Supporting information

Iron doping induced formation of Ni-Co-O Nanotube as Efficient Bifunctional Electrodes

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Electrochemical measurements details

The turnover frequency (TOF, s^{-1}) for HER was calculated with the following equation:

$$TOF=(|J|\times A)/2Fn \quad (1)$$

Where $|J|$ ($A\cdot cm^{-2}$) is the current density at a fixed voltage during the LSV measurement, A is the geometric area of the working electrode (1 cm^2), the factor of 2 is the corresponding electron transfer numbers, F is the Faraday constant (96485 $C\cdot mol^{-1}$), and n is the number of active sites (mol).

$$n=Q/2F \quad (2)$$

The number of active sites (n) was determined by the cyclic voltammetry (CV) with a scan rate of 10 mV s^{-1}. The number of the voltammetric charges (Q) could be determined by integrating.

The turnover frequency (TOF, s^{-1}) for OER was calculated with the following equation:

$$TOF=(|J|\times A)/4Fn \quad (3)$$

$$n=Q/4F \quad (4)$$

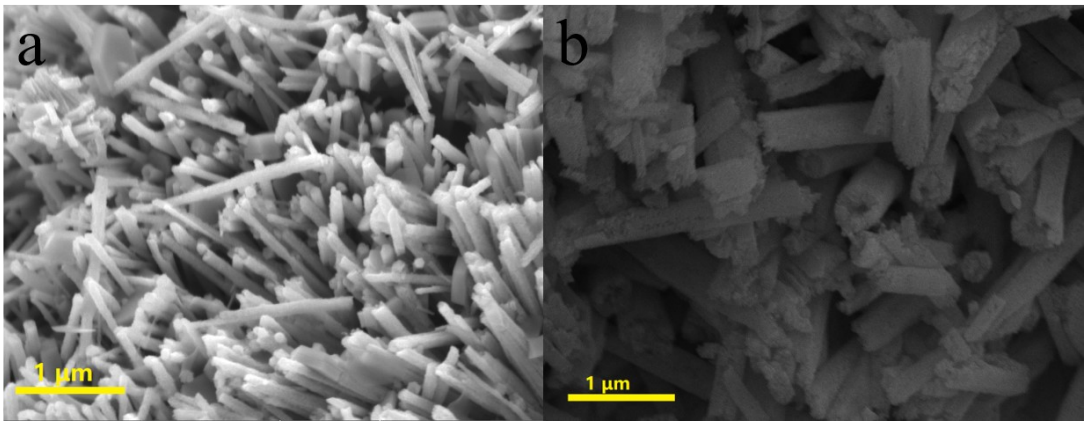

Fig. S1 (a) Fe_3-NCO with an annealing temperature at 300 °C and (b) at 500 °C.

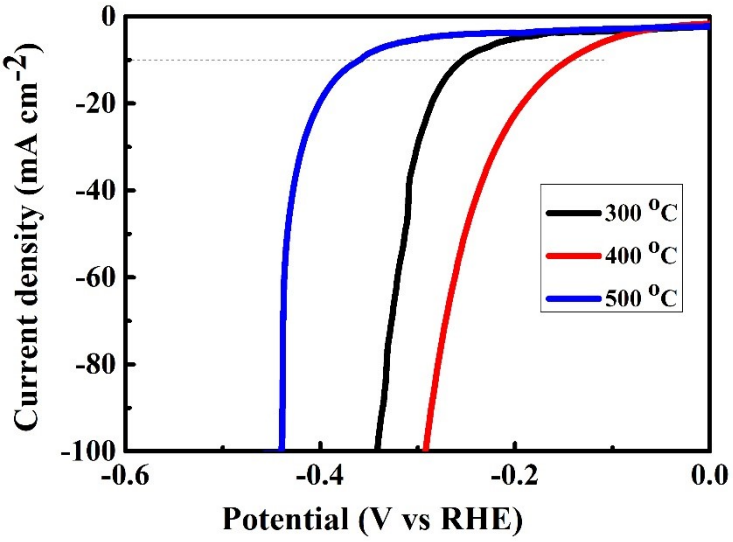

Fig. S2 LSV curves of HER at 5 mV s^{-1} of the Fe_3-NCO at different annealing temperature.

