Ce-doped NiFe-LDH electrocatalysts for oxygen evolution reaction

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Why do we need hydrogen?

Energy source	Energy density (MJ/kg)
Li-ion battery	0.54
Gasoline	46.90
Hydrogen	120.00

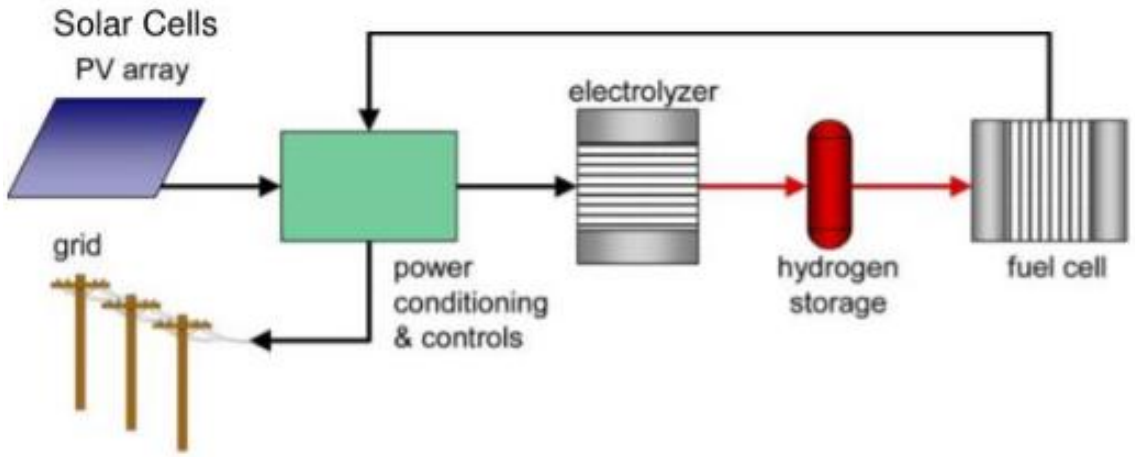
~ 220 times more energy density than batteries
~ 54 times more energy density than gasoline

Department of Energy target

$2/kg H_2 by 2025

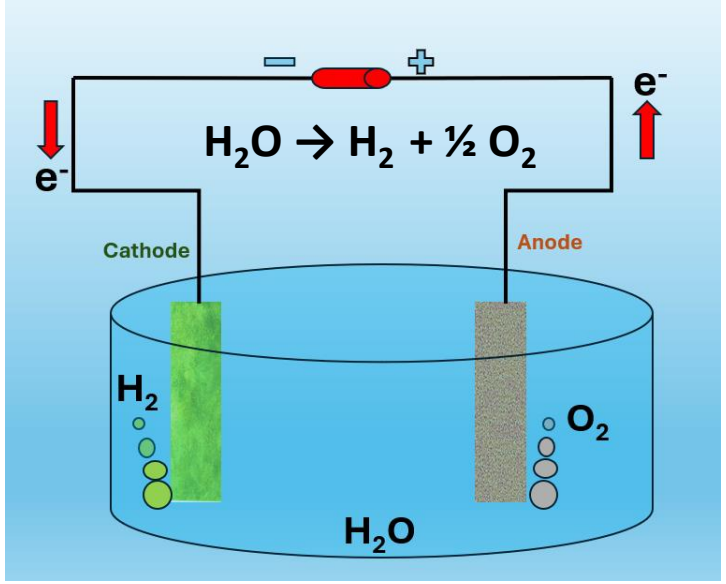
$1/kg H_2 by 2030

Global energy demand: $4x10^{20}$ J/year
H_2 from water: 1 GJ per 90 liters H_2O
Water needed: $3.6x10^{13}$ liters
Oceans: $1.45x10^{21}$ liters
Annual rainfall: $3.62x10^{17}$ liters



https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html

How to produce green H_2?



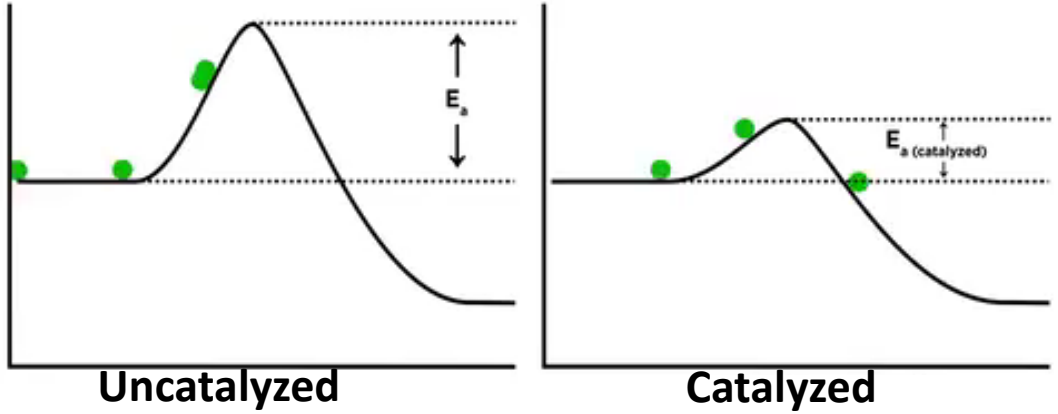
Cathode : $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$

Anode : $4OH^- \rightarrow O_2 + 2H_2O + 4e^-$

Group→	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
↓Period																		
1	1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	57 La	* 72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	89 Ac	** 104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og

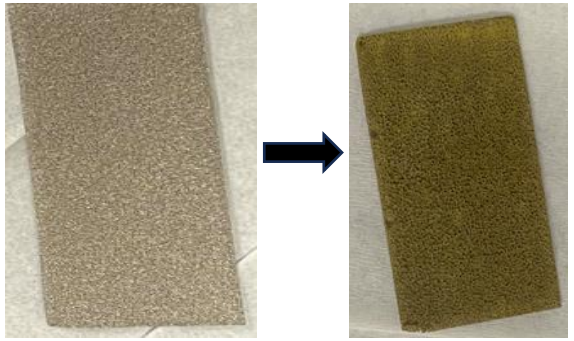
*	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
**	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

periodic table - Search Images (bing.com)



