# Electronic Supplementary Information

## Experimental section

**Materials:** Nickel foam (NF) was provided by Hongshan District, Wuhan Instrument Surgical Instruments business, and treated in hydrochloric acid (HCl) to serve as substrate for active materials. $Co(NO_3)_2·6H_2O$, $CO(NH_2)_2$ and $NH_4F$ were purchased from Aladdin Ltd. in Shanghai. Potassium bicarbonate ($KHCO_3$) was purchased by Chengdu Kelon Chemical Reagent Factory. $RuCl_3·3H_2O$ and Nafion (5 wt%) were bought from Sigma-Aldrich Chemical Reagent Co., Ltd. All chemical regents were used as received without further purification. The water used throughout all experiments was purified through a Millipore system.

**Preparation of CoCH/NF:** CoCH/NF was prepared as follows. A piece of NF was first treated with concentrated HCl, ethanol and deionized water by sonication sequentially to obtain a clean surface before use. To prepare CoCHH/NF, $Co(NO_3)_2·6H_2O$ (0.29 g), urea (0.3 g) and $NH_4F$ (0.07 g) were dissolved in 25 mL water under vigorous stirring for 5 min. Then the solution was transferred to a 50 mL Teflon-lined stainless-steel autoclave and a piece of NF was immersed into the solution. The autoclave was sealed and maintained at 120 °C for 5 h in an electric oven to obtain CoCHH/NF. CoCH/NF was obtained via electrochemical conversion of CoCHH/NF for 2 h at 1.0 V in 1.0 M K-Ci (pH 8.3) at room temperature (25 °C), using CoCHH/NF, saturated calomel electrode (SCE) and graphite plate as the working electrode, reference electrode and counter electrode, respectively. The CoCH loading was determined to be 6 mg $cm^{-2}$ using a high precision microbalance.

**Synthesis of $RuO_2$:** $RuO_2$ was prepared in accordance with reported work.[1] Briefly, 2.61 g of $RuCl_3·3H_2O$ and 1.0 mL KOH (1.0 M) were added into 100 mL distilled water and stirred for 45 min at 100 °C. Then the above solution was centrifuged for 10 min and filtered. The precipitates were collected by centrifugation and washed with water for several times, followed by drying at 70 °C. Finally, the product was annealed at 300 °C for 3 h under air atmosphere. $RuO_2$ ink was prepared by dispersing 20 mg of catalyst into 490 μL of water/ethanol (v/v = 1:1) and 10 μL of 5 wt% Nafion using sonication for 30 min. Then 37.5 μL of the $RuO_2$ ink (containing 1.5 mg of $RuO_2$) was loaded onto a bare NF of 0.25 $cm^{-2}$ in geometric area (loading: 6 mg $cm^{-2}$).

**Characterizations:** XRD data were acquired from a LabX XRD-6100 X-ray diffractometer with Cu Kα radiation (40 kV, 30 mA) of wavelength 0.154 nm (SHIMADZU, Japan). SEM measurements were performed on a XL30 ESEM FEG scanning electron microscope at an accelerating voltage of 20 kV. TEM images were collected on a HITACHI H-8100 electron microscopy (Hitachi, Tokyo, Japan) operated at 200 kV. XPS spectra were acquired on an ESCALABMK II X-ray photoelectron spectrometer using Mg as the excitation source.

**Electrochemical measurements:** Electrochemical measurements were performed with a CHI 660E electrochemical analyzer (CH Instruments, Inc., Shanghai) in a standard three-electrode system. CoCH/NF was used as the working electrode, and a graphite plate and a SCE were used as the counter electrode and the reference electrode, respectively. The temperature of solution was kept at 25 °C for all the measurements via the adjustment of air condition and heating support, which ensured the variation of diffusion coefficient below 1%. The potentials reported in this work were calibrated to RHE other than especially explained, using the following equation: $E\ (RHE) = E\ (SCE) + (0.242 + 0.059\ pH)$ V.

