

Supplementary Materials

NiCo nanoneedles on 3D carbon nanotubes/carbon foam electrode as an efficient bifunctional catalyst for the electro-oxidation of water and methanol

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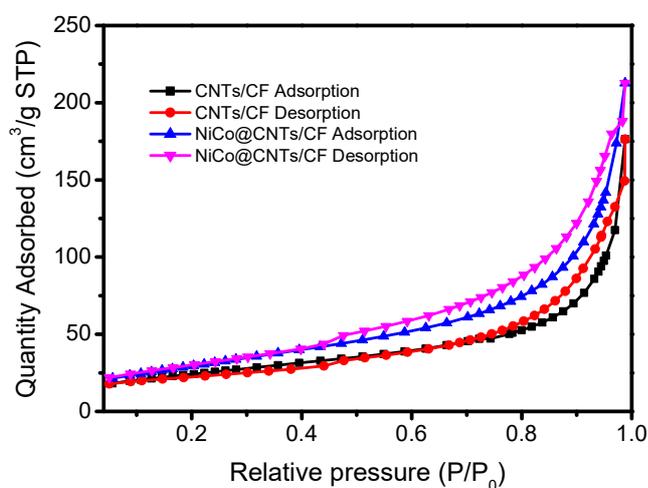


Figure S1. Nitrogen adsorption-desorption isotherm curves of CNTs/CF and NiCo@CNTs/CF samples

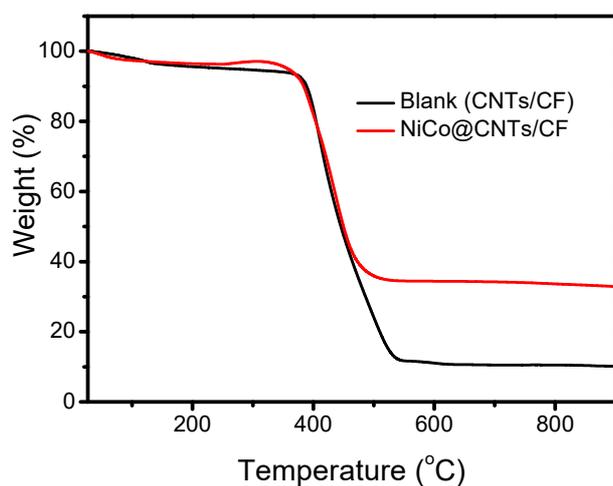


Figure S2. Thermogravimetric analysis results of the blank (CNTs/CF) and the NiCo@CNTs/CF sample.

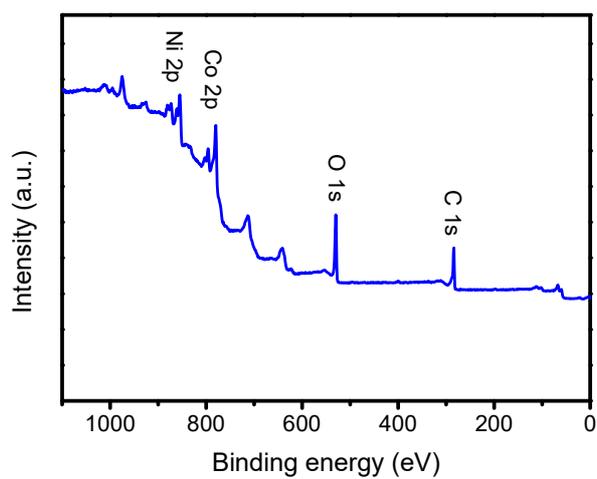


Figure S3. XPS wide spectra of the fresh NiCo@CNTs/CF samples.

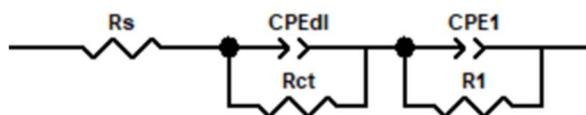


Figure S4. Equivalent circuit model used in the Nyquist plots.

