Electronic Supplementary Material (ESI) for RSC Advances.

Supplementary Information

An enhanced oxygen electrode catalyst by incorporating CoO/SnO_2 nanoparticles in crumpled nitrogen-doped graphene in alkaline media

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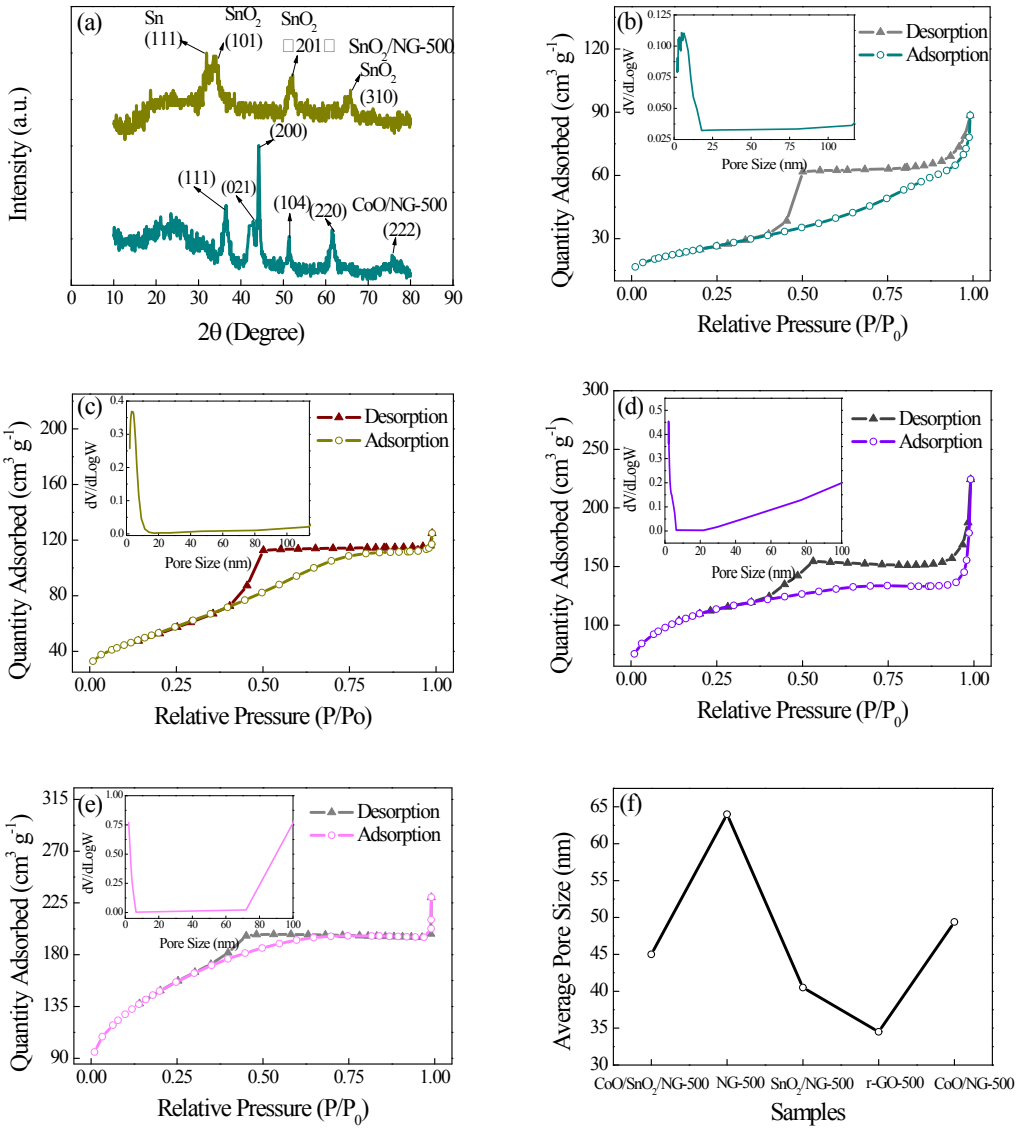

Fig. S1 (a) XRD patterns of SnO_2/NG-500 and CoO/SnO_2/NG-500; (b-e) The nitrogen adsorption-desorption isotherm and the pore distribution curves inset for CoO/NG-500 (b), SnO_2/NG-500 (c), NG-500 (d) and r-GO-500 (e); (f) The average pore width values of CoO/SnO_2/NG-500, SnO_2/NG-500, CoO/NG-500, NG-500 and r-GO-500.