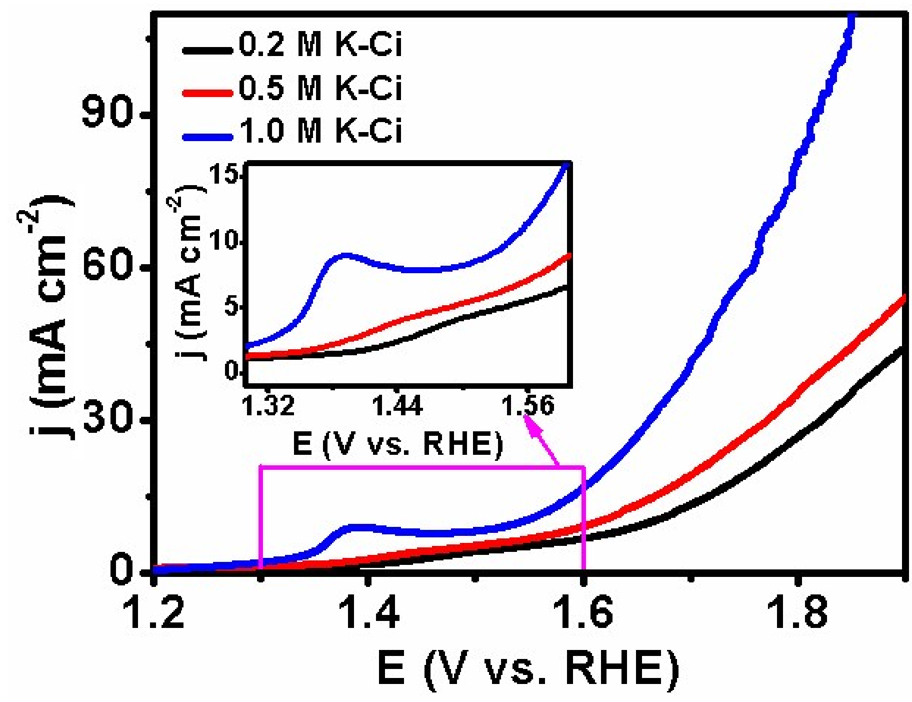

**Fig. S1.** LSVcurves for CoCH/NF in 0.2, 0.5 and 1.0 M K-Ci for OER (inset: local magnification LSV curves).

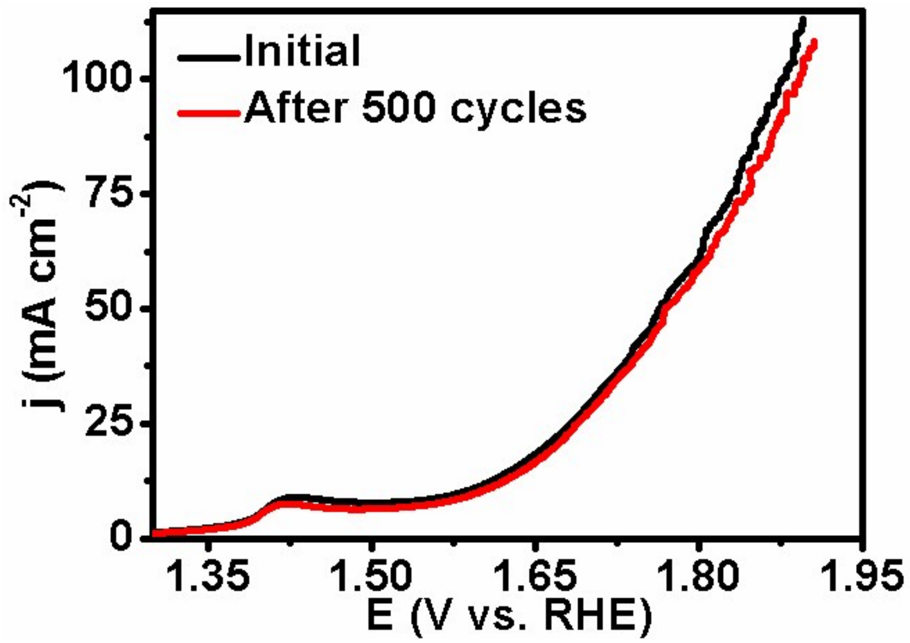

**Fig. S2.** LSV curves recorded for CoCH/NF before and after 500 cyclic voltammetry in 1.0 M K-Ci for OER.

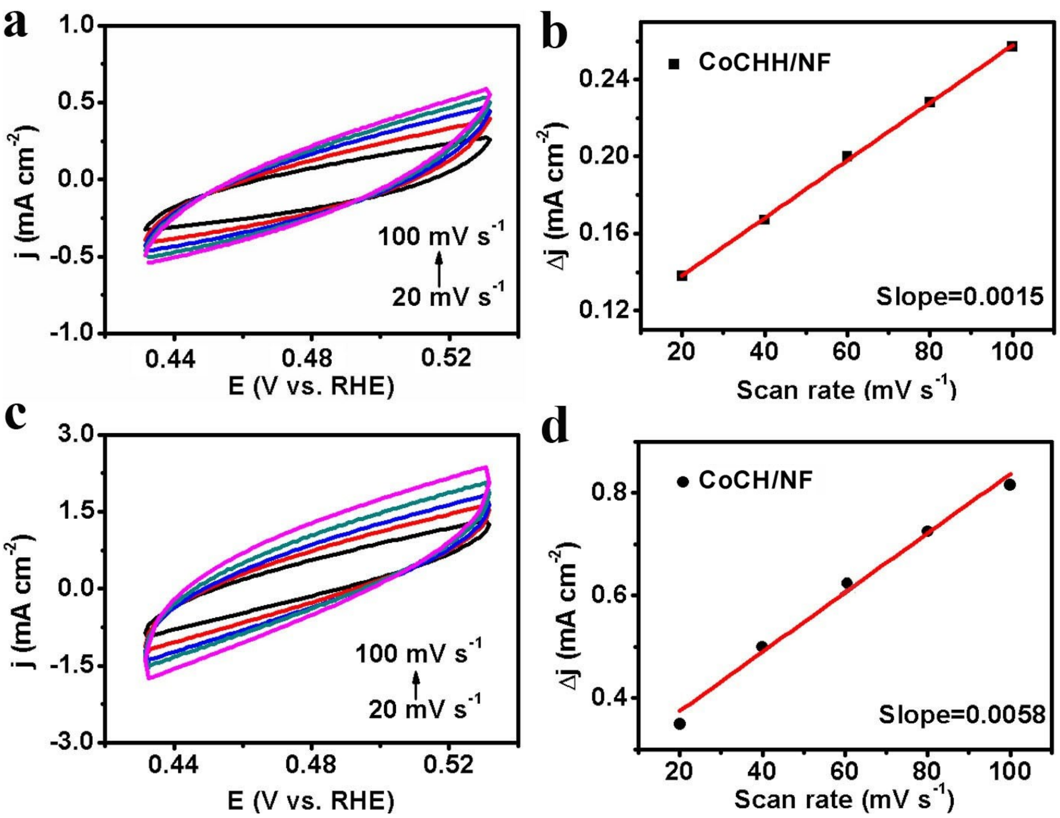

**Fig. S3.** CVs for (a) CoCHH/NF and (c) CoCH/NF in the non-faradaic capacitance current range at scan rates of 20, 40, 60, 80, and 100 mV s$^{-1}$. Corresponding capacitive currents at 0.48 V vs. RHE as a function of scan rates for (b) CoCHH/NF and (d) CoCH/NF in 1.0 M K-Ci.