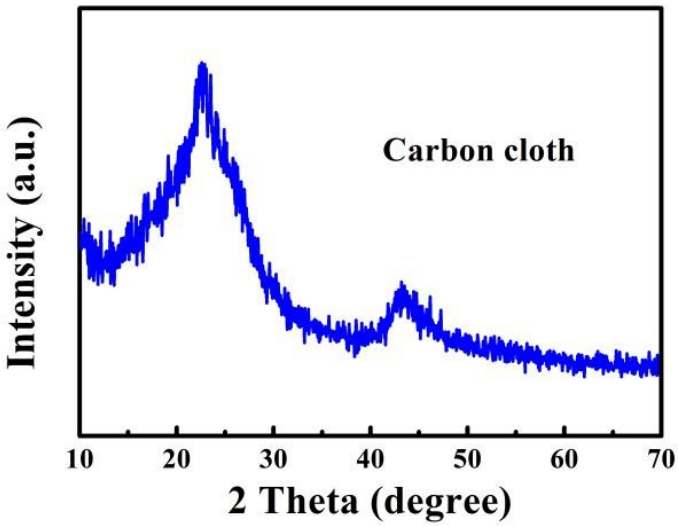

Fig. S3 XRD patterns of carbon textiles.

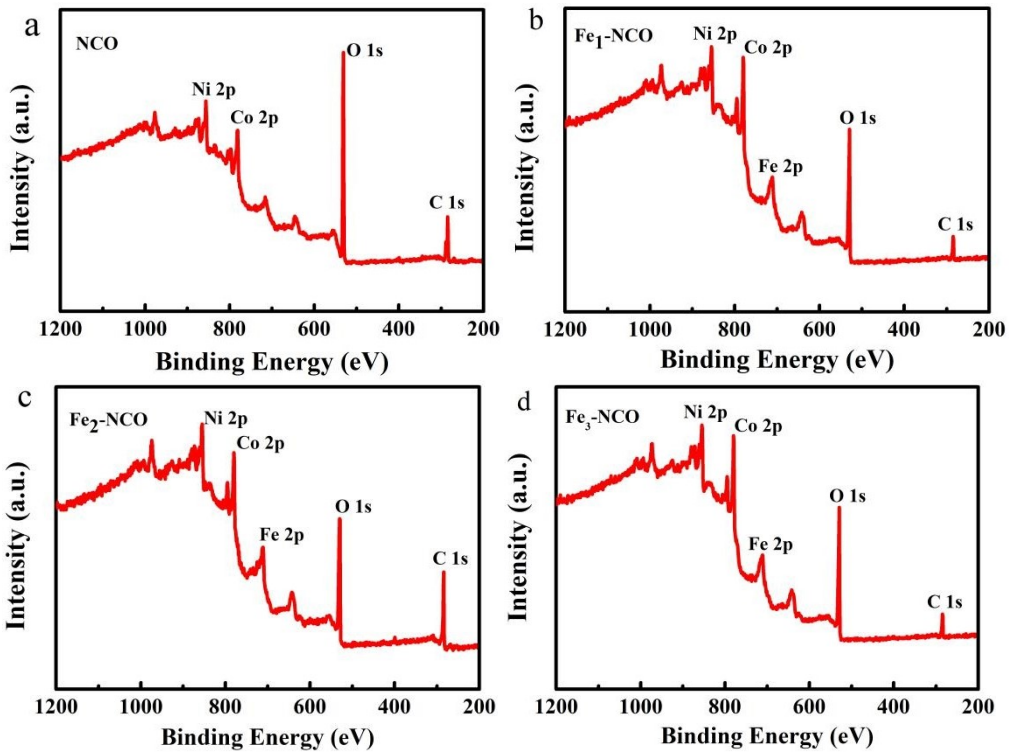
a
NCO
Ni 2p
Co 2p
O 1s
C 1s
Intensity (a.u.)
1200
1000
800
600
400
200
Binding Energy (eV)
b
Fe1-NCO
Ni 2p
Co 2p
Fe 2p
O 1s
C 1s
Intensity (a.u.)
Binding Energy (eV)
c
Fe2-NCO
Ni 2p
Co 2p
Fe 2p
O 1s
C 1s
Intensity (a.u.)
Binding Energy (eV)
d
Fe3-NCO
Ni 2p
Co 2p
Fe 2p
O 1s
C 1s
Intensity (a.u.)
Binding Energy (eV)

Fig. S4 Overall XPS survey spectra of as-prepared various electrocatalysts.

