Supplementary Information

Accelerating Water Dissociation Kinetics by Isolating Cobalt Atoms into Ruthenium Lattice

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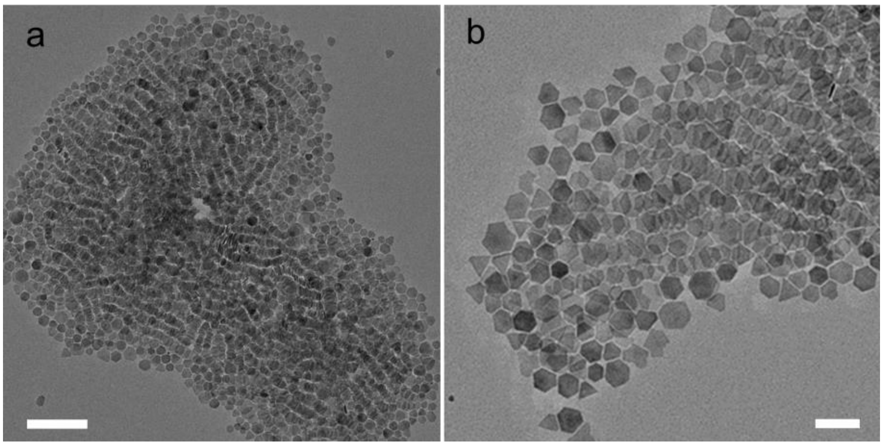
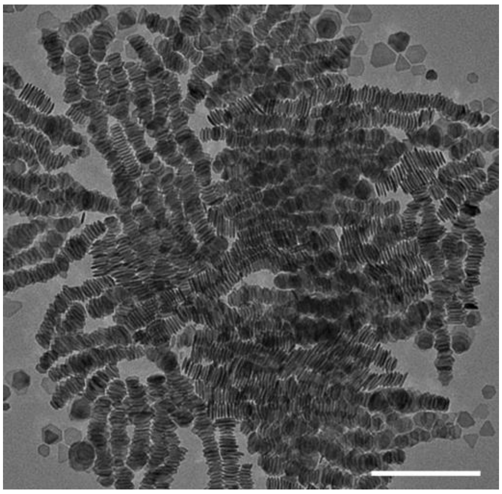
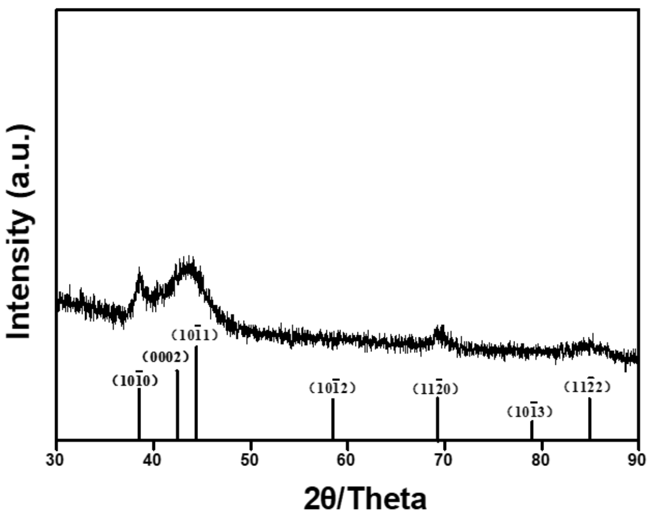
Supplementary Figures and Tables



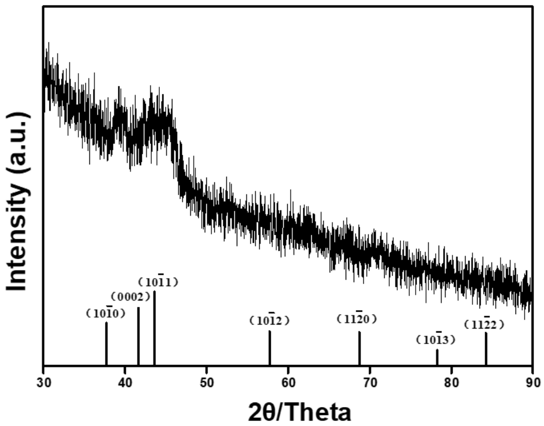
Supplementary Figure 1. TEM images of Co-substituted Ru nanosheets with different magnifications. **a** Scar bar: 200 nm. **b** Scar bar: 60 nm.



