

## Supporting Information

### Defect-rich carbon-coated nickel-cobalt alloy nanoparticles enhanced OER catalytic activity through surface reconstruction

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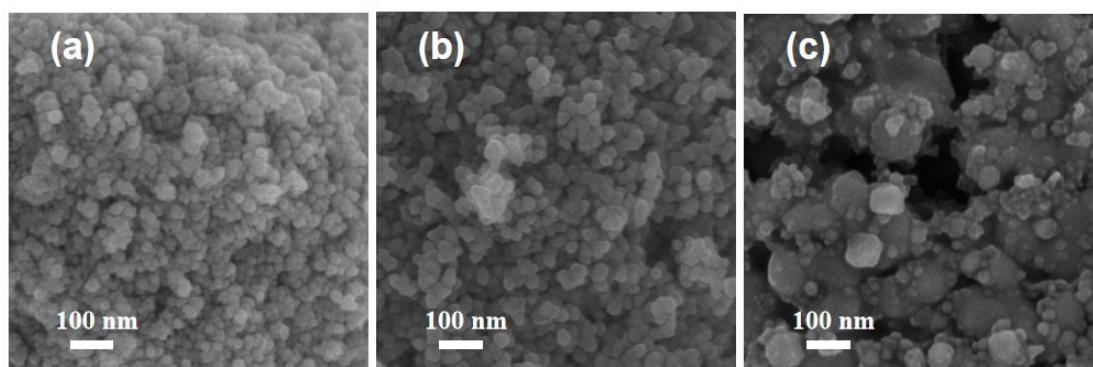
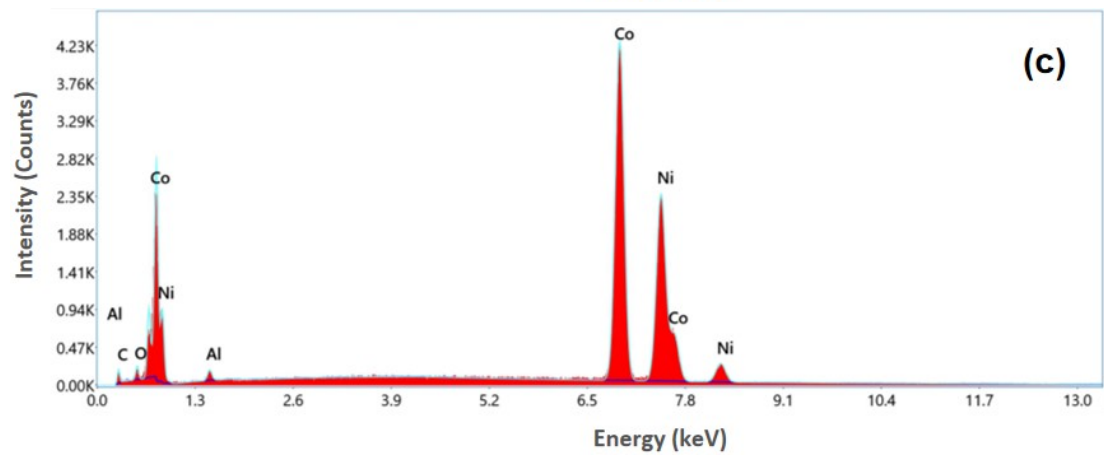
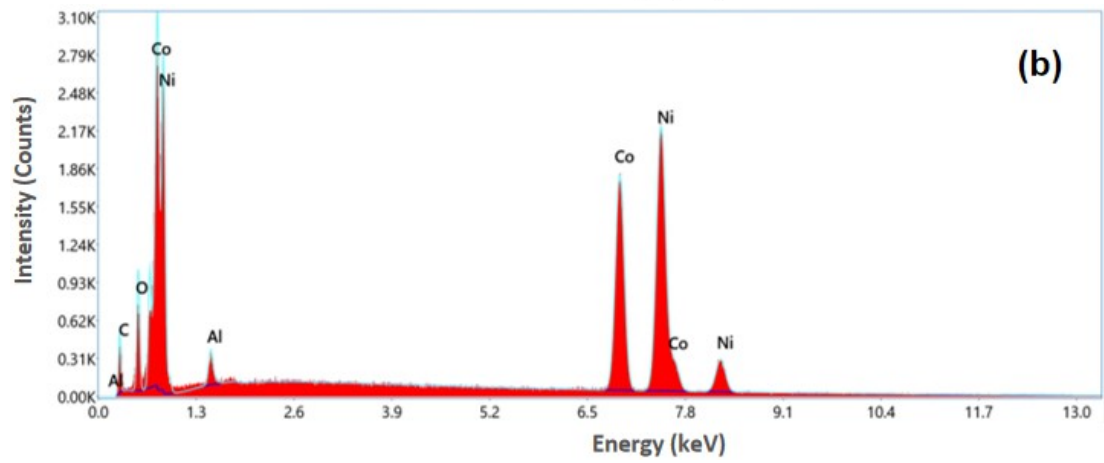
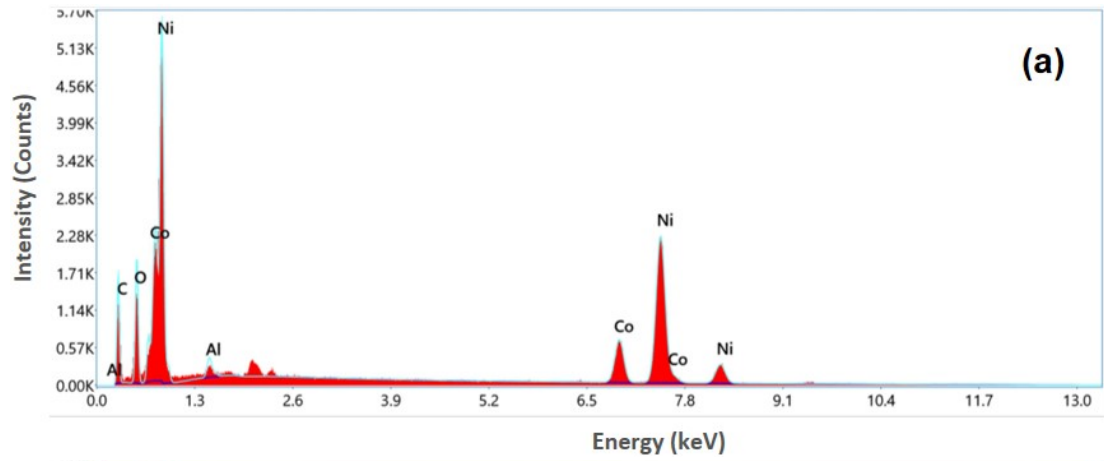


