Interpenetrated nano-MOFs for ultrahigh-performance supercapacitors and excellent dye adsorption performance

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Equations

Specific capacitances derived from cyclic voltammetry (CV) tests can be calculated from the equation-S1:

$$C = \frac{1}{2m\nu(V_2 - V_1)}\int_{V_1}^{V_2} I(V)dV \qquad (1)$$

where C (F g^{-1}), m (g), ν (V s^{-1}), V_1 and V_2, and I (A) are the specific capacitance, mass of the active materials in the electrode, scan speed, low and high potential limits of the CV tests, and the instant current on CV curves, respectively.

Specific capacitances derived from galvanostatic charge-discharge (GCD) tests can be calculated from the equation-S2:

$$C = (I\Delta t)/(m\Delta V) \qquad (2)$$

where C (F g^{-1}), I (A), Δt (s), m (g) and ΔV are the specific capacitance, the discharge current, the discharge time, the mass of the active materials in electrode, and the potential window, respectively.

The energy density E_s of the Co-MOFs electrodes calculated from the equation-S3:

$$E_s = 0.5C(\Delta V)^2 \times 1/3.6 \qquad (3)$$

where E_s (Wh kg^{-1}), C (F g^{-1}) and ΔV are the specific energy, the specific capacitance and potential window separately.

The power density P_s of the Co-MOFs electrodes calculated from the equation-S4:

$$P_s = E_s / \Delta t \qquad (4)$$

where E_s (Wh kg^{-1}), P_s (W kg^{-1}) and Δt (s) are the specific energy, the specific power and the discharge time separately.

The apparent diffusion coefficient (D) of OH^- ion at 25 ºC is calculated by employing Randles–Sevcik equation-S5:

$$i = 2.69 \times 10^5 \times n^{3/2} \times A \times \sqrt{D} \times C_0 \times \sqrt{v} \qquad (5)$$

where n is the number of the electrons transferred, A is the surface area of the electrode, D is the diffusion coefficient, v is the scan rate, i is the peak current and C_0 is the proton concentration.

Tables

Table S1 Selected bonds (Å) and angles (º) for SC1.

Co(1)-O(1)	1.990(3)	O(1)-Co(1)-O(4)#2	105.75(13)
Co(1)-N(2)#1	2.010(4)	N(2)#1-Co(1)-O(4)#2	129.23(15)
Co(1)-O(4)#2	2.021(3)	O(1)-Co(1)-N(3)	94.29(15)
Co(1)-N(3)	2.053(4)	N(2)#1-Co(1)-N(3)	108.16(15)
O(1)-Co(1)-N(2)#1	109.21(13)	O(4)#2-Co(1)-N(3)	104.62(15)

Symmetry codes: #1 -x,y-1/2,-z+1/2; #2 x-1,-y+1/2,z-1/2 .

Table S2 Ni-MOFs and Ni-MOFs-derived materials for SCs in recent reports.

Sample	C_s (F g^{-1})	^{a}CD (A g^{-1})	Electrolyte	Retention(%)/CN^b	Ref.
Nanorods	**2405**	**0.75**	**4.0M KOH**	**93.5/3000**	This work
Ni-MOF-24	1127	0.5	6.0M KOH	90/3000	4
Cu-MOFs	1274	1.0	1.0M LiOH	88/2000	5
Co-LMOFs	2474	1.0	1.0M KOH	94.3/2000	6
[$Ni_3(HITP)_2$]	111	0.05	1.0M $TBABF_4$/ACN	/	11
Pillared Ni-MOFs	552	1.0	2.0M KOH	>98/16000	13
Co8-MOF-5	0.49	25 mV s^{-1}	0.1M $TBAPF_6$/ACN	/	22
Co-MOF-71	206.76	0.6	1.0M LiOH	98.5/1000	23
Fe_3O_4/C	139	0.5	1.0M KOH	83.3/4000	24
Fe_3O_4/Fe/C	600	1.0	6.0M KOH	>80/10000	25
$Ni_xCo_{1-x}(OH)_2$	1235.9	0.5	6.0M KOH	73/10000	26

^{a} Current density; ^{b} Cycle number.

