Role of Ce in enhanced performance of water oxidation reaction and urea oxidation reaction for NiFe Layered Double Hydroxide

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Turnover frequency (TOF) value of catalysts was calculated based on the equation: TOF=($J\times A$)/($4\times F\times$n), where J (mA/cm^2) is the current density; A is the surface area of electrode (1 cm^2); F is the Faraday constant (96485 C/mol); n is molar number of active sites on the electrode. Both Ni, Fe and Ce in NiFe LDH, Ce-NiFe LDH and $Ce(OH)_3$@NiFe LDH are regarded as active sites. The mass activity (MA) is calculated according to the equation: MA= J/m, where J (mA/cm^2) is the current density at overpotential of 300 mV; m is the mass of active sites (Ni, Fe and Ce) deposited onto nickel foam.

Table S1. XPS fitting parameters for the binding energies of the resulting material.

Samples	Binding energy [eV]									
	Ni^{2+}		Ni^{3+}		Fe^{3+}		Ce^{3+}		Ce^{4+}	
	$2p_{3/2}$	$2p_{1/2}$	$2p_{3/2}$	$2p_{1/2}$	$2p_{3/2}$	$2p_{1/2}$	$3d_{5/2}$	$3d_{3/2}$	$3d_{5/2}$	$3d_{3/2}$
$Ce(OH)_3$@NiFe	856.45	873.0	/	/	713.3	724.1	873.6	899.1	875.5	902.5
LDH							879.1	905.0	881.3	907.8
									884.1	917.2
Ce-NiFe LDH	856.4	872.9	/	/	713.6	724.3	873.7	899.2	875.6	902.6
							879.2	905.1	881.4	907.9
									884.2	917.3
NiFe-LDH	856.3	872.8	/	/	714.0	724.5	/	/	/	/

Table S2. XPS fitting parameters for the Ce peak area of the resulting material.

Samples (Ce^{3+}/Ce^{4+} ratio)	Peak area			
	Ce^{3+}		Ce^{4+}	
	$3d_{5/2}$	$3d_{3/2}$	$3d_{5/2}$	$3d_{3/2}$
$Ce(OH)_3$@NiFe	5648	4958	14539	5654
LDH	6622	3790	3843	3248
			2479	4256
Ce-NiFe LDH	8137	2179	13954	15886
	21892	10237	5321	5347
			2742	2395

Table S3. Comparison of OER performances for $Ce(OH)_3$@NiFe LDH/NF with other reported electrocatalysts.

Electrocatalysts	Overpotential	References
$Ce(OH)_3$@NiFe LDH	**220 mV at 10mA cm^{-2}**	**This work**
ZnCo LDH	325 mV at 10mA cm^{-2}	J. Mater. Chem. A, 2020,8, 8692-8699
$NiCo_2S_4$@NiFe LDH	201 mV at 60 mA cm^{-2}	ACS Appl. Mater. Interfaces 2017, 9, 15364−15372
CoO_x/FeO_x/CNT	308 mV at 10 mA cm^{-2}	J. Mater. Chem. A, 2020, 8, 15140–15147
$NiS_2/NiSe_2$ nanocage	290 mV at 20 mA cm^{-2}	Small 2020, 16, 1905083
Co-Fe-V metal oxides	249 mV at 10 mA cm^{-2}	J. Mater. Chem. A, 2020, 8, 15951–15961
P-doped $NiCo_2O_4$	300 mV at 10 mA cm^{-2}	ACS Appl. Mater. Interfaces 2020, 12, 2763−2772
NiS/Fe_3O_4 HNPs@CNT	243 mV at 10 mA cm^{-2}	ACS Appl. Mater. Interfaces 2020, 12, 31552−31563
Fe_3O_4/FeS_2	253 mV at 10 mA cm^{-2}	J. Mater. Chem. A, 2020, 8, 14145–14151
CoMoOS nanoboxes	281 mV at 10 mA cm^{-2}	Appl. Catal. B: Environ. 2020, 265, 118605
$Ni_{59}Cu_{19}P_9$	307 mV at 10 mA cm^{-2}	Appl. Catal. B: Environ. 2018, 237, 409–415
Fe-Ni-P-B-O	236 mV at 10 mA cm^{-2}	ACS Nano 2019, 13, 12969−12979
hollow Fe-Co_xP	300 mV at 10 mA cm^{-2}	Chem. Eng. J. 2021, 409, 128227

Table S4. Comparison of UOR performances for $Ce(OH)_3$@NiFe LDH/NF with other reported electrocatalysts.

