Electronic Supplementary Material (ESI) for Inorganic Chemistry Frontiers.

Supporting Information

N-doped carbon coated $NiCo_2O_4$ Nanorods for efficient electrocatalytic oxygen evolution

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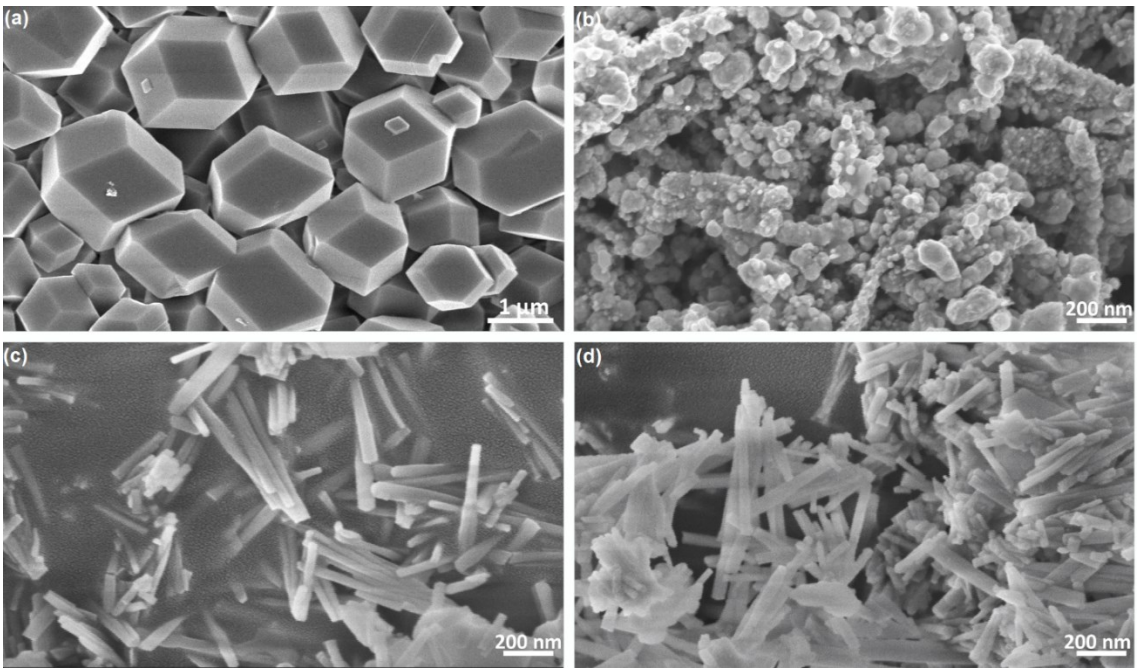

Figure S1. FESEM images of (a) ZIF-67, (b-d) ZIF-67@Ni-TPA after solvothermal reaction of 45 min, 2 h and 10 h, respectively.

Figure S2. Lavender precipitates of ZIF-67@Ni-TPA.

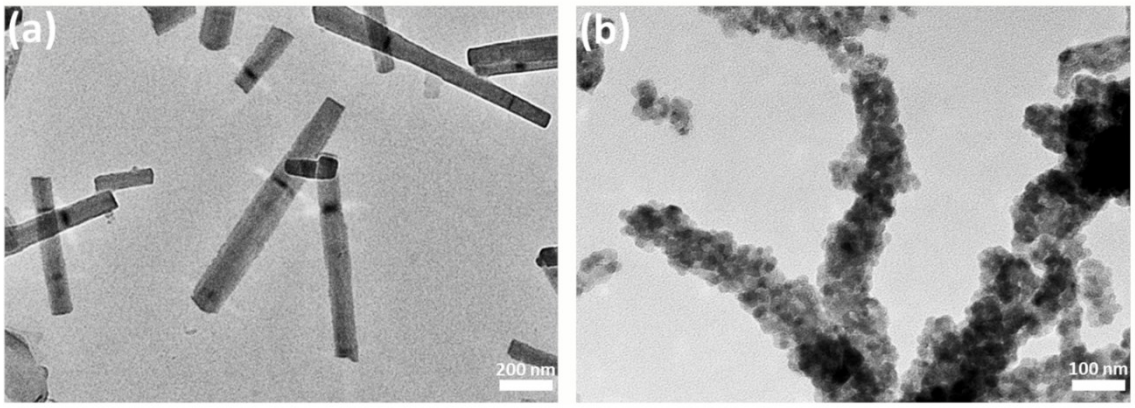

Figure S3. TEM images of (a) ZIF-67@Ni-TPA nanorods and (b) NiCo@NC nanorods.

