

Supplementary Materials

Robust CoRuO_x oxide catalysts with broad electrolyte compatibility toward superior hydrogen evolution

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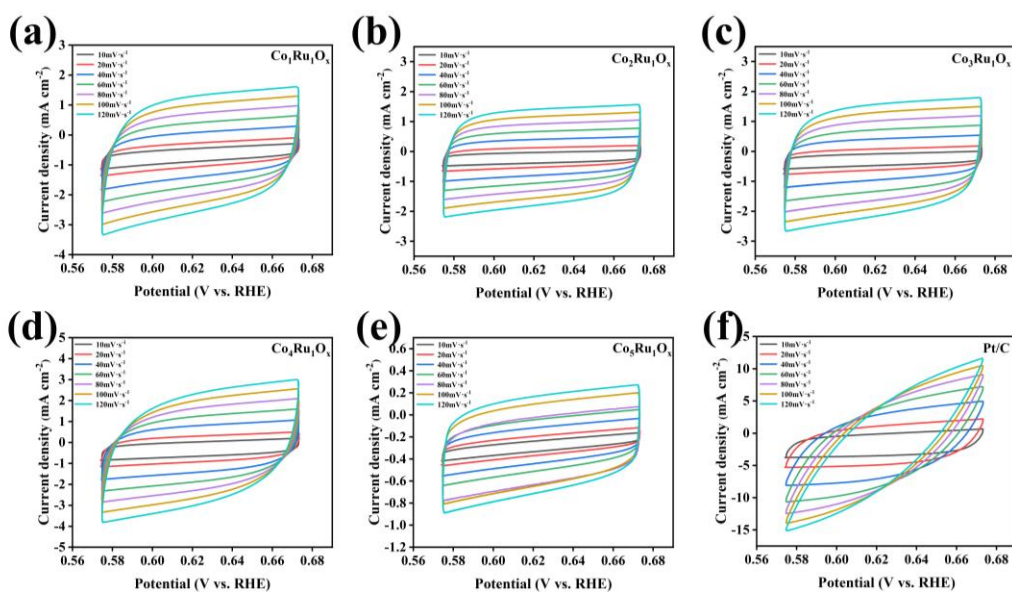


Figure S1 Current density versus potential (V vs. RHE) for various catalysts at different scan rates (10 mV/s, 20 mV/s, 40 mV/s, 60 mV/s, 80 mV/s, 100 mV/s, and 120 mV/s). (a) $\text{Co}_1\text{Ru}_1\text{O}_x$, (b) $\text{Co}_2\text{Ru}_1\text{O}_x$, (c) $\text{Co}_3\text{Ru}_1\text{O}_x$, (d) $\text{Co}_4\text{Ru}_1\text{O}_x$, (e) $\text{Co}_5\text{Ru}_1\text{O}_x$, and (f) Pt/C.

