

Supplementary material

Efficient Water Electrolysis with Ce-WO₃@NiCo Bifunctional Catalysts

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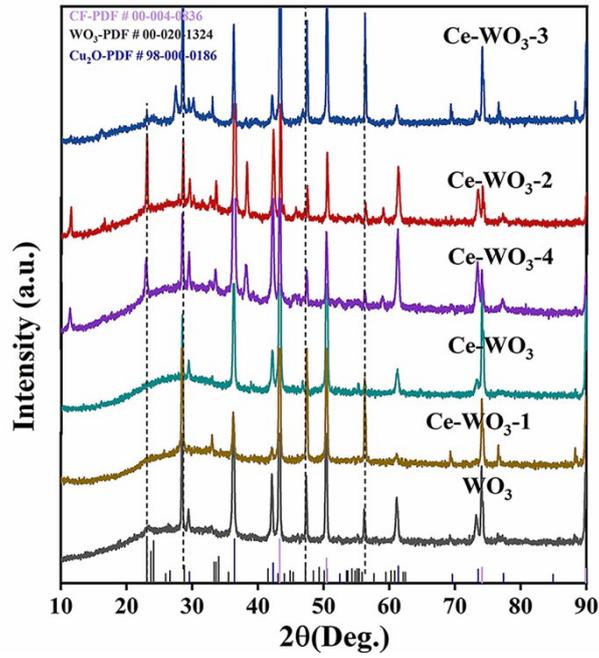


Figure S1. XRD information for doping different amounts of Ce in WO_3 (Ce-WO_3 ($\text{Ce} = 0.0468\text{g}$), $\text{Ce-WO}_3\text{-1}$ ($\text{Ce} = 0.0234\text{g}$), $\text{Ce-WO}_3\text{-2}$ ($\text{Ce} = 0.117\text{g}$), $\text{Ce-WO}_3\text{-3}$ ($\text{Ce} = 0.234\text{g}$), $\text{Ce-WO}_3\text{-4}$ ($\text{Ce} = 0.085\text{g}$)).

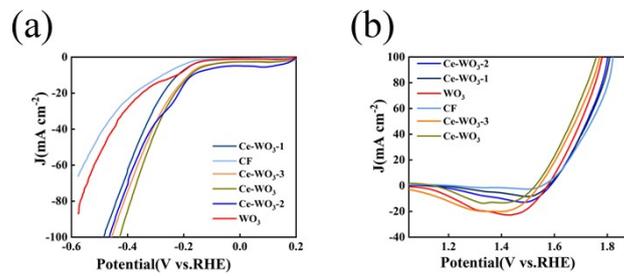


Figure S2. (a) HER and (b) OER performances for doping different amounts of Ce in WO_3 .

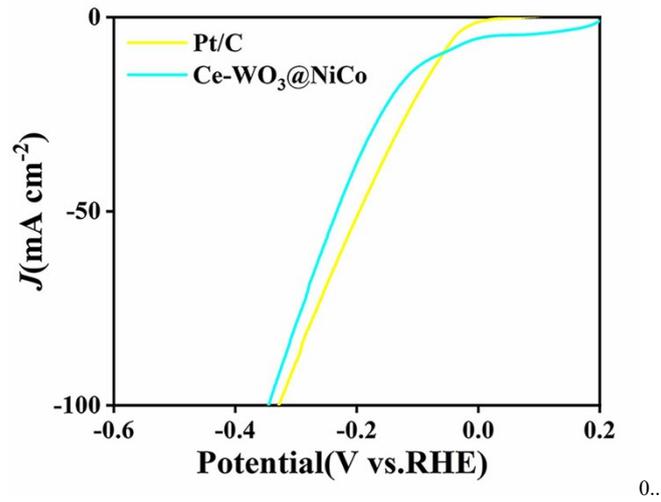


Figure S3. HER of Pt/C and Ce-WO₃@NiCo (without iR compensation).

