Electronic Supplementary Material (ESI) for CrystEngComm.


# Nitrogen-doped carbon encapsulating RuCo heterostructure for enhanced electrocatalytic overall water splitting

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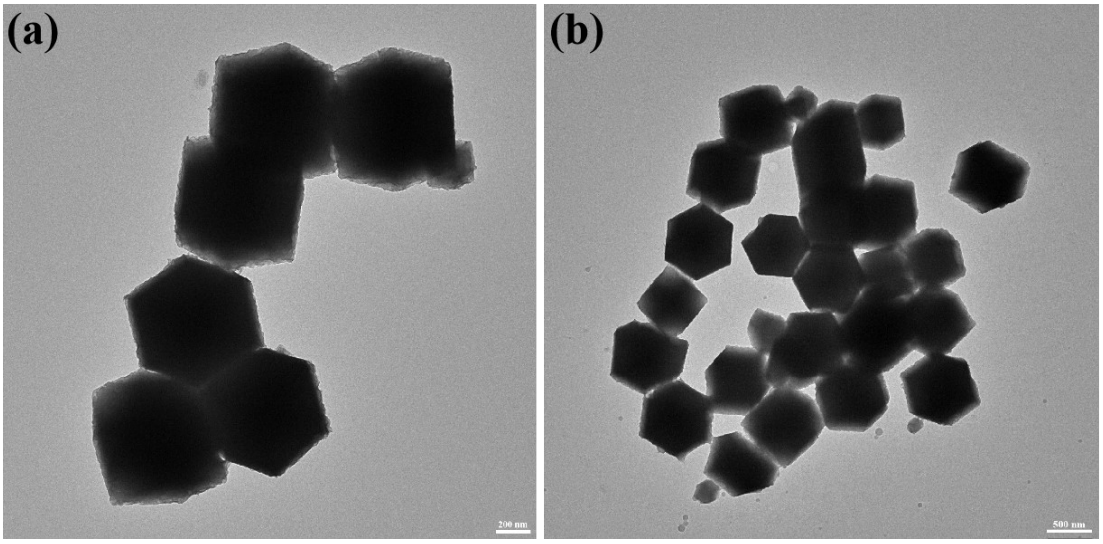