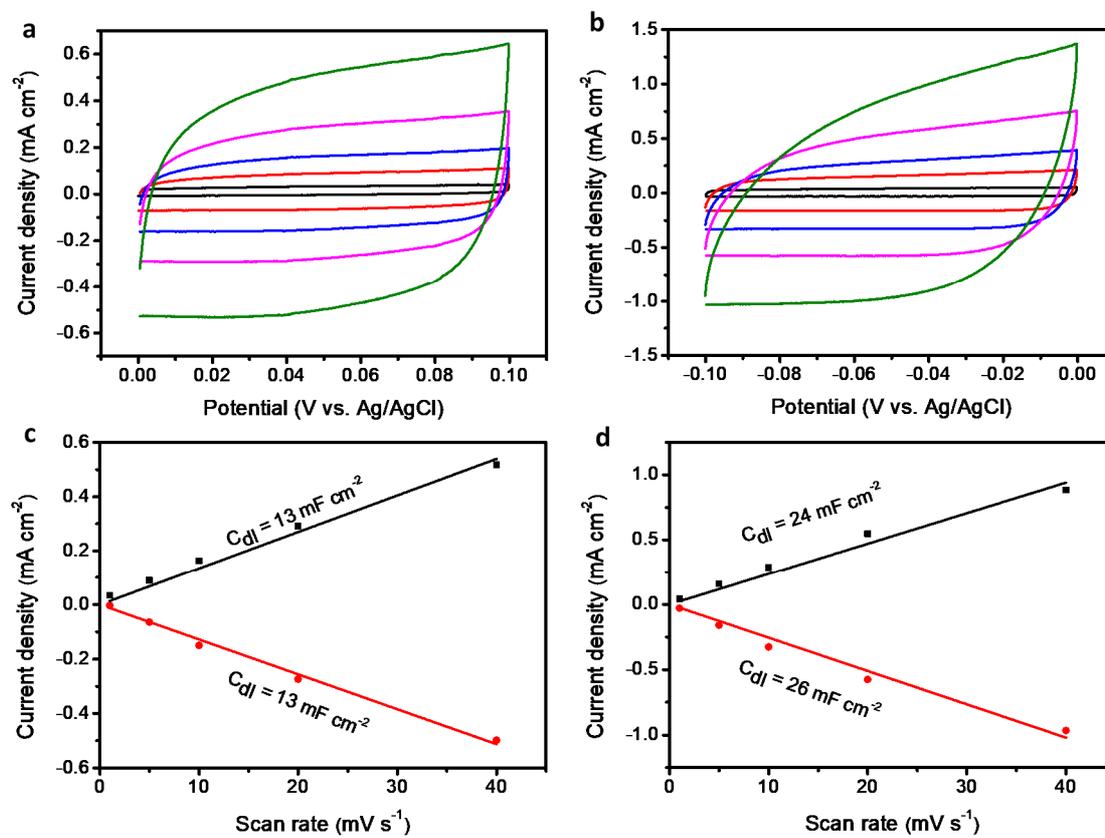
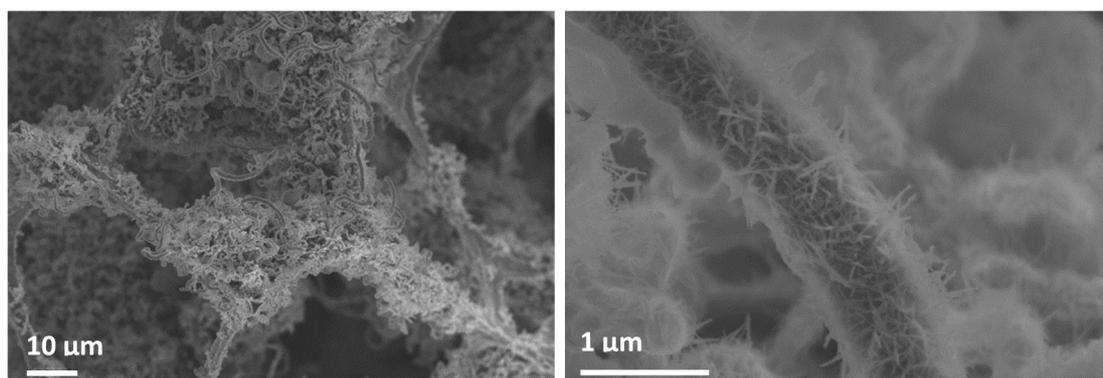


Figure S5. The CVs curves of the NiCo@CNTs/CF electrode before (a) and after (b) the anodization. The calculated C_{dl} of the electrode before (c) and after (d) the anodization.