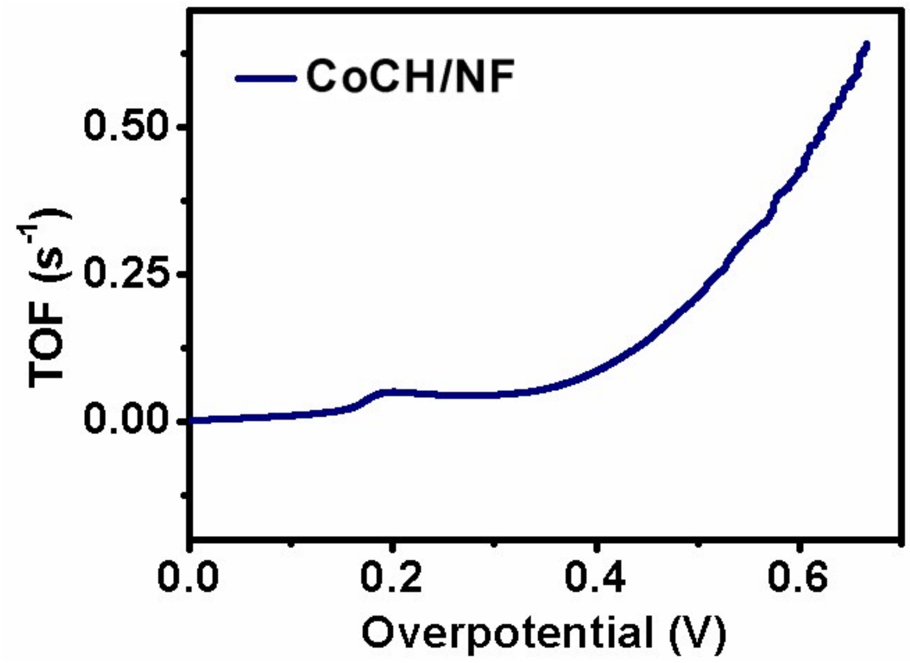

**Fig. S4.** A plot of TOF for CoCH/NF as a function of overpotential.

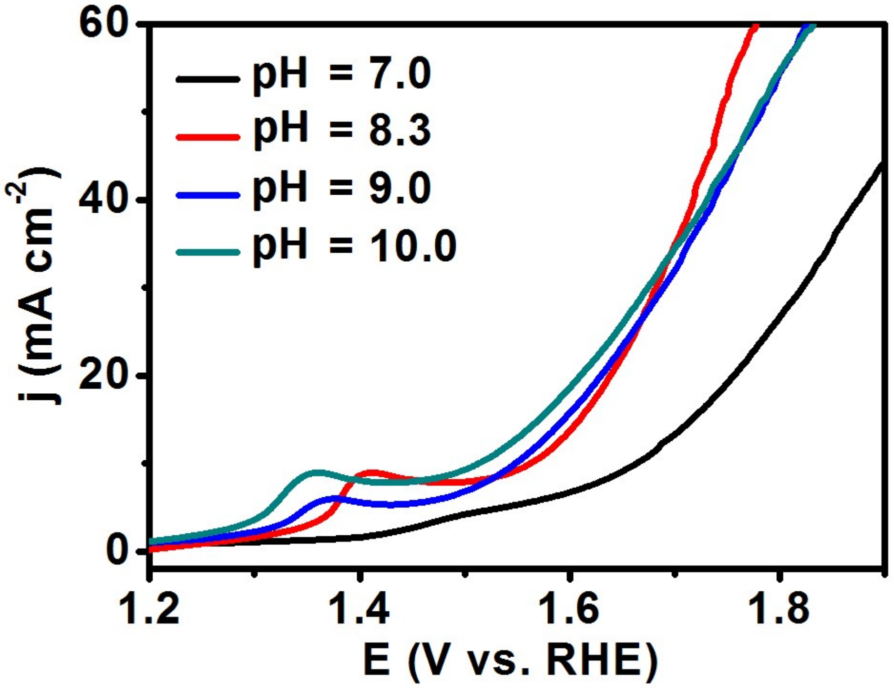

**Fig. S5.** LSV curves of CoCH/NF in 1.0 M K-Ci under different pH values for OER.

**Table S1.** Comparison of OER performance for CoCH/NF with other reported non-noble-metal catalysts under benign conditions.

| **Catalyst** | **j (mA cm$^{-2}$)** | ***η* (mV)** | **Electrolyte** | **pH** | **Loading** | **Ref.** |
|---|---|---|---|---|---|---|
| CoCH/NF | 10 | 434 | 0.2 M K-Ci | 8.3 | 6 mg cm$^{-2}$ | This work |
|  | 10 | 381 | 0.5 M K-Ci | 8.3 |  |  |
|  | 10 | 332 | 1.0 M K-Ci | 8.3 |  |  |
| Fe-Ci/FTO | 10 | 560 | 0.2 M Ci | 9.75 | 91.2 nmol/cm$^2$ | 2 |
| Co-Ci/GC | 9.1 | ~771 | 0.2 M K-Ci | 6.7~6.8 | 7.5 nmol cm$^{-2}$ | 3 |
| NiO@Ni-Ci/CC | 15 | 387 | 1.0 M K-Ci | 8.3 | 1.8 mg cm$^{-2}$ | 4 |
| Co-Bi NA/Ti | 10 | 420 | 0.1 M K-Bi | 9.2 | 2.38 mg cm$^{-2}$ | 5 |
| Co-Pi NA/Ti | 10 | 450 | 0.1 M K-Pi | 7.0 | 0.95 mg cm$^{-2}$ | 6 |