Fig. S1. SEM images of the Ni<sub>x</sub>Co<sub>y</sub>(CA). (a) Ni<sub>0.8</sub>Co<sub>0.2</sub>(CA). (b) Ni<sub>0.6</sub>Co<sub>0.4</sub>(CA). (c) Ni<sub>0.4</sub>Co<sub>0.6</sub>(CA).



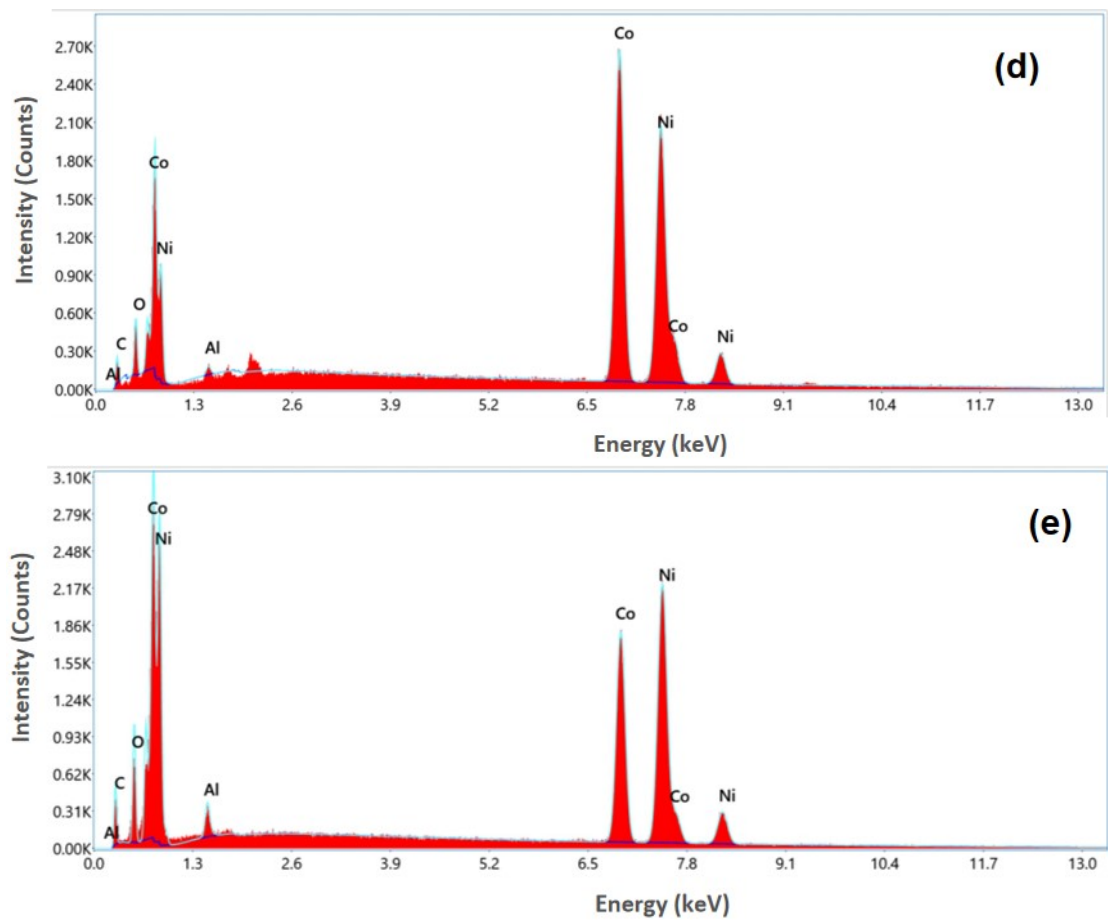


Fig. S2. EDS spectrum of (a)  $\text{Ni}_{0.8}\text{Co}_{0.2}(\text{CA})$ , (b)  $\text{Ni}_{0.7}\text{Co}_{0.3}(\text{CA})$ , (c)  $\text{Ni}_{0.6}\text{Co}_{0.4}(\text{CA})$ , (d)  $\text{Ni}_{0.5}\text{Co}_{0.5}(\text{CA})$ , and (e)  $\text{Ni}_{0.4}\text{Co}_{0.6}(\text{CA})$ .

Table S1. The energy dispersion spectrum(EDS) element analysis results of the Ni/Co atomic ratios in Ni<sub>x</sub>Co<sub>y</sub>(CA).

| Catalyst                                 | Element | Atomic (%) | Weight (%) | Ni/Co (Atom) |
|--|---------|------------|------------|--------------|
| Ni <sub>0.8</sub> Co <sub>0.2</sub> (CA) | C       | 73.81      | 49.89      | 0.8 : 0.190  |
|  | O       | 14.77      | 13.30      |              |
|  | Al      | 0.54       | 0.81       |              |
|  | Ni      | 8.80       | 29.07      |              |
|  | Co      | 2.09       | 6.92       |              |
| Ni <sub>0.7</sub> Co <sub>0.3</sub> (CA) | C       | 61.64      | 30.63      | 0.7 : 0.308  |
|  | O       | 12.99      | 8.60       |              |
|  | Al      | 0.67       | 0.75       |              |
|  | Ni      | 17.14      | 41.62      |              |
|  | Co      | 7.55       | 18.40      |              |
| Ni <sub>0.6</sub> Co <sub>0.4</sub> (CA) | C       | 60.32      | 9.48       | 0.6 : 0.408  |
|  | O       | 10.88      | 0.70       |              |
|  | Al      | 1.28       | 0.62       |              |
|  | Ni      | 16.37      | 34.83      |              |
|  | Co      | 11.15      | 54.37      |              |
| Ni <sub>0.5</sub> Co <sub>0.5</sub> (CA) | C       | 43.51      | 14.62      | 0.5 : 0.543  |
|  | O       | 5.92       | 2.65       |              |
|  | Al      | 0.55       | 0.42       |              |
|  | Ni      | 23.90      | 39.25      |              |
|  | Co      | 26.12      | 43.06      |              |
| Ni <sub>0.4</sub> Co <sub>0.6</sub> (CA) | C       | 33.28      | 28.40      | 0.4 : 0.625  |
|  | O       | 1.83       | 6.83       |              |
|  | Al      | 0.97       | 1.36       |              |
|  | Ni      | 25.02      | 37.66      |              |
|  | Co      | 38.90      | 25.76      |              |

