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Supporting Information

Hierarchical $NiCo_2O_4$ nanosheets decorated carbon nanotubes towards highly efficient electrocatalyst for water oxidation

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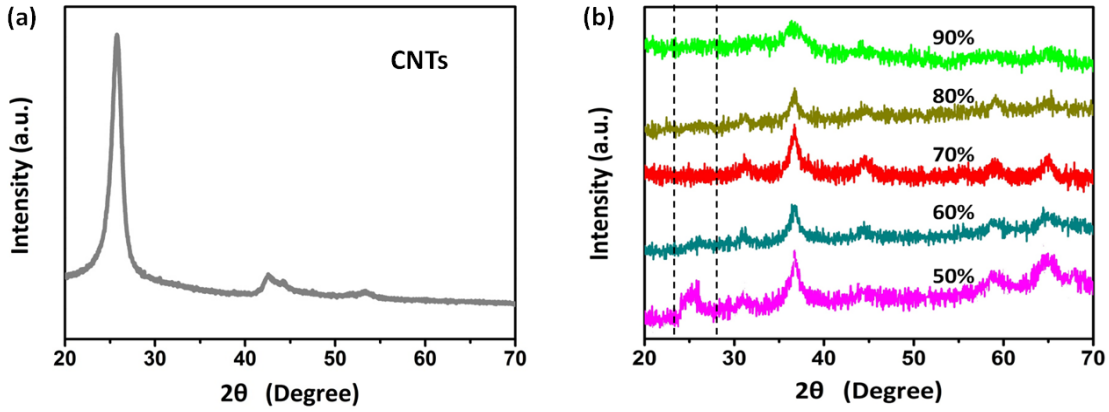


Figure S1. XRD patterns of (a) CNTs and (b) $NiCo_2O_4$/CNTs with different $NiCo_2O_4$ contents.

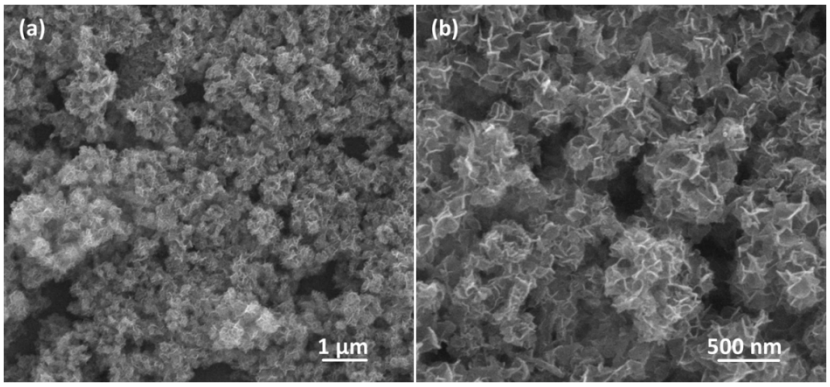


Figure S2. SEM images of the pure $NiCo_2O_4$.

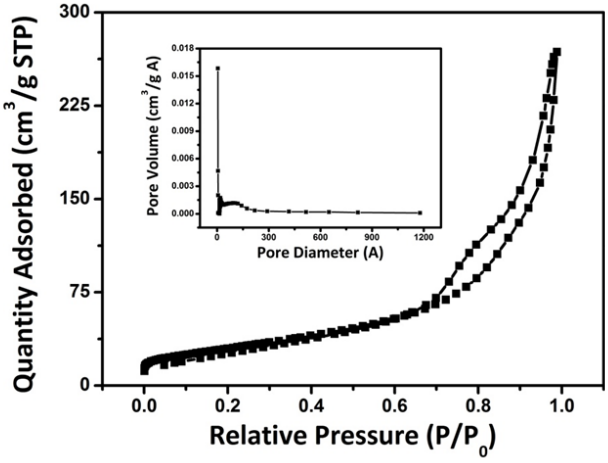


Figure S3. Nitrogen adsorption – desorption isotherm of the pure $NiCo_2O_4$. The inset shows the pore – size distribution from the corresponding adsorption branch.