**Fig. S1** (a,b) Representative TEM images of the ZIF-67 with different magnifications.

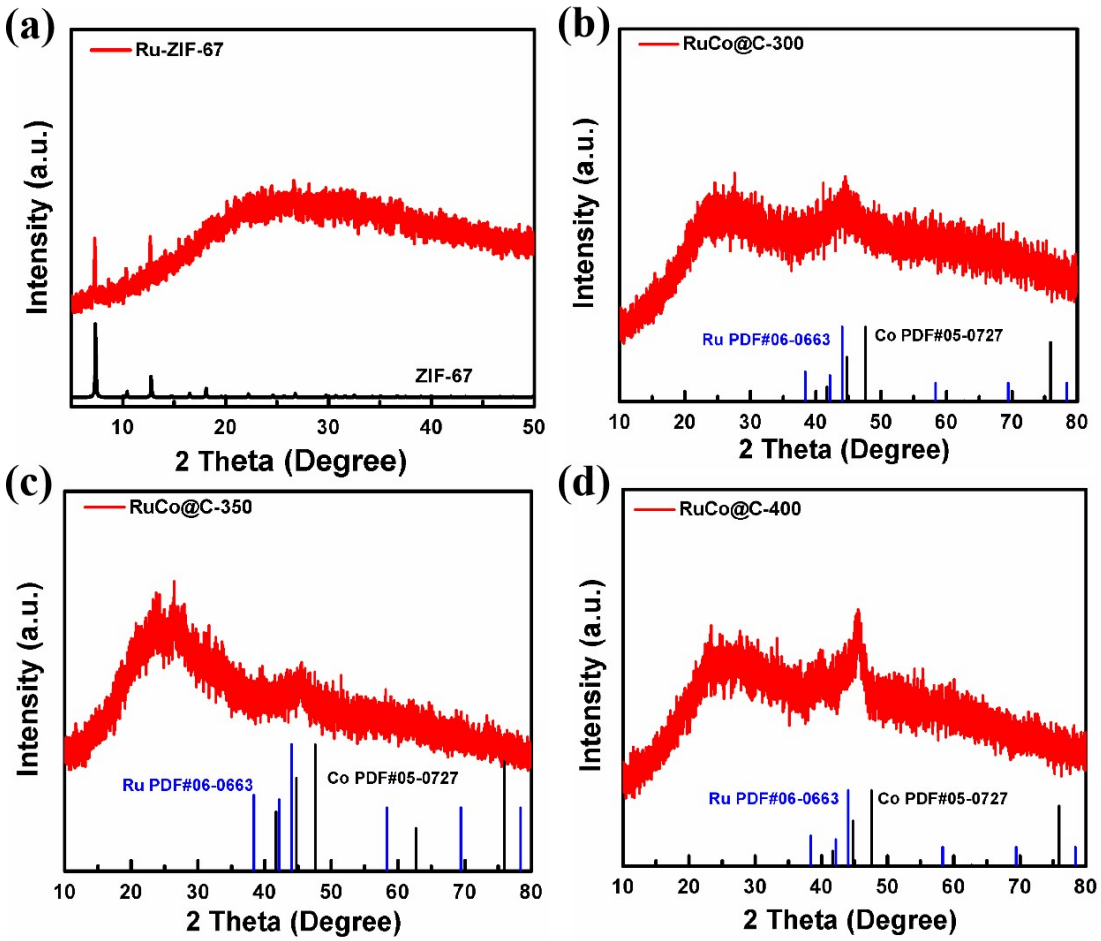


**Fig. S2** XRD patterns of (a) Ru-ZIF-67, (b) RuCo@C-300, (c) RuCo@C-350, (d) RuCo@C-400.

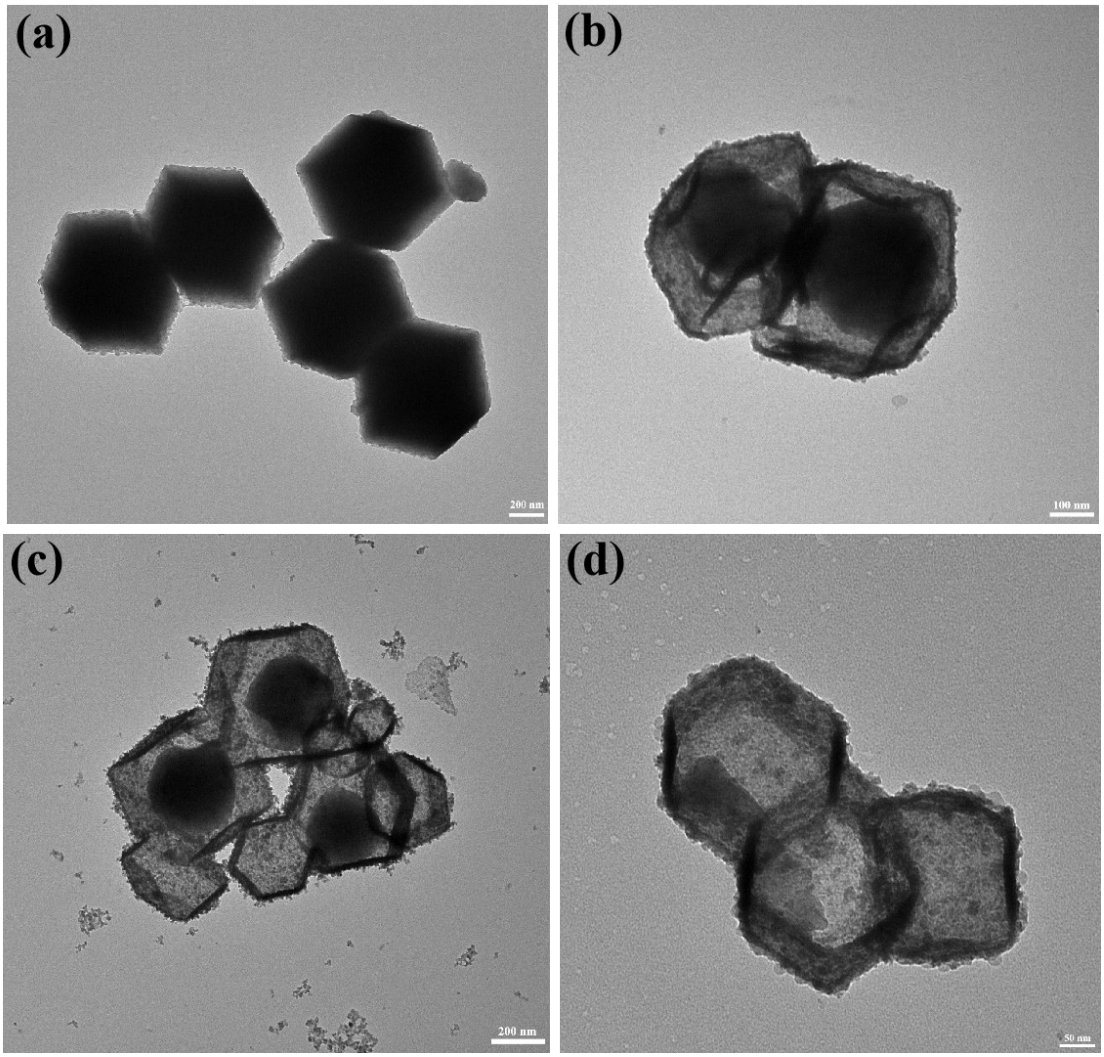


**Fig. S3** Representative TEM images of the Ru etching