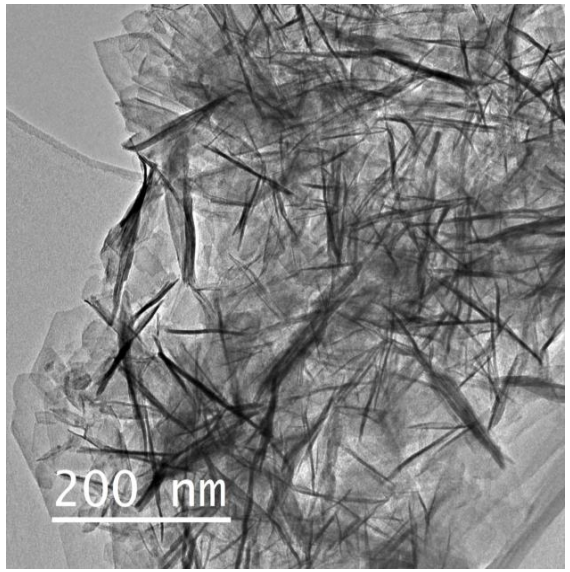
Energy Diagrams, Catalysts, and Reaction Mechanisms on Make a GIF

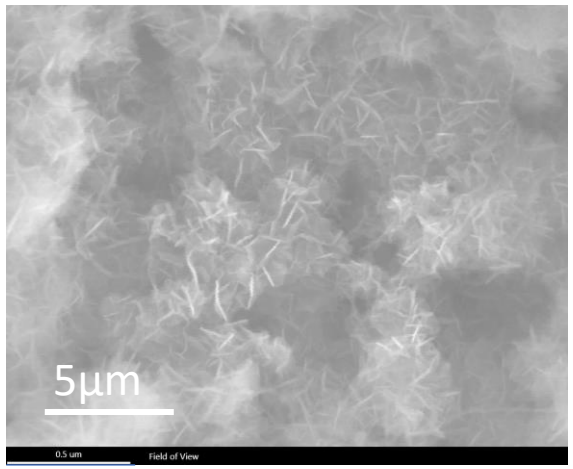
Ni foam

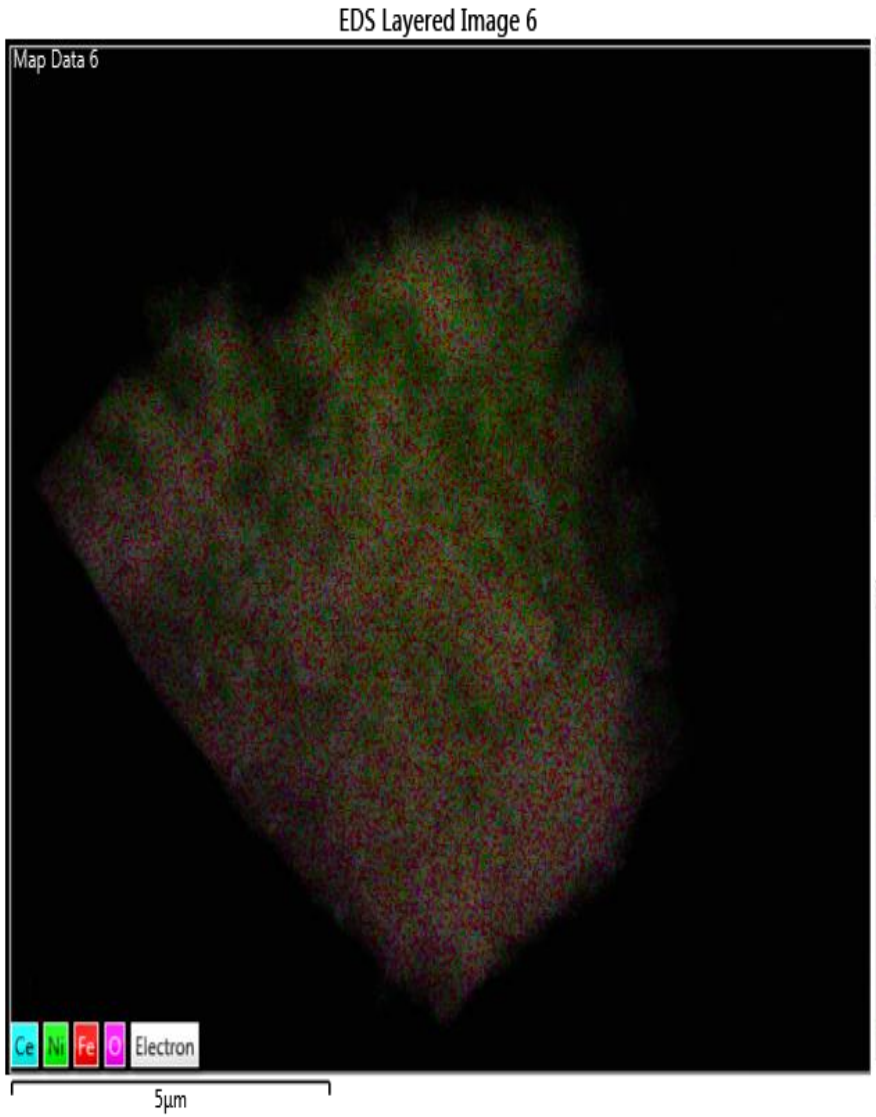


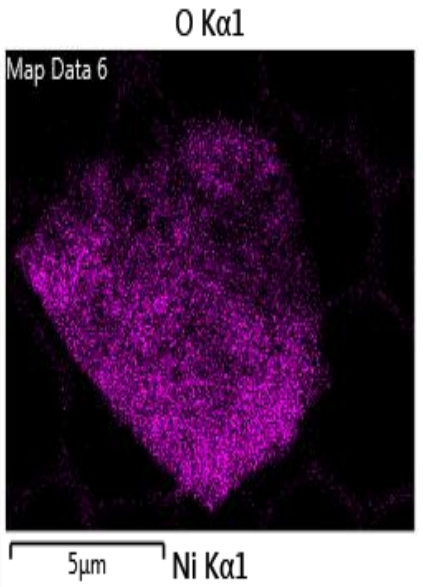
Ni foam + catalyst layer

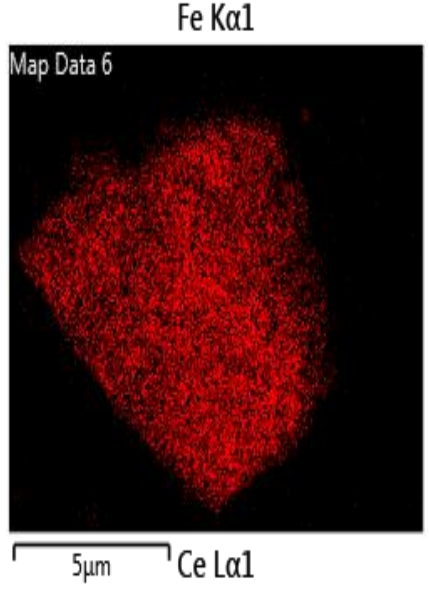
What does our electrocatalyst look like?