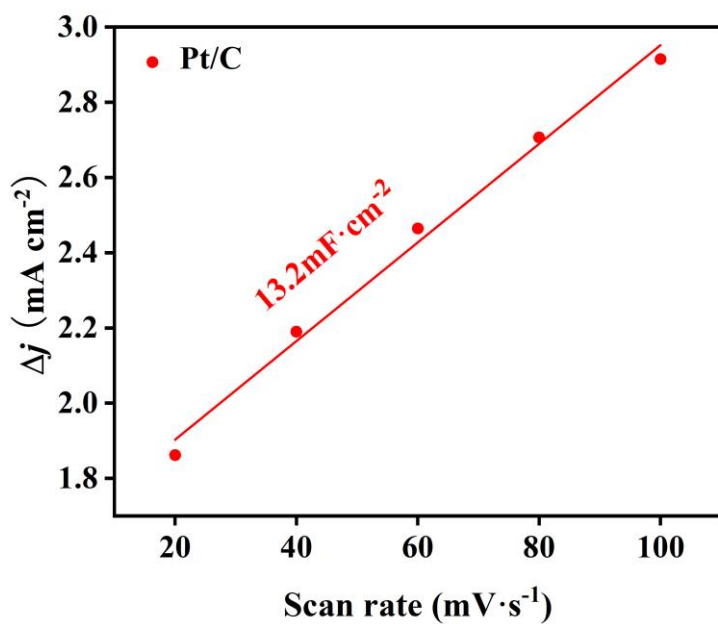


Figure S2 C_{dl} measurements for Pt/C

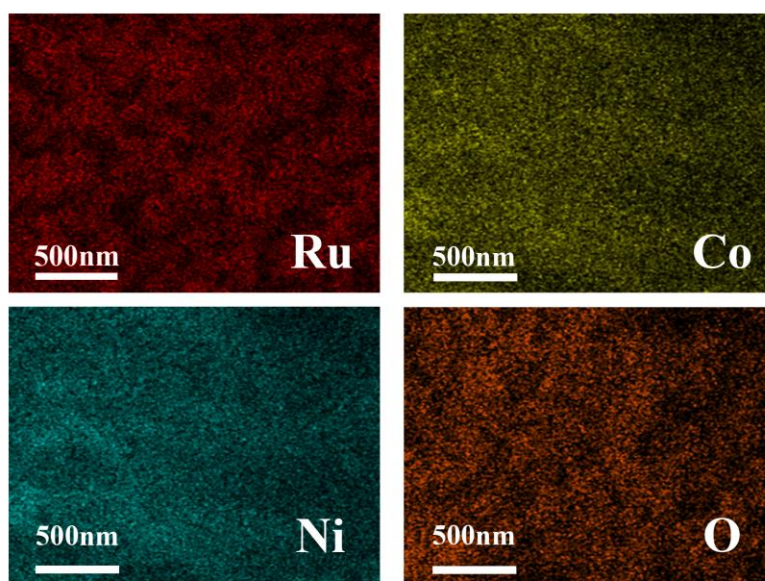


Figure S3 EDS elemental mapping of $\text{Co}_4\text{Ru}_1\text{O}_x$ catalyst before the 200 h HER stability test.

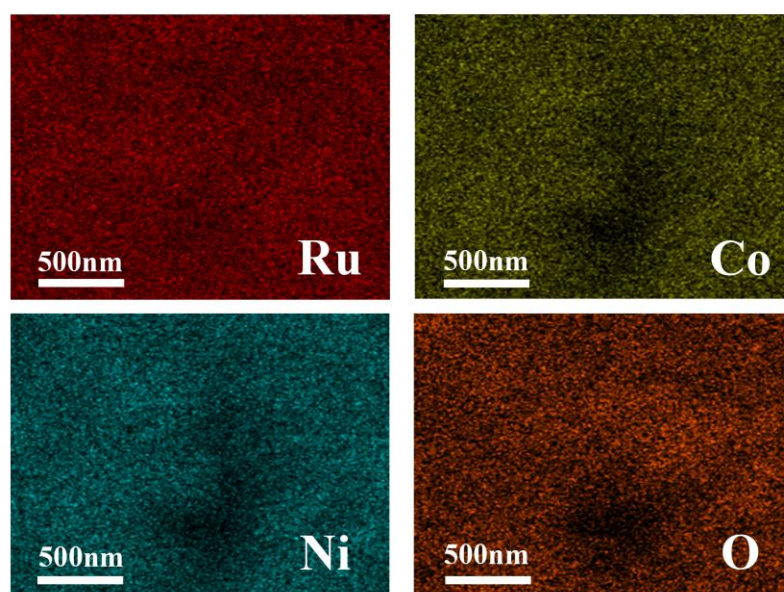


Figure S4 EDS elemental mapping of $\text{Co}_4\text{Ru}_1\text{O}_x$ catalyst after the 200 h HER stability test in 1 M KOH.

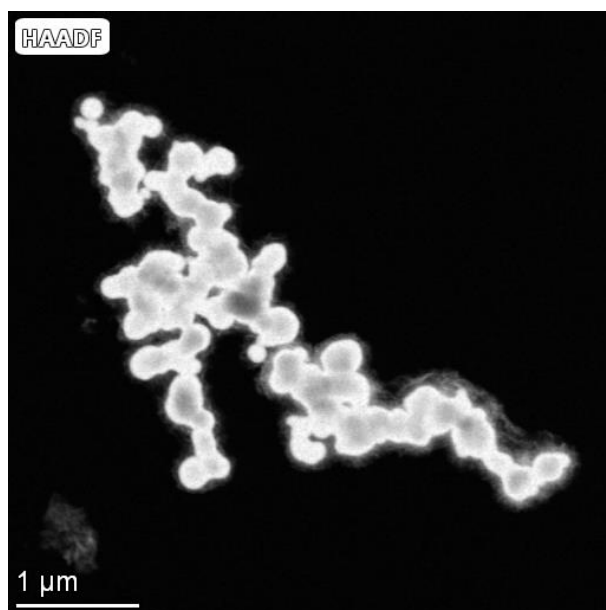


Figure S5 HAADF-STEM images of $\text{Co}_4\text{Ru}_1\text{O}_x$.