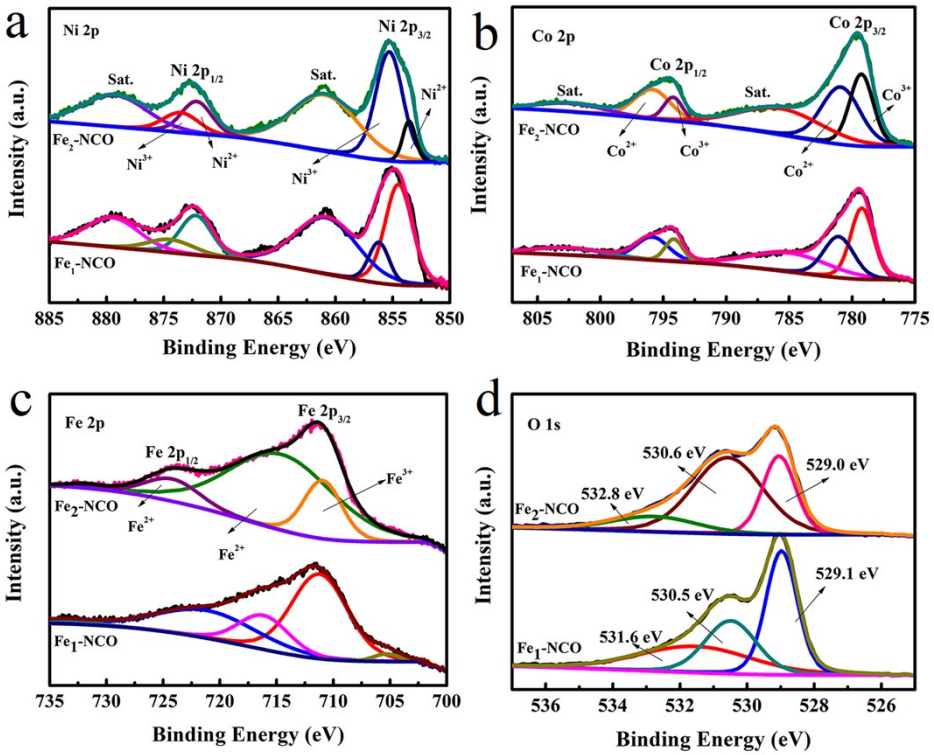

Fig. S5 (a) Ni 2p spectra of Fe_1-NCO and Fe_2-NCO, (b) Co 2p spectra of Fe_1-NCO and Fe_2-NCO, (c) Fe 2p spectra of Fe_1-NCO and Fe_2-NCO and (d) O 1s spectrum of Fe_1-NCO and Fe_2-NCO.

According to the Ni2p spectra of $NiCo_2O_4$, the Ni2p spectrum in Figure S4a was composed of two spinorbit doublets and two satellite, the peaks of Fe_1-NCO at about 854.9 and 872.9eV were corresponded to Ni^{2+}, whereas those at 856.2 and 874.9 eV were fitted with Ni^{3+}. For Fe_2-NCO the peaks at 854.7 and 873.1 eV was fitted with Ni^{2+}, while those at 855.9 and 874.7 eV belongs to Ni^{3+}, respectively.[1] The Co2p

spectrum in Figure S4b was fitted into both Co $2p_{1/2}$ and Co $2p_{3/2}$ with a shakeup satellite for each. The peaks of Fe_1-NCO situated at 781.9 and 796.9 eV can be indexed into Co^{2+} species, while those at 779.7 and 794.8 eV correspond to Co^{3+}. [2] The spin-orbit located at 781.8 and 797.1 eV of Fe_2-NCO can be ascribed to Co^{2+} and the binding energies found at 779.9 and 795.8 can be attributed to Co^{3+}. Compared to pristine $NiCo_2O_4$ (NCO), the binding energies of Ni 2p and Co 2p in Fe_1-NCO and Fe_2-NCO were shifted to lower values. As for the Fe 2p spectrum of Fe_1-NCO, the characteristic peaks of Fe^{3+} occur at 711.4 eV, while that of Fe_2-NCO at 711.6 eV, respectively.[3]

