Electrodeposition of unary oxide on a bimetallic hydroxide as a highly active and stable catalyst for water oxidation

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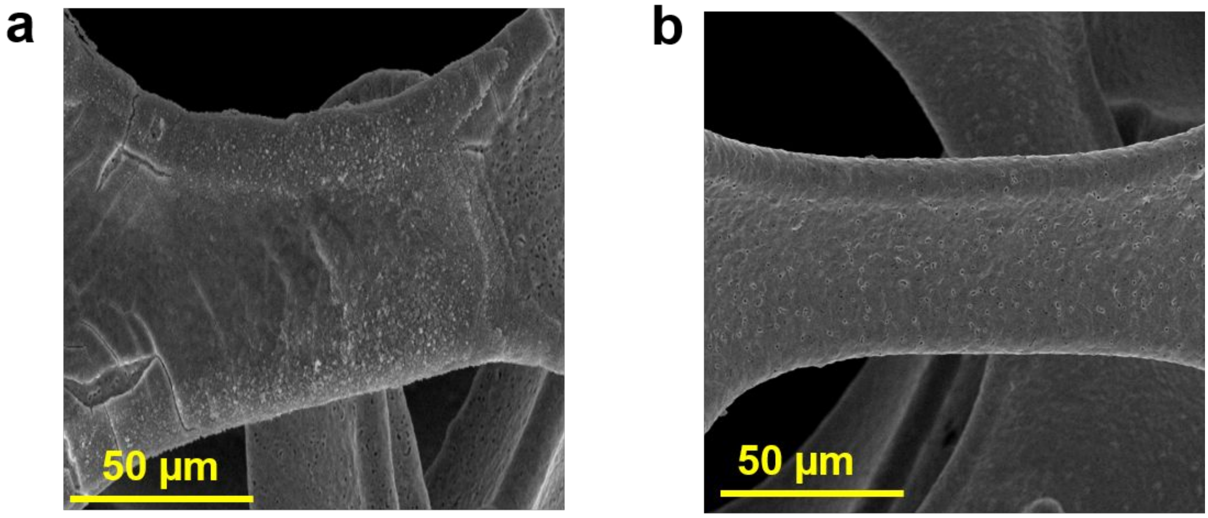

