

Supporting Information

NiCoP/CoP nanoparticles supported on Ti₄O₇ as the electrocatalyst possessing an excellent catalytic performance towards hydrogen evolution reaction

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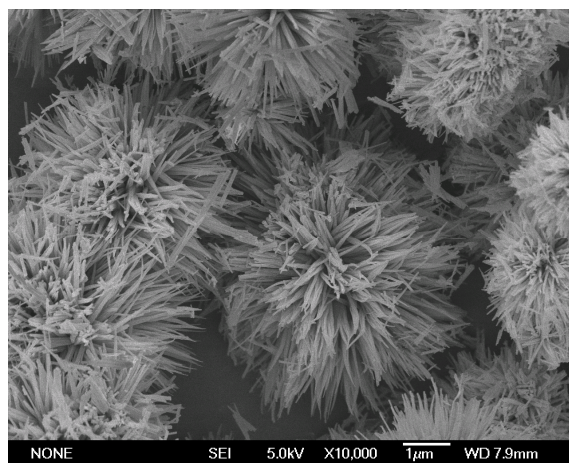


Figure S1. SEM image of NiCo_2O_4 .

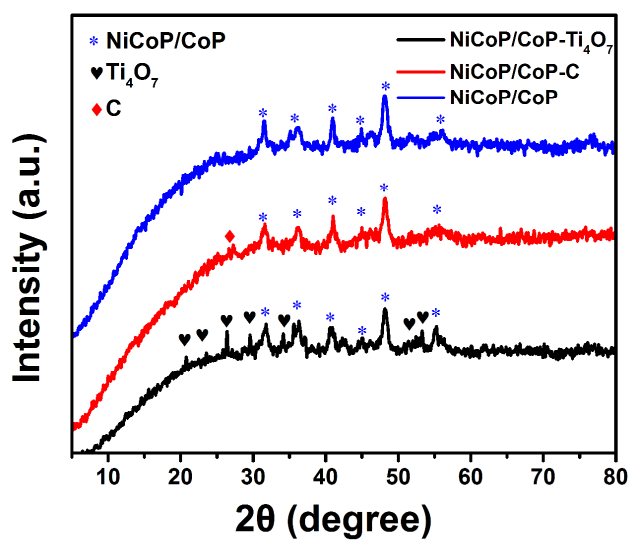


Figure S2. XRD patterns of $\text{NiCoP/CoP-Ti}_4\text{O}_7$, NiCoP/CoP-C and NiCoP/CoP .

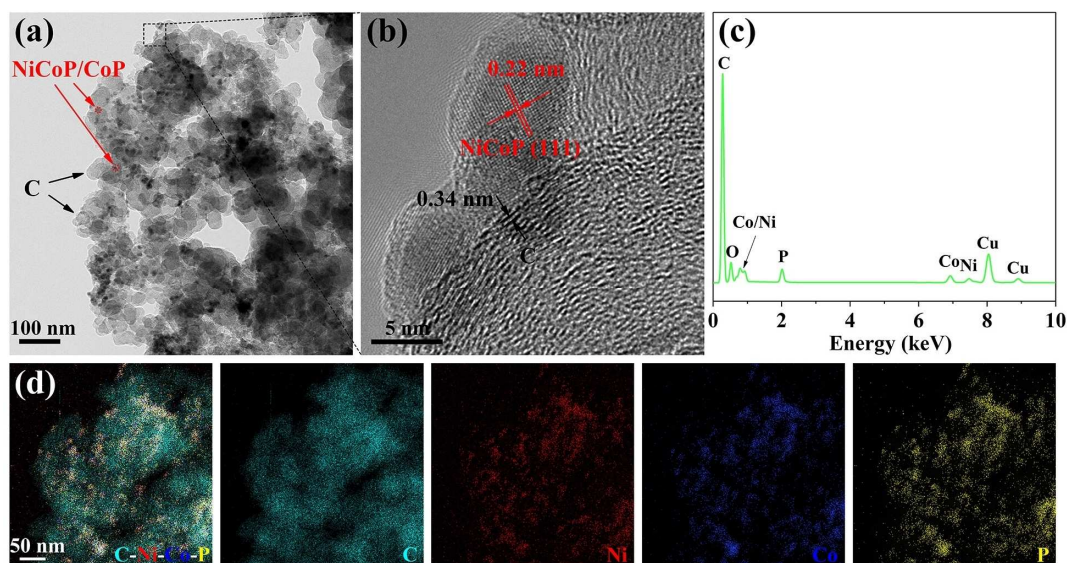


Figure S3. (a) TEM image, (b) HRTEM image, (c) EDX spectra and (d) EDX elemental mapping images of NiCoP/CoP-C.