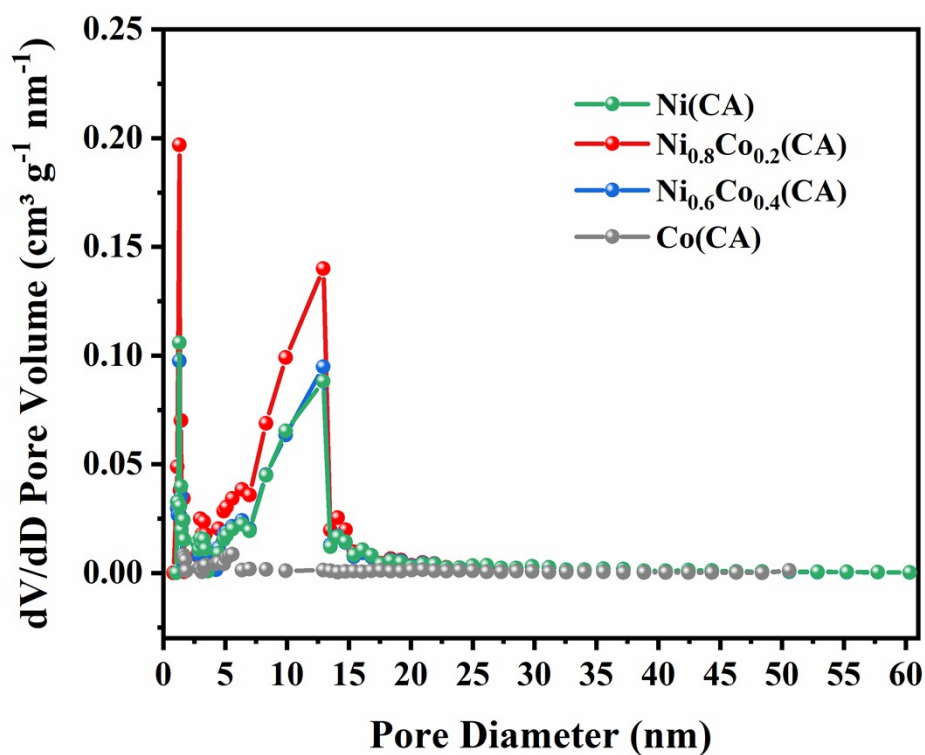


Fig. S3. The pore size distribution curves of Ni(CA), Ni<sub>0.8</sub>Co<sub>0.2</sub>(CA), Ni<sub>0.6</sub>Co<sub>0.4</sub>(CA) and Co(CA).

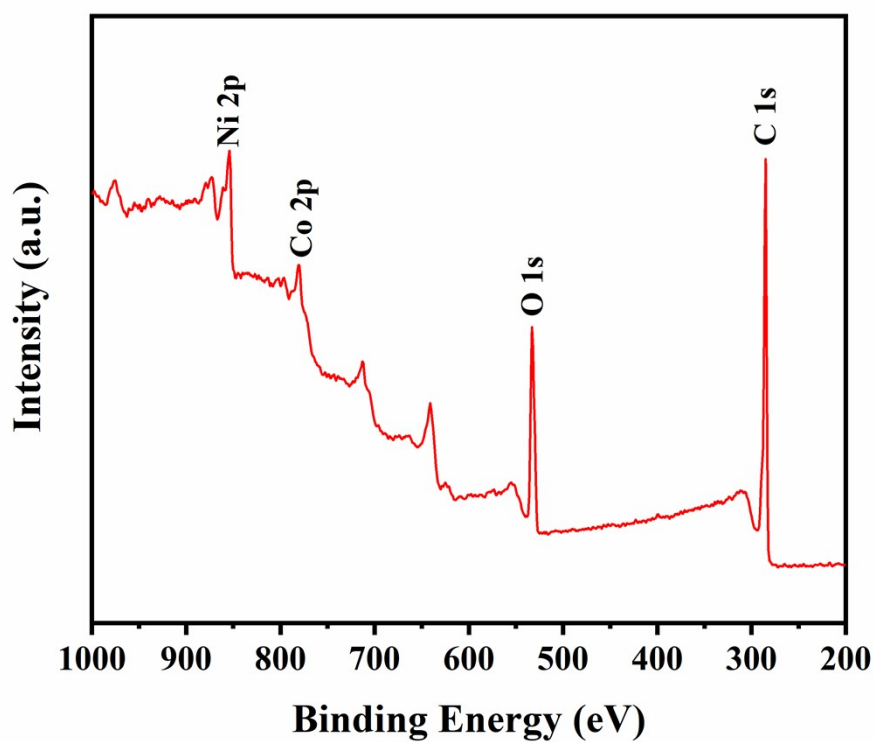


Fig. S4. XPS survey spectrum for Ni<sub>0.8</sub>Co<sub>0.2</sub>(CA).