Catalyst	Electrolyte	potential	Ref
$Ce(OH)_3$@NiFe LDH	**1 M KOH+0.5 M urea**	**1.40@10**	**This work**
Fe_2P@Ni_xP/NF	1 M KOH+0.5 M urea	1.34@100	Chem. Eng. J., 2021,417, 128067
$Fe_{11.1\%}$-Ni_3S_2/NF	1 M KOH+0.33 M urea	1.36@100	J. Mater. Chem. A, 2018, 6, 4346-4353
Mo-Ni_3S_2	1 M KOH+0.3 M urea	1.37@100	J. Mater. Chem. A, 2021, 9, 3418-3426
V-Ni_3N	1 M KOH+0.5 M urea	1.39@100	J. Mater.Chem. A, 2021, 9, 4159-4166
Ni/FeOOH	1 M KOH+0.5 M urea	1.4@100	Chem. Commun., 2020, 56 ,14713-14716
Ni-S-Se/NF	1 M KOH+0.5 M urea	1.41@100	Nano Energy, 2021,81, 105605
CoS_x/Co-MOF	1 M KOH+0.5 M urea	1.42@100	Inorg. Chem. Front., 2020,7, 2602-2610
MNPBA-P	1 M KOH+0.5 M urea	1.43@100	ACS Sus. Chem. Eng., 2020,8, 16037-16045
Co-Z/Se-2	1 M KOH+0.5 M urea	1.44@100	J. Power Sources 2021,491, 229592

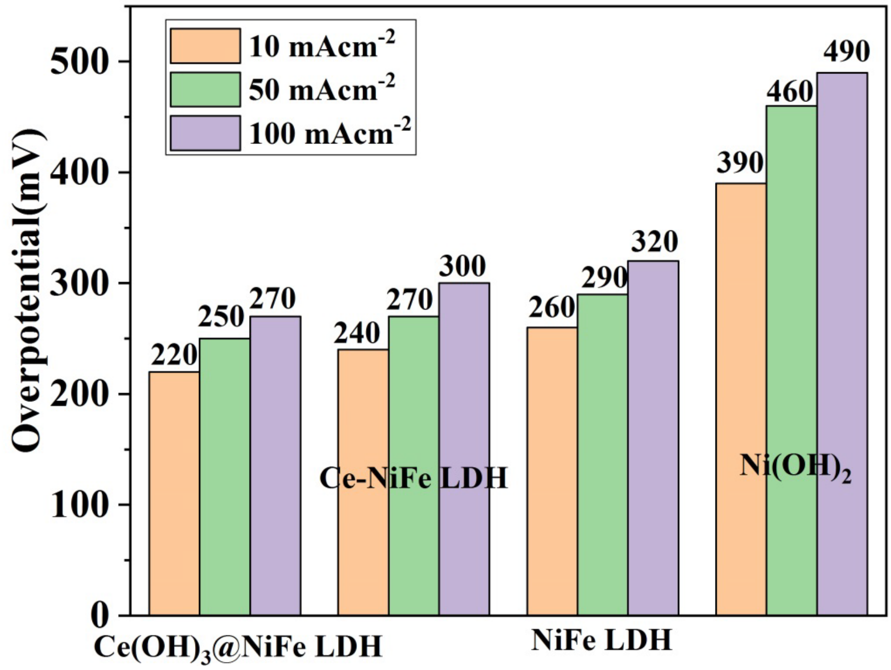

Fig. S1 The overpotential of $Ni(OH)_2$/NF, NiFe LDH/NF, Ce-NiFe LDH/NF and $Ce(OH)_3$@NiFe LDH/NF at 100 mA cm^{-2} for OER.