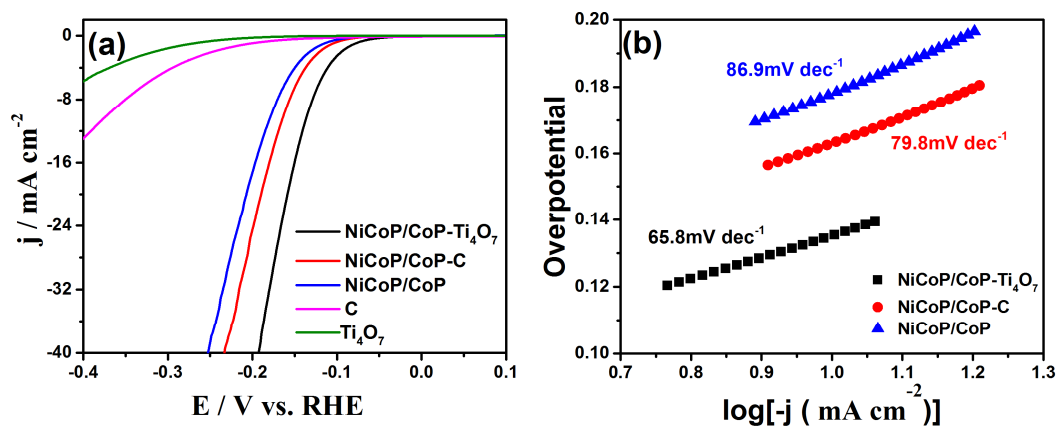


Figure S4. (a) LSV curves, (b) Tafel plots of NiCoP/CoP-Ti₄O₇, NiCoP/CoP-C and NiCoP/CoP (using carbon rod as the counter electrode).

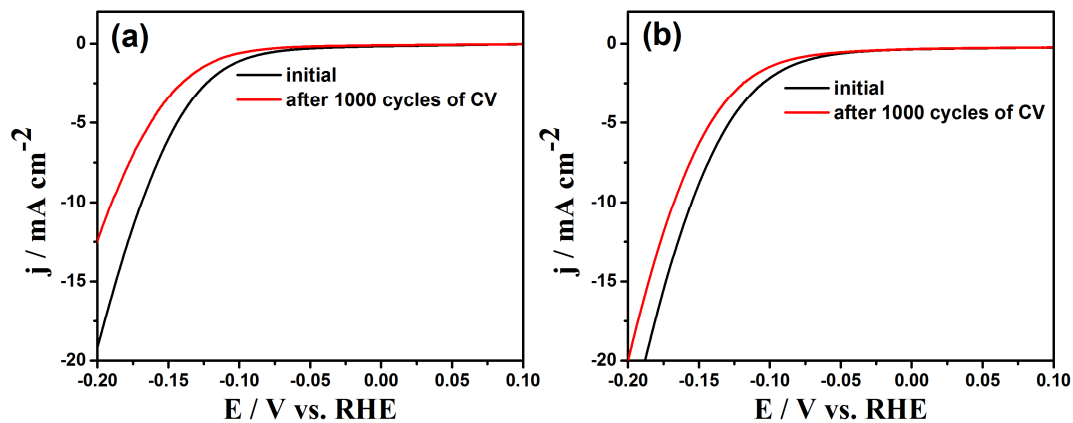


Figure S5. LSV curve comparison before and after 1000 cycles of CV for (a) NiCoP/CoP and (b) NiCoP/CoP-C.