Figure S1. SEM images of (a) NiFe-OH/NF, and (b) CeO_x/NF

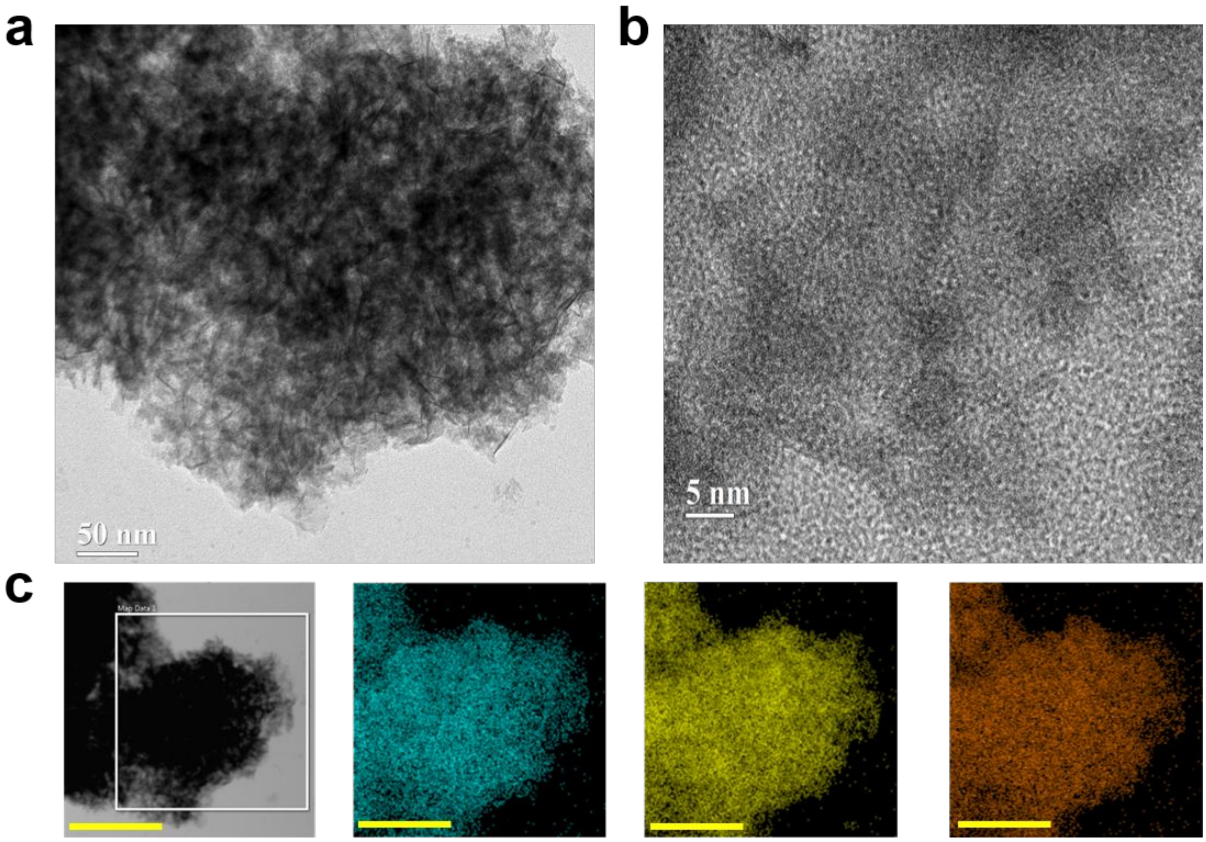

Figure S2. (a,b) HR-TEM images of NiFe-OH/NF, (c) EDX mapping of Ni (cyan), Fe (yellow) and O (orange) elements for NiFe/NF. Scale bar – 100 μm

