Supporting Information

Hierarchical structure N, O co-doped porous carbon/carbon nanotubes composite derived from coal for supercapacitors and CO_2 capture

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Experimental Section

Electrochemical data calculation

The gravimetric specific capacitances (C_m) based on galvanostatic charge-discharge (GCD) for the three-electrode and two-electrode systems were calculated according to Eqs. (1) and (2), respectively:

$C = It/m\Delta V$ (1)

$C = 2It/m\ \Delta V$ (2)

where I is the discharge current (A), t is the discharge time (s), m is the mass of the active material (g) in a single electrode, and ΔV is the discharge potential range (V) .

In the two-electrode device, the energy density (E, Wh kg^{-1}) and power density (P, Wkg^{-1}) were calculated from discharge curves at various current densities according to Eqs. (3) and (4), respectively:

$$E = C (\Delta V)^2/8*3.6 \quad (3)$$

$$P = 3600E/t \quad (4)$$

Where ΔV is the working voltage after ohmic drop (V) and t is the discharge time (s).

Results and discussion

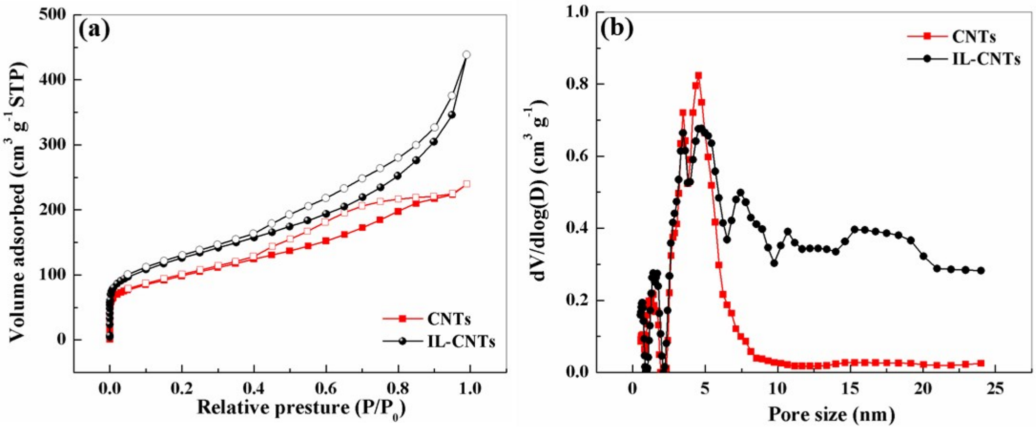

Fig.S1 (a) Nitrogen adsorption desorption isotherms, and (b) pore size distribution of CNTs and IL-CNTs.

Table S1. XPS Analysis of the Samples

Sample	C (at%)	O (at%)	N (at%)	S (at%)
PC	90.98	7.25	1.41	0.36
N, O-PC	88.00	3.61	8.07	0.32
N, O-PC-CNTs	88.71	2.97	8.03	0.29

Table S2. The fitting peak areas of C 1s, N 1s and O 1s spectra of all the samples form XPS analysis.

Sample	Peak area										
	C 1s				N1s				O1s		
	C=C	C-N	C-O	C=O	N-6	N-5	N-Q	N-X	quinone	C=O	C-OH
PC	41951		9036	14489					7552	8345	6087
N, O-PC	34574	9966	7656	5514	6731	7196	2137	119	1452	5617	3782
N, O-PC-CNTs	35217	22143	9767	11466	9844	10675	1263	3767	4929	5225	2619