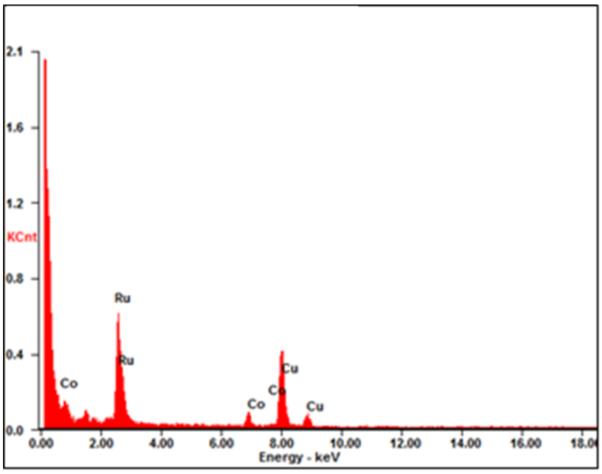
Supplementary Figure 2. TEM image of the assembly of Co-substituted Ru nanosheets, scar bar: 200 nm.



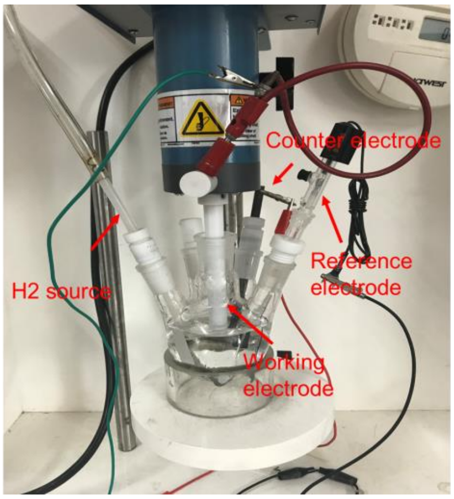
Supplementary Figure 3. XRD pattern of Co-substituted Ru nanosheets. The standard pattern of Ru (JCPDS card No. 06-0663) are shown beneath the plot.



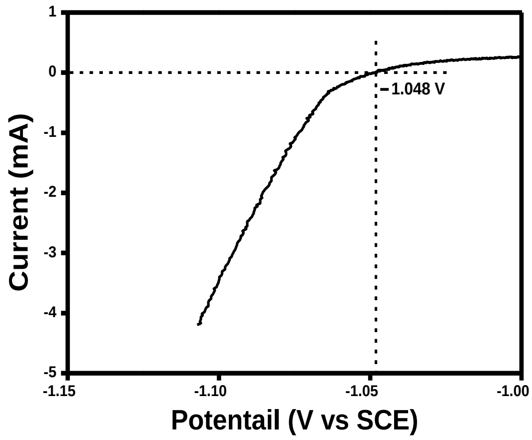
Supplementary Figure 4. XRD pattern of RuCo alloy. The standard pattern of Ru (JCPDS card No. 06-0663) are shown beneath the plot.



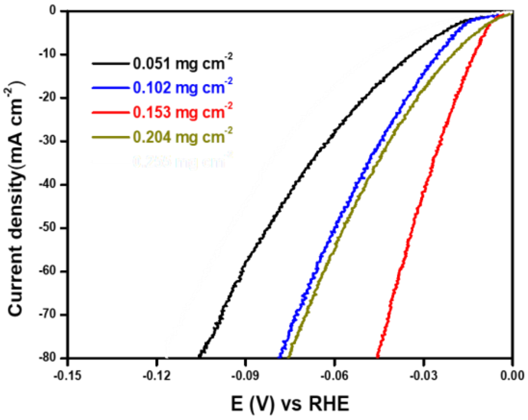
Supplementary Figure 5. EDX pattern of Co-substituted Ru nanosheets. The Ru: Co atomic ratio was 94 : 6.