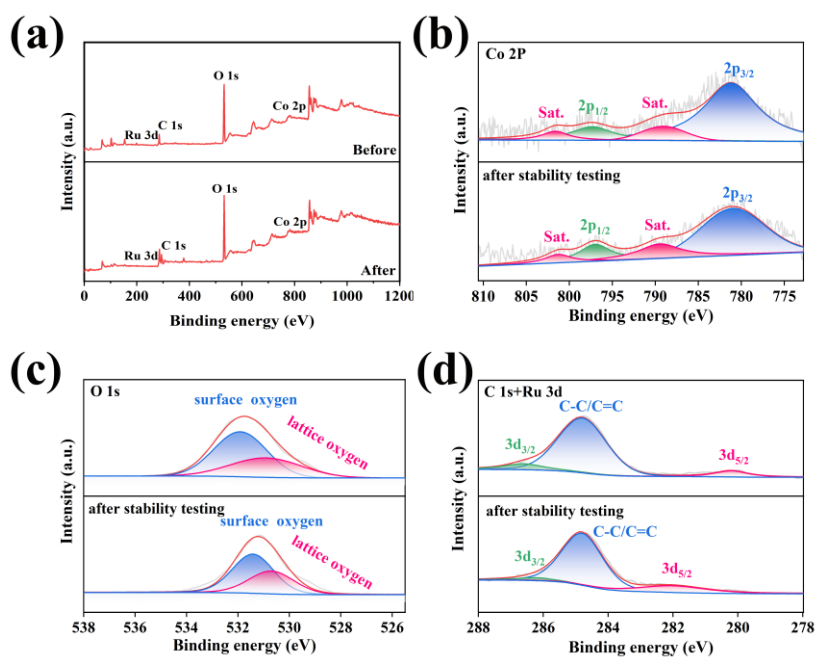


Figure S6. XPS characterization of $\text{Co}_4\text{Ru}_1\text{O}_x$ before and after the 200 h HER stability test in 1 M KOH electrolyte. (a) XPS survey spectra. (b) Co 2p, (c) O 1s, and (d) C 1s + Ru 3d

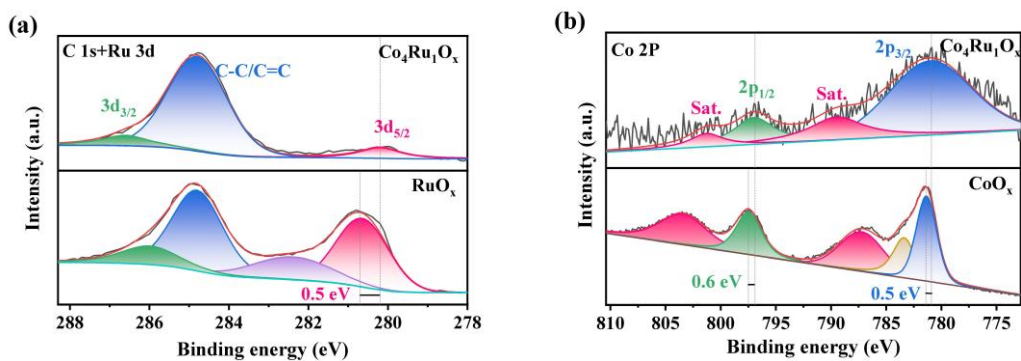


Figure S7. XPS spectra of CoO_x , RuO_x , and $\text{Co}_4\text{Ru}_1\text{O}_x$. (a) Ru 3d spectra of RuO_x and $\text{Co}_4\text{Ru}_1\text{O}_x$; (b) Co 2p spectra of CoO_x and $\text{Co}_4\text{Ru}_1\text{O}_x$.

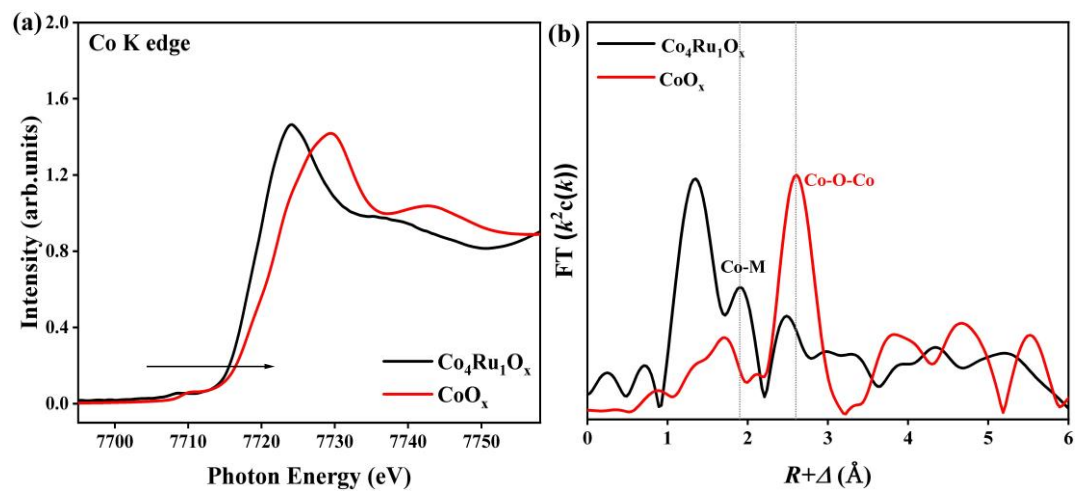


Figure S8. (a) Co K-edge XANES spectra of CoO_x and $\text{Co}_4\text{Ru}_1\text{O}_x$. (b) Fourier-transformed EXAFS spectra of CoO_x and $\text{Co}_4\text{Ru}_1\text{O}_x$.