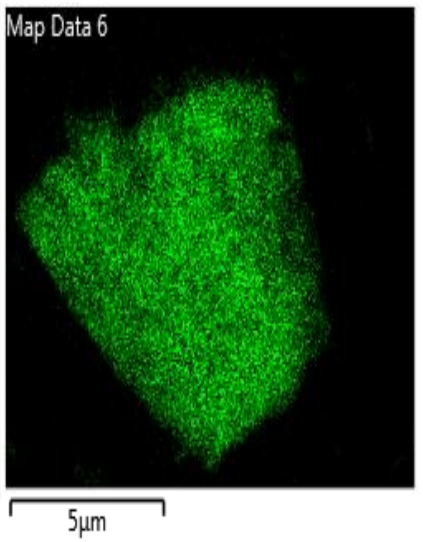


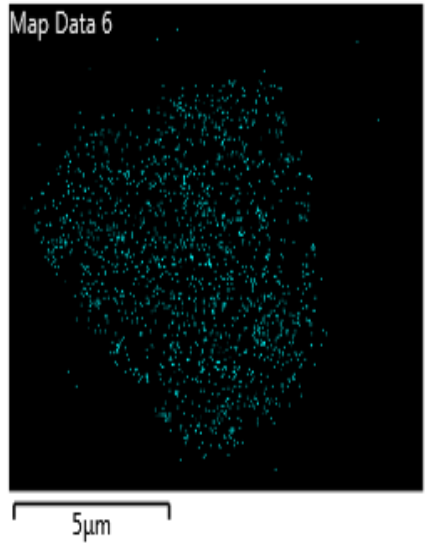




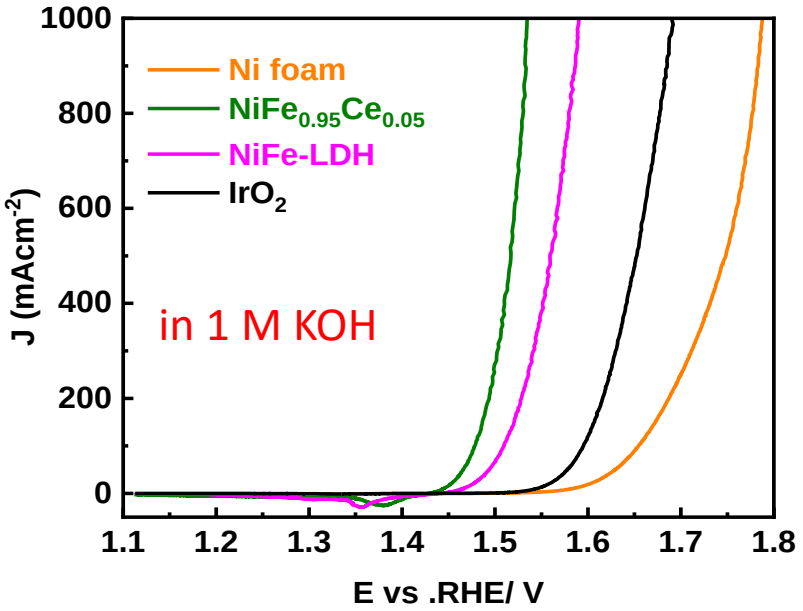


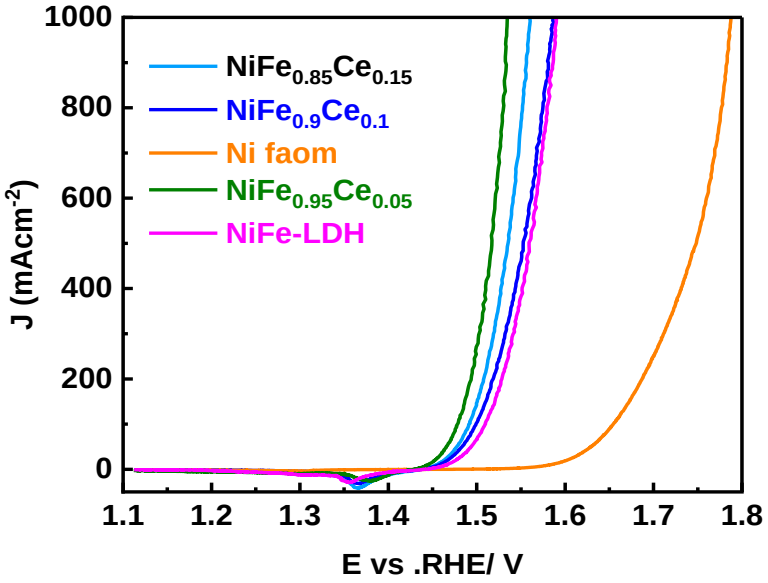


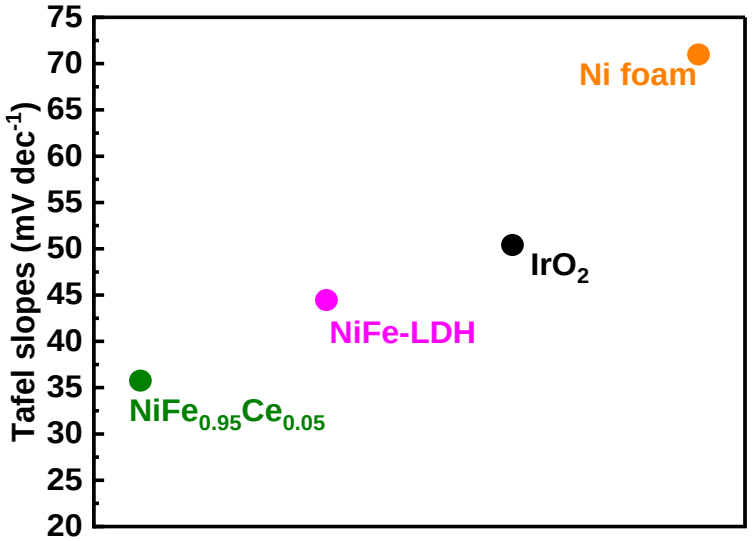


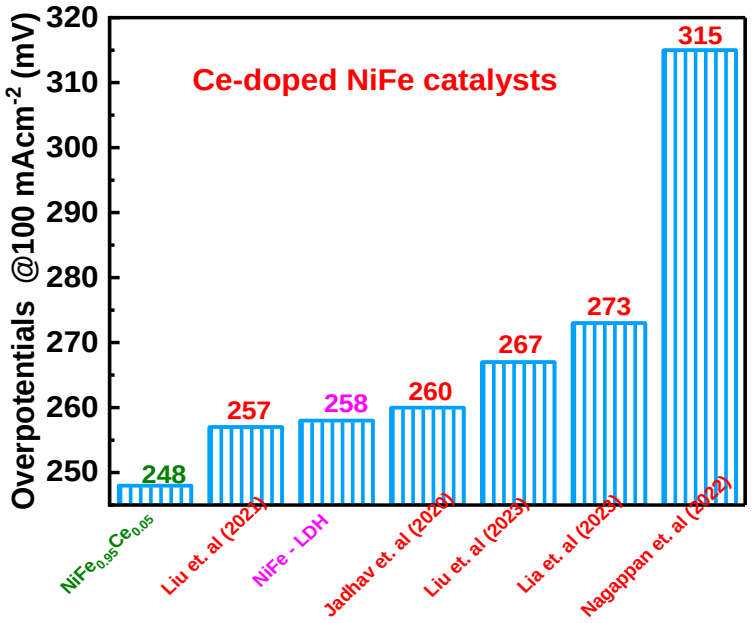


How does the electrocatalyst perform?