Table S1 BET surface area and average pore size for the samples obtained from nitrogen adsorption-desorption isotherm.

Sample	BET Surface Area (m^2 g^{-1})	Average Pore Size (nm)
CoO/SnO_2/NG-500	282.2	45.1
CoO/NG-500	173.5	49.4
SnO_2/NG-500	195.5	40.5
NG-500	359.7	64.0
r-GO-500	509.4	34.5

Table S2 XPS datas of CoO/SnO_2/NG-500, CoO/SnO_2/NG, CoO/NG-500, SnO_2/NG-500, NG-500 and r-GO-500.

Sample	C 1s (eV)	O 1s (eV)	N 1s (eV)	Co 2p (eV)	Sn 3d (eV)	$\Delta BE_{O\text{-}Sn}$
CoO/SnO_2/NG-500	284.8	530.2	400.1	781.1	487.2	43.0
CoO/SnO_2/NG	284.50	531.8	399.2	781.4	486.6	45.2
CoO/NG-500	284.65	530.1	400.3	780.3	-	-
SnO_2/NG-500	284.7	531.2	399.7	-	486.9	44.3
NG-500	284.8	531.9	398.5	-	-	-
r-GO-500	284.7	532.0	-	-	-	-

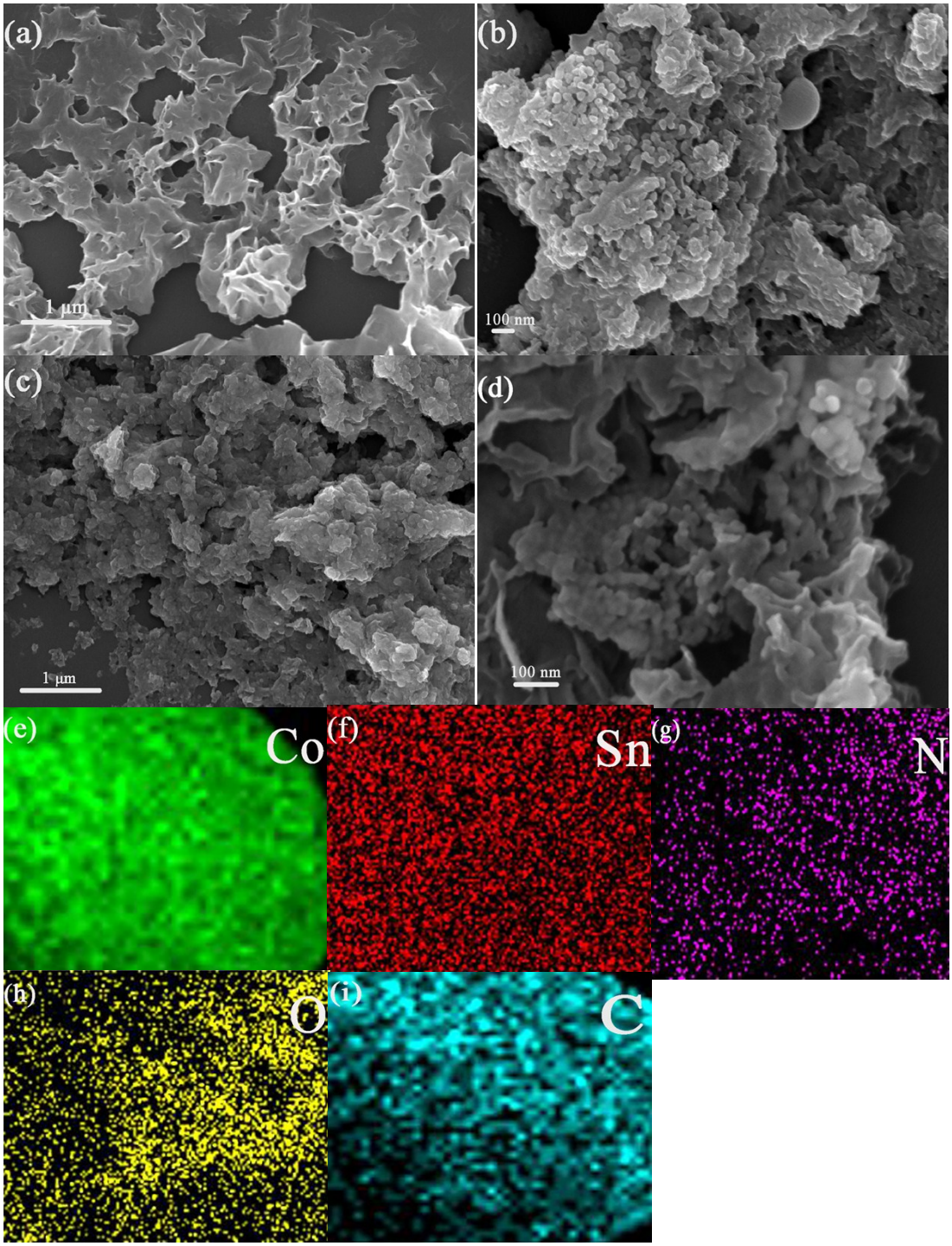

Fig. S2 (a,b,c) SEM images of r-GO-500 (a), CoO/NG-500 (b), and SnO_2/NG-500 (c); (d-i) EDX mapping of CoO/SnO_2/NG-500.

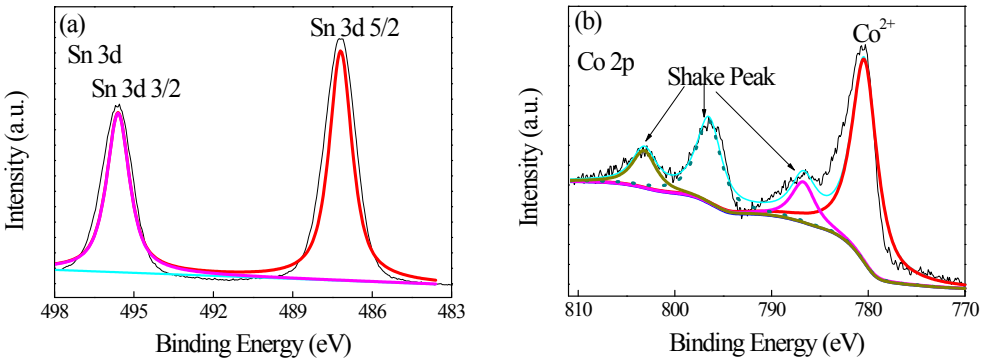

Fig. S3 High resolution XPS spectra of (a) Sn 3d in SnO_2/NG-500 and (b) Co 2p in CoO/NG-500.