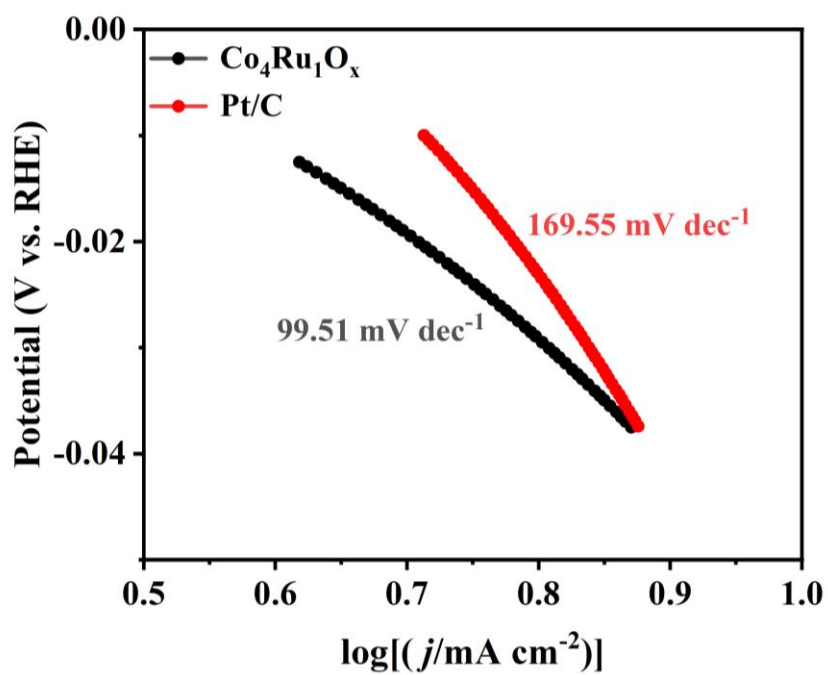


Figure S9. Tafel plots of $\text{Co}_4\text{Ru}_1\text{O}_x$ and Pt/C in 1 M PBS.

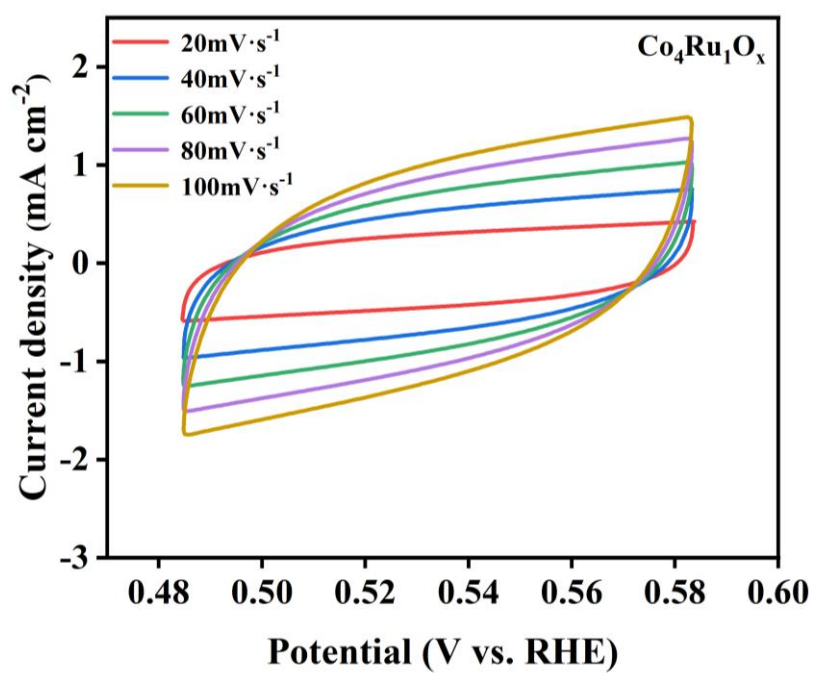


Figure S10. CV curves of $\text{Co}_4\text{Ru}_1\text{O}_x$ at different scan rates in 1 M PBS.