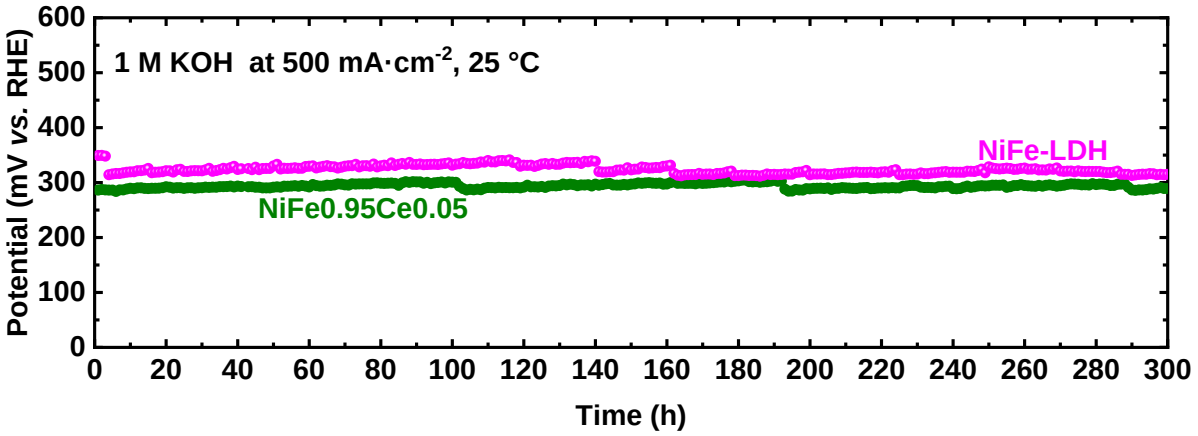


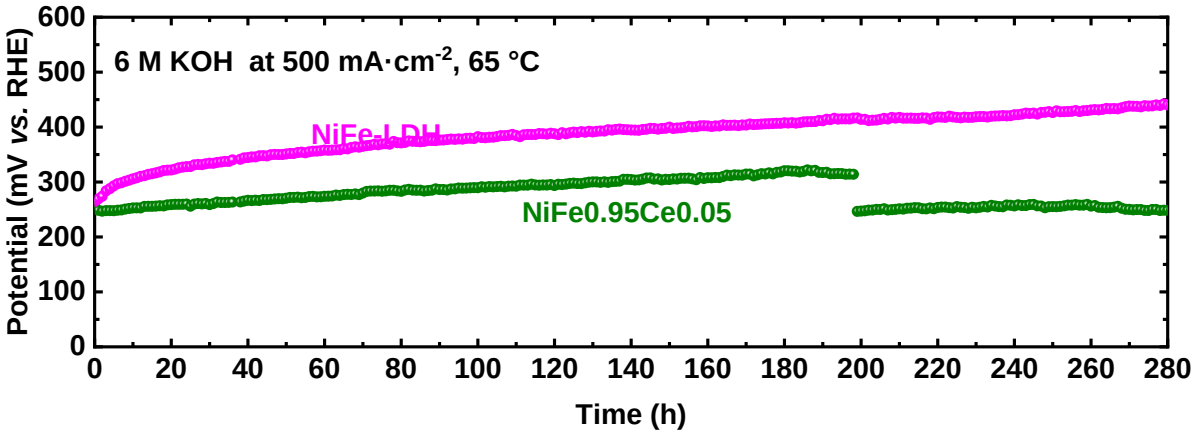


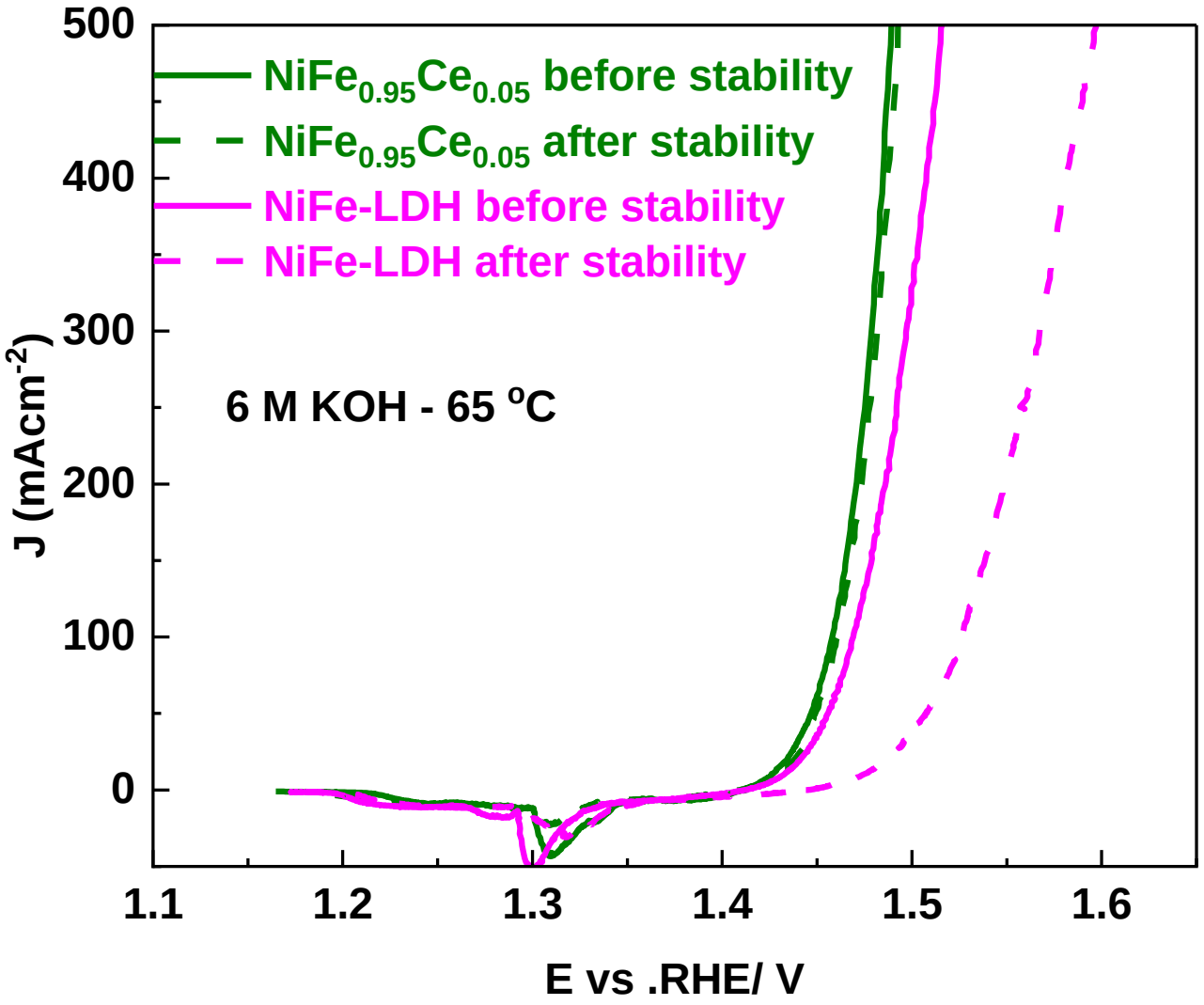




Is our electrocatalyst stable?

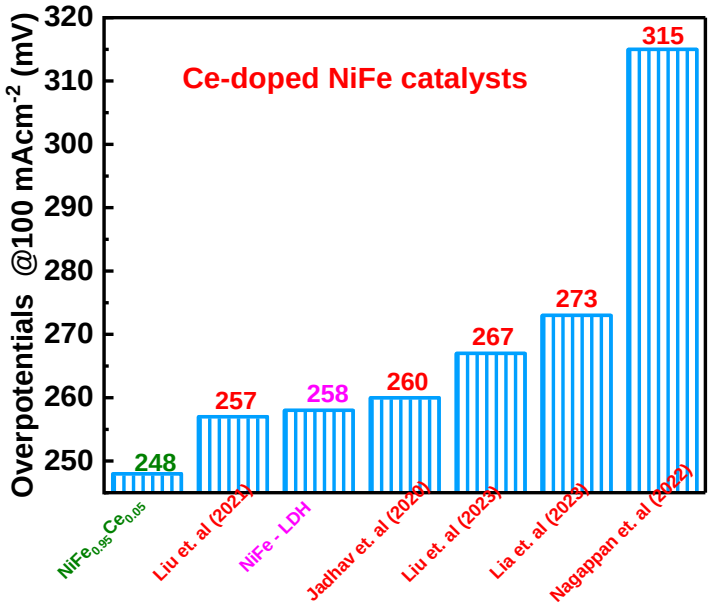


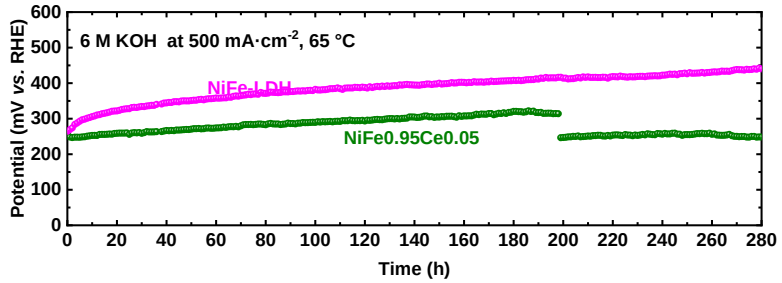




Conclusion


H2

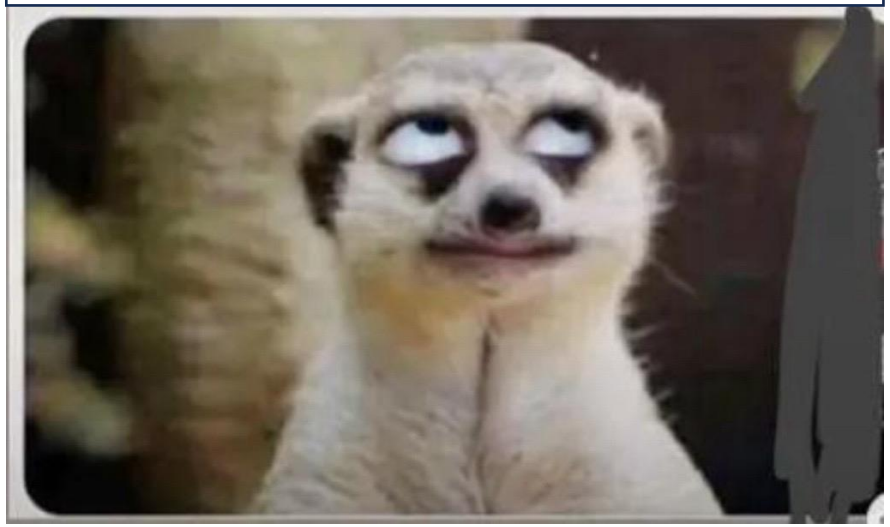

Ce-doped NiFe catalysts
Overpotentials @100 mAcm-2 (mV)
320
310
300
290
280
270
260
250
248
257
258
260
267
273
315
NiFe0.95Ce0.05
Liu et. al (2021)
NiFe - LDH
Jadhav et. al (2023)
Liu et. al (2023)
Lia et. al (2023)
Nagappan et. al (2022)


6 M KOH at 500 mA·cm-2, 65 °C
NiFe-LDH
NiFe0.95Ce0.05
Potential (mV vs. RHE)
600
500
400
300
200
100
0
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
Time (h)

Acknowledgement

1. Mr. Yu Wang
2. Ms. FNU Vidhi
3. Mr. Haroon Muhammad Khan
4. Mr. Minghui Ning
5. Dr. Song Shawei
6. Dr. Dezhi Wang
7. Prof. Zhifeng Ren

Sometimes I shake my head to see if I still have my brain because you in Physics anything can happen