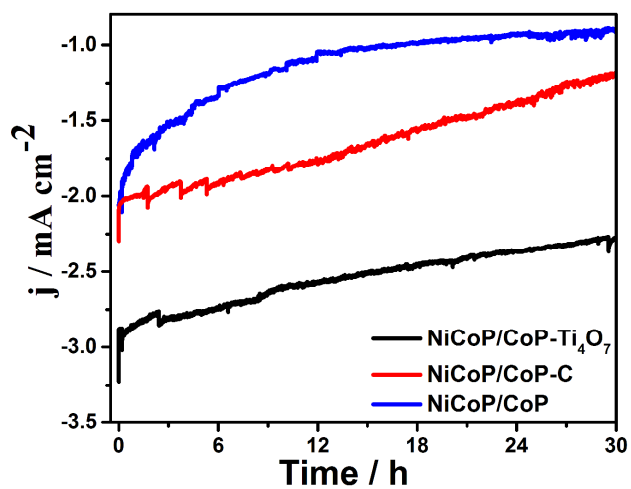


Figure S6. I-t curves of NiCoP/CoP-Ti₄O₇, NiCoP/CoP-C and NiCoP/CoP.

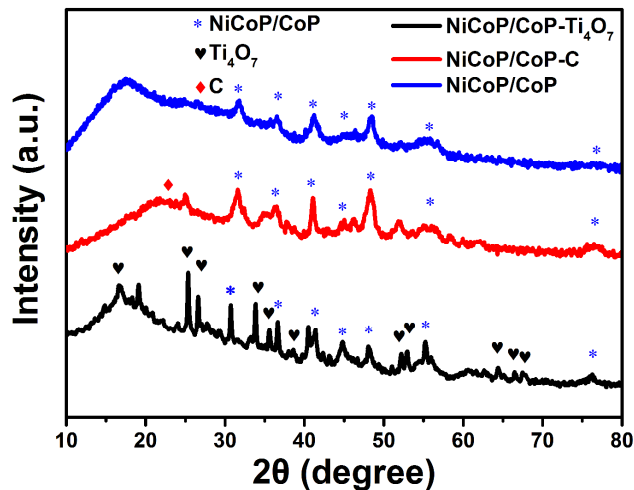


Figure S7. XRD patterns of NiCoP/CoP-Ti₄O₇, NiCoP/CoP-C and NiCoP/CoP after 30 h of I-t measurements.

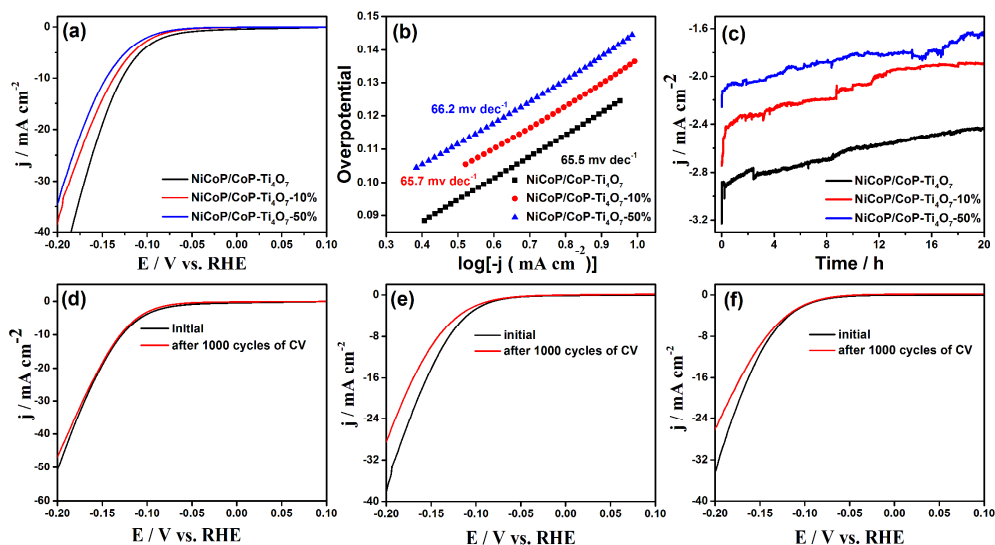


Figure S8. (a) LSV curves, (b) Tafel plots, (c) I-t curves of NiCoP/CoP-Ti₄O₇, NiCoP/CoP-10% and NiCoP/CoP-50%, LSV curve comparison before and after 1000 cycles of CV for (d) NiCoP/CoP-Ti₄O₇, (e) NiCoP/CoP-Ti₄O₇-10% and (f) NiCoP/CoP-Ti₄O₇-50%.