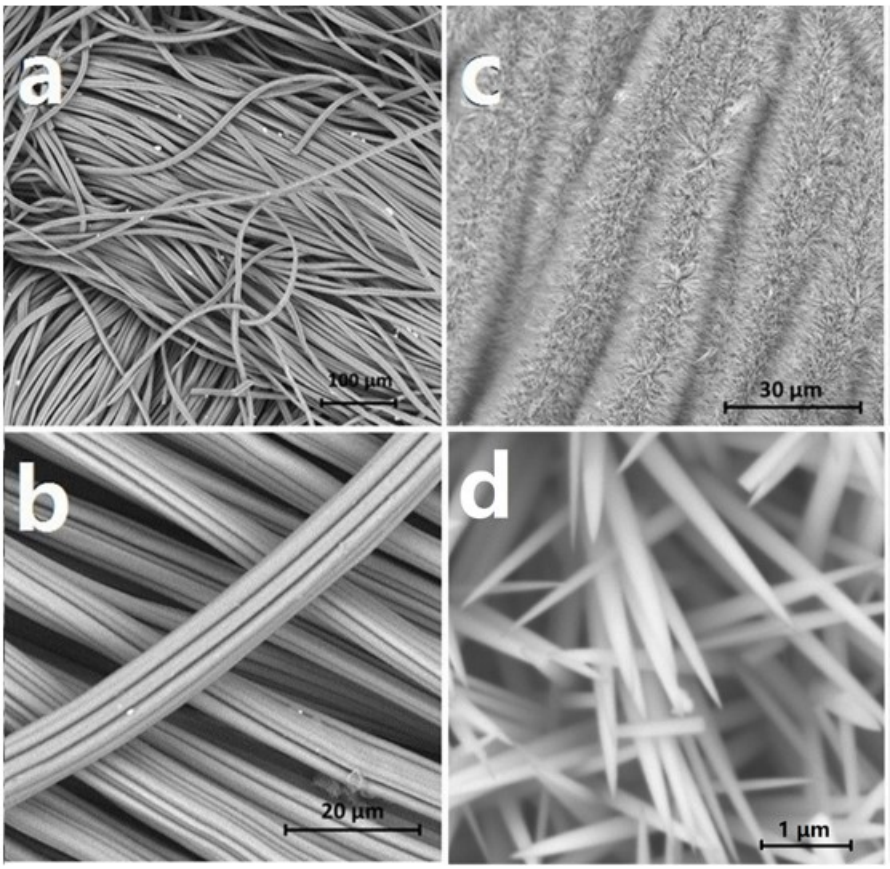

Fig. S6 Low (a) and high (b) magnification of SEM images of the carbon textiles, Low (c) and high (d) magnifications of the NCO.

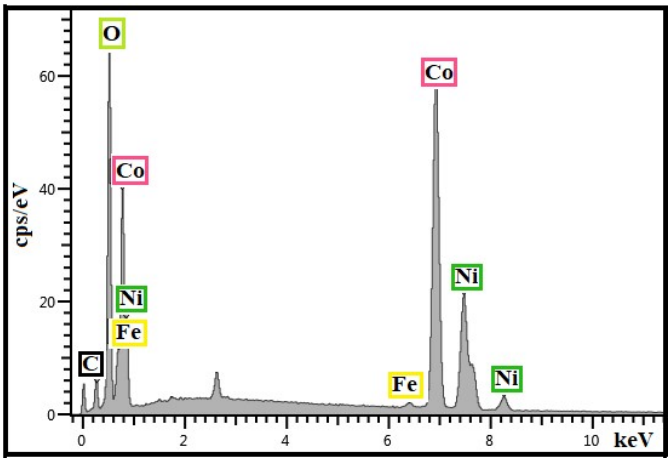

Fig. S7 EDS of Fe_3-NCO.