Table S3 Kinetics parameters of the pseudo first and pseudo second order equations for MO and CR: adsorbent dose, 10 mg/40 ml; initial concentration, 500ppm; temperature, 25℃.

	The pseudo first order			The pseudo second order		
	q_e (mg g^{-1})	k_1 (h^{-1})	R^2	q_e (mg g^{-1})	k_2 ($g \cdot mg^{-1} \cdot h^{-1}$)	R^2
MO	994.9	0.1083	0.9600	1056.7	0.00025	0.9870
CR	597.1	0.1745	0.9756	621.1	0.00090	0.9954

Table S4 Estimated isotherm parameters for MO and CR: adsorbent dose, 10 mg/40 ml; temperature, 25℃.

	Langmuir isotherm model			Freundlich isotherm model		
	k_L (L mg^{-1})	q_m (mg g^{-1})	R^2	n	k_F	R^2
MO	0.00414	1288.2	0.7245	1.35	8.91	0.9303
CR	0.0164	645.2	0.9768	3.42	92.88	0.9593

Figures

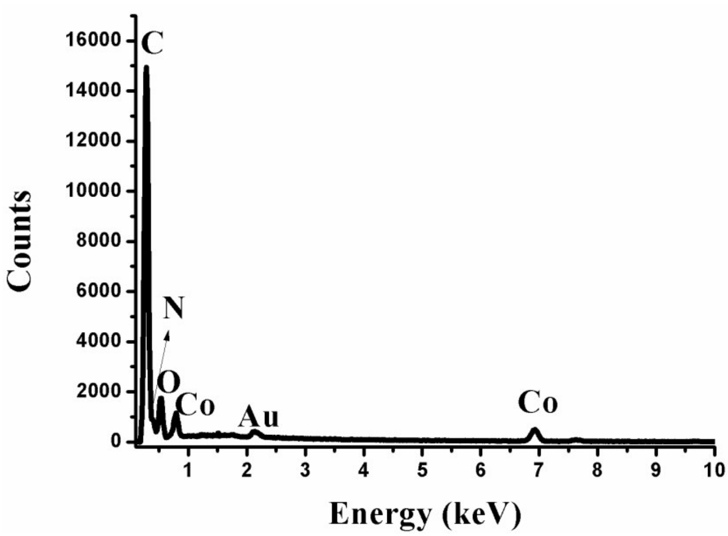

Fig. S1 EDX pattern for the as-synthesized nanorods powder.

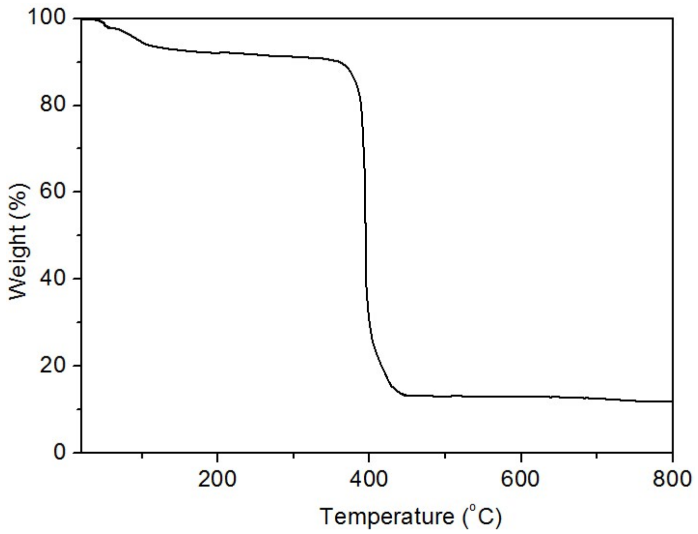

Fig. S2 TGA curves for the as-synthesized nanorods powder.