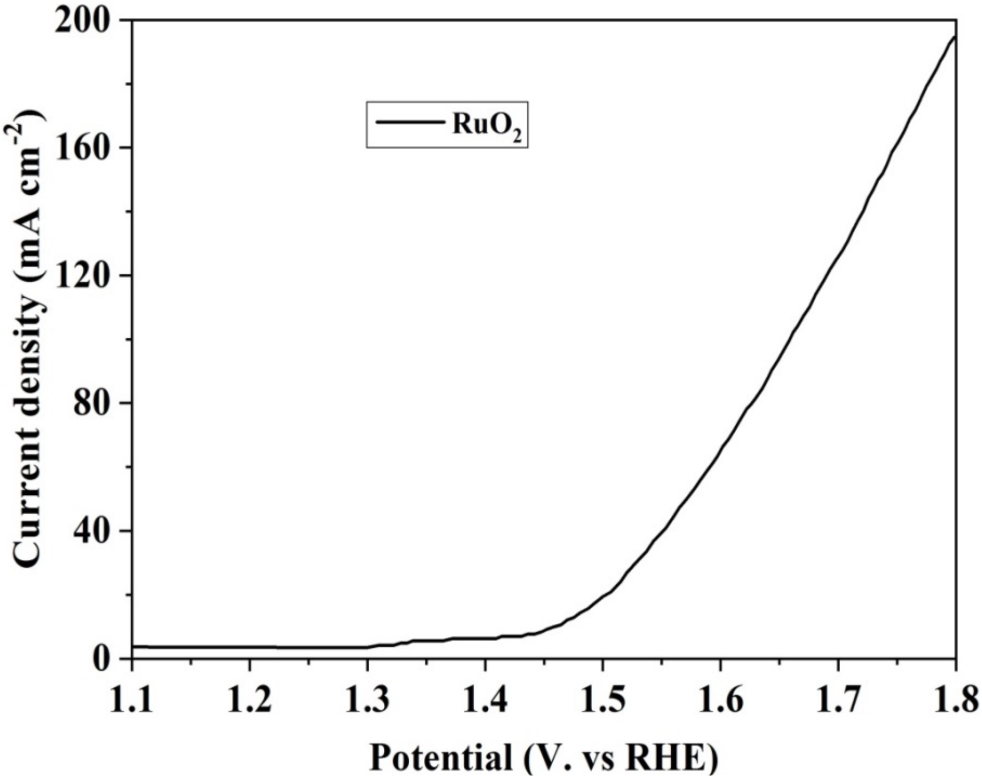

Fig. S2 Polarization curve of the RuO_2 for OER with a scan rate of 5 mV s^{-1} in 1 M KOH.