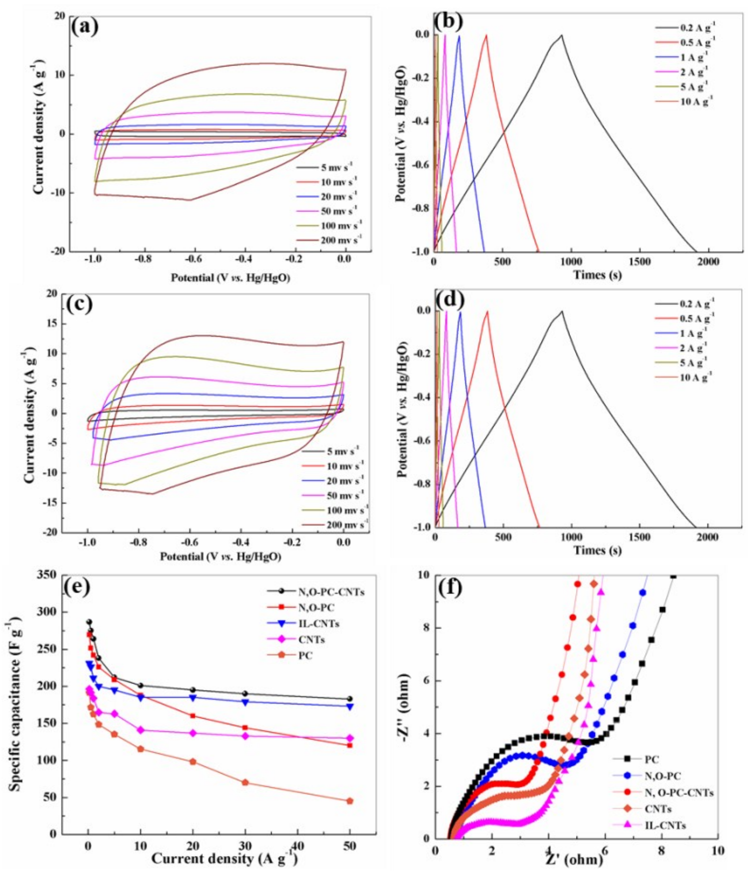

Fig.S2 Electrochemical performance tested by a three-electrode system in 6 mol L^{-1} KOH, (a) CV curves of CNTs, (b) GCD curves of CNTs under different constant currents, (c) CV curves of IL-CNTs, (d) GCD curves of IL-CNTs under different constant currents, (e) Specific capacitance of as-prepared samples at different current densities, and (h) Nyquist plots of as-prepared samples.

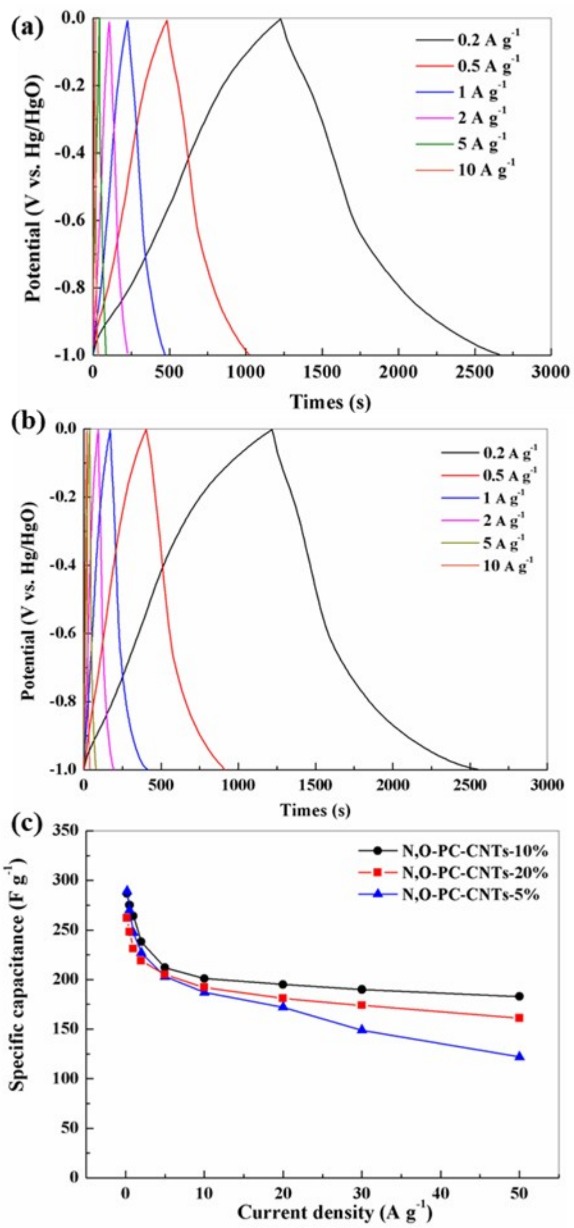

Fig.S3 (a) GCD curves of N, O-PC-CNTs-5% under different constant currents, (b) GCD curves of N, O-PC-CNTs-20% under different constant currents, (c) Specific capacitance of N, O-PC-CNTs-5%, N, O-PC-CNTs-10% and N, O-PC-CNTs-20% at different current densities.