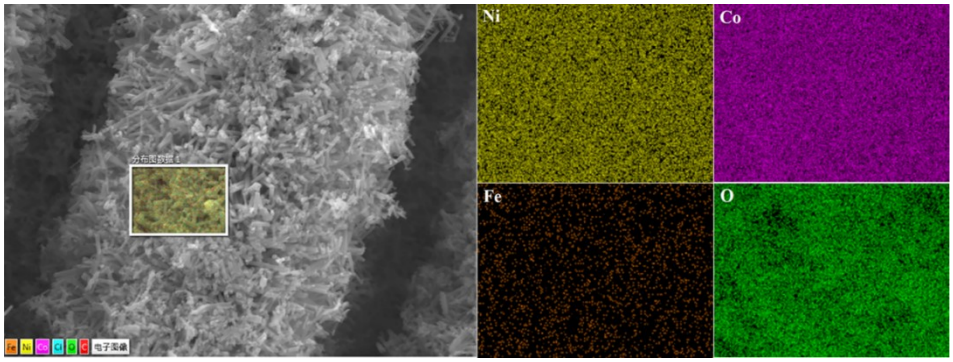

Fig. S8 The element mapping analysis of Fe_3-NCO.

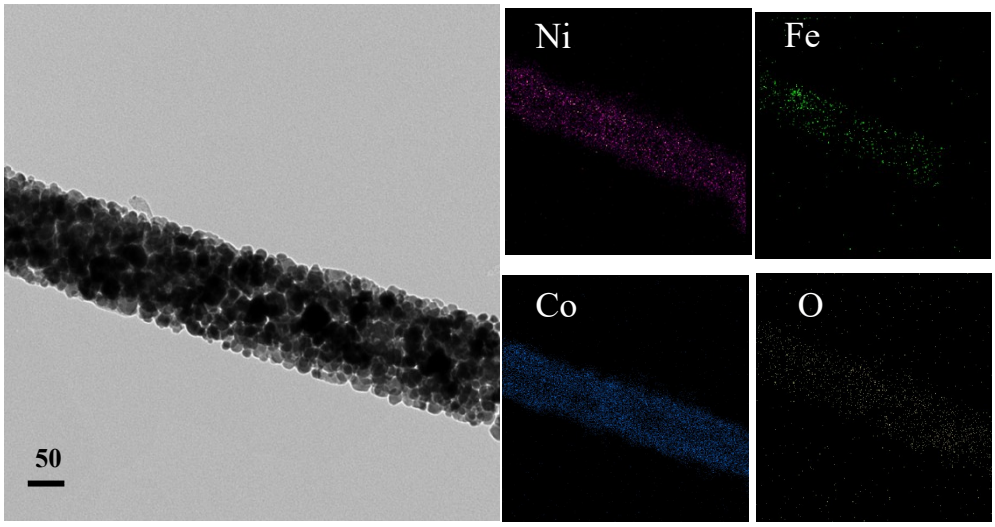

Fig. S9 The EDS mapping images of Fe_3-NCO.

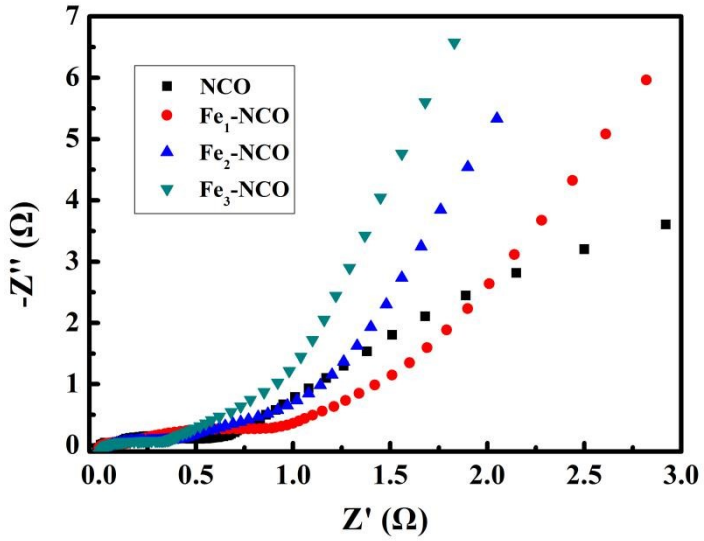

Fig. S10 Nyquist plots of various catalysts in 1 M KOH.