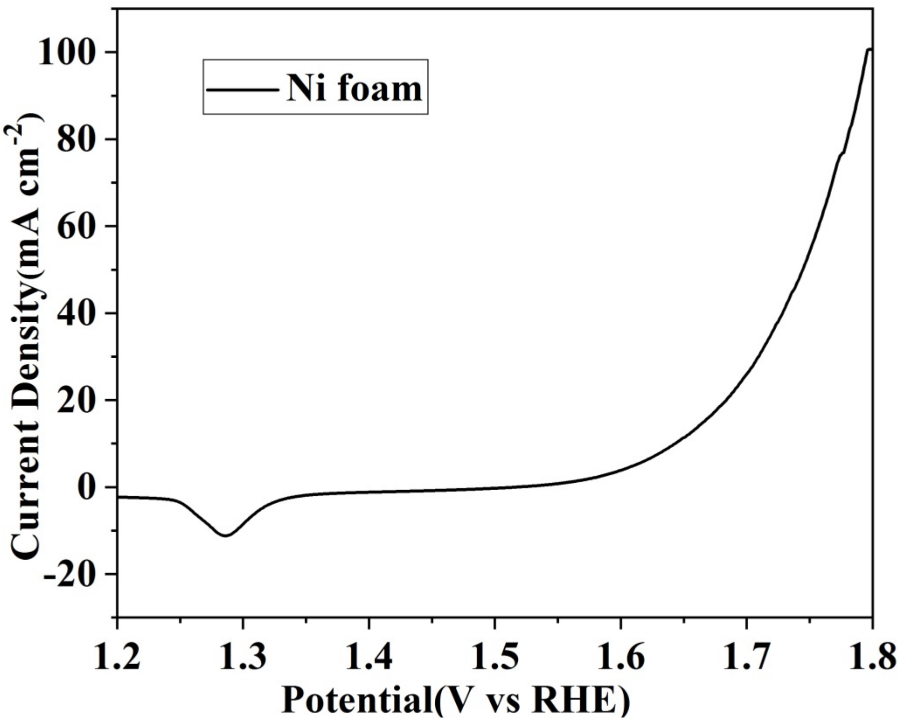

Fig. S3 Polarization curve of the Ni foam for OER with a scan rate of 5 mV s^{-1} in 1 M KOH.

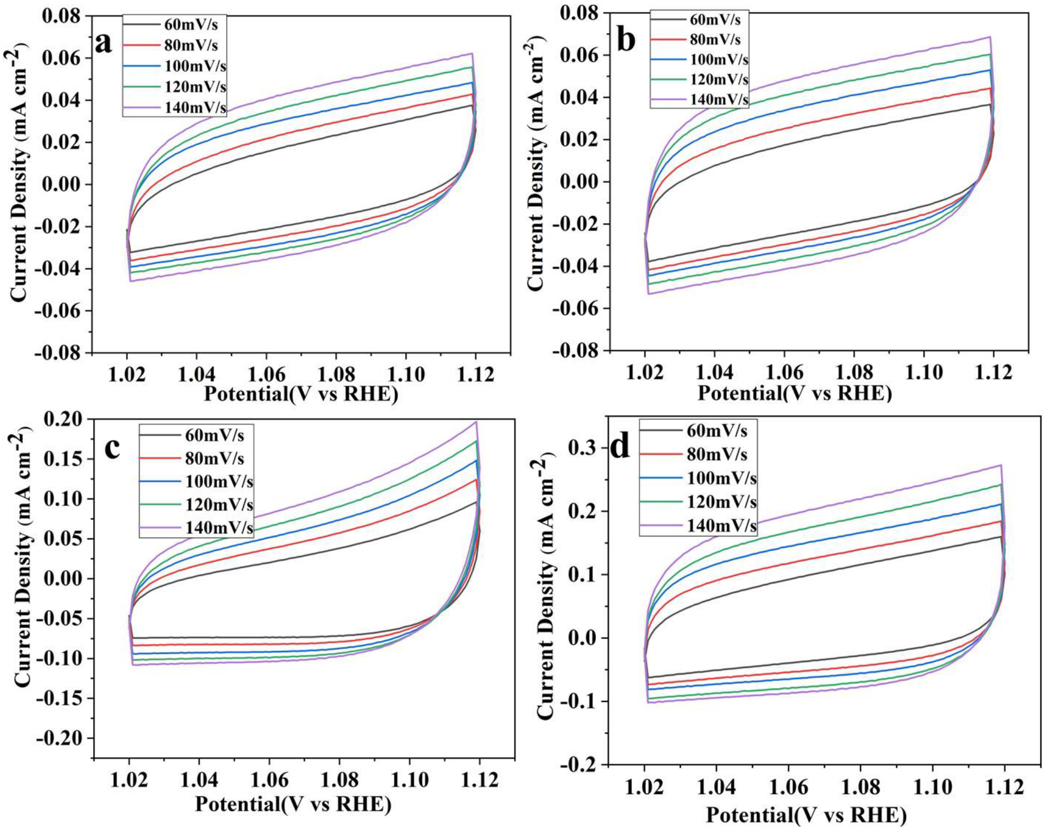

Fig. S4 CV curves with different scan rates for OER, $Ni(OH)_2$/NF (a), NiFe LDH/NF (b), Ce-NiFe LDH/NF (c) and $Ce(OH)_3$@NiFe LDH/NF (d).