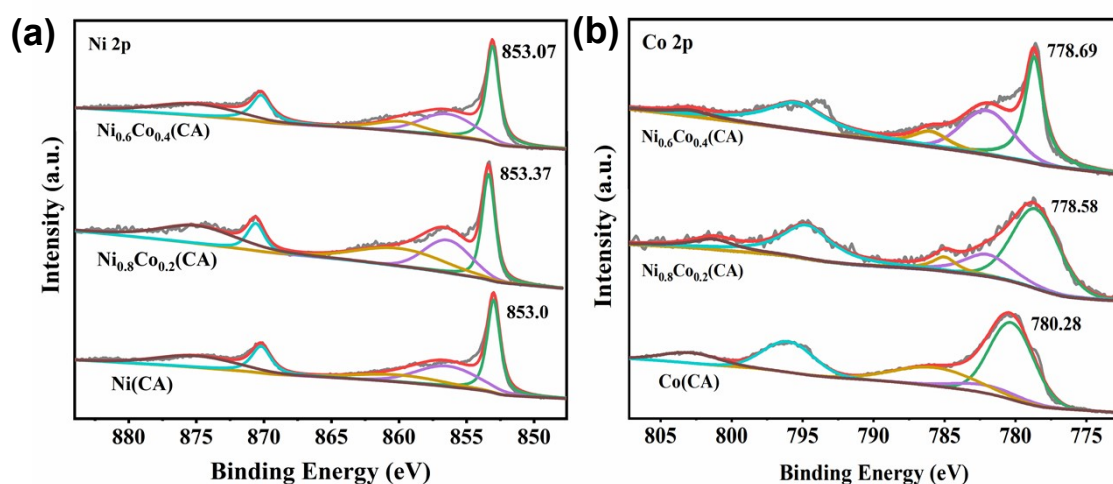


Fig. S5. (a) High-resolution XPS spectrum of Ni 2p for Ni(CA), Ni<sub>0.8</sub>Co<sub>0.2</sub>(CA), and Ni<sub>0.6</sub>Co<sub>0.4</sub>(CA). (b) XPS spectrum of Co 2p for Ni<sub>0.8</sub>Co<sub>0.2</sub>(CA), Ni<sub>0.6</sub>Co<sub>0.4</sub>(CA) and Co(CA).

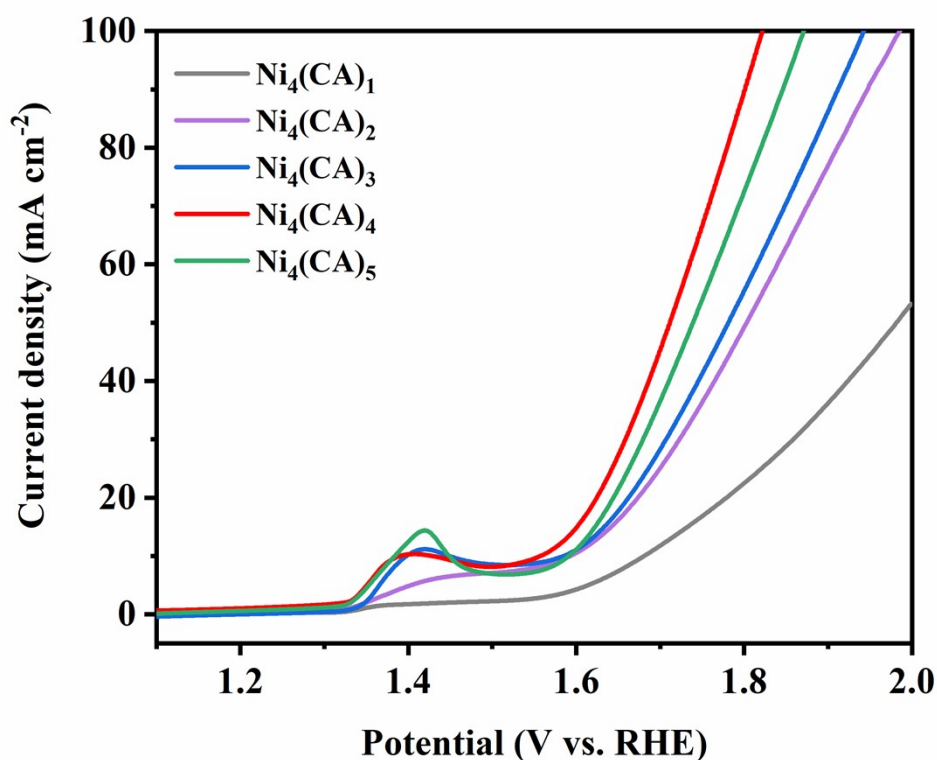


Fig. S6. LSV curves of different metal to citric acid molar ratio (M/C) at 1 M KOH.