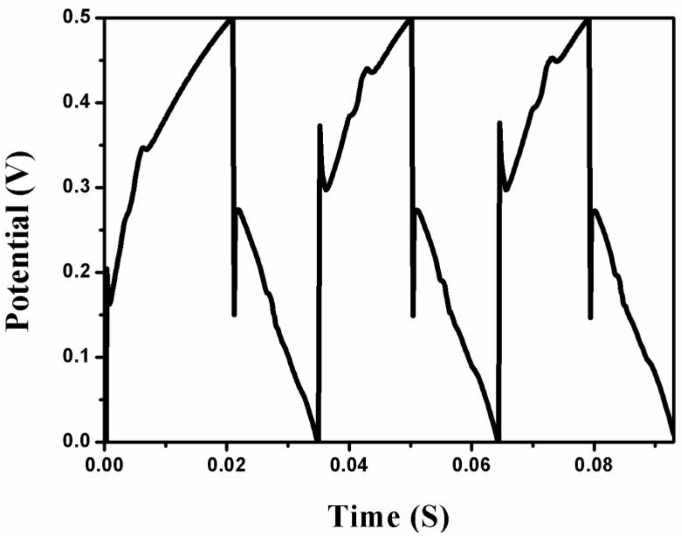

Fig. S3 A GCD curve for nickel foam used in preparing SCs electrode.

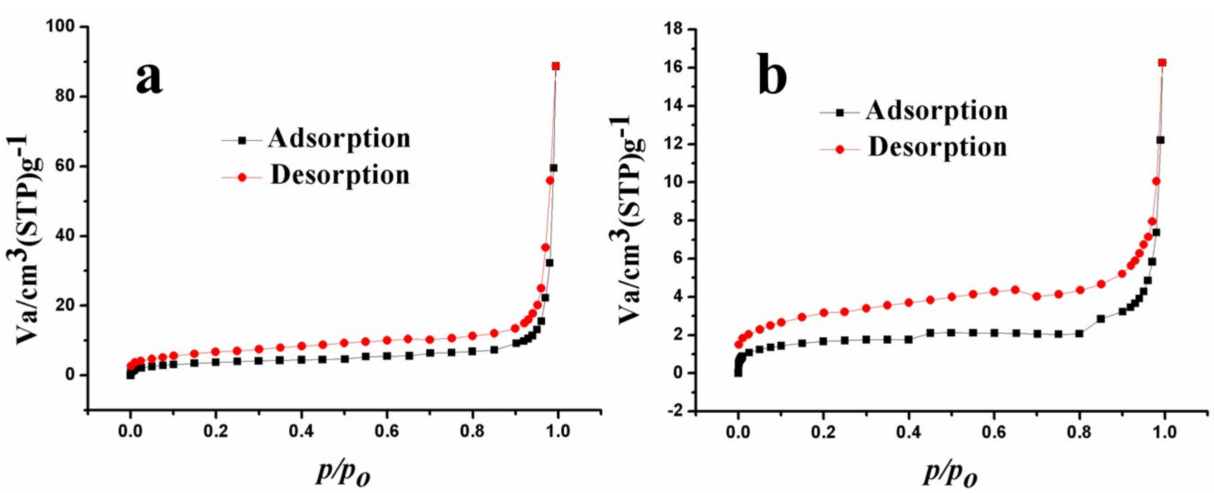

Fig. S4 N_2 adsorption-desorption curves of the as-synthesized nanorods and crystals electrode.