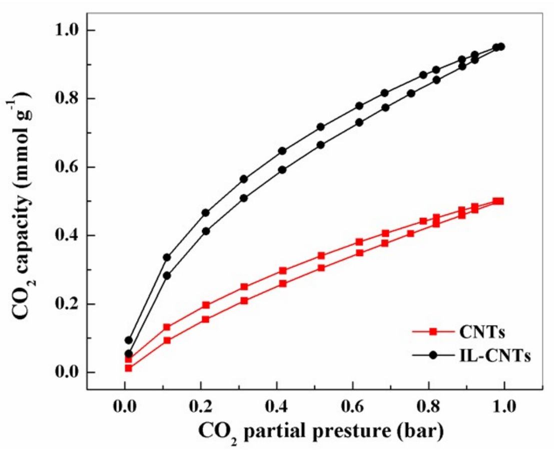

Fig.S4 CO_2 adsorption isotherms for CNTs and IL-CNTs at 298 K.

Table S3 Comparision of the supercapacitors performance in three-electrode cell of porous carbons in the literatures.

Samples	Synthetic method (activation agent)	S_{BET} ($m^2\ g^{-1}$)	Specific capacitance ($F\ g^{-1}$)	Current density	Electrolyte	Ref.
Activated carbon850-1	KOH	1968	223	0.1 A g^{-1}	6 mol L^{-1} KOH	[1]
N,S,O-doped PC	KOH	1593.8	285	0.5 A g^{-1}	6 mol L^{-1} KOH	[2]
PICNs(NiSSC-140-2-0.45)	KOH	2372.18	312	0.5 A g^{-1}	6 mol L^{-1} KOH	[3]
Nanohexahedron PC	Carbonizing ZIF-8	1142	187	0.5 A g^{-1}	2 mol L^{-1} KOH	[4]
C-N bond PC	KOH	3965	342	1 A g^{-1}	6 mol L^{-1} KOH	[5]
NPCM-600	KOH	1778	298	1 A g^{-1}	6 mol L^{-1} KOH	[6]
AC	H_3PO_4	633.43	234.4	1 A g^{-1}	1 mol L^{-1} KOH	[7]
WP carbon	KOH	416.59	160	1 mAcm^{-2}	6 mol L^{-1} KOH	[8]
AC-35	KOH	2312	342.8	0.5 A g^{-1}	KOH/LiOH	[9]
BL-ACs	KOH	3557	188	1 mAcm^{-2}	0.1molL^{-1}H_2SO_4	[10]
AHC-4	KOH	849	264	0.25 A g^{-1}	6 mol L^{-1} KOH	[11]
N-doped porous carbon	CO_2	1414.97	179	1 A g^{-1}	6 mol L^{-1} KOH	[12]
3D-MP-CFW	KOH	1270	240	1 A g^{-1}	6 mol L^{-1} KOH	[13]
LC-550-1	$NaNH_2$	1087	266	0.5 A g^{-1}	6 mol L^{-1} KOH	[14]
OAC-4	KOH	2869	287	0.5 A g^{-1}	6 mol L^{-1} KOH	[15]
PNPC-4	KOH	2599.61	287.1	1 A g^{-1}	6 mol L^{-1} KOH	[16]
N, O-PC-CNTs	KOH-IL	2164	287	0.2 A g^{-1}	6 mol L^{-1} KOH	This work

Table S4 Comparision of the CO_2 adsorption performance at 25°C of porous carbons in the literatures

Samples	Synthetic method (activation agent)	S_{BET} (m^2 g^{-1})	CO_2 uptake (mmol g^{-1})	Ref.
C-char -800	CO_2-ammonia	610	2.26	[17]
ANCs-3-700	KOH	3401	4.7	[18]
C-KU-600	KOH/Urea	1087	3.5	[19]
BGC-1-700	KOH	1258	3.46	[20]
SMLK-1	LiCl/KCl	951	3.00	[21]
MB	KOH	1379	2.50	[22]
NAC	KOH	1593	3.20	[23]
CRF	K_2CO_3	595-683	2.3-3.0	[24]
MMCs	CO_2	1192	3.6 0	[25]
AC	KOH	1503	3.15	[26]
PC-2:1-700	KOH	1433	3.68	[27]
BC	CO_2	809	2.20	[28]
OTSS-3-350	$NaNH_2$	779	3.50	[29]
CN-600-3	K_2CO_3/CN	1082	3.71	[30]
CAC-S	NaOH	1149	4.28	[31]
WTP-PVA	Annealing	783-1384	2.62-2.91	[32]
AC-900-800-1-H	N_2/CO_2	798	2.94	[33]
N, O-PC-CNTs	KOH-IL	2164	3.7	This work

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