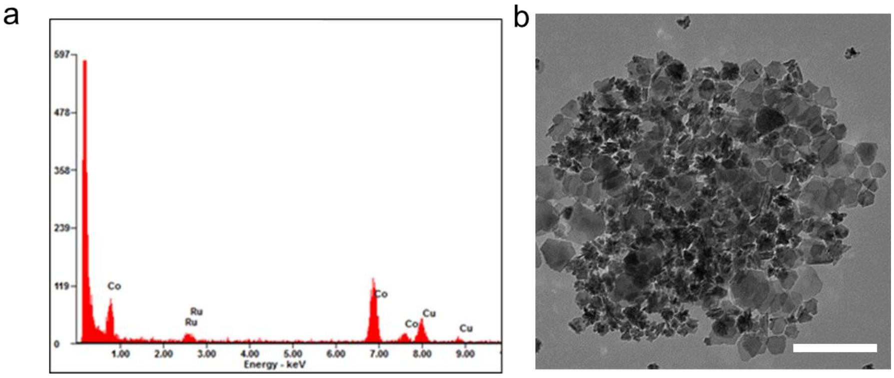
Supplementary Figure 6. Photograph of the three-electrode system for the electrochemical test.



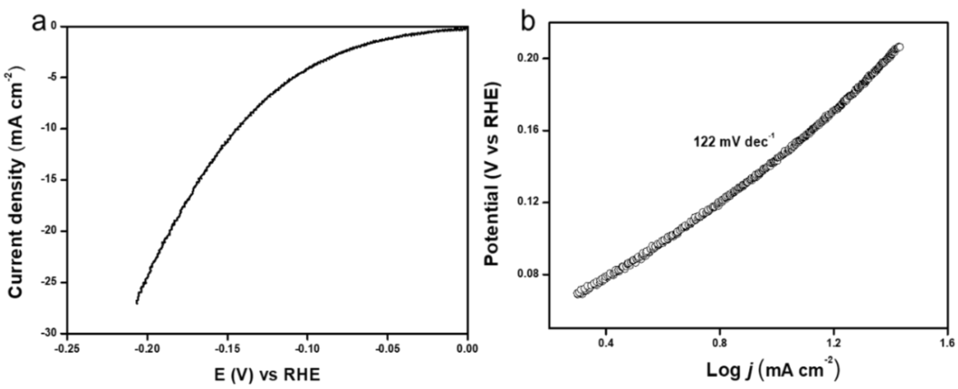
Supplementary Figure 7. LSV curves of Pt in 1.0 M KOH solution (H_2-saturated), used for calibration of the SCE with respect to RHE. Scan rate: 5 mV s^{-1}.



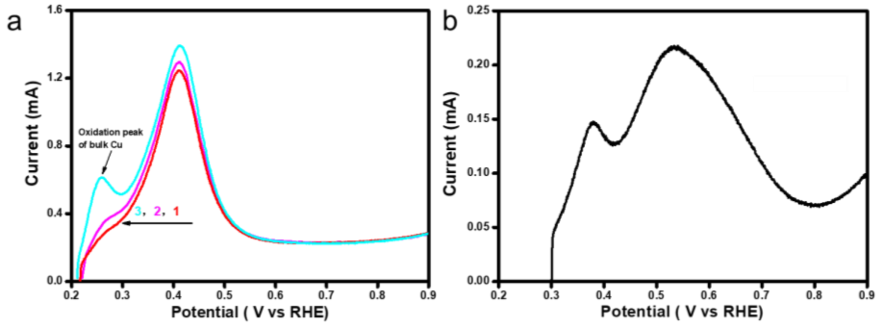
Supplementary Figure 8. LSV curves of Co-substituted Ru catalyst at different loading weight in 1.0 M KOH. Scan rate: 5 mV s^{-1}.