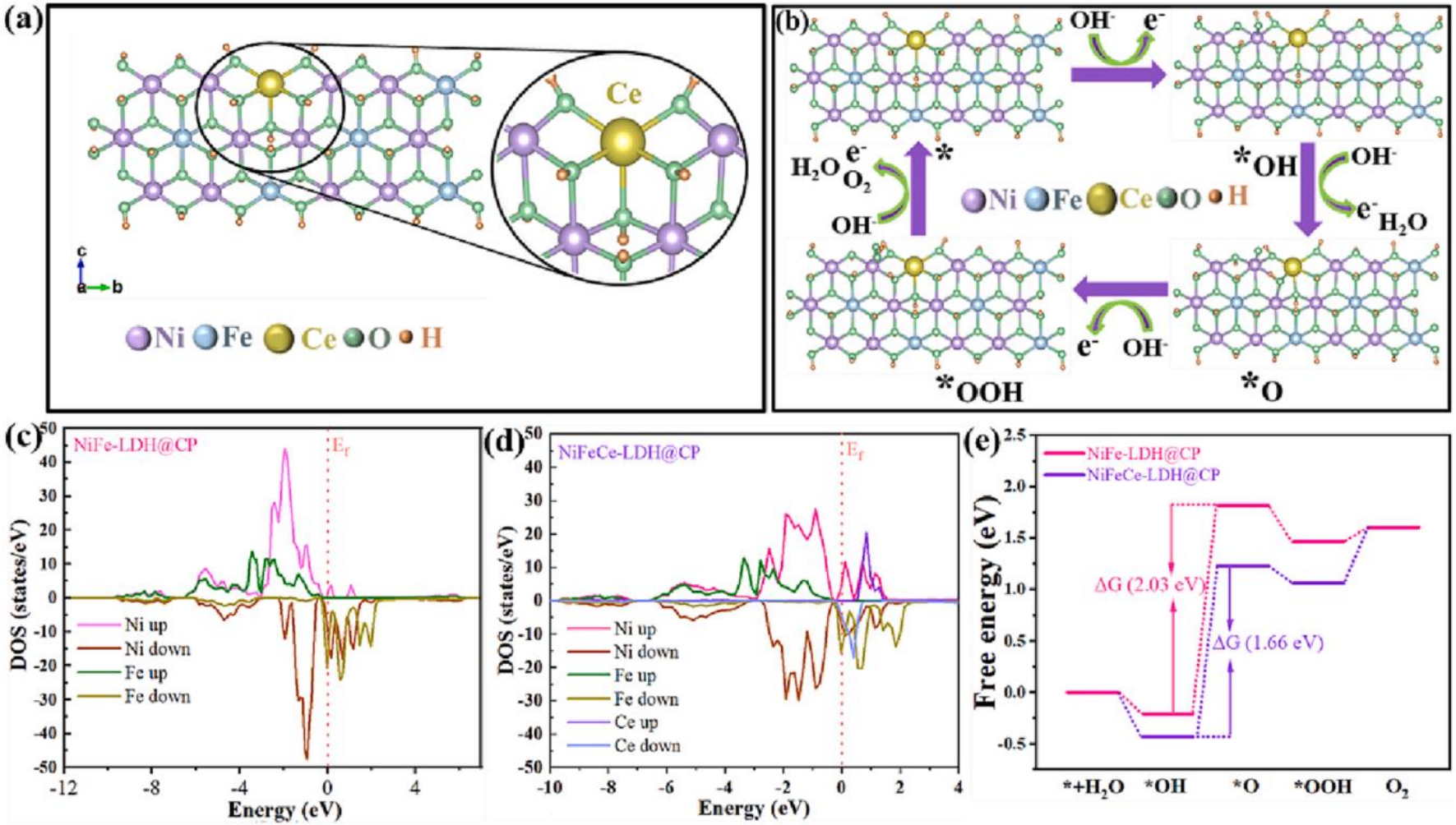


My meme of the year so far…

Thank you

Additional slides

Effect of Ce doping



Liao, Yuanyuan, et al. (2023)