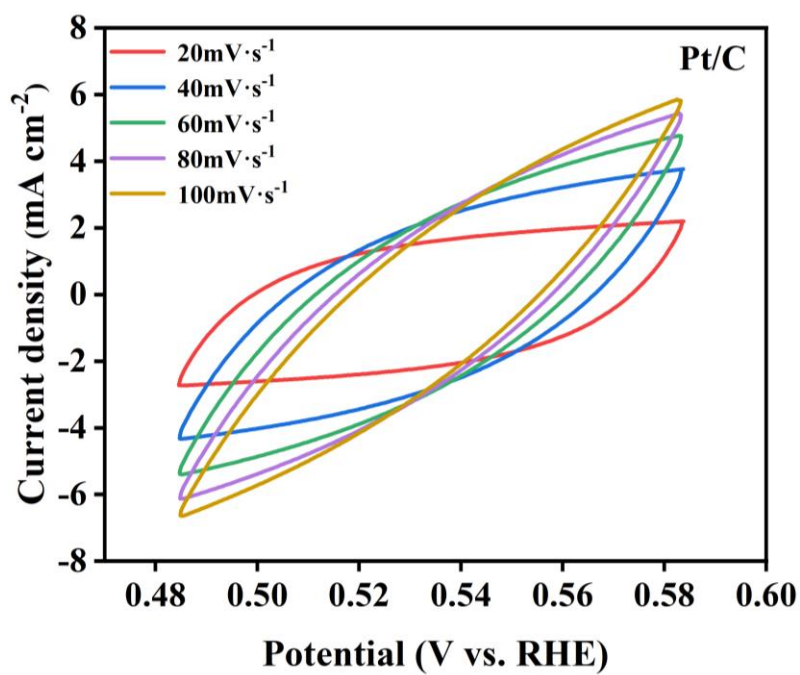


Figure S11. CV curves of Pt/C at different scan rates in 1 M PBS.

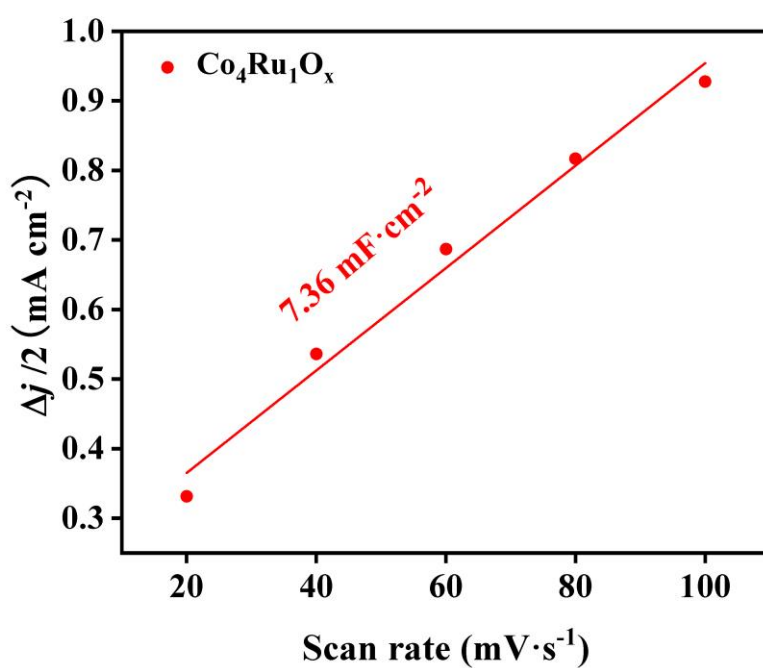


Figure S12. C_{dl} values of $\text{Co}_4\text{Ru}_1\text{O}_x$ in 1 M PBS.

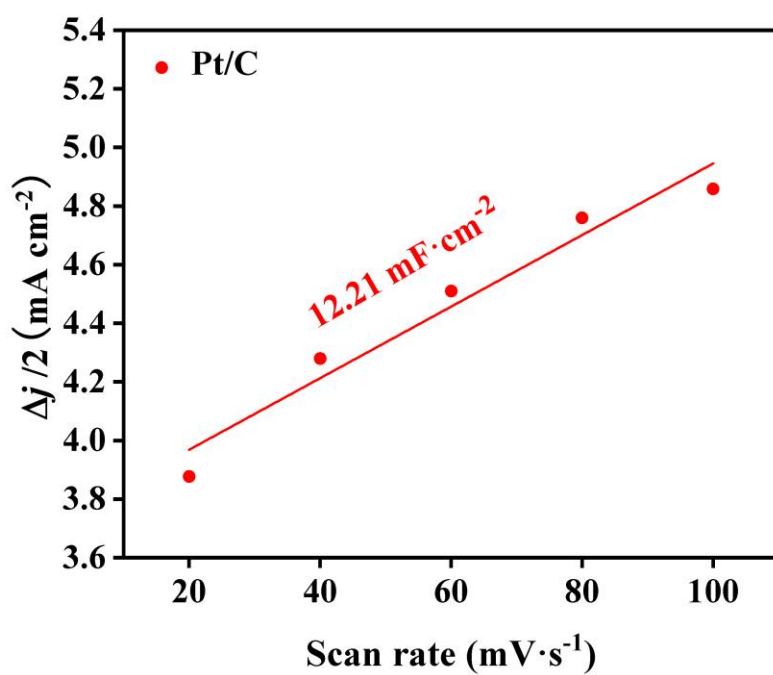


Figure S13. C_{dl} values of Pt/C in 1 M PBS.