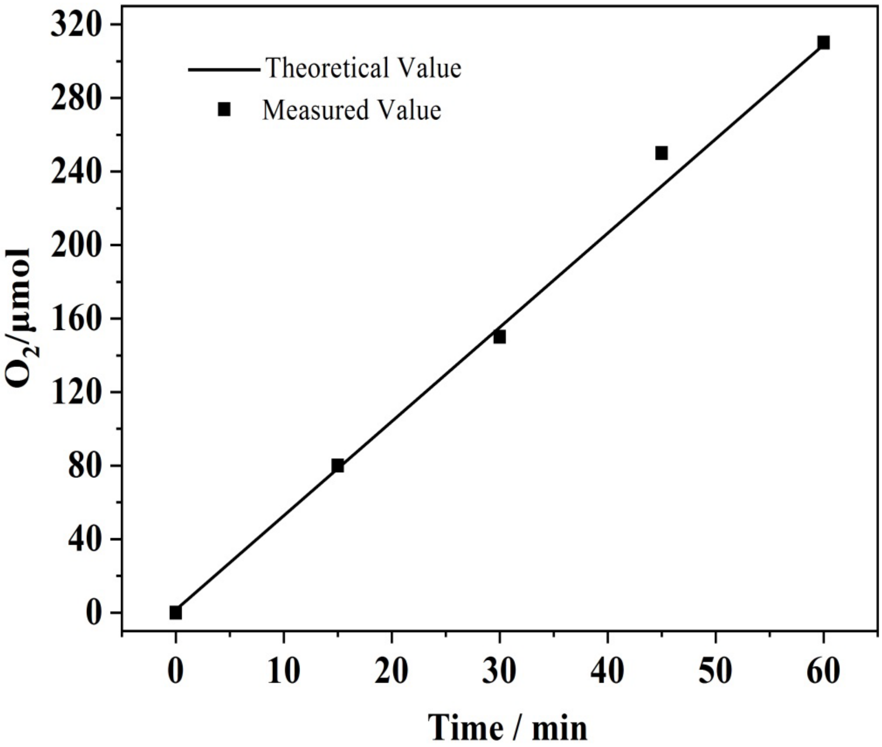

Fig. S5 Electrocatalytic efficiency of O_2 production over $Ce(OH)_3$@NiFe LDH/NF.