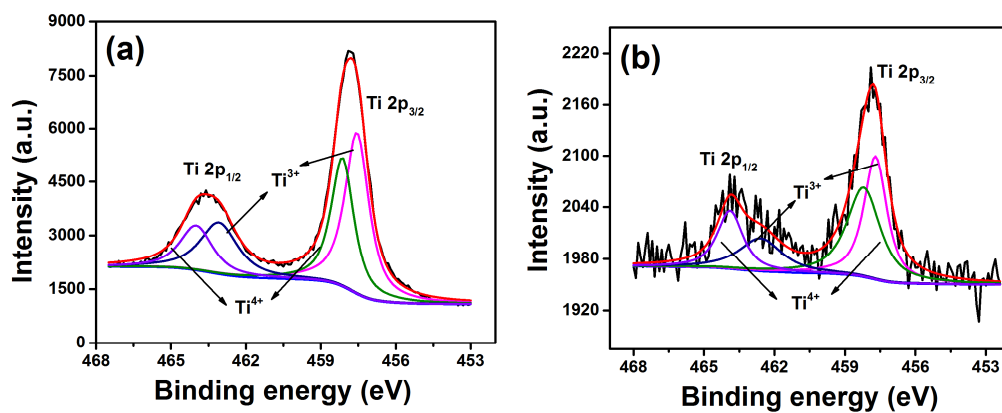


Figure S9. (a-b) XPS spectra of Ti (2p) for Ti_4O_7 and $\text{NiCoP/CoP-Ti}_4\text{O}_7$, respectively.

Table S1. The catalytic performance of NiCoP/CoP-Ti₄O₇, NiCoP/CoP-C, NiCoP/CoP and other reported electrocatalysts towards HER in 0.5 M H₂SO₄.

	Loading mass (mg cm ⁻²)	E _{onset} (mV)	E _{10mA cm⁻²} (mV)	Tafel slope (mV dec ⁻¹)	Ref.
NiCoP/CoP-Ti ₄ O ₇	0.199	48	128	65.5	this work
NiCoP/CoP-C	0.199	75	156	79.3	
NiCoP/CoP	0.199	92	171	86.3	
CoS ₂ film	/	/	190	51.4	(S1)
CoS ₂ MW	25	/	158	58	
CoS ₂ NW	1.7	/	145	51.6	
MoS ₂ /CNFs	/	64	190	110	(S2)
WS _{2(1-x)} Se _{2x} -CFs	0.21	190	250	105	(S3)
MoS ₂ /CoS ₂	18.6	/	87	73.4	(S4)

Synthesis of NiCo₂O₄-Ti₄O₇-10% and NiCo₂O₄-Ti₄O₇-50%

NiCo₂O₄ nanowires were synthesized by the hydrothermal method and calcination. First of all, 291 mg of Co(NO₃)₂·6H₂O, 145 mg of Ni(NO₃)₂·6H₂O and 300 mg of urea were dissolved in 35 mL deionized water and stirred for 30 min to form a homogeneous solution. After that, 13.7 or 123 mg of Ti₄O₇ was uniformly dispersed in the solution and sonicated for 30 min. Next, the as-prepared compounds were transferred into a 50 mL Teflon-lined stainless autoclave and heated at 120 °C for 6 h. Afterward, the autoclave was naturally cooled down to room temperature. The black

precipitate was washed four to five times with deionized water and ethanol, respectively, and then dried in a vacuum oven at 60 °C for 8 h. Finally, it was annealed at 250 °C in N₂ for 2 h with a heating rate of 2 °C min⁻¹. The obtained materials were denoted as NiCoP/CoP-Ti₄O₇-10% and NiCoP/CoP-Ti₄O₇-50%, respectively.

Synthesis of NiCoP/CoP-Ti₄O₇-10% and NiCoP/CoP-Ti₄O₇-50%

100 mg of NiCo₂O₄-Ti₄O₇-10% and NiCo₂O₄-Ti₄O₇-50% were mixed with 500 mg sodium hypophosphite using a mortar to grind into powder, respectively. Subsequently, the samples were heated at 300 °C for 120 min under N₂ atmosphere. The obtained catalysts were denoted as NiCoP/CoP-Ti₄O₇-10% and NiCoP/CoP-Ti₄O₇-50%, respectively.

References

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