| CCH@Co-Pi NA/Ti | 10 | 460 | 0.1 M K-Pi | 7.0 | 2.0 mg cm$^{-2}$ | 7 |
| Ni-Bi film/FTO | 1.0 | 390 | 0.5 M K-Bi | 9.2 | 1.4 nmol/cm$^2$ | 8 |
| Ni-Bi film/FTO | 1.0 | 413 | 1.0 M K-Bi | 9.2 | 10 nmol/cm$^2$ | 9 |
| Fe-Bi/ITO | 10 | 600 | 0.5 M BBS | 9.2 | - | 10 |
| Fe-$Co_3O_4$@Fe-Co-Bi/CC | 10 | 420 | 0.1 M K-Bi | 9.2 | 1.32 mg cm$^{-2}$ | 11 |
| CoP@Co-Bi-Pi/Ti | 10 | 410 | 0.1 M K-Bi | 9.2 | 1.2 mg cm$^{-2}$ | 12 |
| Fe-Pi-Bi/CC | 10 | 434 | 0.1 M K-Bi | 9.2 | 2.21 mg cm$^{-2}$ | 13 |
| $CoO_2$/$CoSe_2$-Ti | 10 | 510 | 1.0 M PBS | 7.0 | 2.0 mg cm$^{-2}$ | 14 |
| Cu-Bi/FTO | 10 | 810 | 0.2 M BBS | 9.2 | - | 15 |
| Co-Bi/FTO | 1 | 390 | 1.0 M K-Bi | 9.2 | - | 16 |
| Co-W/FTO | 1 | 420 | 0.05M K-Bi | 8.0 | - | 17 |
| Co-Ni LDH/FTO | 1.0 | 490 | 0.1 M K-Pi | 7.0 | 0.17 μg cm$^{-2}$ | 18 |
| Ni-4Gly | 1.0 | 480 | 0.25 M PBS | 9.0 | - | 19 |
| $NiO_x$-Bi | 1.0 | 650 | 0.5 M K-Bi | 9.2 | 10.0 mC cm$^{-2}$ | 20 |

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