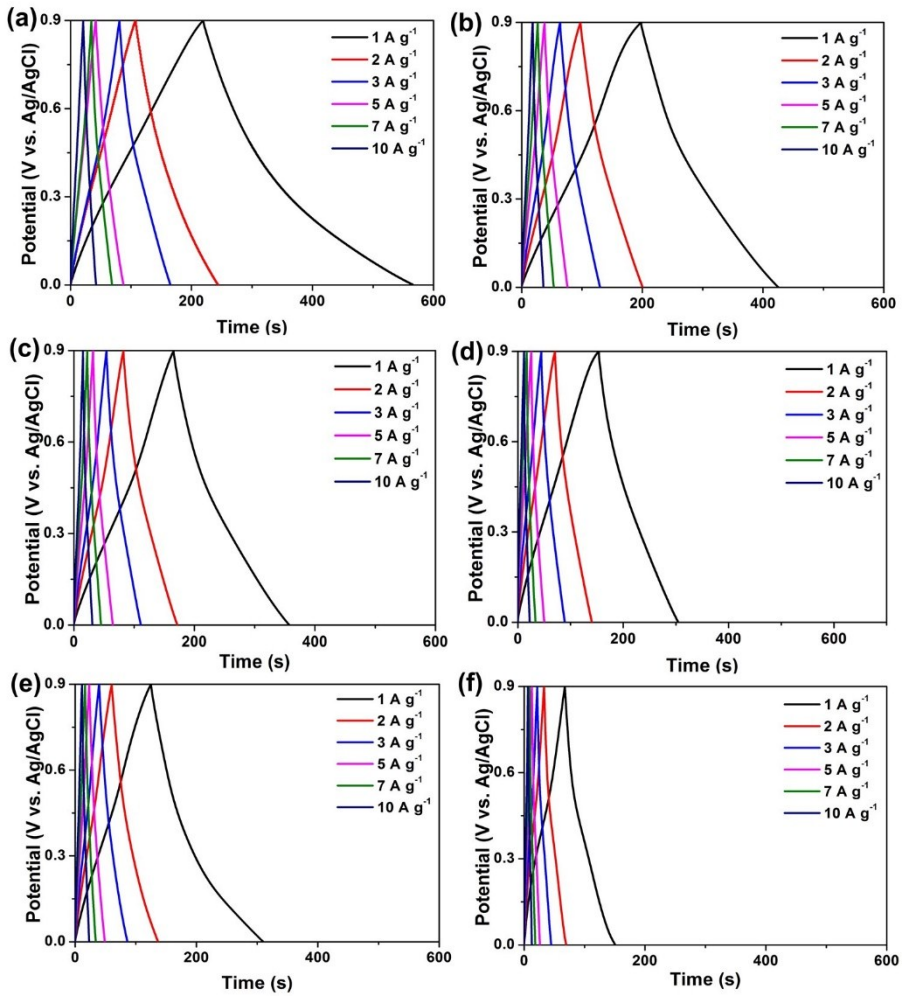

Fig. S7 Galvanostatic charge-discharge curves of (a) MWCNT/NPC-L, (b) MWCNT/NPC-M, (c) MWCNT/NPC-S, (d) NPC-L, (e) MWCNT/NPC-Mix, and (f) MWCNTs electrodes at various current density in a range from 1 to 10 A/g. All measurements were conducted in 1.0 M H_2SO_4.