Zif-67 process. (a) Reaction for 0 minutes, (b) Reaction for 15 minutes, (c) Reaction for 30 minutes, (d) Reaction for 45 minutes.

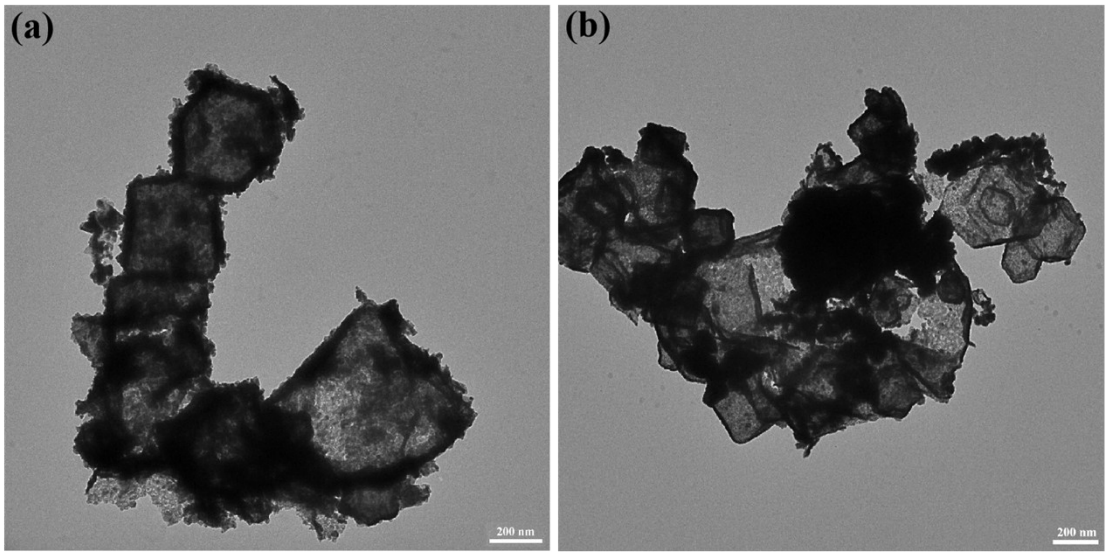


**Fig. S4** Representative TEM images of the RuCo@C with different magnifications. (a) TEM images of the RuCo@C-300; (b) TEM images of the RuCo@C-400.