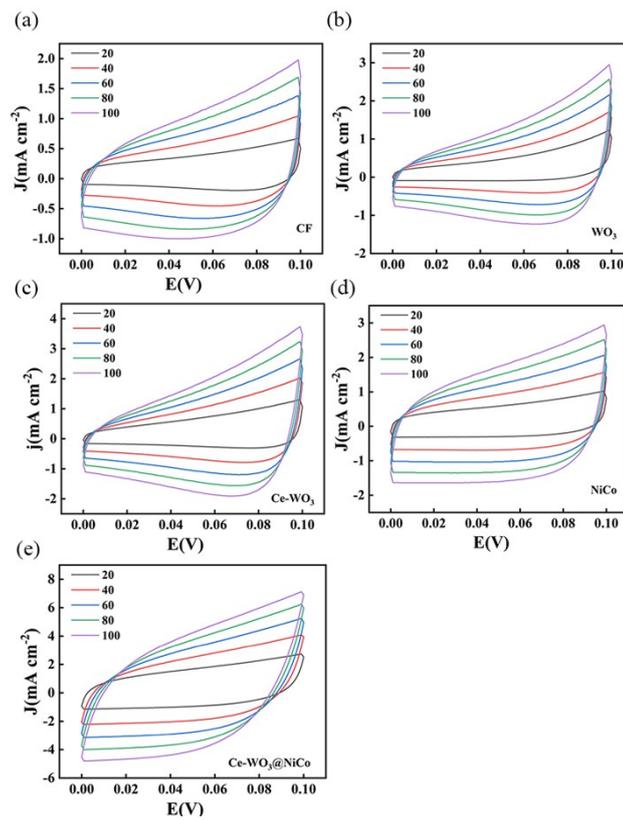


Figure S4. CVs for HER of (a) CF, (b) WO₃, (c) Ce-WO₃, (d) NiCo, (e) Ce-WO₃, (f) Ce-WO₃@NiCo.

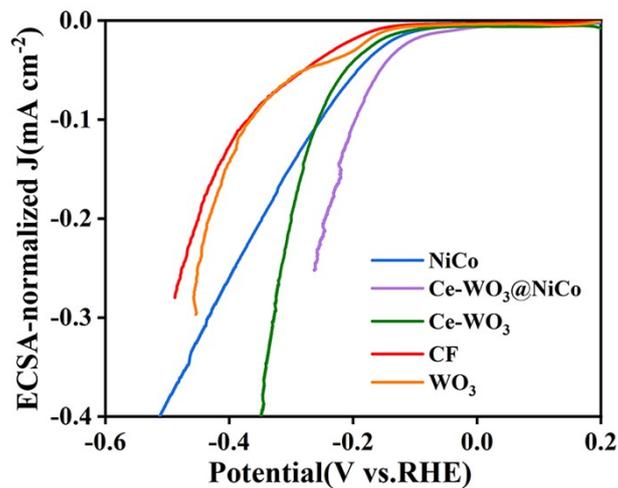


Figure S5. Normalization of current density using ECSA.

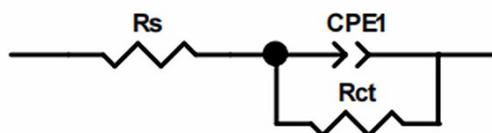


Figure S6. Equivalent Circuit Model: Randles circuit model.

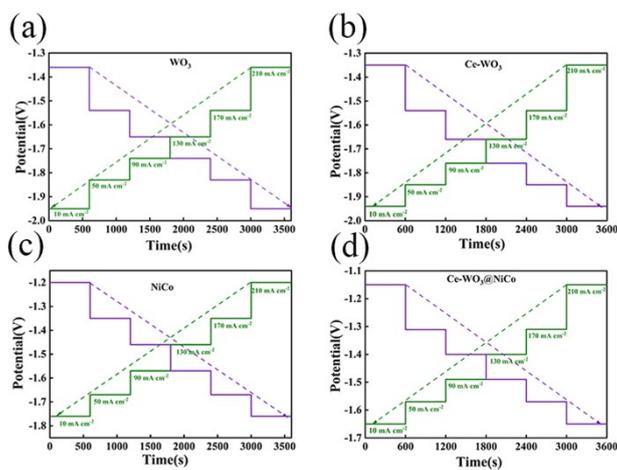


Figure S7. The HER stability measurements of the WO_3 , Ce-WO_3 , NiCo and $\text{Ce-WO}_3@NiCo$ electrocatalysts via the multi-step chronopotentiometry method.

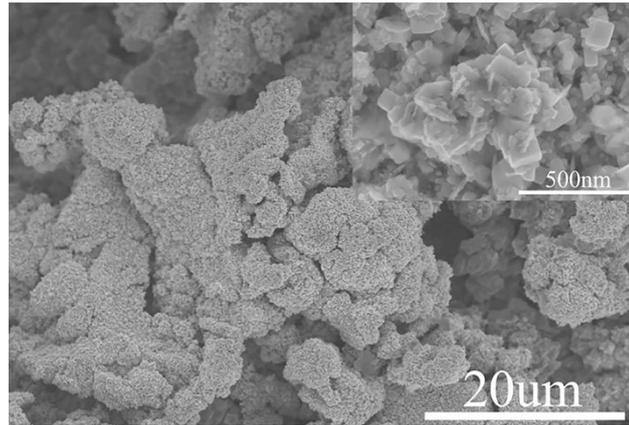


Figure S8. SEM images of Ce-WO₃@NiCo after LSV test.