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Figure S6. SEM images of the spent (after the third galvanostatic test) NiCo@CNTs/CF sample at low (left) and high (right) magnification.

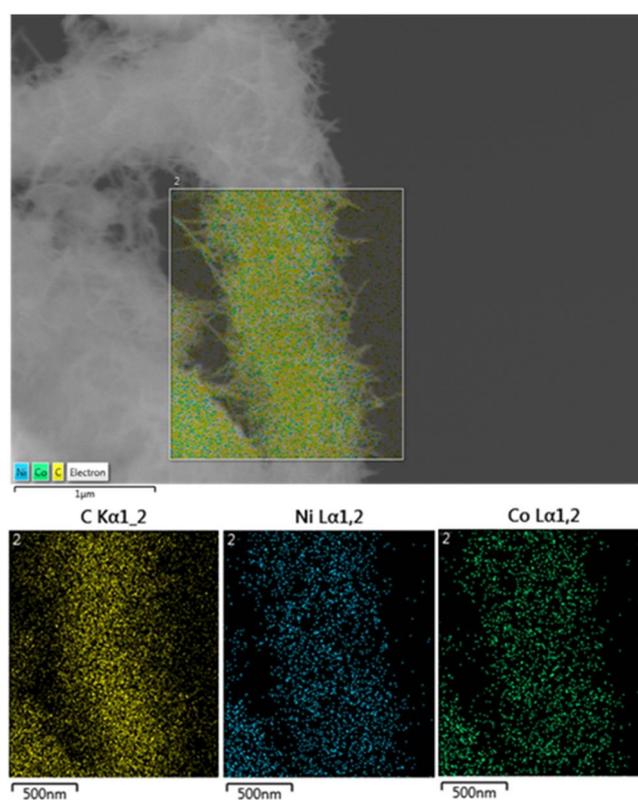


Figure S7. SEM-EDX mapping of C, Ni, and Co elements on the NiCo@CNTs/CF sample after the third galvanostatic test.

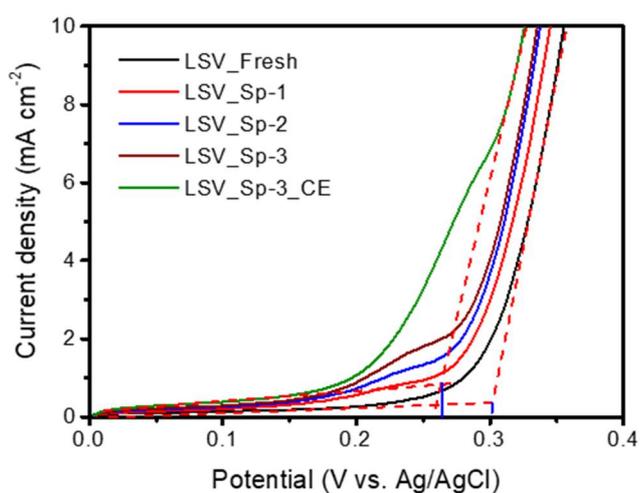


Figure S8. Determination of the onset potential before and after each potentiostatic test of the NiCo@CNTs/CF electrode (LSV_Sp-3_CE: The LSV was performed after the third potentiostatic test and then change the old electrolyte by the new electrolyte).