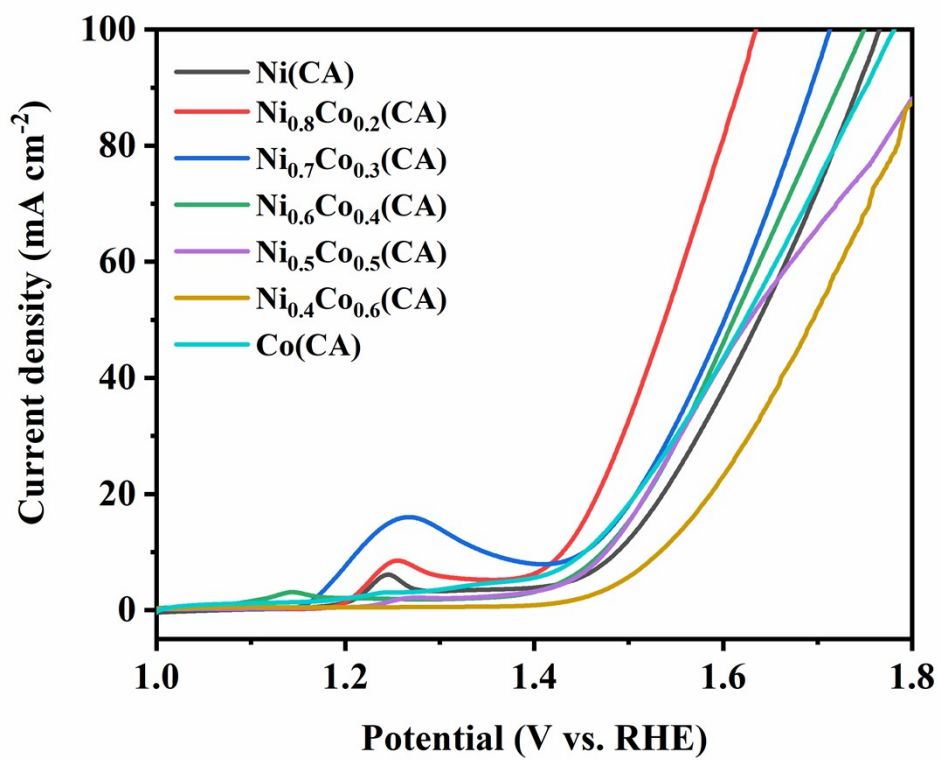


Fig. S7. LSV curves of different Ni to Co molar ratio (Ni/Co) at 1 M KOH.