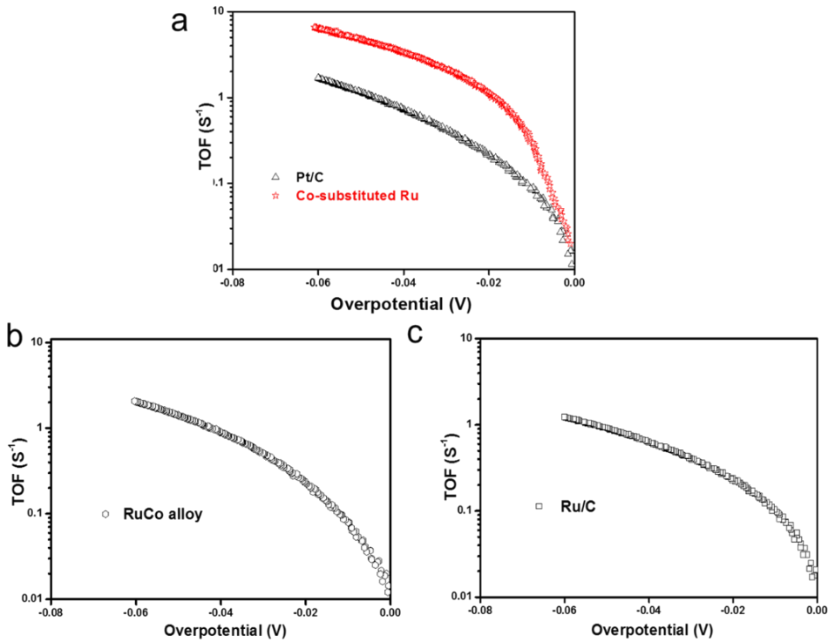
Supplementary Figure 9. a EDX analysis. Ru : Co atomic ratio was 32:68 (close to 1:2). **b** TEM image of $RuCo_2$ catalyst. Scar bar:100 nm.



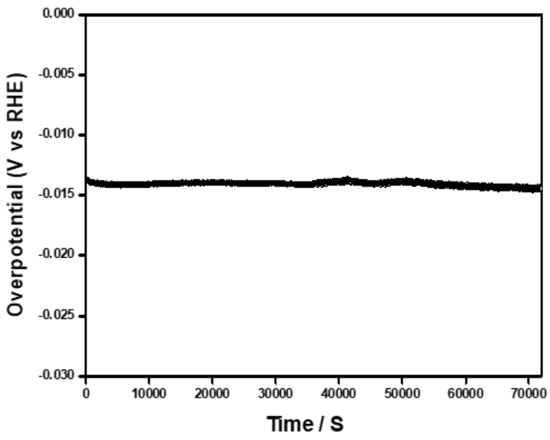
Supplementary Figure 10. a LSV curves of $RuCo_2$ catalyst in 1 M KOH solution. **b** Tafel plots of the polarization curves in a.



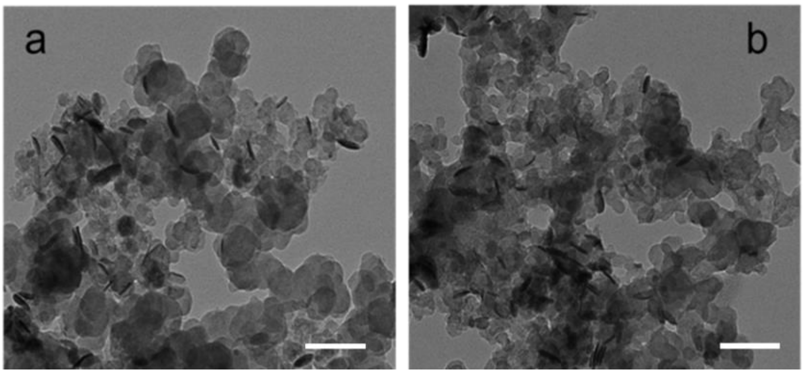
Supplementary Figure 11. Copper UPD in the presence of 5 mM $CuSO_4$ on **a** Co-substituted Ru, and **b** Pt/C catalyst.



