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

Supporting Information for

Nitrogen-Doped Mesoporous Carbon Nanosheet/Carbon Nanotube Hybrids as Metal-Free Bi-functional electrocatalysts for Water Oxidation and Oxygen Reduction

Xinzhe Li, Yiyun Fang, Shiling Zhao, Juntian Wu, Feng Li, Min Tian, Xuefeng Long, Jun Jin* and Jiantai Ma*

State Key Laboratory of Applied Organic Chemistry, The Key Laboratory of Catalytic Engineering of Gansu Province and Chemical Engineering, College of Chemistry and Chemical Engineering, Lanzhou University, Lanzhou, 730000, P. R. China. *E-mail: jinjun@lzu.edu.cn, majiantai@lzu.edu.cn.

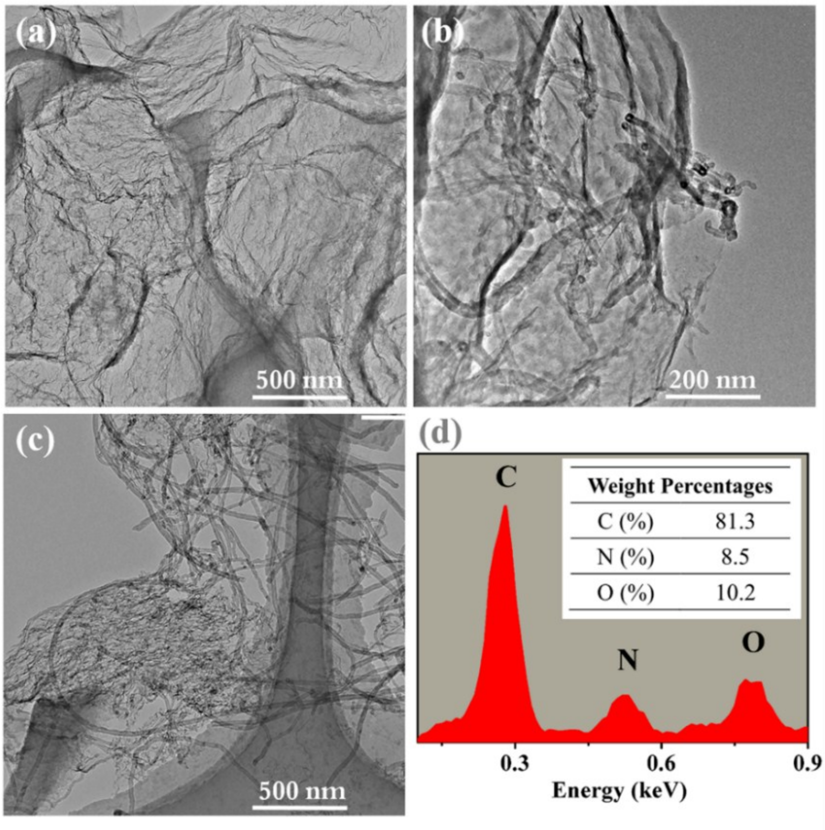

Fig. S1 TEM images of (a) N-MCN, (b) N-MCN/CNTs, (c) mixed N-MCN+CNTs, and (d) EDX characterization.