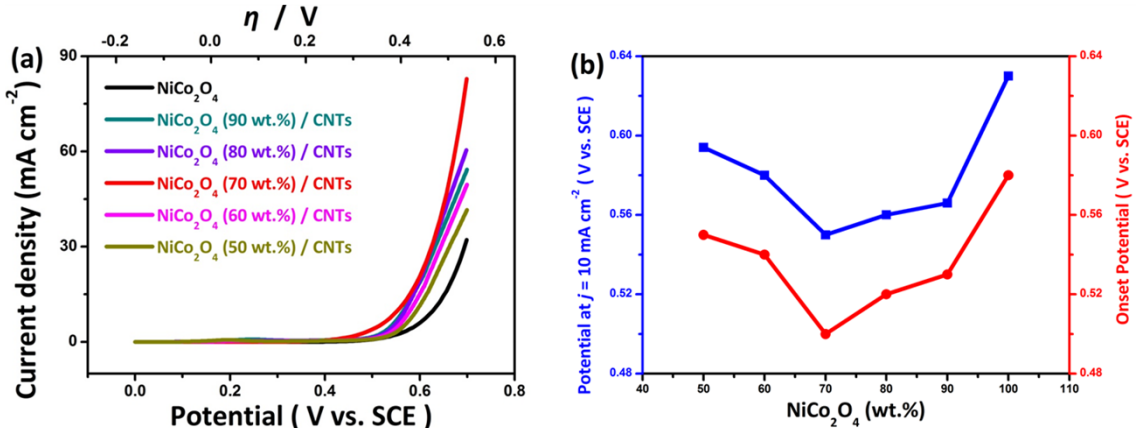


Figure S4. Oxygen evolution polarization curves of the hierarchical $NiCo_2O_4$/CNTs with $NiCo_2O_4$ contents of 50 wt %, 60 wt %, 70 wt %, 80 wt % and 90 wt %.

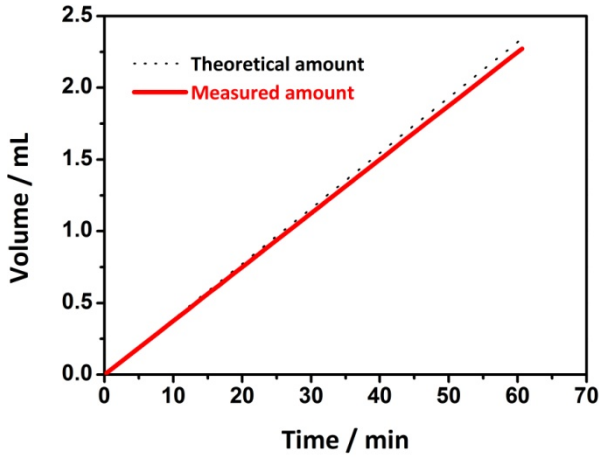


Figure S5. Coulombic efficiency for OER during constant current electrolysis at 0.01 A. The theoretical O_2 line represents the expected amounts of O_2. The measured O_2 line represents the detected O_2.