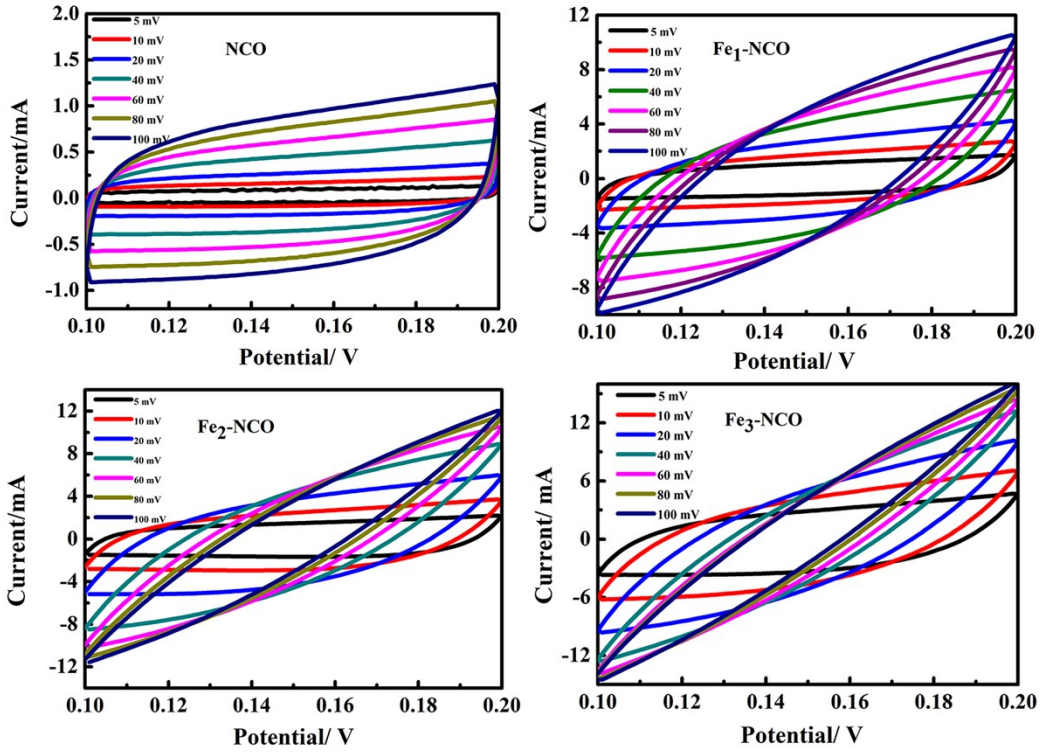

Fig. S11 CV curves of the various catalysts for the OER in 1 M KOH.