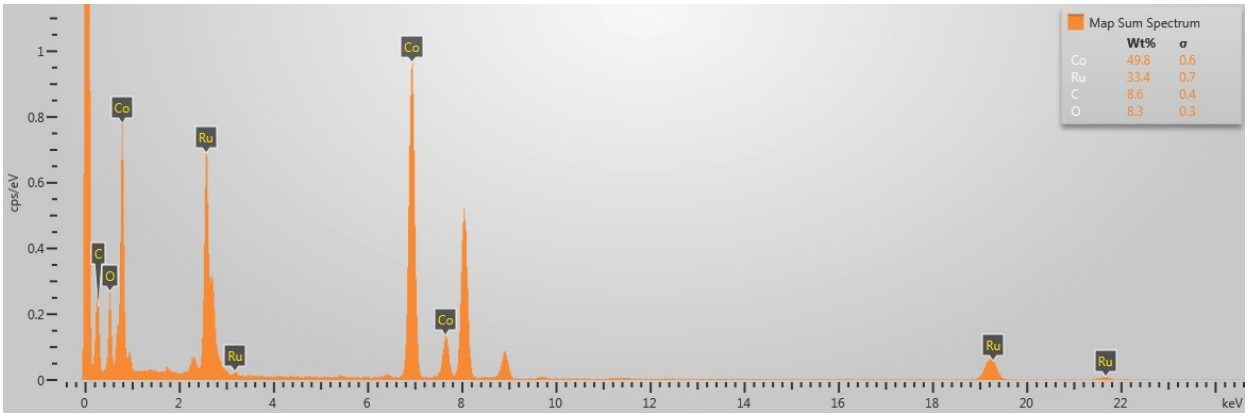


**Fig. S5** EDX patterns of the RuCo@C-350.

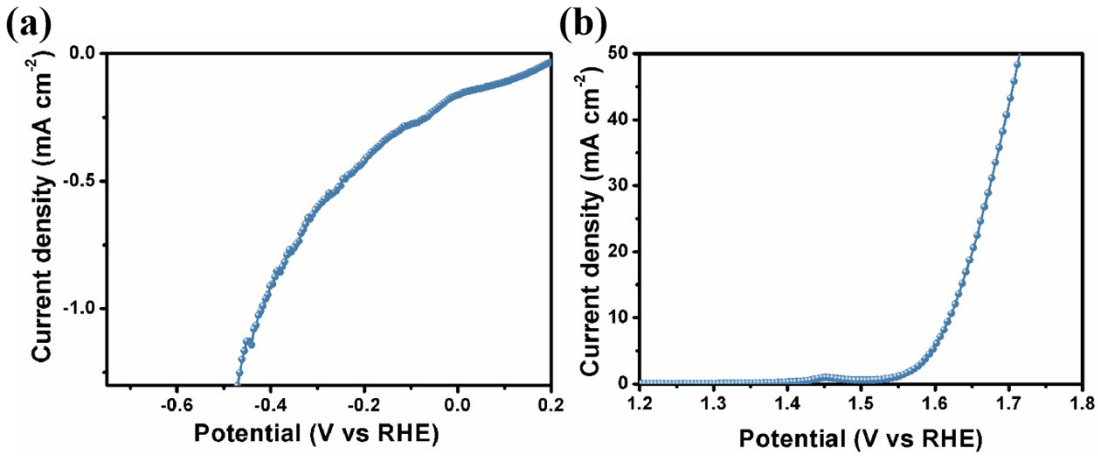


**Fig. S6** Electrochemical performance of ZIF-67-350. (a) HER curve, (b) OER curves.

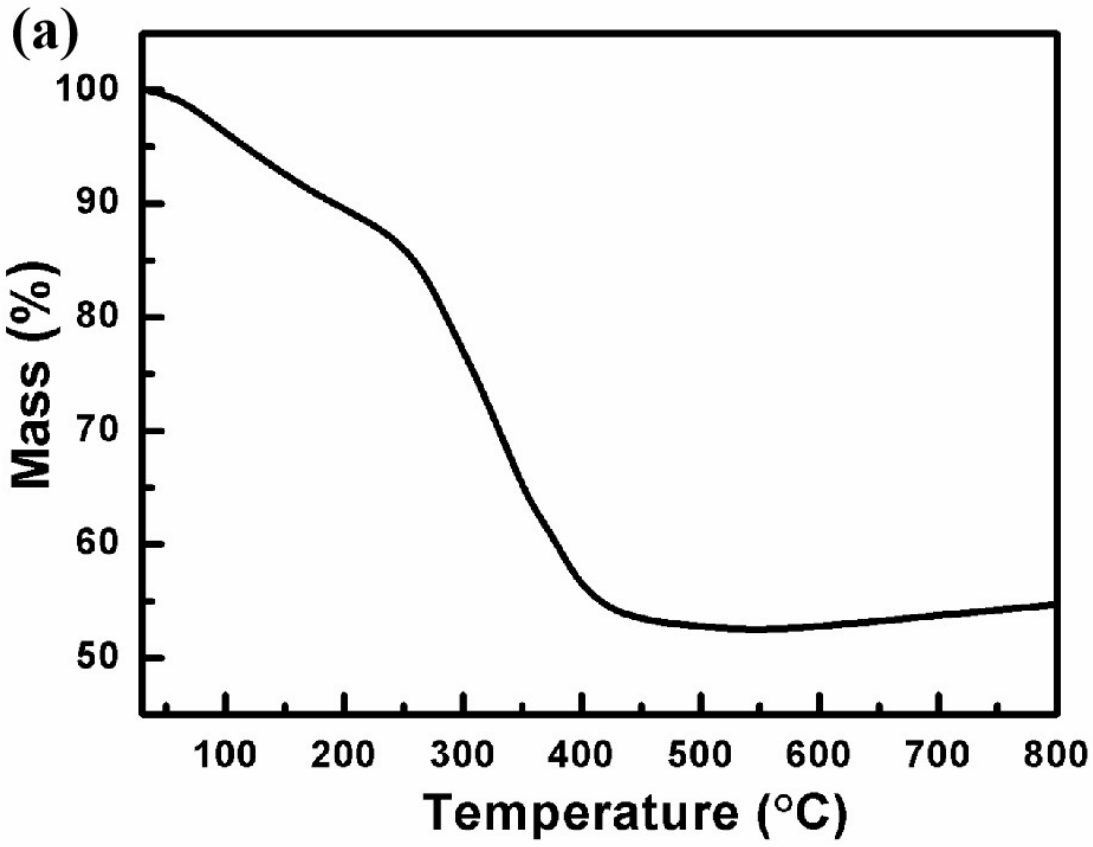