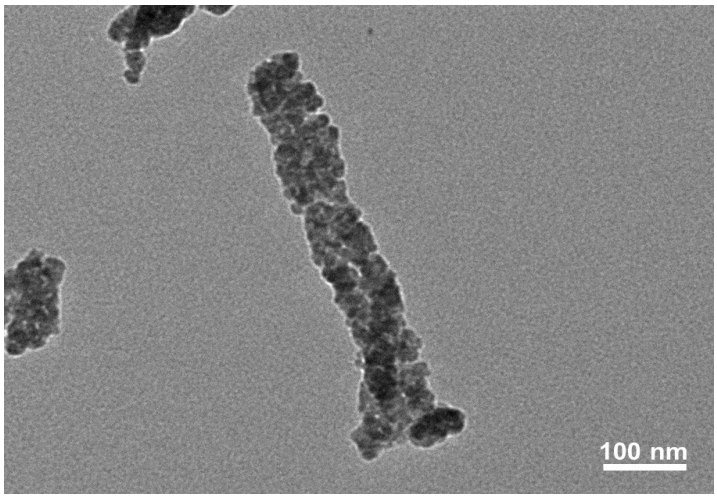

Figure S4. TEM image of $NiCo_2O_4$@NC nanorods after thermal reduction and oxidation process.

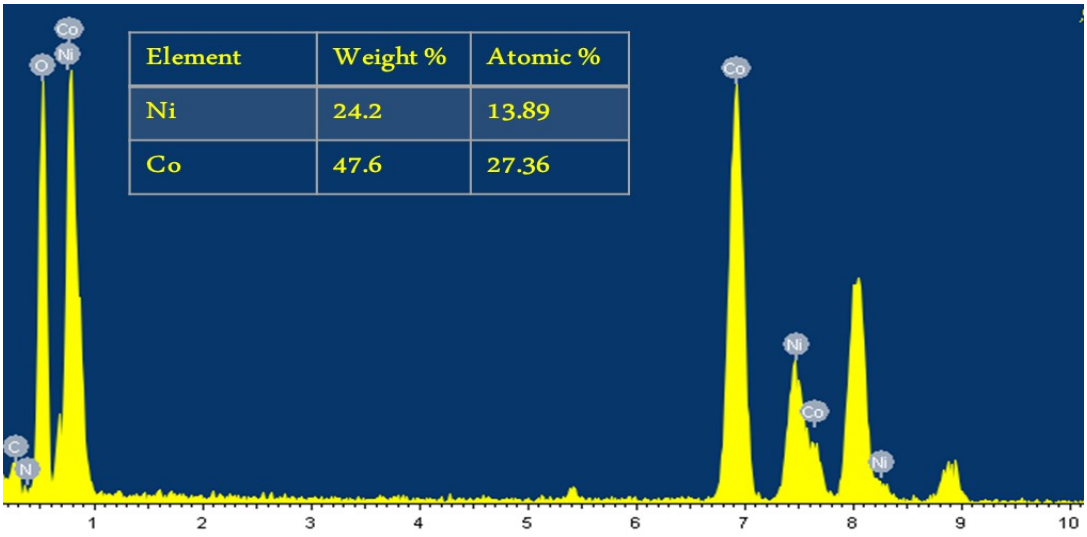

Figure S5. EDX spectrum of $NiCo_2O_4$@NC nanorods.