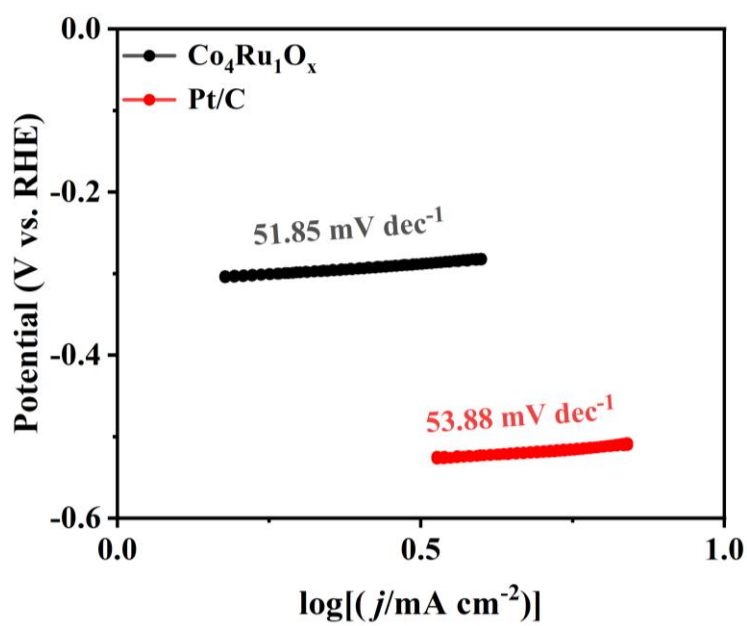


Figure S14. Tafel plots of $\text{Co}_4\text{Ru}_1\text{O}_x$ and Pt/C in saturated KHCO_3 electrolyte.

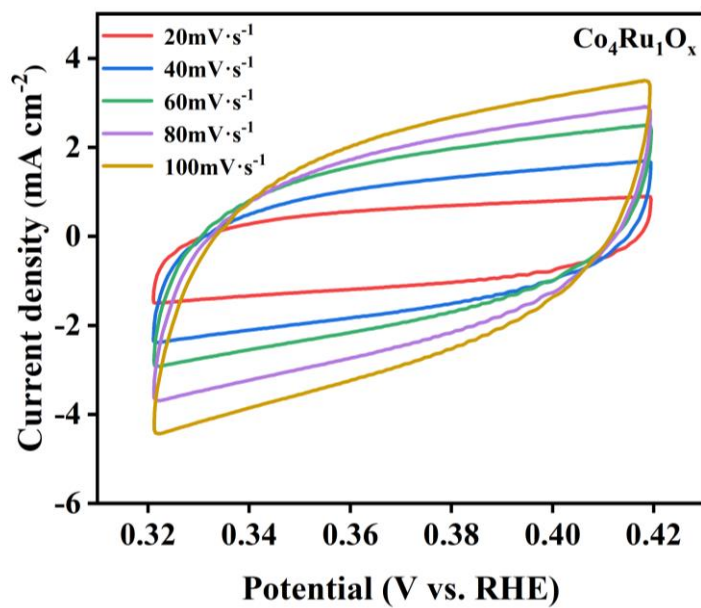


Figure S15. CV curves of $\text{Co}_4\text{Ru}_1\text{O}_x$ at different scan rates in saturated KHCO_3 electrolyte.

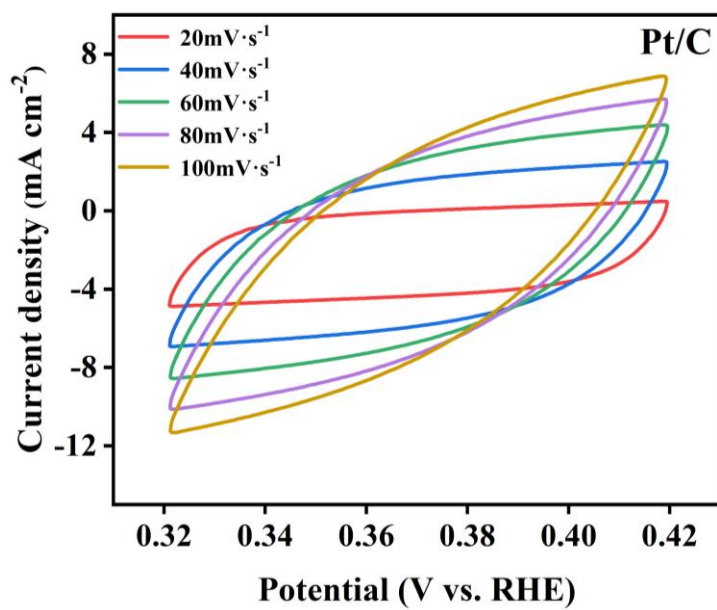


Figure S16. CV curves of Pt/C at different scan rates in saturated KHCO_3 electrolyte.