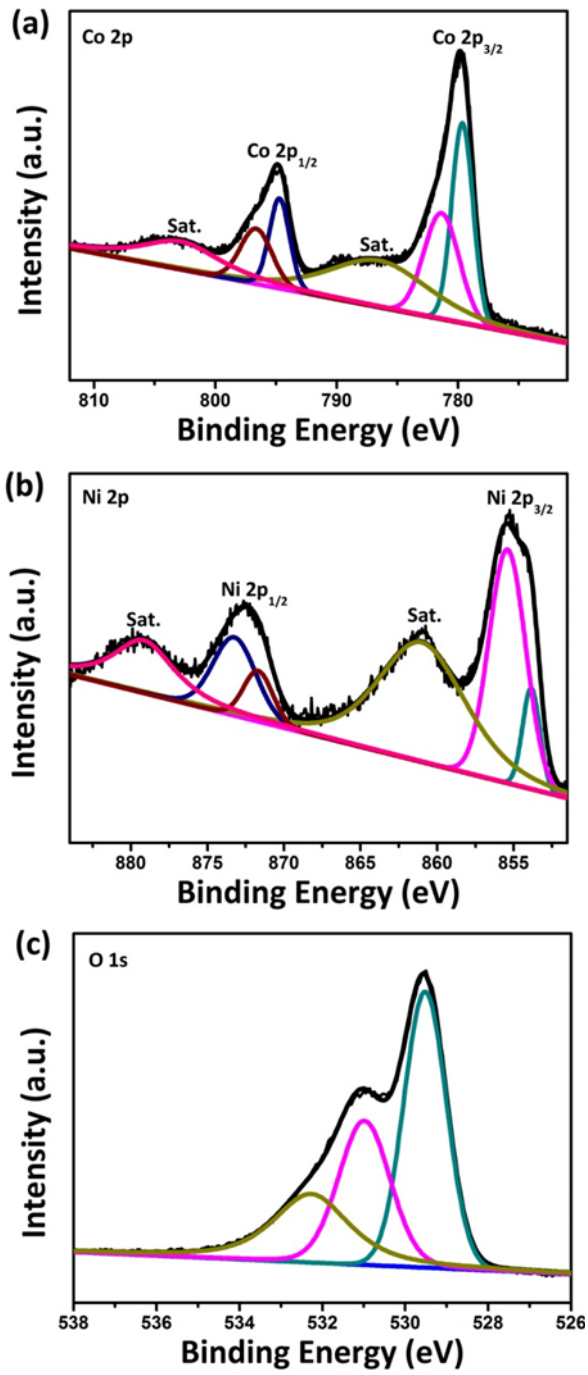


Figure S6. XPS spectra for the pure $NiCo_2O_4$.

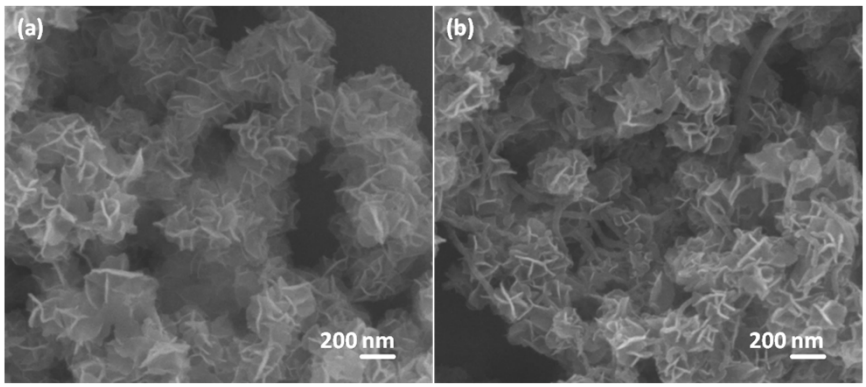


Figure S7. SEM images of $NiCo_2O_4$/CNTs (a) before the stability test and (b) after the stability test.

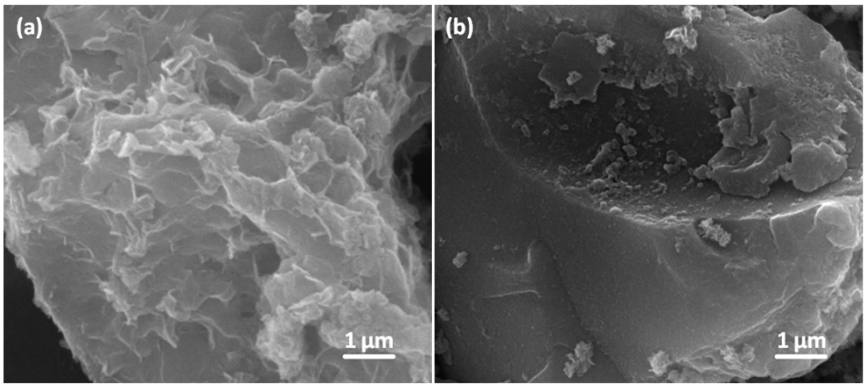


Figure S8. SEM images of $NiCo_2O_4$/AC (a) before the stability test and (b) after the stability test.