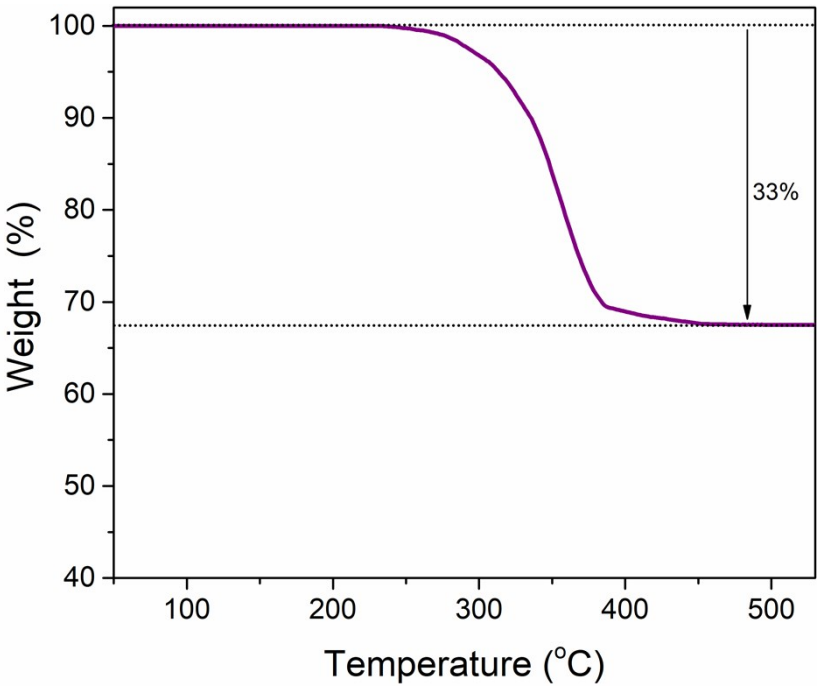

Figure S6. TGA curve of $NiCo_2O_4$@NC nanorods in the air atmosphere.

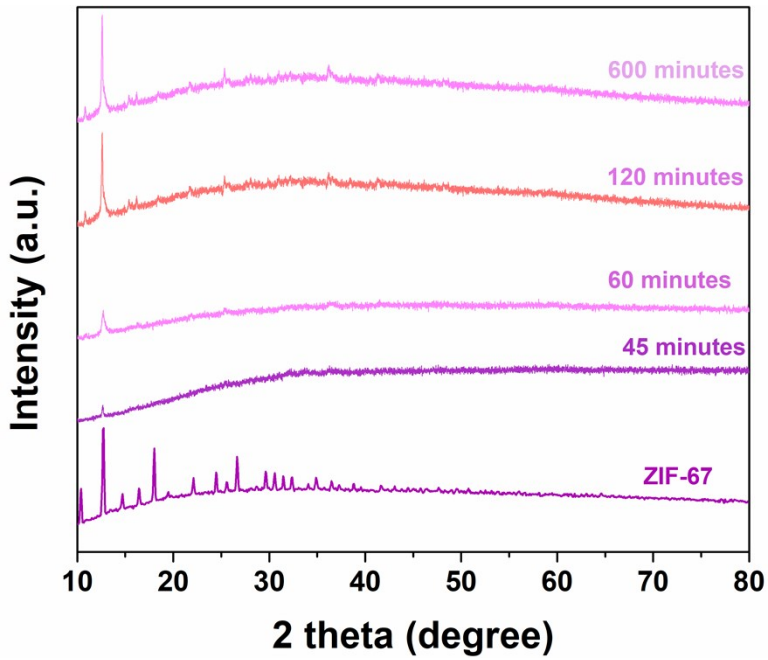

Figure S7. XRD patterns of ZIF-67 to ZIF-67@Ni-TPA obtained at different reaction time.