**Fig. S7** TGA diagram of Ru-ZIF-67.

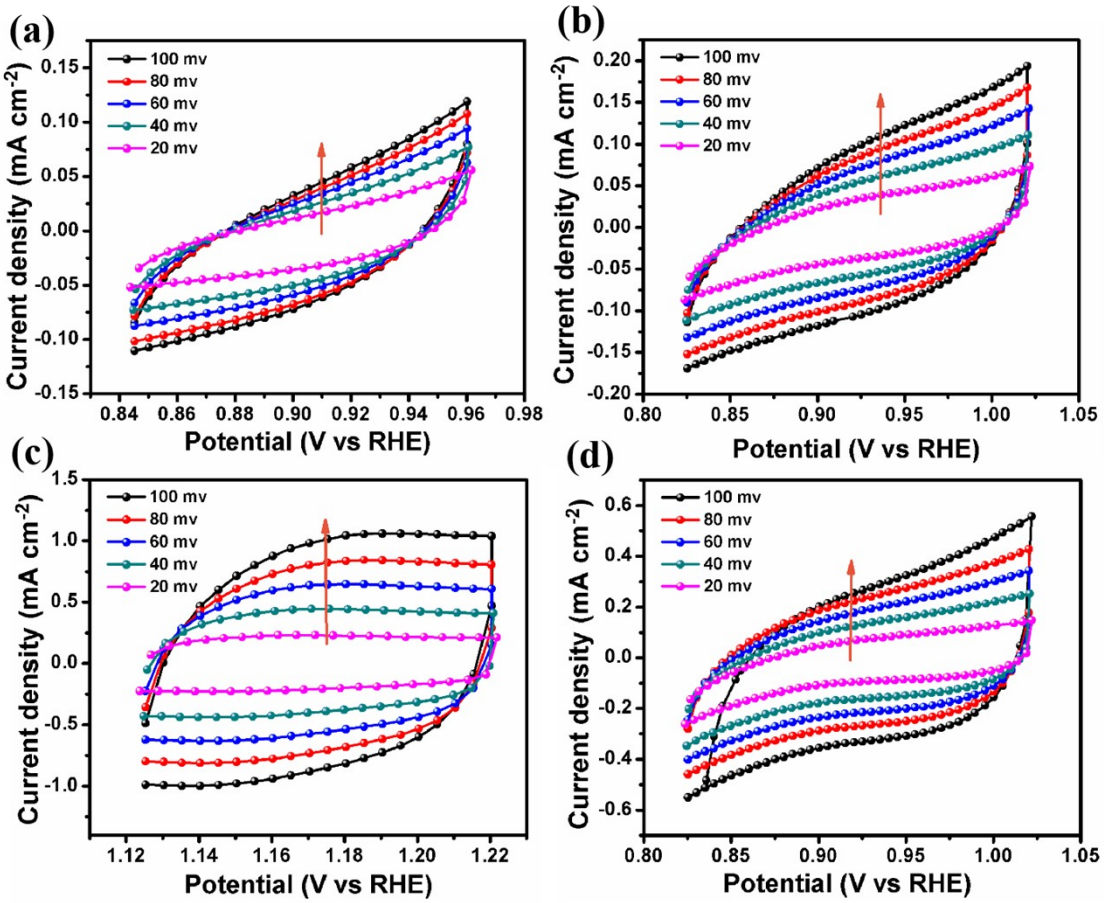


**Fig. S8** CVs measured for (a) Ru-ZIF-67, (b) RuCo@C-300, (c) RuCo@C-350, (d) RuCo@C-400 in 1 M KOH at different scan rates of 20, 40, 60, 80 and 100 mV $s^{-1}$.