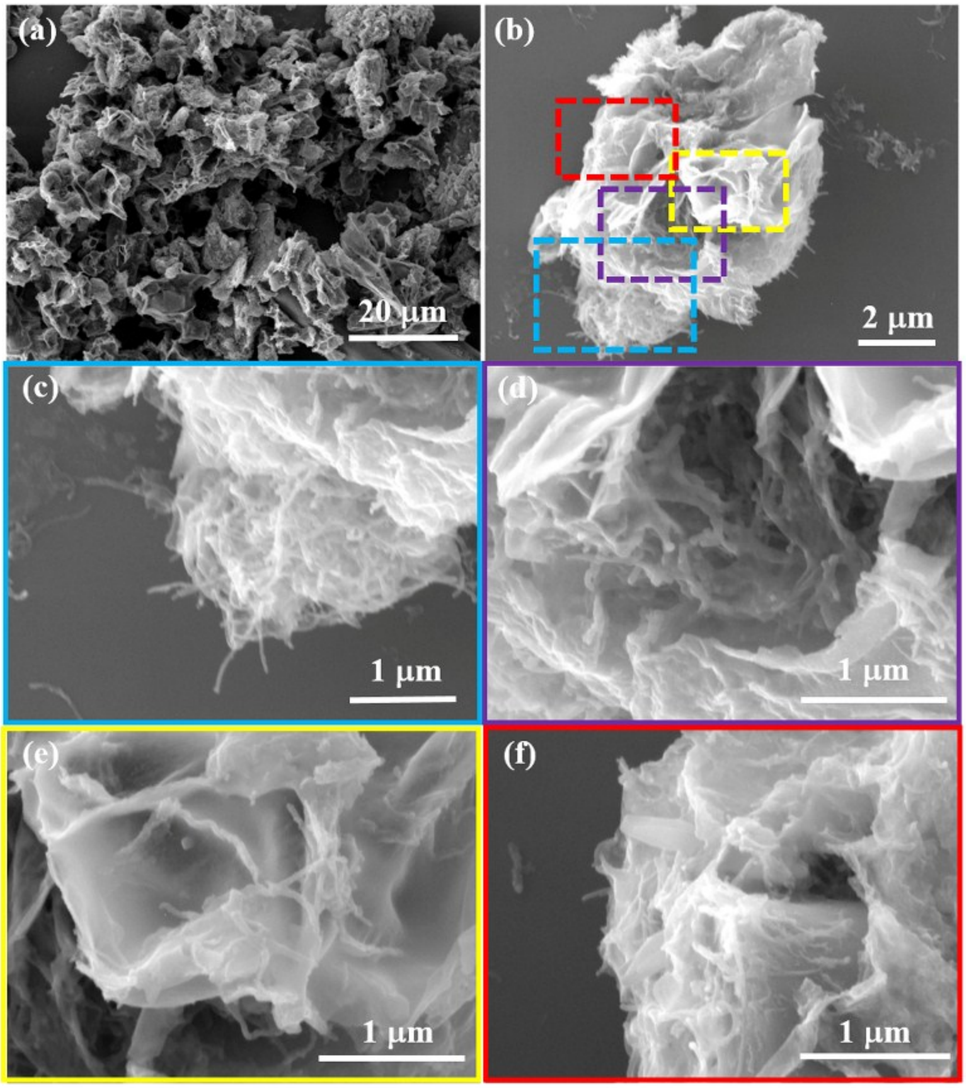

Fig. S2 SEM images to show the homogeneity in morphology and its structure of N-MCN/CNTs (images c-f are local image of b).

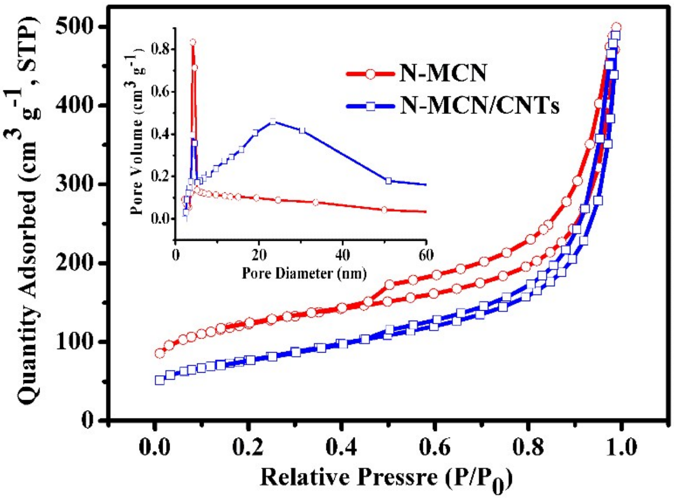

Fig. S3 Nitrogen adsorption–desorption isotherms of N-MCN and N-MCN/CNTs (inset: the corresponding pore-size distributions curves).