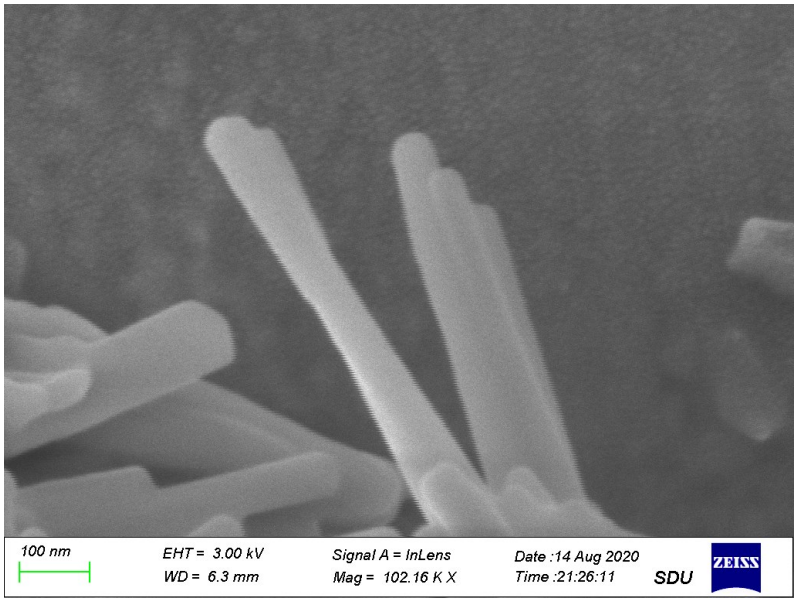

Figure S8. SEM image of $NiCo_2O_4$ nanorods.

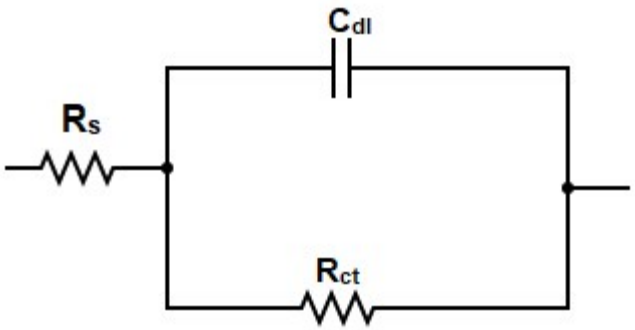

Figure S9. Equivalent circuit employed to calculate R_{ct} value.

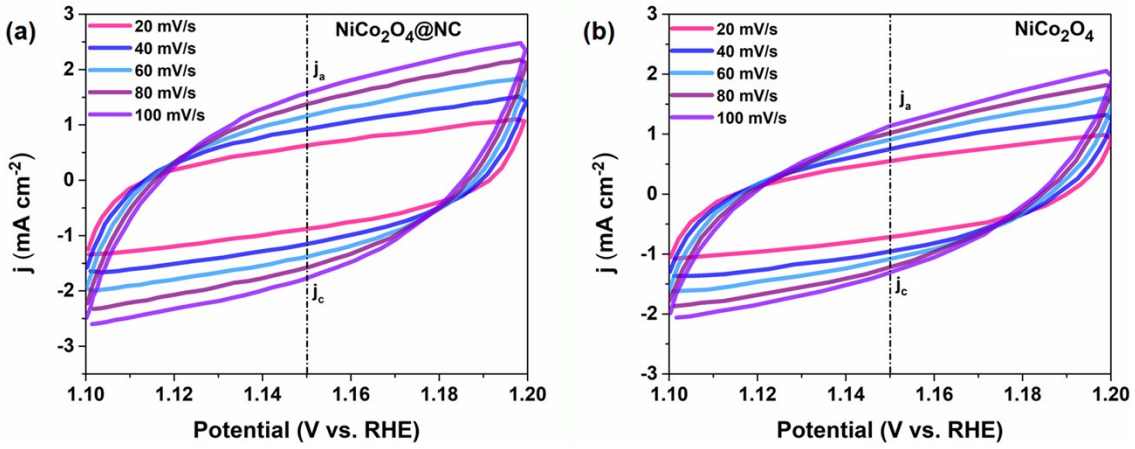

Figure S10. Cyclic voltammetry (CV) curves of electrocatalysts at various scan rates: (a) $NiCo_2O_4$@NC, (b) $NiCo_2O_4$.