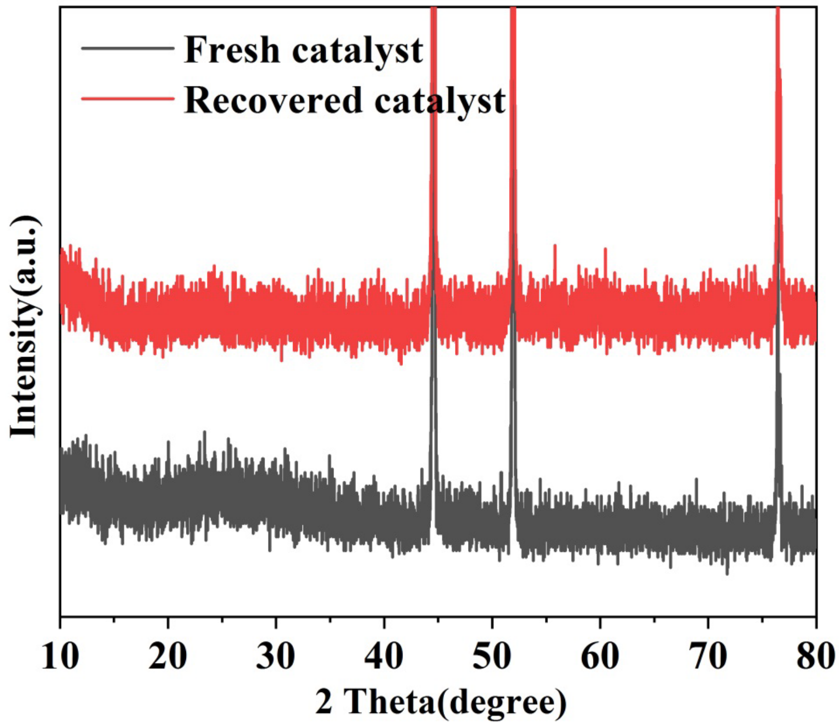

Fig. S6 XRD of fresh (a) and recovered (b) $Ce(OH)_3$@NiFe LDH/NF for OER.

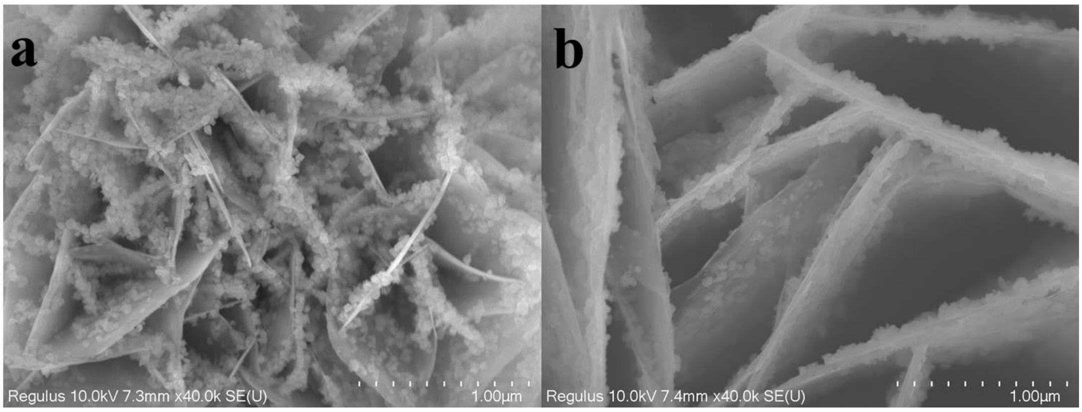

Fig. S7 SEM of fresh (a) and recovered (b) $Ce(OH)_3$@NiFe LDH/NF for OER.