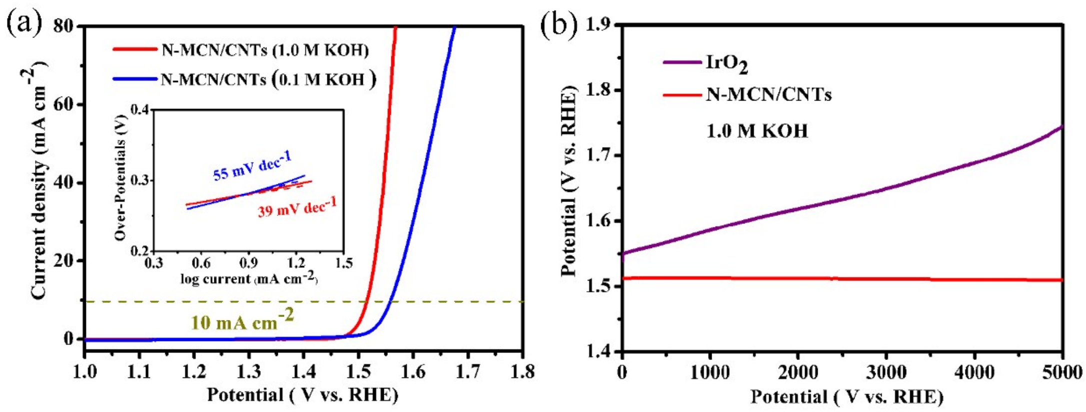

Fig. S4 (a) LSVs of N-MCN/CNTs in 0.1 M and 1.0 M KOH solutions, respectively. (b) Chronopotentiometric response of N-MCN/CNTs in 1.0 M KOH solution as compared to that obtained for IrO_2 catalyst.

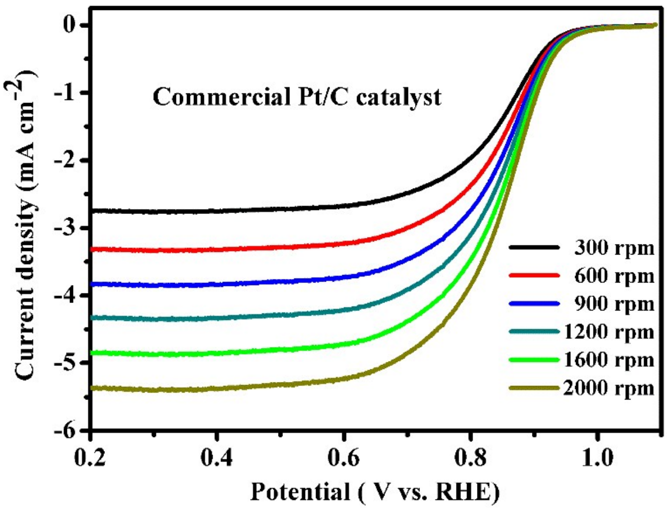

Fig. S5 LSVs of commercial 20% Pt/C catalyst in O_2-saturated 0.1M KOH with a sweep rate of 5 mV s^{-1} at the different rotation rates.

Table S1 XPS results of N-MCN/CNTs on the atomic percentages of C, N, O and the N distributions.

C (%)	N (%)	O (%)	N distribution (%)			
			pyridinic N	pyrrolic N	graphitic N	oxygenated N
85.1	10.7	4.2	37.7	20.5	31.6	10.2

Table S2 Comparison of the OER activity for several recently reported high performance OER catalysts.