Challenges

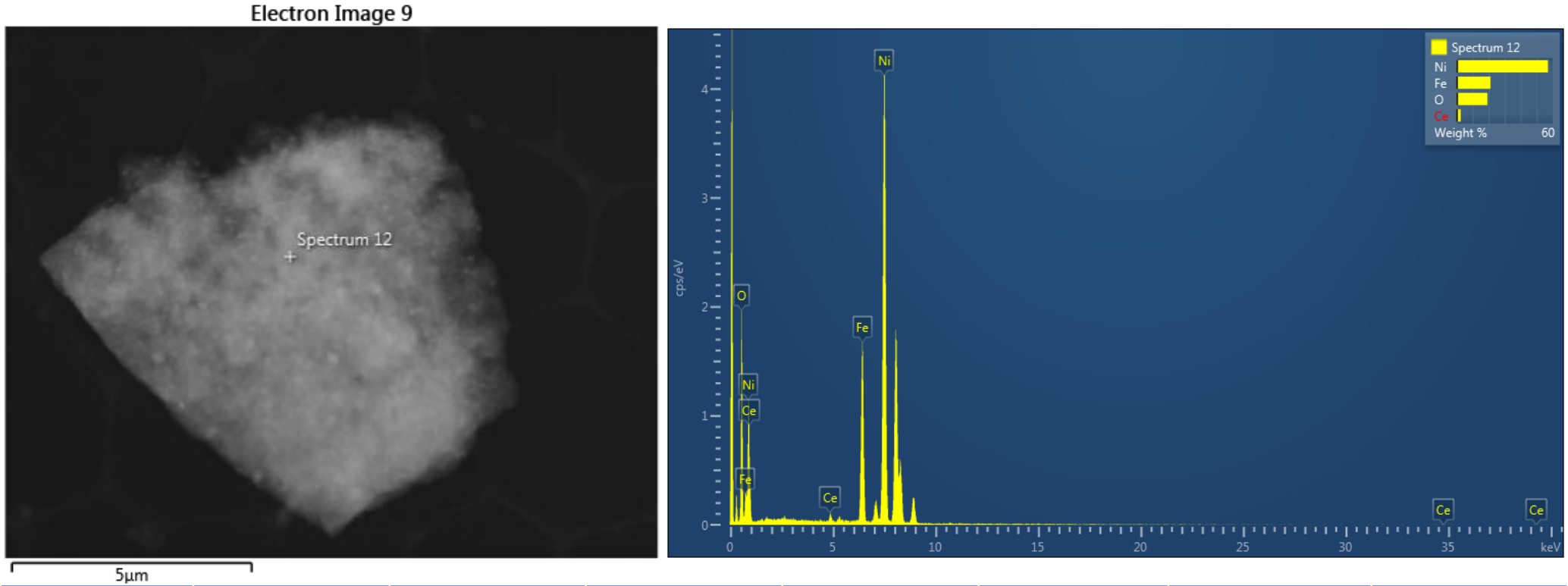
Pure Ni foam

Ce doped layer with NH_4F
Difficult to synthesize.
Poor performance

Ce doped layer without NH_4F
Synthesis possible
Poor perfprmance

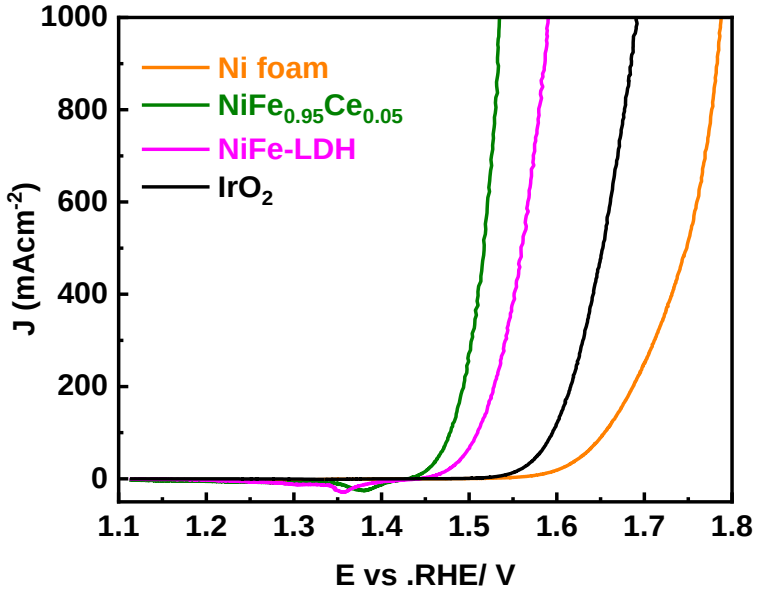
Ce doped layer with NH_4Cl
Synthesis possible
Good perfprmance

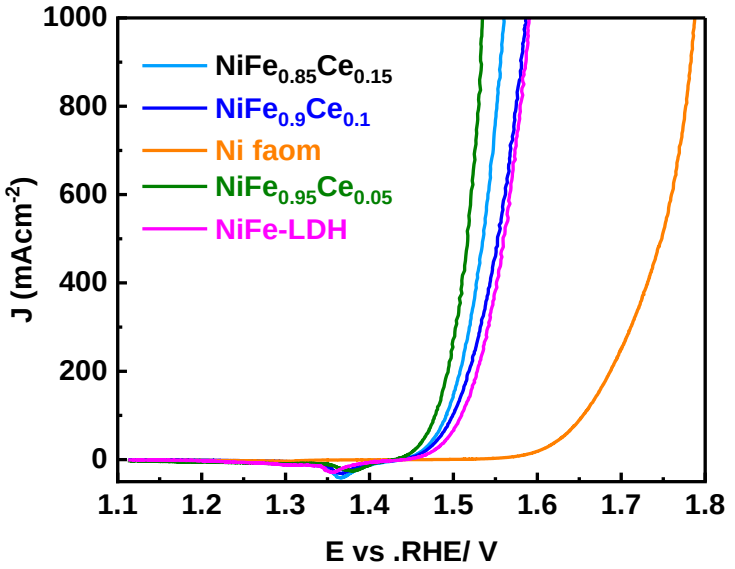
Composition analysis

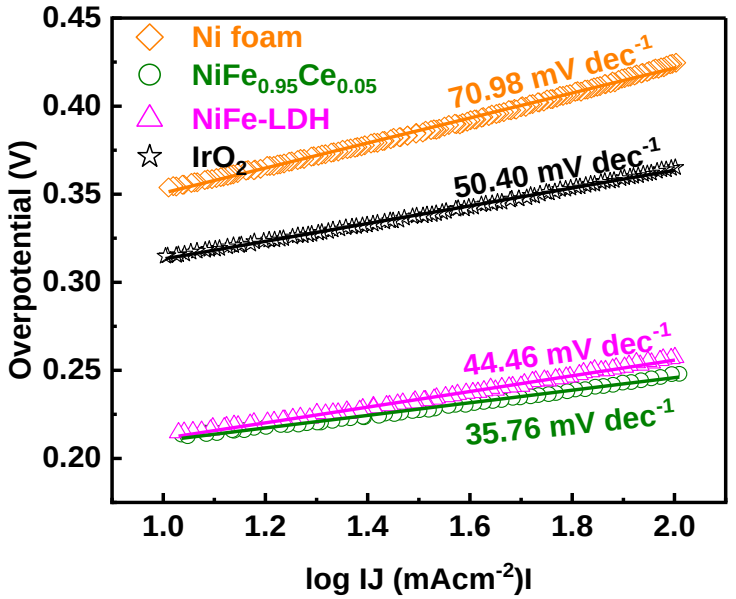


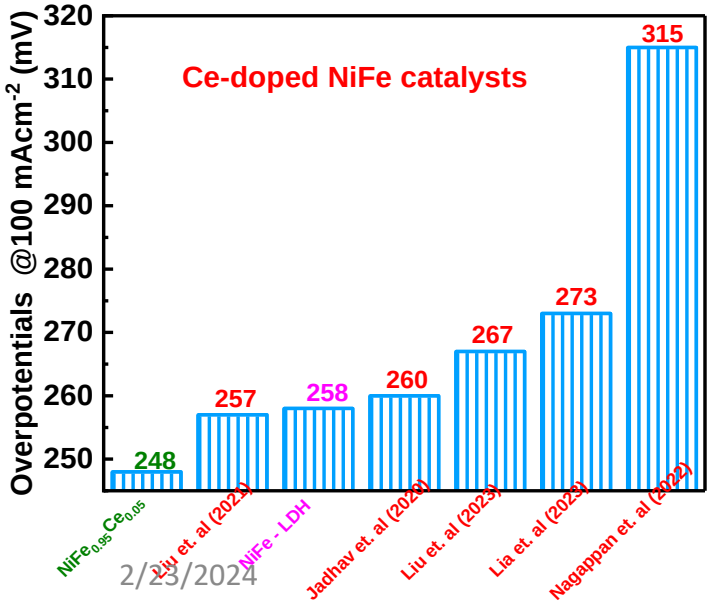
Element	Line Type	k Factor	k Factor type	Absorption Correction	Wt%	Wt% Sigma	Atomic %
O	K series	1.032	Theoretical	1.00	19.28	0.36	46.82
Fe	K series	0.602	Theoretical	1.00	21.15	0.29	14.72
Ni	K series	0.621	Theoretical	1.00	57.07	0.40	37.77
Ce	L series	1.059	Theoretical	1.00	2.51	0.26	0.70
Total:					100.00		100.00