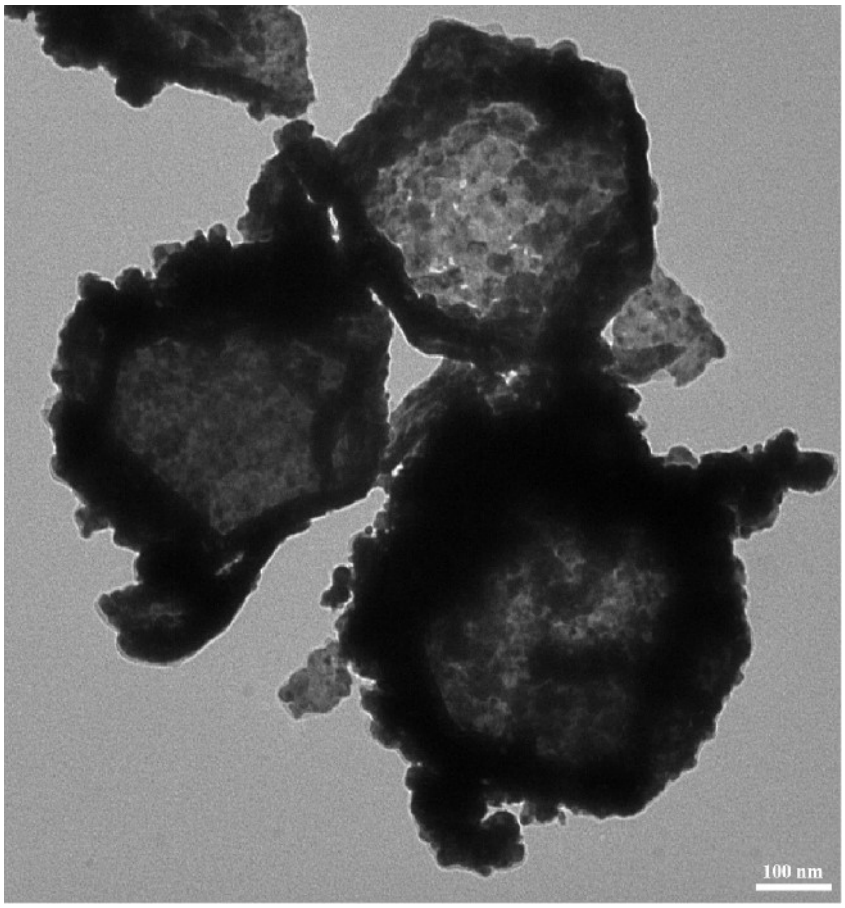


**Fig. S9** Representative TEM images of the RuCo@C-350 after performance test.

**Table S1.** Comparison of some recently reported representative electrocatalysts for OER.

| Catalysts | Electrolytes | η@j(mV@mA $cm^{-2}$) | Ref. |
|---|---|---|---|
| RuCo@C-350 | 1 M KOH | 91@10 | This work |
| Co-NC/CF | 1 M KOH | 157@10 | Energy Environ. Sci. 2020, 13, 545 |
| $RuO_2/Co_3O_4$-RuCo@NC | 1 M KOH | 141@10 | ACS Appl. Mater. Interfaces 2019, 11, 47894 |
| Ru NCs/$Co_2P$ | 1 M KOH | 118@10 | Chinese Chem Lett 2021, 32, 511-515 |
| Ce-CoP/Ti | 1 M KOH | 92@10 | Nano Energy 2017, 38, 290 |
| RuCo@NC-600 | 1 M KOH | 34@10 | J. Mater. Chem. A, 2020, 8, 12810-12820 |
| NiFe LDH@NiCoP/NF | 1 M KOH | 120@10 | Adv. Funct. Mater. 2018, 28, 1706847 |
| Ru@CN | 1 M KOH | 32@10 | Energy Environ. Sci. 2018, 11, 800 |
| $Ni_xCo_{3-x}S_4/Ni_3S_2$/NF | 1 M KOH | 136@10 | Nano Energy 2017, 35, 161 |

**Table S2.** Comparison of some recently reported representative electrocatalysts for HER.

| Catalysts | Electrolytes | η@j(mV@mA $cm^{-2}$) | Ref. |
|---|---|---|---|
| RuCo@C-350 | 1 M KOH | 230@10 | This work |
| $RuO_x$-nc@$Co_3O_4$-250 | 1 M KOH | 280@10 | Energy Storage Mater. 2020, 32, 20-29 |