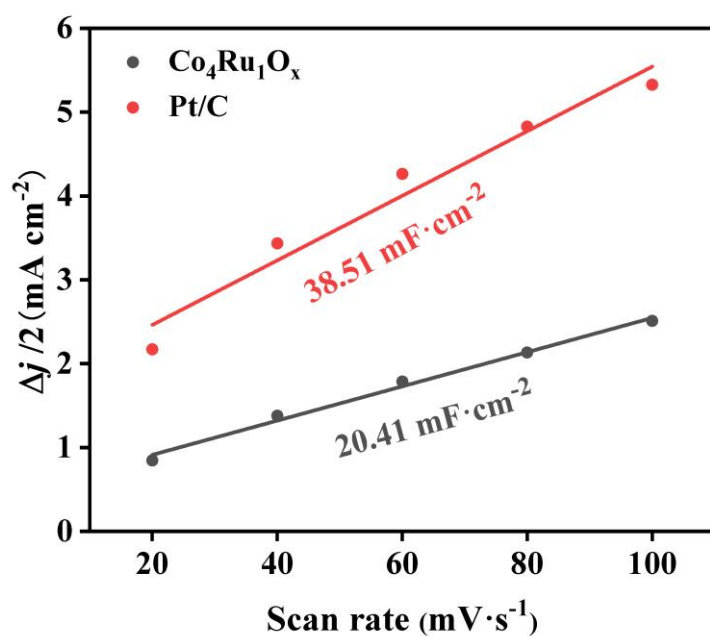


Figure S17. C_{dl} values of $\text{Co}_4\text{Ru}_1\text{O}_x$ and Pt/C in saturated KHCO_3 electrolyte.

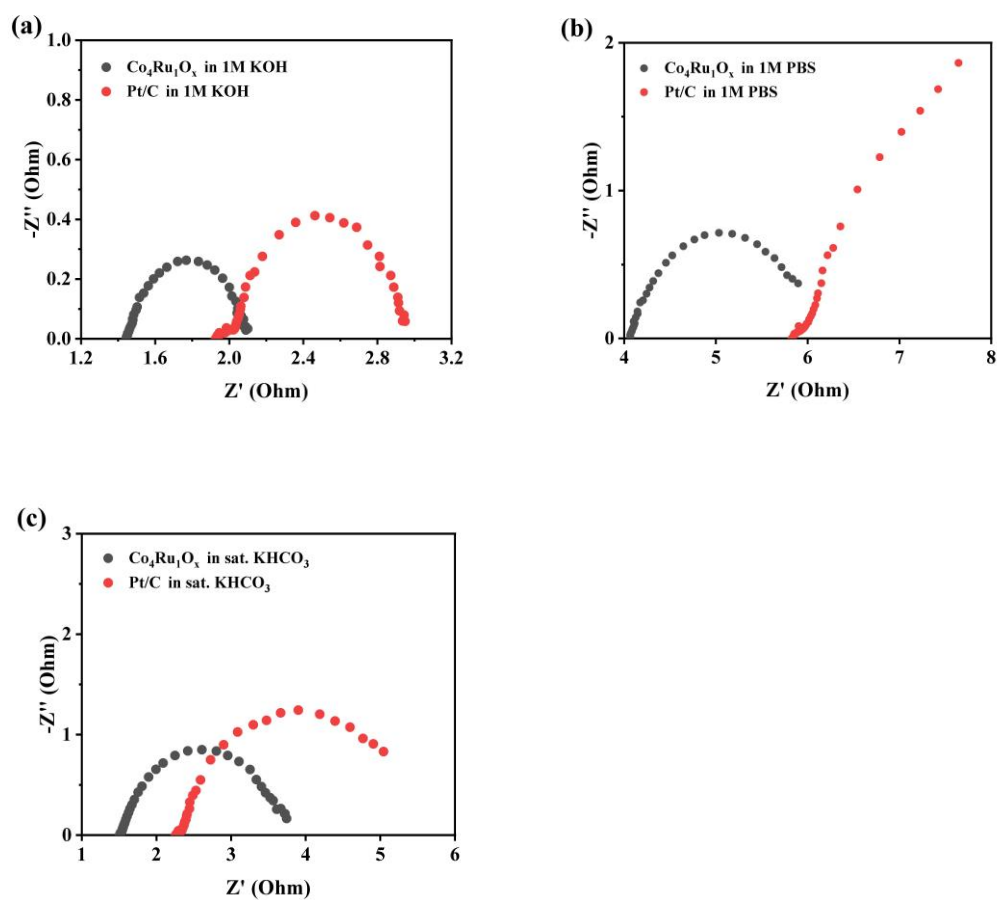


Figure S18. EIS characterization of $\text{Co}_4\text{Ru}_1\text{O}_x$ and Pt/C in different electrolytes. Nyquist plots of $\text{Co}_4\text{Ru}_1\text{O}_x$ and Pt/C in (a) 1 M KOH, (b) 1 M PBS, and (c) saturated KHCO_3 .