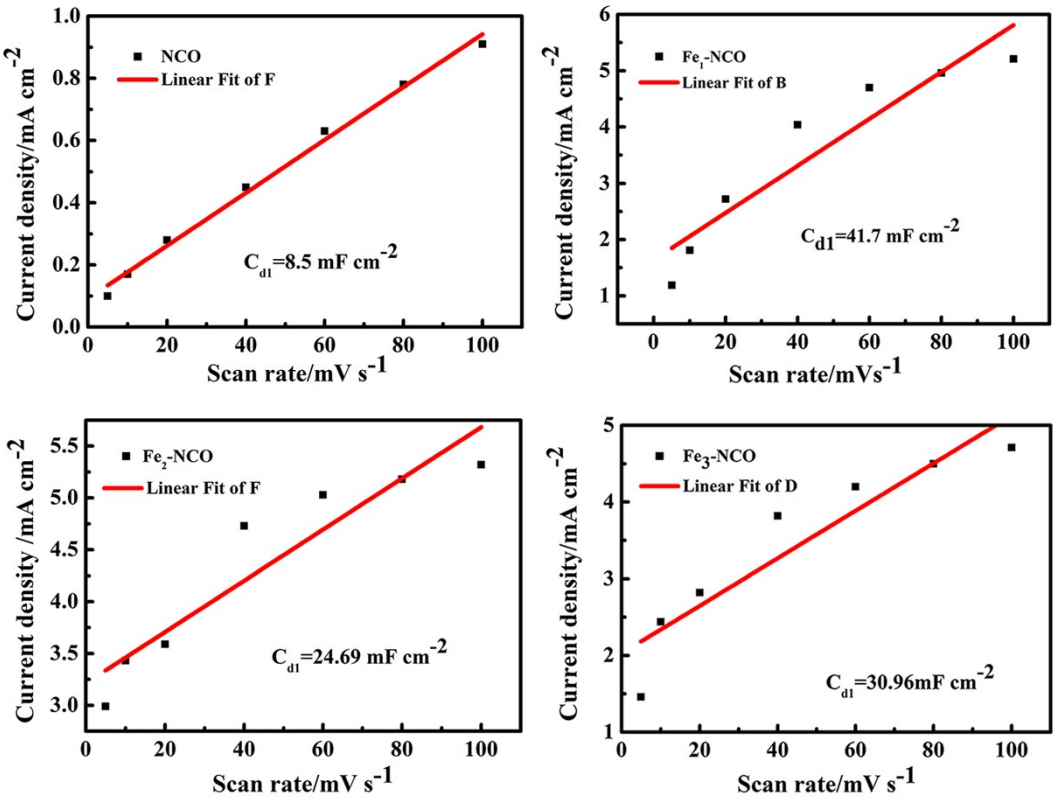

Fig. S12 ECSA of the various catalysts in 1 M KOH.

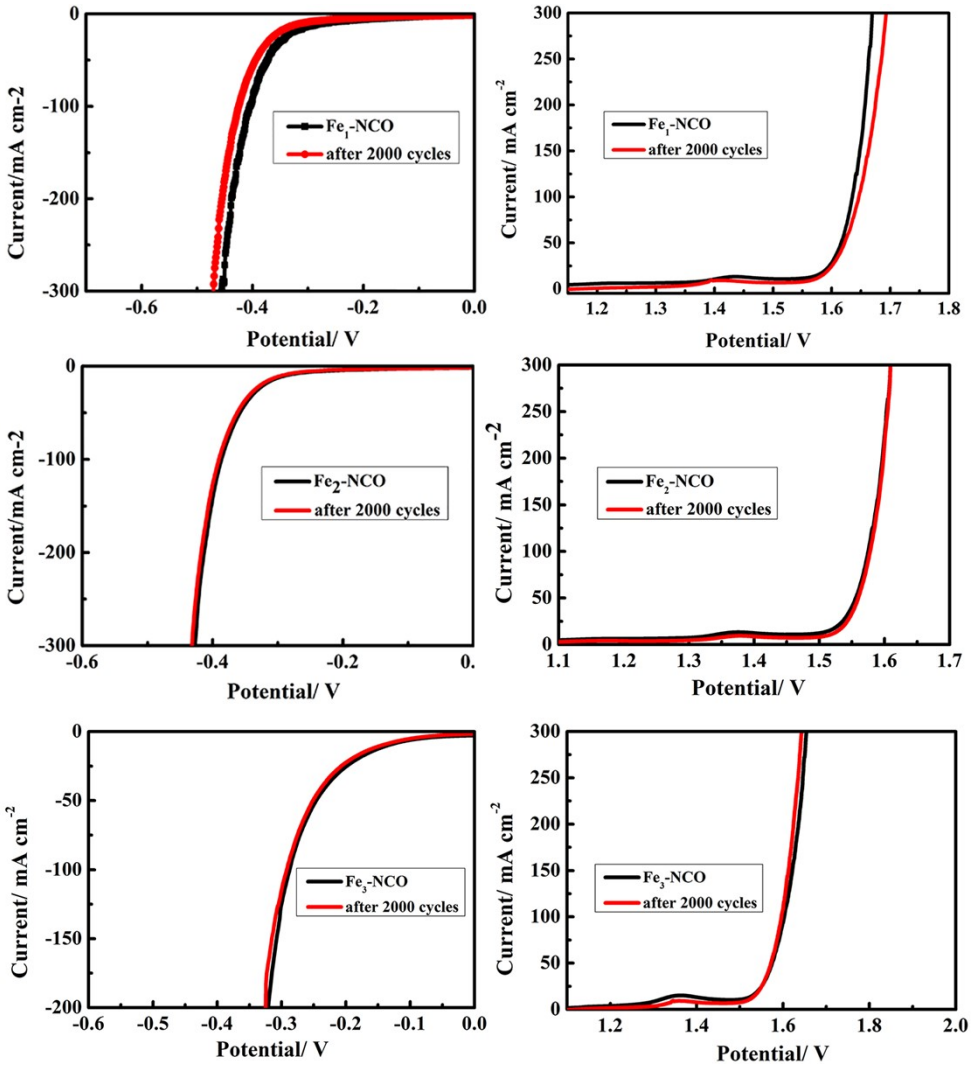

Fig. S13 LSV curves of the various electrodes for HER and OER before and after 2000

continuous cycles.