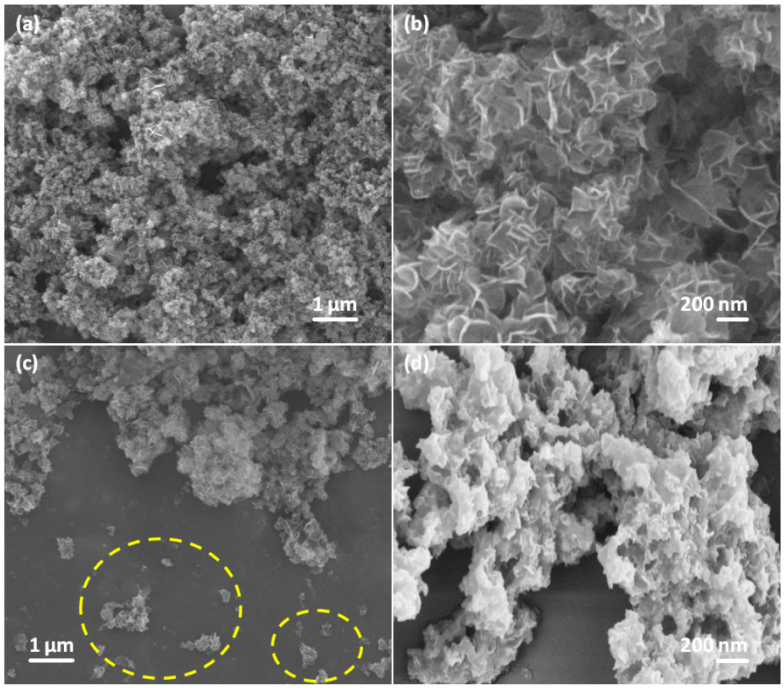


Figure S9. SEM images of pure $NiCo_2O_4$ (a, b) before the stability test and (c, d) after the stability test.

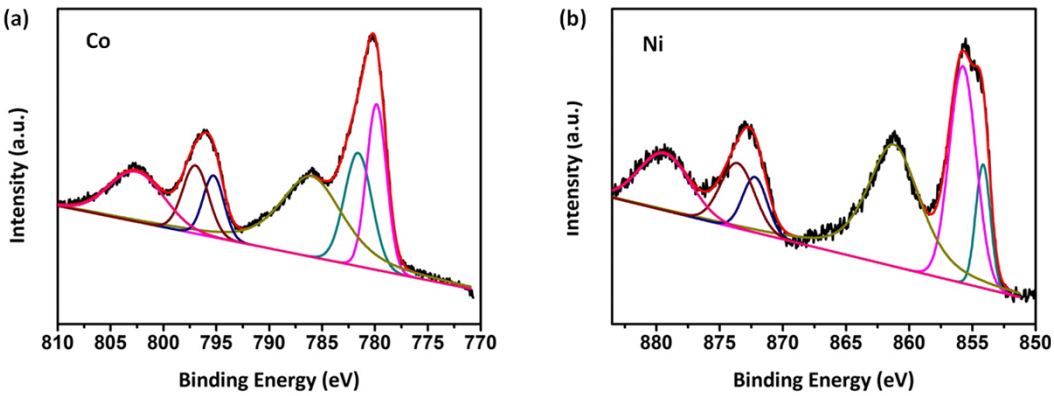
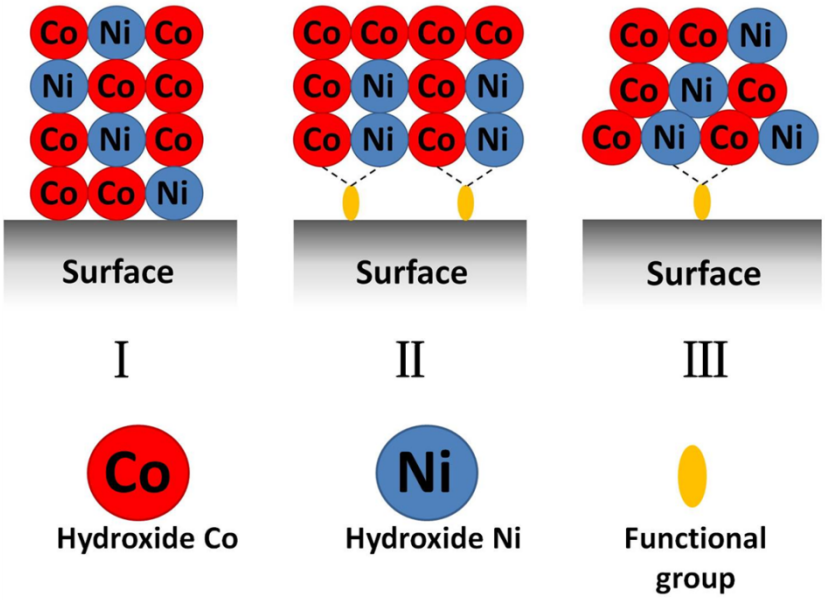