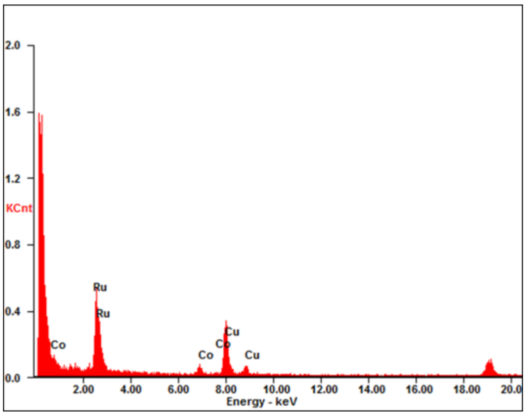
Supplementary Figure 12. TOF values of **a** Co-substituted Ru (red line), Pt/C (black line), **b** RuCo alloy and **c** Ru/C catalyst.



Supplementary Figure 13. Chronopotentiometric curves of Co-substituted Ru catalyst recorded at a constant current density of 10 mA cm^{-2} in 1.0 M KOH.



Supplementary Figure 14. TEM images of the Co-substituted Ru /C catalyst **a** before and **b** after electrochemical test. Scar bar: 100 nm.



Supplementary Figure 15. EDS analysis of Co-substituted Ru catalyst after electrochemical test. The Ru : Co atomic ratio was 94 : 6.

Supplementary Table 1.

Comparison of HER performance between Co-substituted Ru NSs and other reported Pt-free catalysts in alkaline medium.

Catalysts	Electrode	Loading amount (mg cm^{-2})	Electrolyte	Overpotential at 10 mAcm^{-2} (mV)	Tafel plots (mVdec^{-1})	Ref.
Co-substituted Ru	GC	0.153	1 M KOH	13	29	This work
CoOx@CN	GC	0.42	1 M KOH	232	115	1
Co/Co_3O_4	NF	0.85	1 M KOH	90	44	2
$Ru/C_3N_4/C$	GC	0.204	0.1 M KOH	79	/	3
MoP@RGO	GC	0.28	1 M KOH	93 (η_{20})	58	4
$Zn_{0.3}Co_{2.7}S_4$	GC	0.285	1 M KOH	85	/	5
Co_2P@NPG	GC	0.5	1 M KOH	165	96	6
$Mo_1N_1C_2$	GC	0.408	0.1 M KOH	132	90	7
$FePO_4$/NF	NF	0.285	1 M KOH	123	104.49	8
$FeSe_2$	NF/FTO	3/1	1 M KOH	178/235	/	9
CoP NWs 40s/CC	CC	N/A	1 M KOH	146 (η_{100})	42.8	10
Mo_2N-Mo_2C/HGr-3	GC	0.337	1 M KOH	154	68	11
MoB/g-C_3N_4	GC	0.25	1 M KOH	133	46	12
RuP_2 @NPC	GC	1.0	1 M KOH	52	69	13
RuCo@NC	GC	0.275	1 M KOH	28	31	14
Ru@C_2N	GC	0.285	1 M KOH	17	38	15
CoP/rGO-400	GC	0.28	1 M KOH	150	38	16
MoCx nano octahedrons	GC	0.8	1 M KOH	151	59	17
IrCo@NC-500	GC	0.285	1 M KOH	45	80	18
RuCoP	CNF	0.3	1 M KOH	23 mV	37	19

Note: GC stands for glassy carbon. NF stands for nickel foam; FTO stands for fluorine-doped tin oxide. CC stands for carbon cloth. CNF stands for carbon nanofiber. "/": the data was not given.

Supplementary References

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