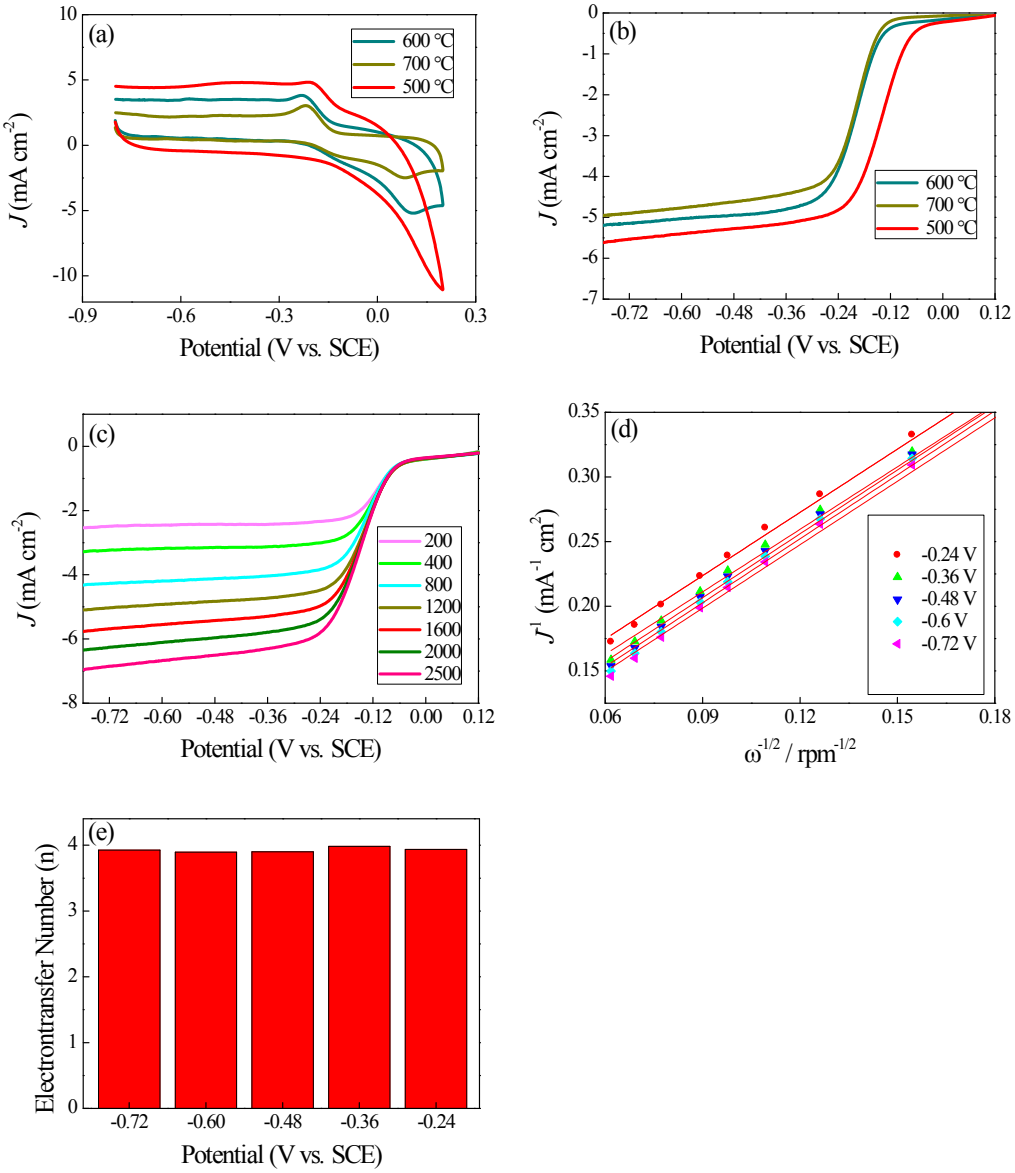

Fig. S4 (a, b) Cycle voltammograms (a) and linear sweep voltammogram measurements (b) of $CoO/SnO_2/NG$ at different temperature; (c, d) LSV polarization curves (c) and K-L plots (d) at different potentials for $CoO/SnO_2/NG$-500 in an O_2-saturated 0.1 M KOH at 1600 rpm; (e) The n values at various potentials of $CoO/SnO_2/NG$-500.

Table S3 Recent literature on the ORR performance.

Catalyst	Tafel Slope ($mV\ dec^{-1}$)	Reference
CoO/SnO_2/NG-500	33	This work
N-CG-CoO	48	Energy Environ. Sci. 2014, 7, 609–616.
$Co(OH)_2$	62	ACS Appl. Mater. Interfaces 2015, 7, 12930−12936.
Co-N-CNT	40	ACS Appl. Mater. Interfaces 2015, 7, 4048−4055.
$Co_{0.5}Fe_{0.5}S$@N-MC	67	ACS Appl. Mater. Interfaces 2015, 7, 1207−1218.
$Co(OH)_x$-NCNT	54	ACS Appl. Mater. Interfaces 2016, 8, 1571−1577.
$Co(OH)_x$-CNT	90	ACS Appl. Mater. Interfaces 2016, 8, 1571−1577.
CoS_2(400)/N,S-GO	75	ACS Catal. 2015, 5, 3625−3637.

Table S4 Recent literature on the OER performance.

Catalyst	$\eta_{J=10}$ [mV vs. SCE]	Tafel Slope [mV dec^{-1}]	Reference
CoO/SnO_2/NG-500	285	41	This work
N-CG-CoO	334	71	Energy Environ. Sci., 2014, **7**, 609–616.
$CoFe_2O_4$/PANI-MWCNT	314	31	J. Mater. Chem. A, 2016.
CoP/rGO	340	66	Chem. Sci., 2016, **7**, 1690–1695.
CoSe	-	40	Electrochimica Acta, 2016, **194**, 59–66.
Co_3O_4/N-CNT–GNR	360	44	J. Mater. Chem. A, 2015, **3**, 13371–13376.
CNCNT	310	50	ACS Appl. Mater. Interfaces, 2015, **7**, 4048−4055.
NCNT/$Co_xMn_{1-x}O$	340	40	Nano Energy, 2016, **20**, 315–325.
$Co(OH)_x$-NCNT	380	36	ACS Appl. Mater. Interfaces, 2016, **8**, 1571−1577.