Figure S10. XPS spectra of $NiCo_2O_4$/CNTs after the stability test.



Scheme S1. Scheme of the proposed formation mechanism of the nickel-cobalt hydroxide on CNTs surface.

Table S1. Comparison of oxygen electrode activities of $NiCo_2O_4$ with various morphology and doping materials.

Catalyst	Onset Potential (V)	Tafel slope (mV dec^{-1})	Overpotential at 10 mA cm^{-2} (V)	Solution	Reference
$NiCo_2O_4$/CNTs	0.50	68.1	0.39 (vs. SCE)	1M KOH	in this work
$NiCo_2O_4$/AC	0.50	70.0	0.43 (vs. SCE)	1M KOH	in this work
$NiCo_2O_4$	0.55	77.3	0.46 (vs. SCE)	1M KOH	in this work
Au/$NiCo_2O_4$	—	63.0	1.59 (vs. RHE)	1M KOH	[1]
Hierarchical nanostructured $NiCo_2O_4$	1.62	87.0	1.62 (vs. RHE)	1M KOH	[2]
$NiCo_2O_4$ nanowire arrays	0.60	95.9	—	1M KOH	[3]
Graphene/$NiCo_2O_4$	0.52	156	—	1M KOH	[4]
graphene hybrid $NiCo_2O_4$ nanoplatelet	0.55	164	—	1M KOH	[5]

Table S2. Summary of XPS data for $NiCo_2O_4$/CNTs, $NiCo_2O_4$/pCNTs and the pure $NiCo_2O_4$.

	Ni^{3+} $2p_{3/2}$(eV)	Ni^{2+} $2p_{3/2}$(eV)	Ni^{3+}/Ni^{2+}	Co^{3+} $2p_{3/2}$(eV)	Co^{2+} $2p_{3/2}$(eV)	Co^{3+}/Co^{2+}	Co/Ni
$NiCo_2O_4$/CNTs	**855.53**	**853.99**	**0.88**	**781.28**	**779.14**	**0.87**	**3.09**
$NiCo_2O_4$/pCNTs	**855.81**	**854.16**	**2.38**	**781.63**	**779.79**	**0.90**	**2.18**
$NiCo_2O_4$	**855.41**	**853.85**	**4.90**	**781.36**	**779.64**	**0.88**	**1.71**

References

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[2] M. Parbu, K. Ketpang and S. Shanmugam, *Nanoscale*, 2014, **6**, 3173-3181.

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[5] D. U. Lee, B. J. Kim and Z. W. Chen, *J. Mater. Chem. A*, 2013, **1**, 4754-4762.