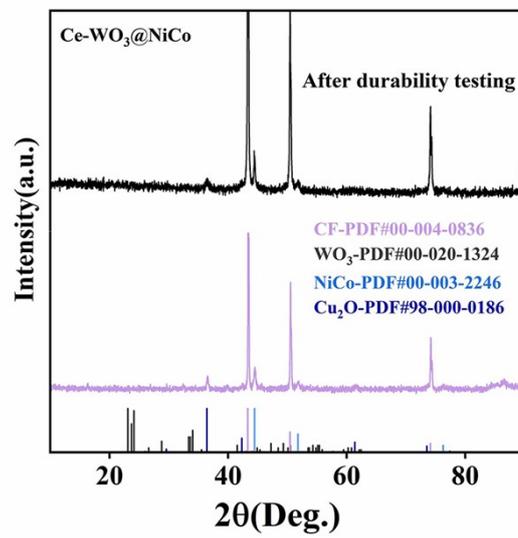


Figure S9. XRD pattern of Ce-WO₃@NiCo before and after durability testing.

Catalyst	HER (mV vs. RHE)	Reference
(Co _{1-x} Ni _x)(S _{1-y} P _y) ₂ /G	117mV@10 mA cm ⁻²	1
Ni ₃ S ₂ /Cu-NiCo LDH/NF	156 mV@10 mA cm ⁻²	2
WO ₃ @NPRGO	225 mV@10 mA cm ⁻²	3
h-WO ₃ /m-WO ₃ nanorods	170 mV@10 mA cm ⁻²	4
WO _{3-x} nanoplates on carbon nanofibers	185 mV@10 mA cm ⁻²	5
WSe ₂ /WO _{3-x}	150 mV@10 mA cm ⁻²	6
WO ₃ /Ni ₃ S ₂	100 mV@10 mA cm ⁻²	7
WS ₂ /WO ₃	395 mV@10 mA cm ⁻²	8
Ni _{0.4} WO _{3-x} S _x	173 mV@10 mA cm ⁻²	9
P-WO _{3-x}	122 mV@10 mA cm ⁻²	10
Ce-WO ₃ @NiCo	56 mV@10 mA cm ⁻²	This work

Table S1 Comparison table for HER activity of Ce-WO₃@NiCo with similar type of catalyst.

Catalyst	Rs(Ohmic resistance)	Rct(Charge transfer resistance)
Ce-WO ₃ @NiCo	1.591	10.82
Ce-WO ₃	1.522	60.25
WO ₃	1.582	268.1
NiCo	1.573	49.77
CF	1.524	271.4

Table S2 Reaction impedances HER for Ce-WO₃@NiCo, Ce-WO₃, WO₃, NiCo and CF.

Catalyst	OER (mV vs. RHE)	Reference
SiW ₉ Co ₃ [h]@ZIF-67	420 mV@10 mA cm ⁻²	11
WS ₂ nanorods	351 mV@10 mA cm ⁻²	12
Co ₉ S ₈ -CoSe ₂	340 mV@10 mA cm ⁻²	13
Co-BPDC/Co-BDC-3	335 mV@10 mA cm ⁻²	14
Co MOF/CC	346 mV@10 mA cm ⁻²	15
WO ₃ @CoWO ₄	380 mV@10 mA cm ⁻²	16
NiWO ₄ /Ni	336mV@10 mA cm ⁻²	17
Co NC@Mo ₂ C	347mV@10 mA cm ⁻²	18
NiFe@g-C ₃ N ₄ /CNT	326mV@10 mA cm ⁻²	19
FeCoNi@FeN C	330mV@10 mA cm ⁻²	20
Ce-WO ₃ @NiCo	323 mV@10 mA cm ⁻²	This work

Table S3 Comparison table for OER activity of Ce-WO₃@NiCo with similar type of catalyst.

Catalyst	Overpotential (V vs. RHE)	Reference
Ce@NiCo-LDH	1.68	21
NiCo/NiCoO _x @FeOOH	1.65	22
(Co _{1-x} Ni _x) (S _{1-y} P _y) ₂ /G	1.65	1
NiCo ₂ S ₄ NWs	1.68	23
Ni ₃ S ₂ /Cu-NiCo LDH/NF	1.75	2
Ce-WO ₃ @NiCo	1.624	This work

Table S4 Comparison table for total water splitting of Ce-WO₃@NiCo with similar type of catalyst.

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