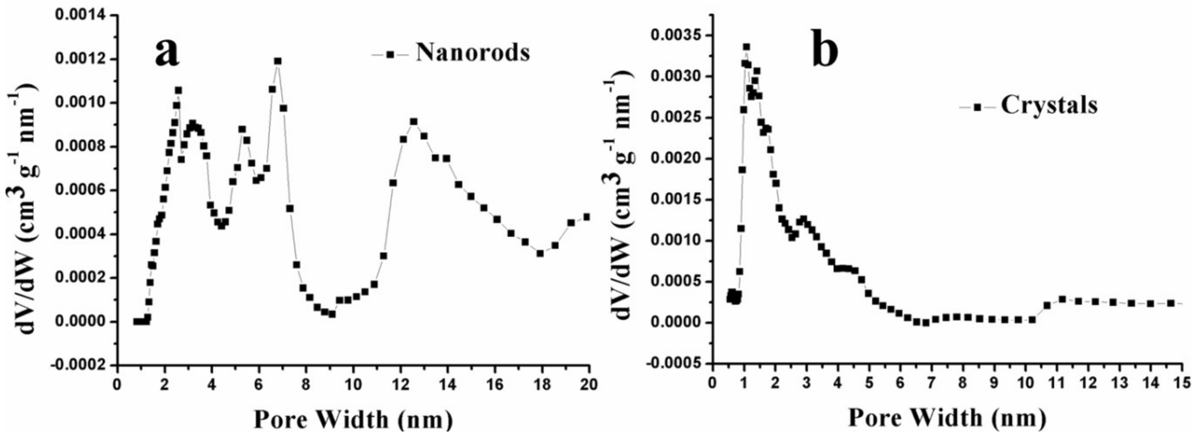

Fig. S5 Pore size distribution plots for the as-synthesized nanorods and crystals electrode.

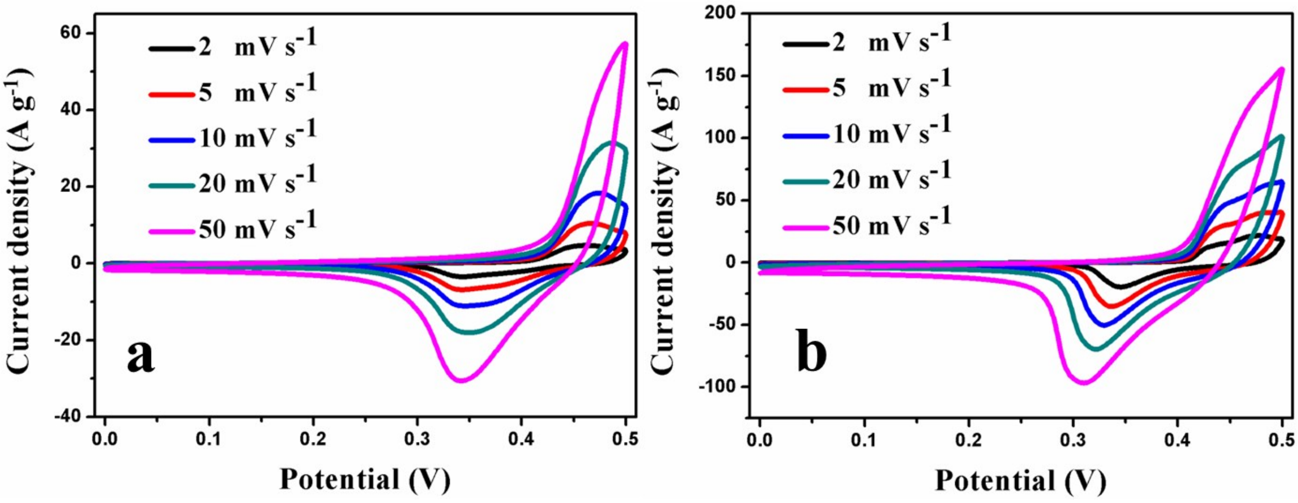

Fig. S6 (a-b) CV curves of the as-synthesized nanorods electrode at various scan rates in 1M and 4M KOH solution separately.