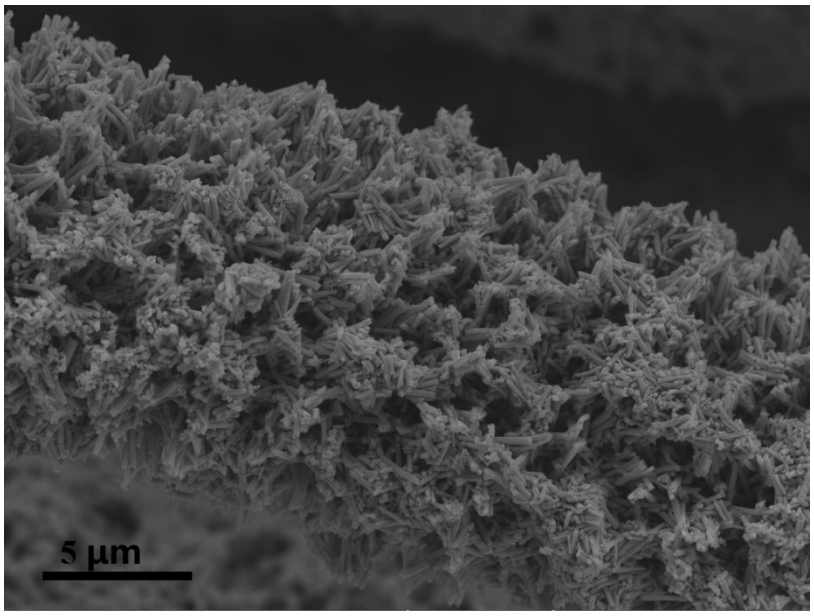

Fig. S14 SEM image of Fe_3-NCO after 2000 continuous cycles in the alkaline electrolyte.

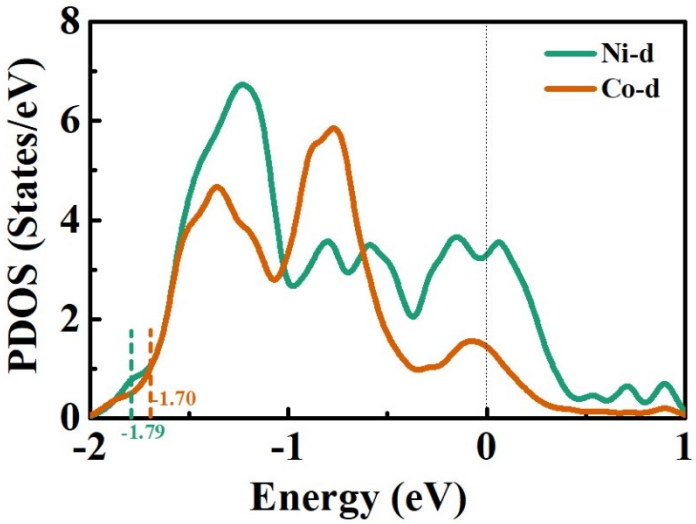

Fig.S15 The projected density-of-states of d orbitals of Ni, Co sites with aligned Fermi level in NCO.

Table S1. Elemental compositions of various samples

Sample	Ni (wt%)	Co (wt%)	Fe (wt%)	Atomic ratio of Ni, Co
NCO	22.26	46.86		1:2.11
Fe_1-NCO	20.20	42.90	5.63	1:2.12
Fe_2-NCO	10.28	22.49	7.21	1:2.18
Fe_3-NCO	12.99	30.15	9.36	1:2.32

References

1 Z. Liu, H. Tan, D. Liu, X. Liu, J. Xin, J. Xie, M. Zhao, L. Song and H. Liu, *Adv. Sci.* 2019, **6,** 1801829.

2 M. Yu, S. Zhou, Z. Wang. J. Zhao and J. Qiu, *Nano Energy*, 2018, **44,** 181-190.

3 J. Zhang, X. Shang and H. Ren, *Adv. Mater.* 2019, **31,** 1905107.