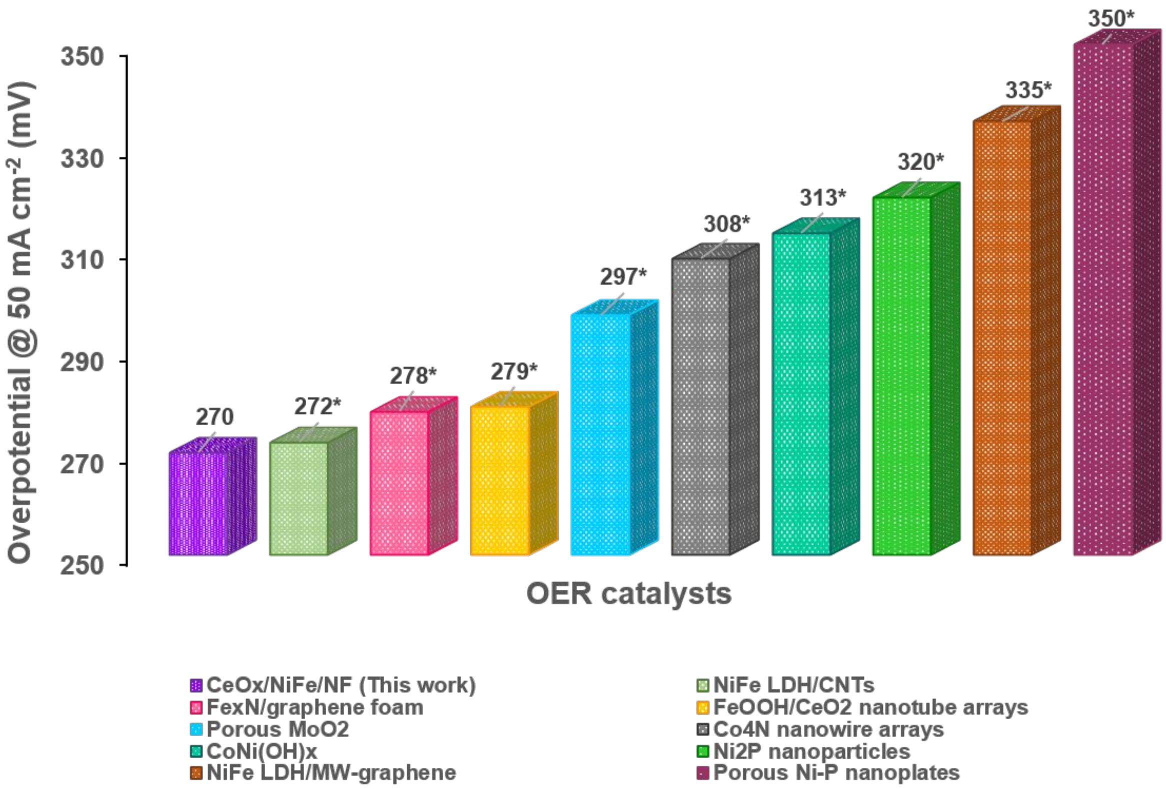

Figure S3. Comparison of the overpotentials at 50 mA cm^{-2} between our as-constructed CeO_x/NiFe-OH/NF and other reported robust OER catalysts in 1 M KOH such as NiFe LDH / CNTs,[1] Fe_xNi/ graphene foam,[2] FeOOH/CeO_2 nanotube arrays,[3] Porous MoO_2,[4] Co_4N nanowire arrays,[5] $CoNi(OH)_x$,[6] Ni_2P nanoparticles,[7] NiFe LDH/MW- graphene,[8] porous Ni-P nanoplates.[9] * The value is calculated from the curves shown in the literature.

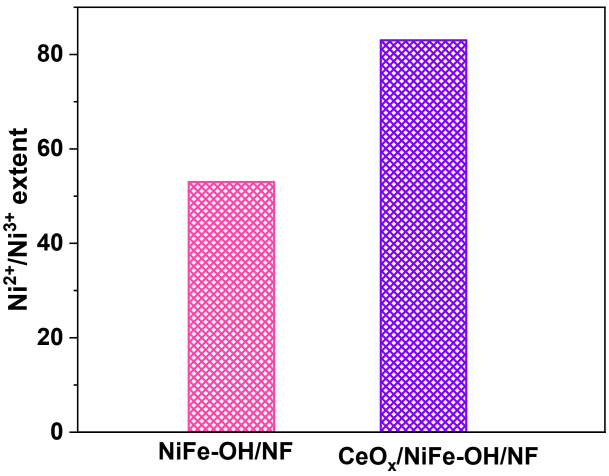

Figure S4. The extent of Ni^{2+}/Ni^{3+} transformation for NiFeOH and CeO_x/NiFe-OH catalyst.

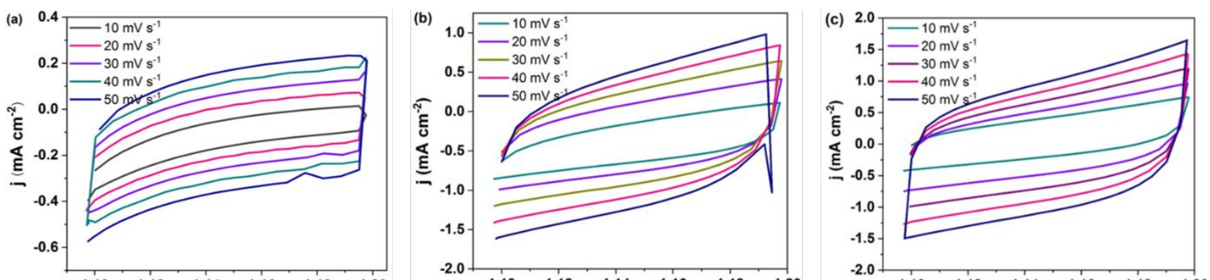

Figure S5. CV curves of (a) CeO_x/NF, (b) NiFe-OH/NF and (c) CeO_x/NiFe-OH/NF in 1.0 M KOH solution.

Turnover frequency (TOF) calculation:

The TOF value was calculated using the following formula as described elsewhere:[10-12]

$$TOF = \frac{J \times A}{4 \times F \times m} \qquad (S1)$$

J corresponds to the current density at the overpotential of 280 mV in A cm^{-2}. A is the surface area of the Ni foam electrode. The number 4 means 4 electrons per mole of oxygen (O_2). F corresponds to the faraday constant (96485 C mol^{-1}), m is the number of moles of the active materials that are deposited onto the NF.