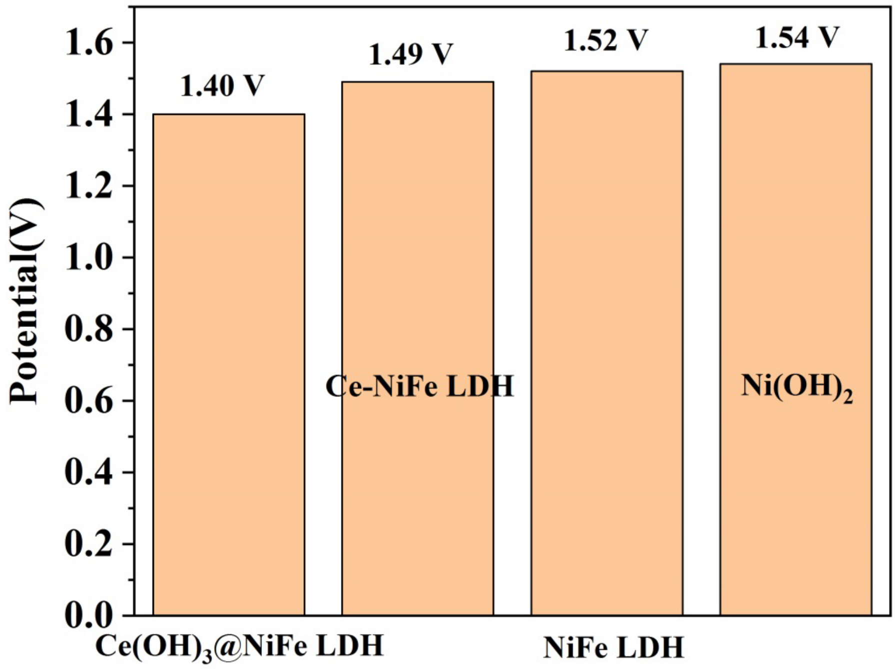

Fig. S8 The potential of $Ni(OH)_2$/NF, NiFe LDH/NF, Ce-NiFe LDH/NF and $Ce(OH)_3$@NiFe LDH/NF at 10 mA cm^{-2} for UOR.

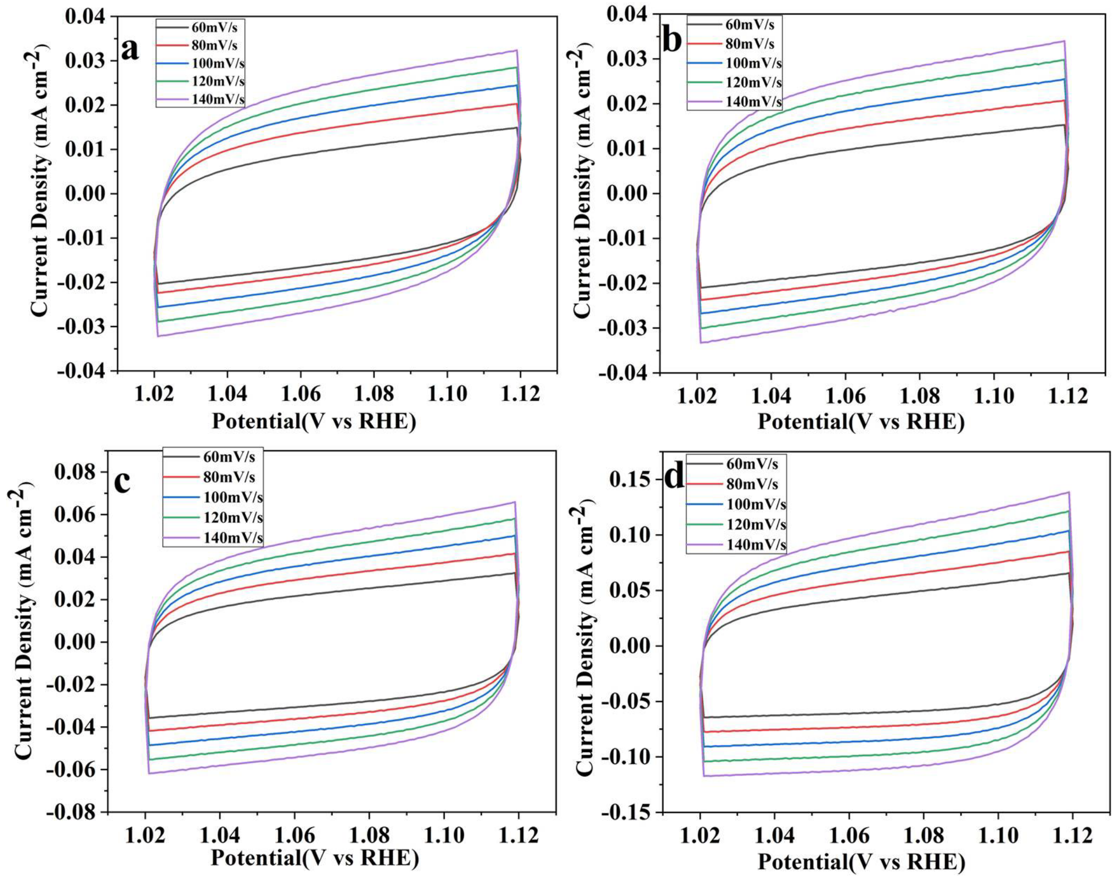

Fig. S9 CV curves with different scan rates for OER, $Ni(OH)_2$/NF (a), NiFe LDH/NF (b), Ce-NiFe LDH/NF (c) and $Ce(OH)_3$@NiFe LDH/NF (d).