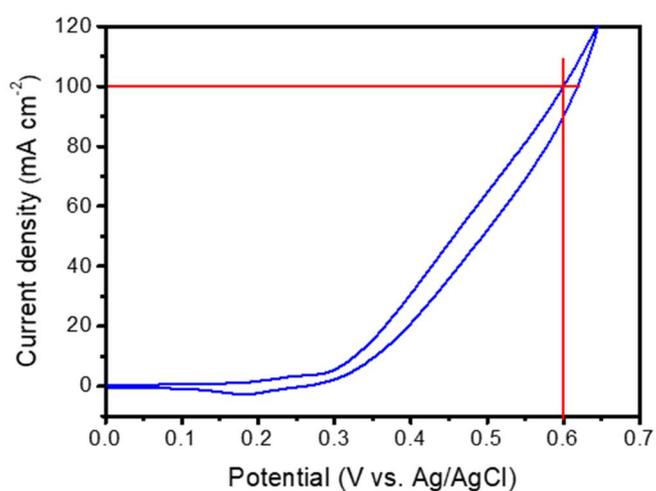


Figure S9. The CV curve of the NiCo@CNTs/CF electrode after the third potentiostatic test and change the electrolyte (1 M KOH + 0.5 M CH₃OH) at a scan rate of 10 mV s⁻¹.

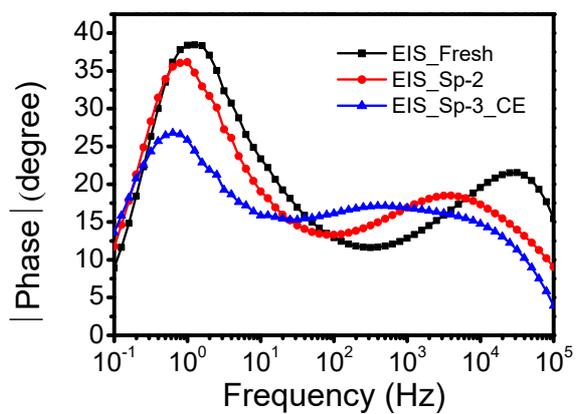


Figure S10. Bode-phase plots of the NiCo@CNTs/CF electrode at the potential of 0.3 V vs. Ag/AgCl



Figure S11. Picture of a carbon foam electrode before being covered by the carbon glue.

Table S1. Comparison of the OER performance of reported NiCo based electrocatalysts at the current density $i_e = 10 \text{ mA cm}^{-2}$ in 1 M KOH electrolyte.

Electro-catalyst	Substrate	Overpotential (mV)	Tafel slope (mV dec ⁻¹)	Reference
NiCo hydroxides	CNTs/CF	320	82	This work*
NiCo ₂ O ₄	Carbon fiber paper	307	64	[1]
NiCo ₂ O ₄	Graphene nanosheets	383	137	[2]
NiCo ₂ O ₄	Nickel foam	271	172	[3]
NiCo ₂ O ₄	Stainless steel	293	43/142	[4]
Co ₃ O ₄ / NiCo ₂ O ₄	Nickel foam	340	88	[5]
NiCo ₂ O ₄	Glassy carbon-Rotating disk electrode (GC-RDE)	340	75	[6]
NiCo ₂ O ₄	GC-RDE	280	50	[7]
NiCo ₂ O ₄ /Ti ₄ O ₇	GC	398	64	[8]
NiCo ₂ O ₄	Fluorine-doped tin oxide	375	54	[9]
NiCo-LDH	Nickel foam	271	72	[10]
NiFeO _x	Carbon fiber paper	230	73.6	[11]
Ni-Fe NPs	Nickel foam	210	53	[12]

* After the anodization.

Table S2. Comparison of the MOR performance of reported NiCo based electrocatalysts in 1 M KOH + 0.5 M CH₃OH electrolyte.

Electro-catalyst	Scan rate (mV s ⁻¹)	Applied voltage	Current density (mA cm ⁻²)	Reference
NiCo@CNTs/CF	10	0.6 V vs. Ag/AgCl	100	This work*
NiCo ₂ O ₄ nanosheet	10	0.6 V vs. SCE	111	[13]
NiCo ₂ O ₄ /carbon xerogel	50	0.6 V vs. Ag/AgCl	98	[14]
NiCo ₂ O ₄ nanoparticles	10	0.6 V vs. Hg/HgO	93	[15]
NiCo ₂ O ₄	10	0.6 V vs. Hg/HgO	98	[16]
Mesoporous NiCo ₂ O ₄	10	0.6 V vs. Hg/HgO	125	[17]
Co ₃ O ₄ / NiCo ₂ O ₄	10	0.6 V vs. Hg/HgO	140	[18]
NiO nanosheets@nanowire	10	1.62 V vs. RHE	89	[19]

* After the third potentiostatic test and change of the new electrolyte.

References

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