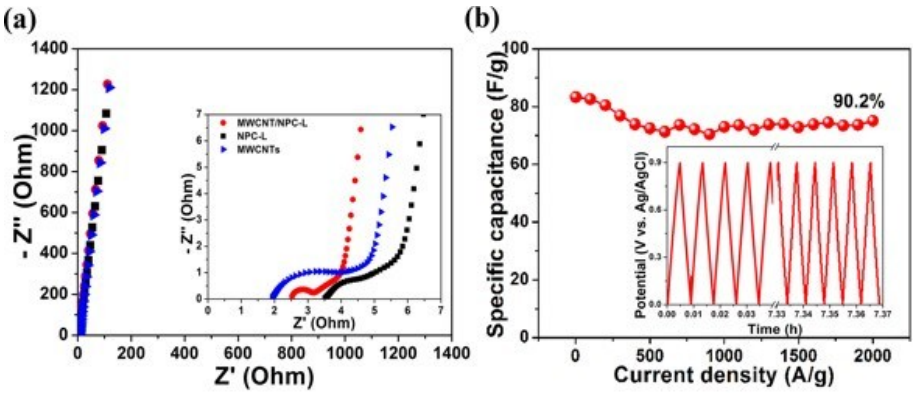

Fig. S8 (a) Nyquist plots of SSCs of MWCNT/NPC-L, NPC-L, and MWCNTs, the inset showed an expanded view for high-frequency range. **(b)** Variation of the specific capacitance within 2,000 cycles at the current density of 5 A/g.

Table S3. Specific capacitance at different scan rates and current densities.

Sample	Specific capacitance (F/g)							
	Scan rate (mV/s)				Current density (A/g)			
	5	50	100	200	2	3	5	10
MWCNTs	85.8	70.8	68.1	65.9	81.5	77.7	74.2	71.5
NPC-L	166.7	120.1	94.9	69.6	157.1	149.3	137.7	118.3
MWCNT/NPC-Mix	155.7	127.4	118.5	100.5	168.7	155	142.7	134.1
MWCNT/NPC-S	192.1	163.1	146.2	119.2	198.6	190	182.8	172.1
MWCNT/NPC-M	222.6	189.5	170.2	138.9	229	220.8	211.4	200
MWCNT/NPC-L	293.4	249.9	237.2	219.5	302.2	279.4	257.2	247.8

Table S4. Specific capacitance of various NPC materials using three-electrode cells reported in literatures.

Material	Electrolyte	Potential range (V)	Specific capacitance (F/g)	Current density (A/g)	Ref.
MWCNT/NPC-L	1 M H_2SO_4	0.9	302.2 293.4	2 5 mV/s	This work
OMFLC-N	0.5 M H_2SO_4	1.2	790	1	Ref. 1
HC/KOH/N	1 M H_2SO_4	1.0	492	0.1	Ref. 2
CBC-N	6 M KOH	1.0	238.4	0.5	Ref. 3
PC1000@C	6 M KOH	1.0	225	0.5	Ref. 4
NPC	1 M H_2SO_4	0.9	251	5 mV/s	Ref. 5
NOMC	6 M KOH	1.0	281	0.5	Ref. 6
C-GZ-2	1 M H_2SO_4	1.0	238	1	Ref. 7
ZnO QDs/ carbon/CNTs	1 M Na_2SO_4	1.0	185	0.5	Ref. 8
NPC-800	0.5 M H_2SO_4	0.8	238	20 mV/s	Ref. 9
NC@GC	1 M H_2SO_4	0.8	270	2	Ref. 10

Table S5. Comparison of high performance carbons materials for supercapacitors

Material	S_{BET} (m^2/g)	Electrolytes	Current density (A/g)	Specific capacitance (Cs, F/g)	Ref.
MWCNT/NPC-L [3]	928.2	1M H_2SO_4	2	302.2	This work
NPC-L [3]	999.7	1 M H_2SO_4	2	157.1	This work
C-GZ-2 [2]	280.4	1 MH_2SO_4	1	238	Ref. 7
C-ZIF-8 [2]	616.5	1 M H_2SO_4	1	~ 45	Ref. 7
CESM-300 [3]	221.2	1 MKOH	0.2	297	Ref. 11
AC-KOH [3]	1575	1 MKOH	0.2	203	Ref. 11
a-MEGO [2]	3100	TEA BF_4 /AN	0.8	150	Ref. 12
AS-ZC-800 [3]	2972	1 M H_2SO_4	10 mV/s	211	Ref. 13
S-ZC-800 [3]	1955	1 M H_2SO_4	10 mV/s	158	Ref. 13
ZC-800 [3]	1051	1 M H_2SO_4	10 mV/s	104	Ref. 13

The number in superscript represents the configuration of supercapacitor cell, i.e. 2- or 3- electrode system.

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