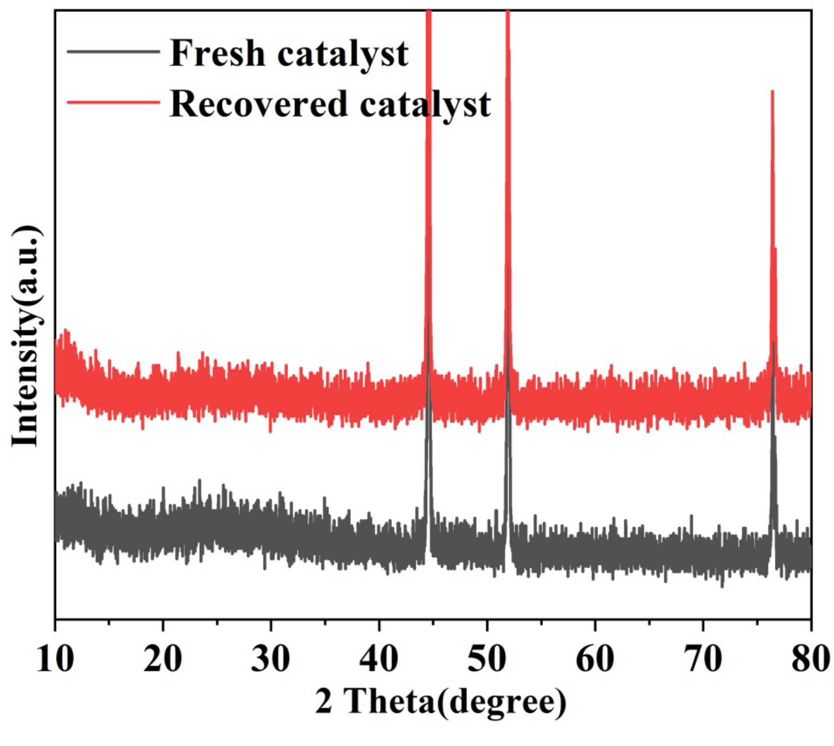

Fig. S10 XRD of fresh (a) and recovered (b) $Ce(OH)_3$@NiFe LDH/NF for UOR.

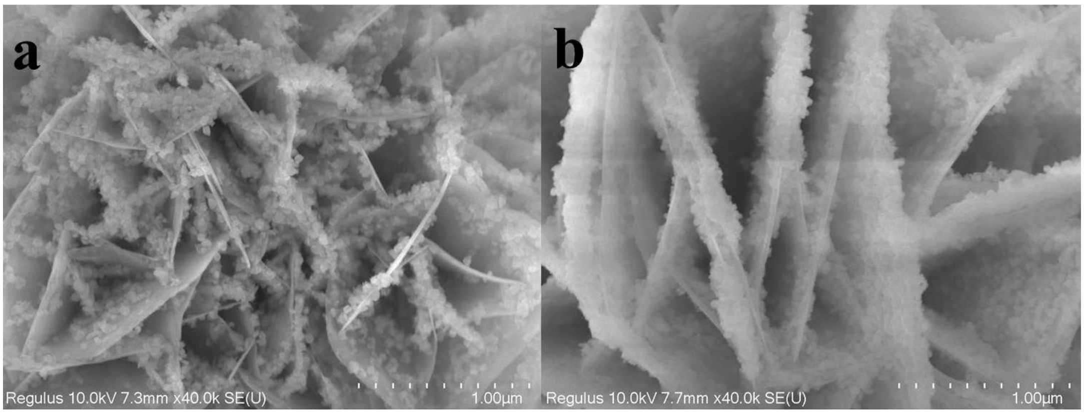

Fig. S11 SEM of fresh (a) and recovered (b) $Ce(OH)_3$@NiFe LDH/NF for UOR.