Catalysts	Onset potential (V)	η@10.0 mA cm^{-2} (V)	Tafel slope (mV dec^{-1})	Catalyst loadings (mg cm^{-2})	Electrolyte	Reference
N-MCN/CNTs	**1.50**	**0.32**	**55**	**0.21**	**0.1 M KOH**	**This work**
	1.46	**0.28**	**39**	**0.21**	**1.0 M KOH**	**This work**
g-C_3N_4 NS-CNT	1.53	0.37	83	0.20	0.1 M KOH	1
	1.47	~0.29	/	0.20	1.0 M KOH	1
N/C	~1.50	0.38	/	0.20	0.1 M KOH	2
N,P-GCNS	1.32	0.34	70	0.14	0.1 M KOH	3
NGSH	~1.44	0.40	83	0.25	0.1 M KOH	4
NPMC-1000	~1.30	~0.60	/	0.15	0.1 M KOH	5
OCC-8	~1.57	0.48	82	/	0.1 M KOH	6
g-C_3N_4/graphene	1.5	0.54	68.5	0.48	0.1 M KOH	7
Fe_3C@NG800-0.2	~1.50	0.36	62	0.20	0.1 M KOH	8
Au@Co_3O_4/C	~1.51	0.35	60	0.20	0.1 M KOH	9
Ni-P	1.48	0.30	64	0.20	1.0 M KOH	10
Ni–Co ADHs nanocages	1.50	0.35	65	0.2	1.0 M KOH	11
Co-P/NC	~ 1.50	0.32	52	0.28	1.0 M KOH	12
N-CG–CoO	~ 1.52	0.34	71	0.71	1.0 M KOH	13
Co_3O_4@C-MWCNTs	1.50	320	62	0.33	1.0 M KOH	14
FeNi@NC	1.44	0.28	70	0.32	1.0 M NaOH	15

NiCo-LDH	~ 1.52	0.37	40	0.17	1.0 M KOH	16
Ni_2P	~ 1.47	0.29	/	0.14	1.0 M KOH	17
CoOx@CN	1.51	~0.33	60	0.14	1.0 M KOH	18
CNTs-Au@Co_3O_4	1.52	0.35	68	0.36	1.0 M KOH	19
$Zn_xCo_{3-x}O_4$ nanowire	~ 1.50	0.32	51	1.0	1.0 M KOH	20

Notes: For the convenience of comparison, the measure potentials vs. Ag/AgCl were converted to a reversible hydrogen electrode (RHE) scale accorting to the Nerst equation ($E_{RHE} = E_{Ag/AgCl} + 0.059 \times pH + 0.198$).

Table S3 Comparison of the ORR activity for several recently reported high performance ORR catalysts (electro rotating speed is 1600 rpm).

Catalysts	Onset potential (V)	Half-wave potential (V)	Electron transfer numbers	Catalyst loadings (mg cm^{-2})	Electrolyte	Reference
N-MCN/CNTs	**0.95**	**0.82**	**3.8-3.9**	**0.21**	**0.1 M KOH**	**This work**
N-doped porous C	0.86	0.7	3.3-3.9	0.20	0.1 M KOH	21
N,P-doped C fiber	0.88	0.79	~ 4	0.10	0.1 M KOH	22
NG-NCNT	0.87	/	3.7	0.05	0.1 M KOH	23
NC900	0.83	~0.68	3.3	0.034	0.1 M KOH	24
N,S,O-OMC	0.85	~0.79	3.5	0.16	0.1 M KOH	25
CoP NCs	0.80	0.70	3.5	0.28	0.1 M KOH	26
Pt/$CaMnO_3$	0.90	~0.79	3.9	0.09	0.1 M KOH	27

NC-NZ-13	~ 0.98	~ 0.84	~ 4	0.21	0.1 M KOH	28
meso/micro-P*o*PD	~ 1	0.87	3.97	0.5	0.1 M KOH	29
NC-A	~ 0.975	0.832	0.372	0.128	0.1 M KOH	30
NDCN-22	0.955	0.855	3.67–3.94	0.6	0.1 M KOH	31
NG-900	0.935	~ 0.785	3.70	0.051	0.1 M KOH	32
$NG/Fe_{10.0}$	0.961	~ 0.74	3.91	0.051	0.1 M KOH	32

Notes: For the convenience of comparison, the measure potentials vs. Ag/AgCl were converted to a reversible hydrogen electrode (RHE) scale accorting to the Nerst equation ($E_{RHE} = E_{Ag/AgCl} + 0.059 \times pH + 0.198$).

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