| Ru@NiCo-MOF HPNs | 1 M KOH | 284@10 | Inorg. Chem. 2021, 60, 5882-5889 |
| Ru-$Ni(OH)_2$ | 1 M KOH | 295@10 | Chem. Eng. J. 2022, 429, 132478 |
| $Co_3O_4$-NP/N-rGO | 1 M KOH | 380@10 | Adv. Energy Mater., 2018, 8, 1702222 |
| $RuO_2$/NiO/NF | 1 M KOH | 250@10 | Small 2018, 14, 1704073 |
| RuCo@NC | 1 M KOH | 280@10 | Green Chem., 2020, 22, 7884-7895 |
| Ru/Cu-$RuO_2$@C | 1 M KOH | 204@10 | Small 2018, 14, 1803009 |
| $RuIrO_x$ | 1 M KOH | 250@10 | Nat. Commun. 2019, 10, 4875 |

**Table S3.** Comparison of some recently reported representative bifunctional electrocatalysts for overall water splitting.

| Catalysts | Electrolytes | η@j(V@mA $cm^{-2}$) | Ref. |
|---|---|---|---|
| RuCo@C-350 (+,-) | 1 M KOH | 1.56@10 | This work |
| Ru@NiCo-MOF HPNs (+,-) | 1 M KOH | 1.57@10 | Inorg.Chem. 2021, 60, 5882-5889 |
| Ru-$Ni(OH)_2$ ‖ Pt/C | 1 M KOH | 1.55@10 | Chem. Eng. J. 2022, 429, 132478 |
| CoRu-O/A@HNC-2 (+,-) | 1 M KOH | 1.56@10 | ACS Appl. Mater. Interfaces 2020, 12, 51437-51447 |
| Ru NCs/$Co_2P$ (+,-) | 1 M KOH | 1.53@10 | Chinese Chem Lett 2021, 32, 511-515 |
| NF@RuCo-750 (+,-) | 1 M KOH | 1.54@10 | Electrochim Acta. 2019, 327,134958 |
| Co-$RuO_2$ ‖ Ni-$RuO_2$ (+,-) | 1 M KOH | 1.54@10 | J. Mater. Chem. A. 2019, 7, 6411 |