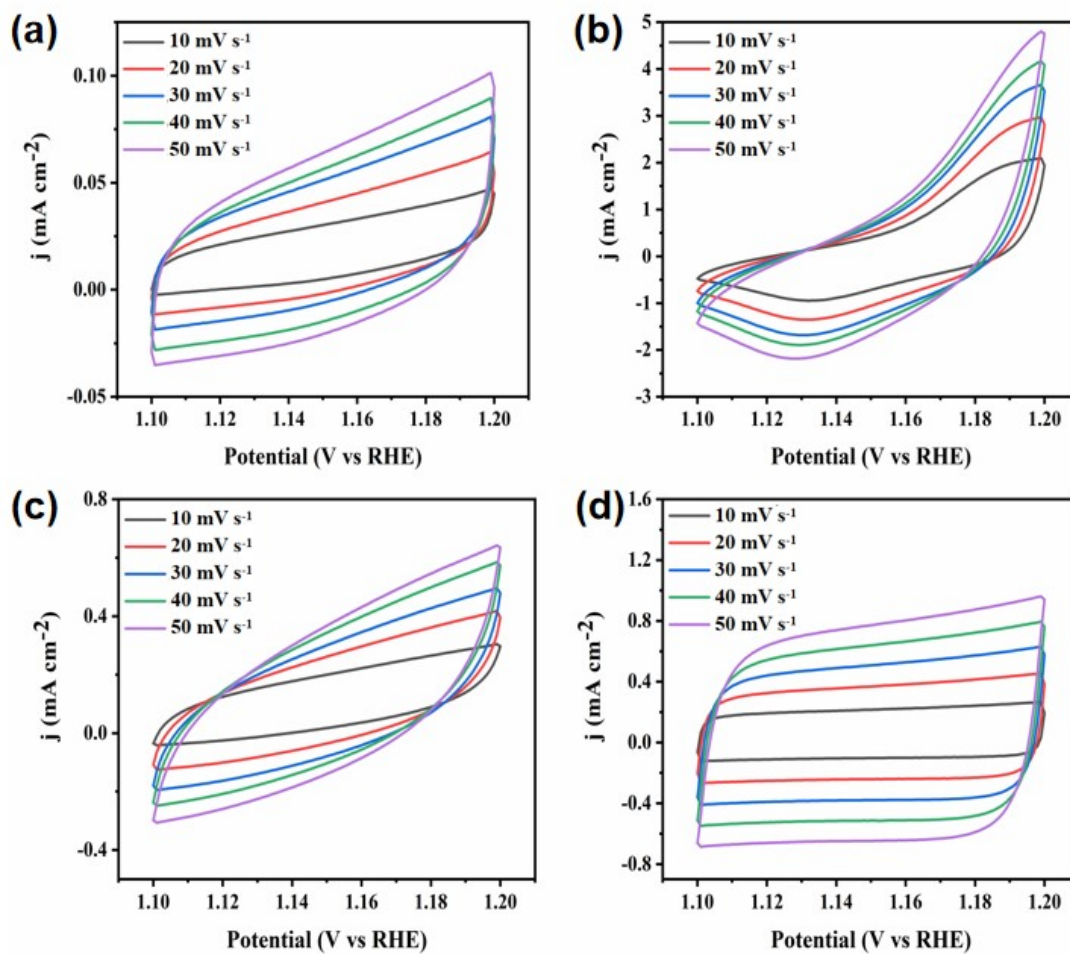


Fig. S8. CV curves acquired at the different scanning rates of 10~50  $\text{mV s}^{-1}$  from (a)  $\text{Ni(CA)}$ , (b)  $\text{Ni}_{0.8}\text{Co}_{0.2}\text{(CA)}$ , (c)  $\text{Ni}_{0.6}\text{Co}_{0.4}\text{(CA)}$ , and (d)  $\text{Co(CA)}$ .



Table S2. Comparison of the activity for the Ni<sub>0.8</sub>Co<sub>0.2</sub>(CA) catalyst with recently reported electrocatalysts

| Catalyst                                 | $\eta_{10}$ (vs.RHE) | Tafel slope | Electrolyte | References |
|--|----------------------|-------------|-------------|------------|
| Ir-NiCo LDH                              | 220 mV               | 33.2 mV/dec | 1 M KOH     | [1]        |
| CoNi-NCNT                                | 390 mV               | 67 mV/dec   | 1 M KOH     | [2]        |
| CoOOH HNSs                               | 305 mV               | -           | 1 M KOH     | [3]        |
| Co <sub>x</sub> Ni <sub>y</sub> @NC      | 300 mV               | 67.4 mV/dec | 1 M KOH     | [4]        |
| CoN <sub>2</sub> O <sub>2</sub>          | 300 mV               | -           | 1 M KOH     | [5]        |
| Pt/NiO/Ni/CNTs                           | 350 mV               | 33 mV/dec   | 0.1 M KOH   | [6]        |
| NiFe-MOF                                 | 215 mV               | 49.1 mV/dec | 1 M KOH     | [7]        |
| Ni-BDC/Ni(OH) <sub>2</sub>               | 320 mV               | 41 mV/dec   | 1 M KOH     | [8]        |
| Co <sub>3</sub> O <sub>4</sub> /Co@NCs   | 320 mV               | 51.7 mV/dec | 0.1 M KOH   | [9]        |
| Ni/NC-600                                | 336 mV               | 22 mV/dec   | 1 M KOH     | [10]       |
| RuO <sub>2</sub>                         | 300 mV               | 165 mV/dec  | 1 M KOH     | This work  |
| Ni <sub>0.8</sub> Co <sub>0.2</sub> (CA) | 200 mV               | 87 mV/dec   | 1 M KOH     | This work  |