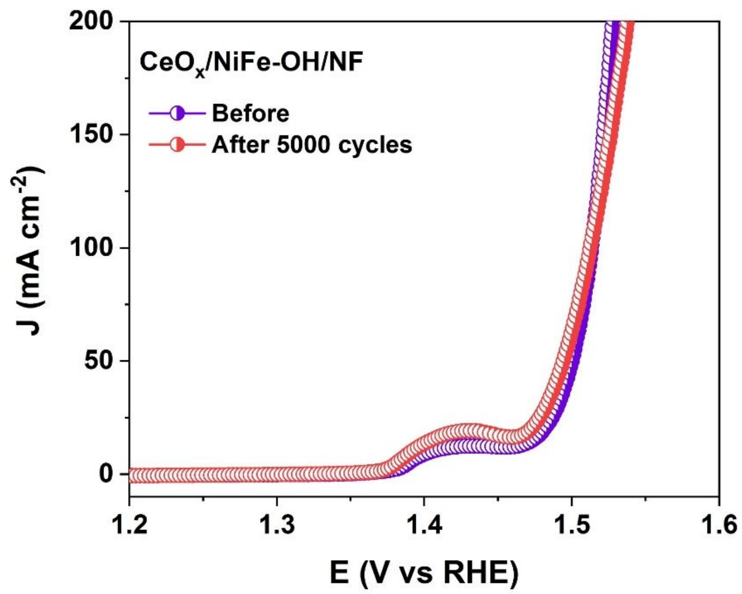

Figure S6 Polarization curves of CeO_x/NiFe-OH catalyst before and after 5000 CVs in 1M KOH (pH ~ 14) solution.

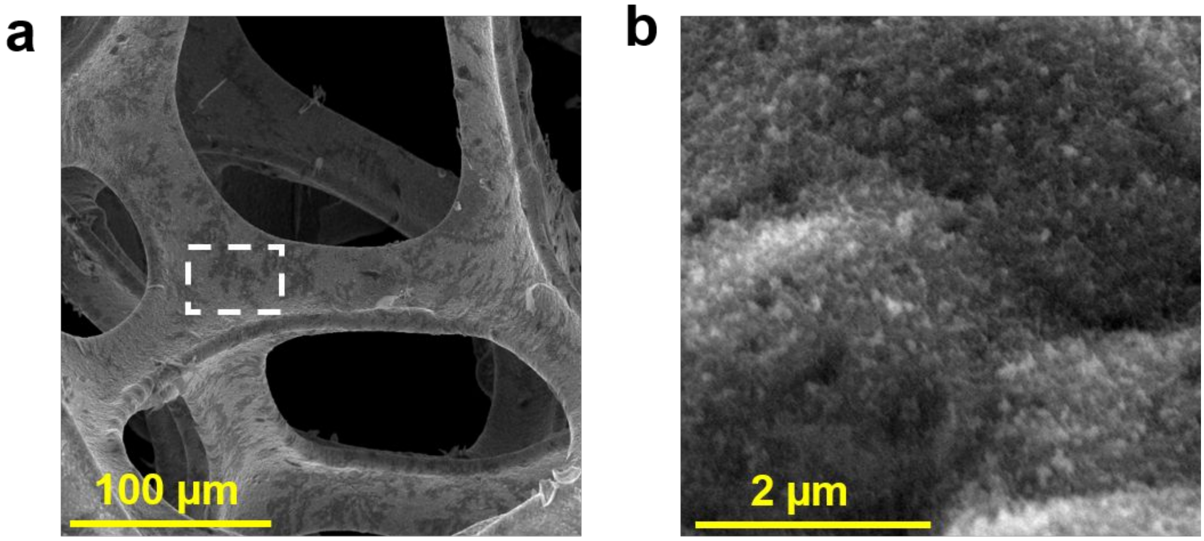

Figure S7. SEM images (after stability) of CeO_x/NiFe-OH/NF with different magnifications