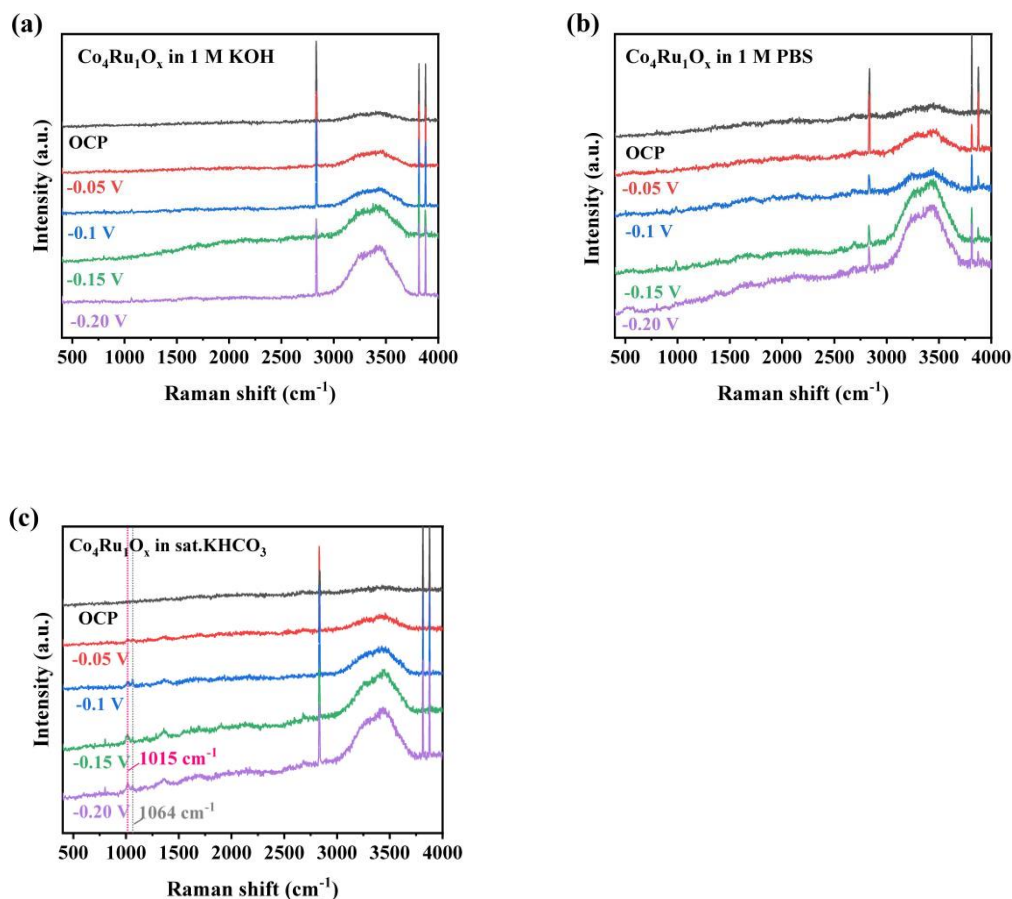


Figure S19. Operando Raman characterization of $\text{Co}_4\text{Ru}_1\text{O}_x$ in various electrolytes. (a) 1 M KOH, (b) 1 M PBS, and (c) saturated KHCO_3 electrolytes under different applied cathodic potentials (OCP - 0.20 V).

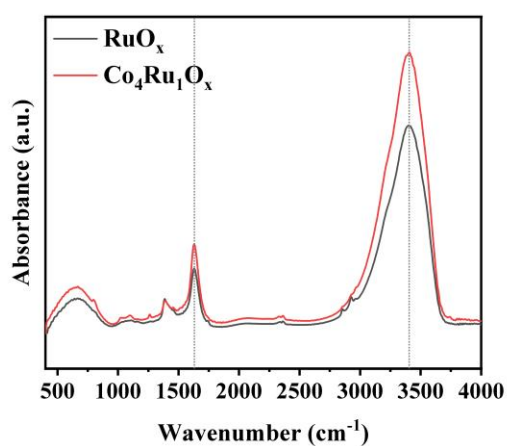


Figure S20. FTIR spectra of RuO_x and $\text{Co}_4\text{Ru}_1\text{O}_x$ catalysts.