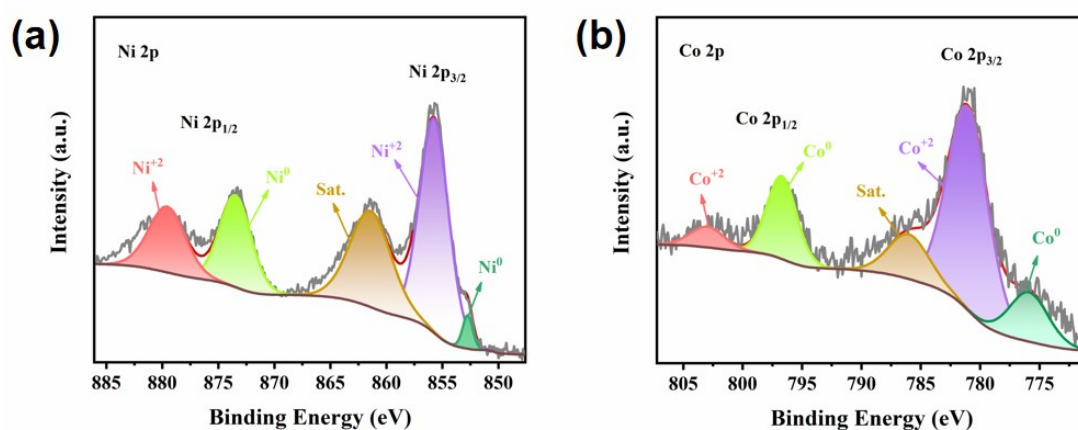


Fig. S9 XPS spectra. High-resolution spectra of (a) Ni 2p and (b) Co 2p for Ni<sub>0.8</sub>Co<sub>0.2</sub>(CA) after 10 h i-t test.

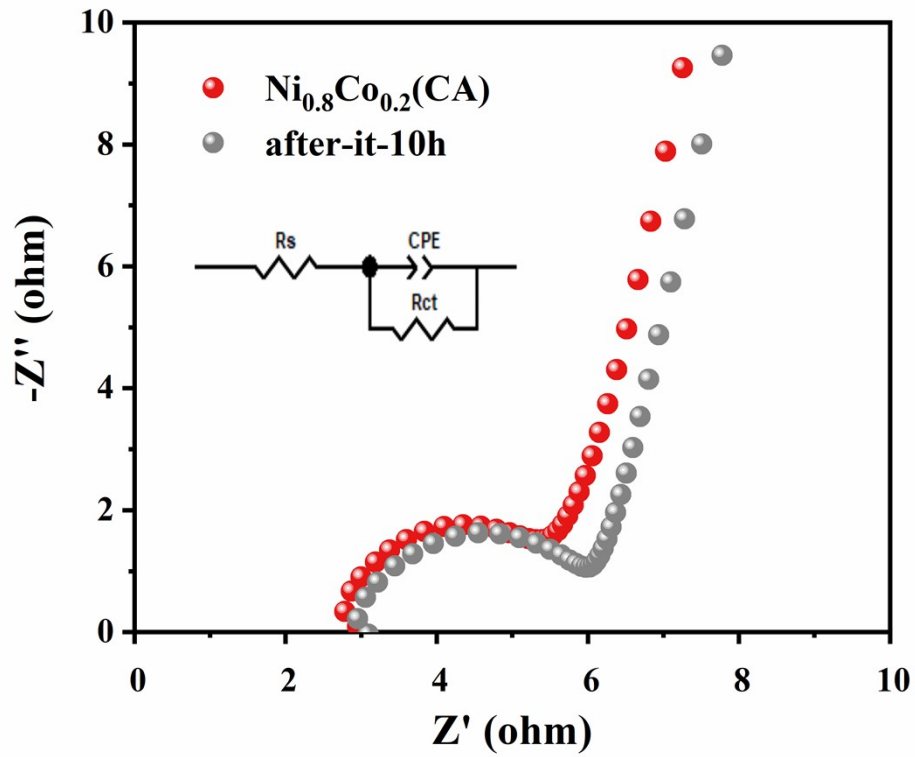


Fig. S10 EIS Nyquist plots of  $\text{Ni}_{0.8}\text{Co}_{0.2}(\text{CA})$  before and after the reaction (inset: the equivalent circuit.  $R_s$  and  $R_{ct}$  correspond to the electrolyte and charge transfer resistance, respectively).

## References

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