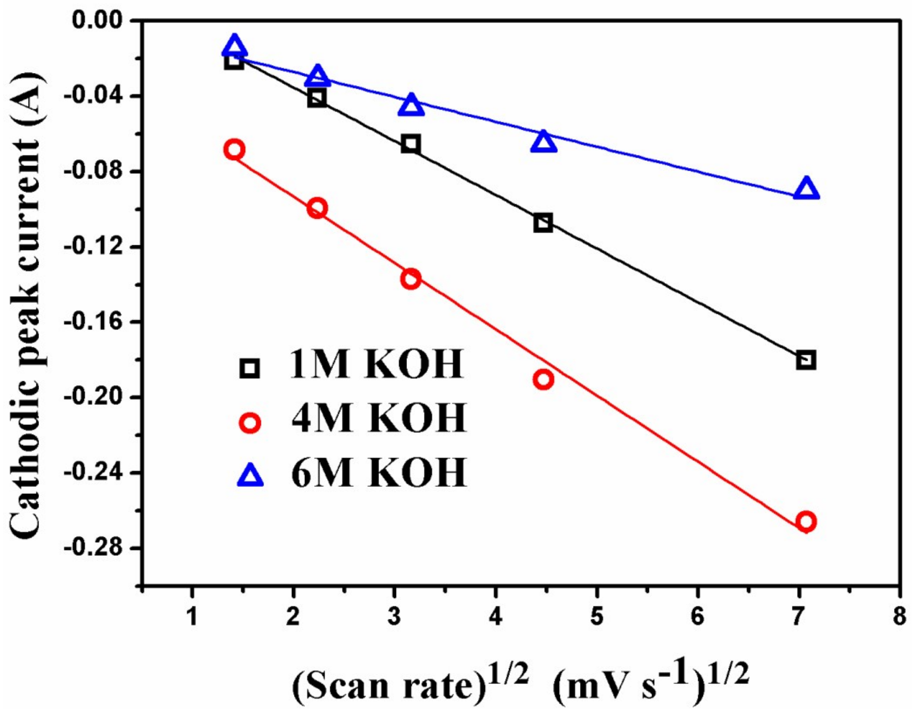

Fig. S7 Voltammetric current as a function of square root of scan rate of the nanorods electrodes in various concentrations of KOH electrolytes.

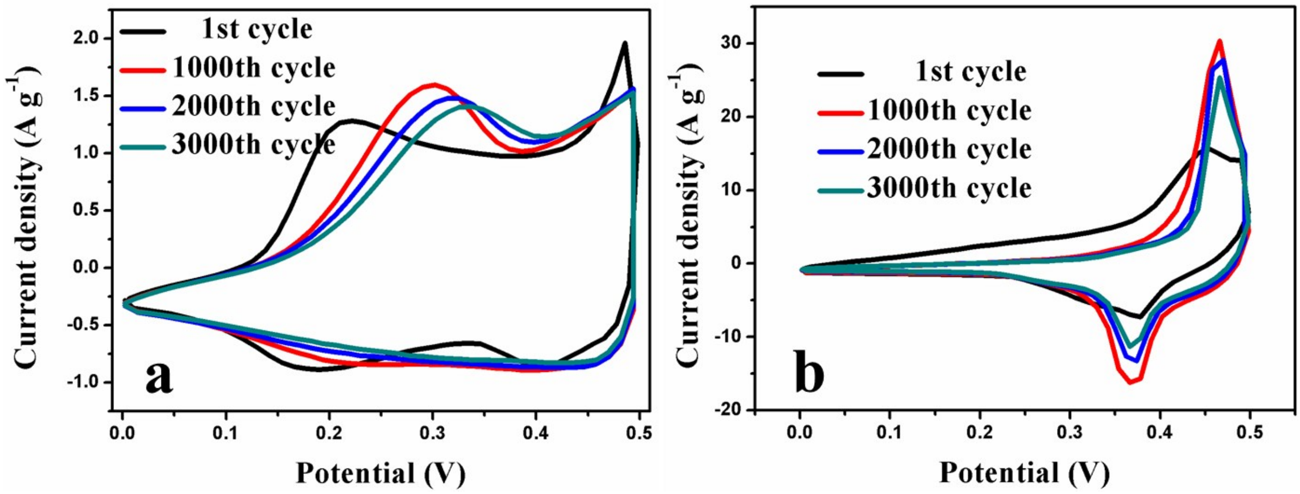

Fig. S8 Endurance testing comparison after 3000 continuous cycles for the as-prepared nanorods electrode at a nominal scan rate of 10 mV s^{-1} in 1M (a) and 6M KOH (b) solution separately.