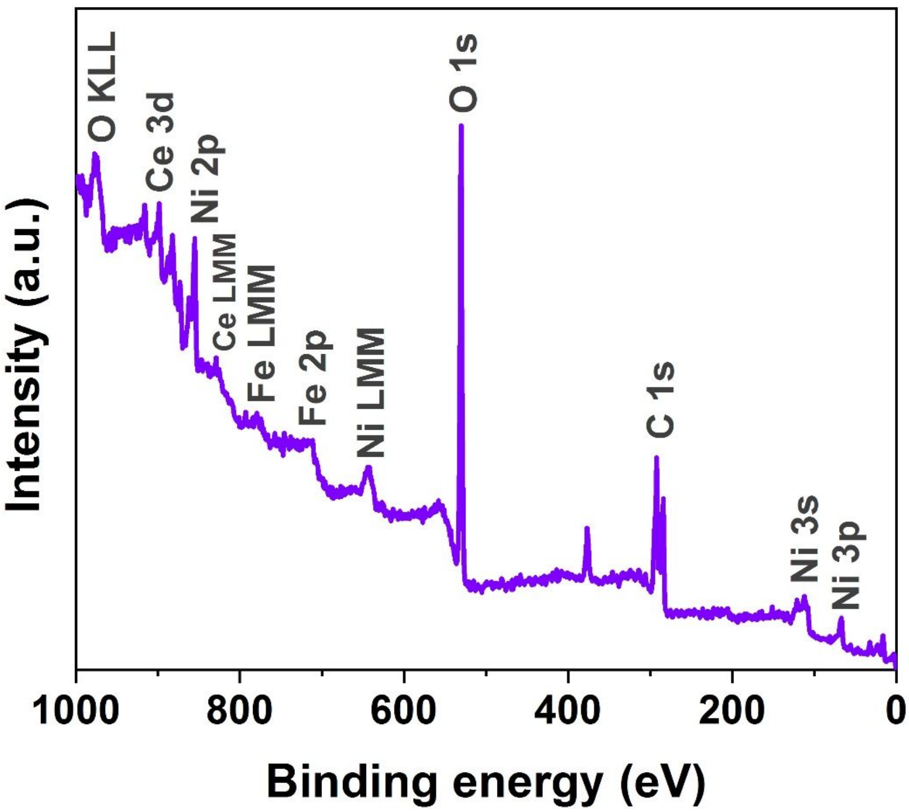

Figure S8. XPS survey spectra of CeO_x/NiFe-OH/NF (after stability test)

Calculation of theoretical volume of oxygen (O_2)

The theoretical volume of oxygen is calculated from the previous reported works:[13]

The total amount of charges passed through the cell (Q) was calculated using Faraday's relation

Q= i.t where i = 4×10^{-3} A and t = 7200 s

Q= 4×10^{-3}A × 7200 s = 28.8 coulomb

Mole of O_2 was calculated as follows:

$$n_{O_2} = \frac{28.8\ C}{4\ X\ 96485\ C.mol^{-1}} = 7.462\ X\ 10^{-5}\ mol \qquad (S2)$$

Theoretical volume of O_2 was calculated using ideal gas law as shown in below:

$$P.V_{O_2} = n_{O_2}.R.T \qquad (S3)$$

Where P = 0.911 atm, n_{O_2} = 7.462 X 10^{-5} mol, T = 298 K, R = 0.082 L.atm.K^{-1}

$V_{O_2} = 2.01\ X\ 10^{-3}\ L$

Table S1. Comparison of the electrocatalytic activity of CeO_x/NiFe-OH/NF electrocatalysts in alkaline medium with some recently reported electrocatalysts

Catalyst	η_j (mV)	j (mA cm^{-2})	Tafel slope (mV/dec)	Reference
CeO_x/NiFe-OH/NF	**249**	**20**	**43.2**	**This work**
	280	**100**		
$NiCeO_x$/NF	295	10	66	ACS Catal. 2019, 9, 1605
V-doped CoNiB/NF	370	100	NA	Adv. Energy Mater. 2019, 9, 1803799
Ni-Fe LDH/NF	295	10	59	Angew.Chem.Int. Ed.2018,57,172
CeO_x/CoS	269	10	50	Angew. Chem. 2018, 130, 8790
Au@$CoFeO_x$	328 ± 3	10	58	Nano Lett. 2017, 17, 6040
NiFe-DH/NF	323	10	77	ACS Energy Lett. 2017, 2, 1035.
Ni_3FeN	280	10	46	Adv. Energy Mater. 2016, 6, 1502585
CeO_2/FeOOH	250	17.6	92.3	Adv. Mater. 2016, 28, 4698
Ni_4Ce_1@CP	220	10	81.9	ACS Nano. 2018, 12, 6245
RuO_2/Ni	290	10	85	ACS Energy Lett. 2017, 2, 1035.
$NiCeO_x$–Au	271	10	NA	Nat. Energy 2016,
NiFe LDH/Ni	256	10	50	Chem. Commun. 2014, 50, 6479.
NiFeP/Ni	270	10	59	ACS Energy Lett. 2017, 2, 1035.
CoFePO/Ni	274	10	51.7	ACS Nano. 2016, 10, 8738.
$Ni_xFe_{3-x}O_4$/Ni	225	10	44	ACS Energy Lett. 2018, 3, 1698.
CoNi(20:1)-P/GC	273	10	45	Energy Environ. Sci. 2017, 10, 893
$Co_{0.85}$Se|CoP/CFP	240	10	46	Part. Part. Syst. Charact. 2018, 1800135
(Ni, Co)$_{0.85}$Se/CC	255	10	79	Adv. Mater. 2016, 28, 77.
NiS → NiO_x/FTO	320	10	NA	ACS Energy Lett. 2016, 1, 195.
IrO_2*	290	10	63	Energy Environ. Sci., 2016,9, 123-129

*1M NaOH electrolyte

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