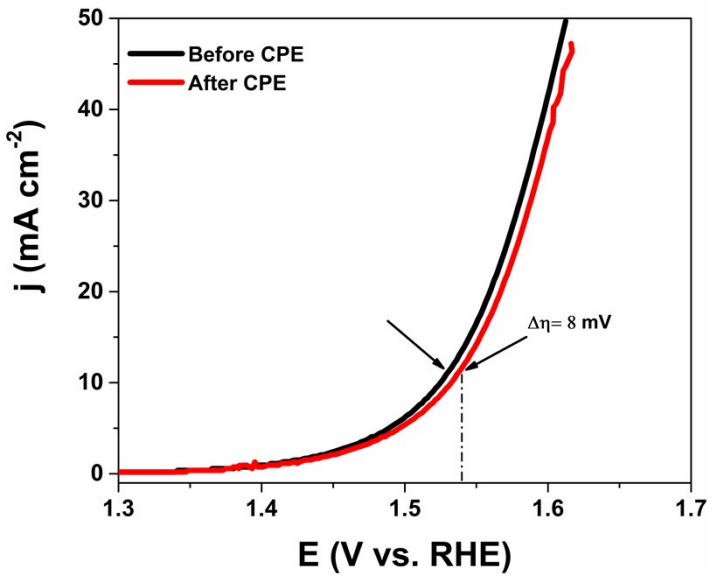

Figure S11. LSV curves of $NiCo_2O_4$@NC recorded before and after chronoamperometry measurement.

Electrochemical measurements

Exchange current density [(mA cm^{-2})]

Exchange current density can be calculated by considering charge/electron transfer resistance at electrode-electrolyte interphase using following equation (S1).

$$J_{exc} = RT/nAF\theta \quad \text{(S1)}$$

Where,

R = universal gas constant (8.314 J/(mol.K)), T= temperature (298 K), n= number of electrons F= Faraday's constant (96485 C/mol), θ = charge transfer resistance (Ω), A= geometrical area of working electrode.

$NiCo_2O_4$@NC nanorods

$$= \frac{8.314\frac{J}{mol.K}\times 298K}{4\times 96485\frac{C}{mol}\times 27\ \Omega\times 0.196\ cm^2} = 1.21\ mA\ cm^{-2} \quad \text{(S2)}$$

$NiCo_2O_4$ nanorods

$$= \frac{8.314\frac{J}{mol.K}\times 298K}{4\times 96485\frac{C}{mol}\times 37\ \Omega\times 0.196\ cm^2} = 0.8\ mA\ cm^{-2} \quad \text{(S3)}$$

NiCo@NC

$$= \frac{8.314\frac{J}{mol.K}\times 298K}{4\times 96485\frac{C}{mol}\times 49\ \Omega\times 0.196\ cm^2} = 0.66\ mA\ cm^{-2} \quad \text{(S4)}$$

Active electrochemical surface area (ECSA)

$$\text{ECSA} = \frac{C_{dl}}{C_s} \quad \text{(S5)}$$

Where, C_{dl} = double layer capacitance and C_s= specific capacitance value for flat standards with 1 cm^2 of real surface area.

Table S1. ICP-MS analysis: Ni/Co compositions obtained from $NiCo_2O_4$@NC and $NiCo_2O_4$ nanorods.

Sample	Nickel (mmol/L) × 10^3	Cobalt (mmol/L) × 10^3	Ni/Co
$NiCo_2O_4$@NC	0.292	0.585	1/2
NiC_2O_4	0.276	0.549	0.98/2

Table S2. Comparison of $NiCo_2O_4$@NC electrocatalyst with other reported electrocatalysts.

Electrode material	**Overpotential (mV) @10 mA cm^{-2}**	**Tafel slope (mv dec^{-1})**	**References**
$NiCo_2O_4$ nanorods	420	101	S1
$NiCo_2O_4$ nanoflowers	383	137	S2
Fe doped $NiCo_2O_4$ nanowires	297	68	S3
$NiCo_2O_4$ core shell	320	63	S4
$NiCo_2O_4$ nanobelts	325	71	S5
$NiCo_2O_4$@NC nanoflowers	383	53.5	27
Ni/Co_3O_4@NC	350	52.7	S6
$NiCo_2O_4$@NC nanorods	296	53	**This work**

References

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S3 Z. Hao, P. Wei, H. Kang, Y. Yang, J. Li, X. Chen and L. Liu, Nickel cobalt oxide nanowires with iron incorporation realizing a promising electrocatalytic oxygen evolution reaction, *Nanotechnology*, 2020, **31**, 435707.

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