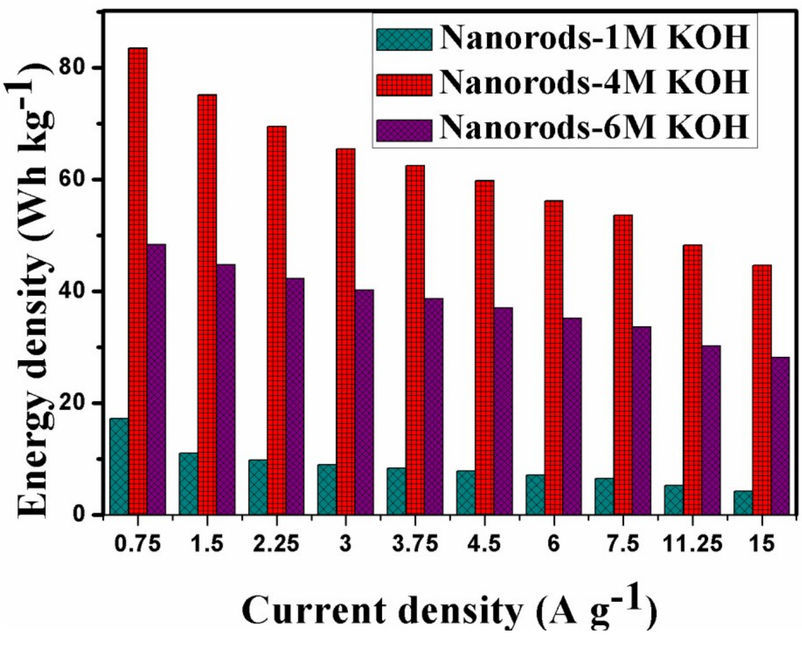

Fig. S9 The histogram of energy density vs. current density for nanorods in 1M, 4M and 6M KOH solution.

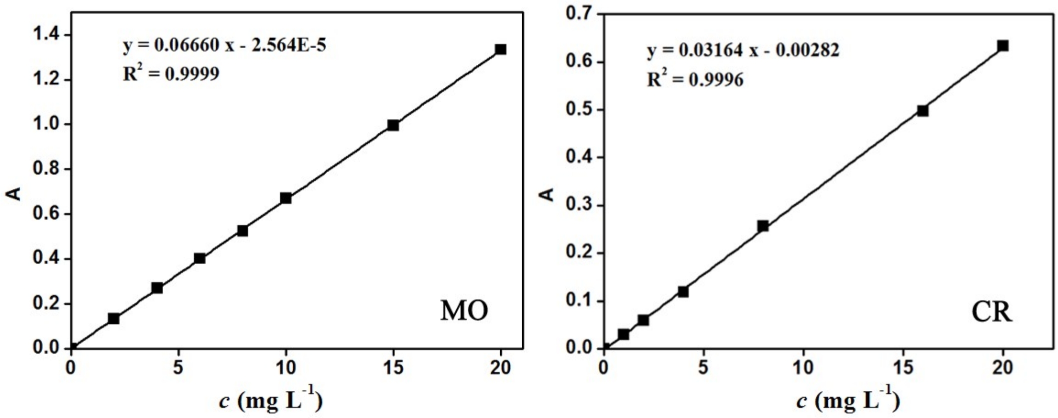

Fig. S10 Standard curves of MO and CR.