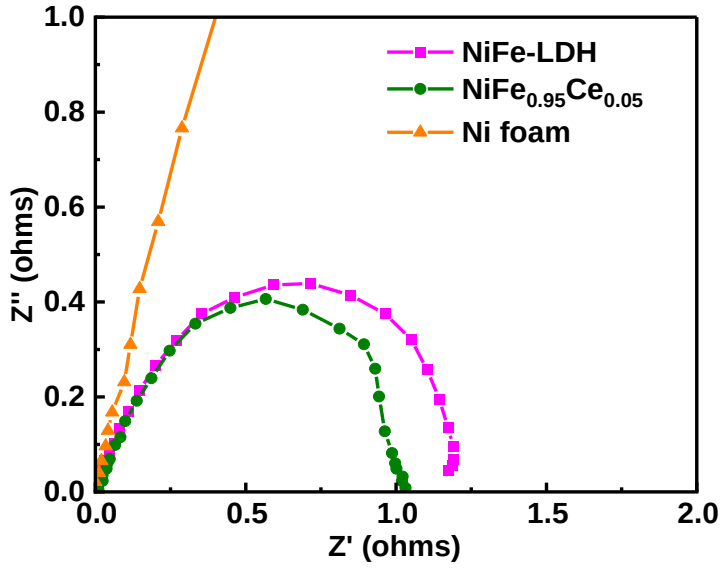
Performance results of our catalysts

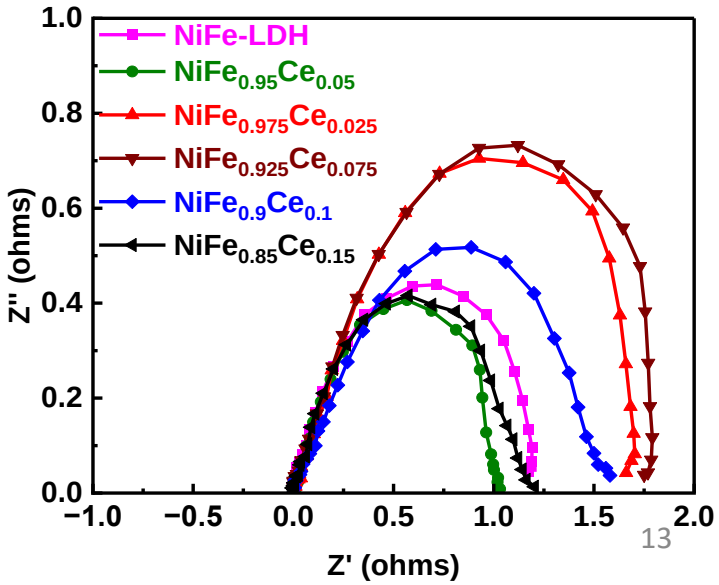


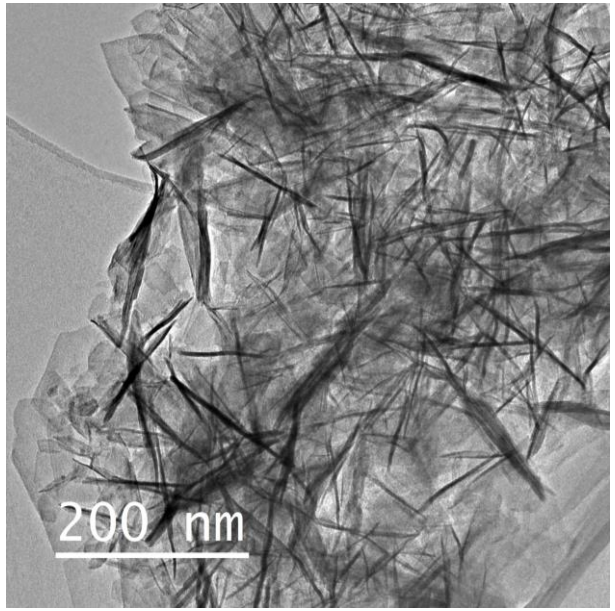


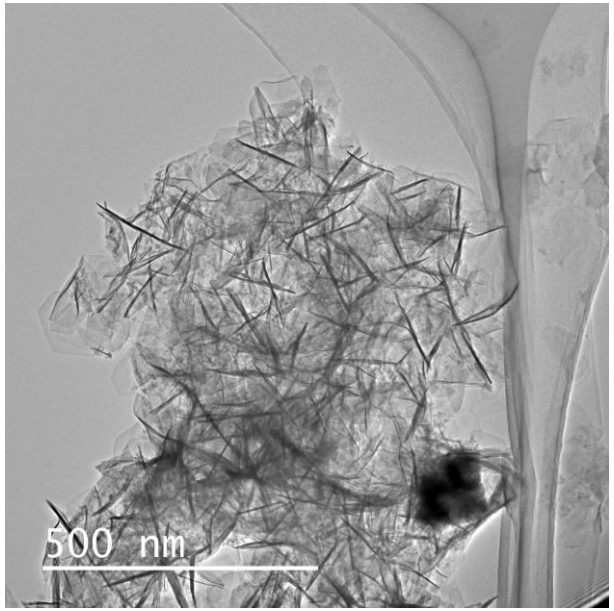


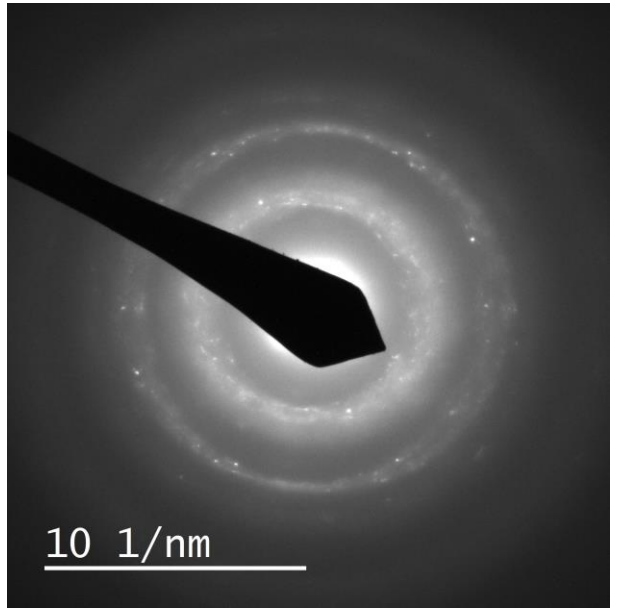




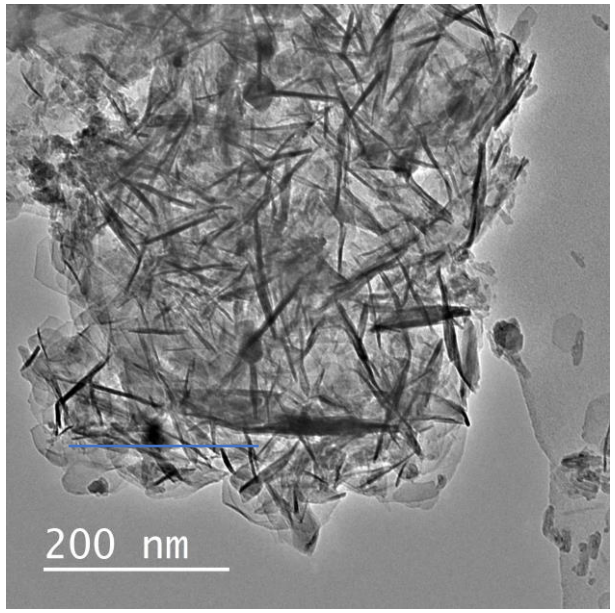


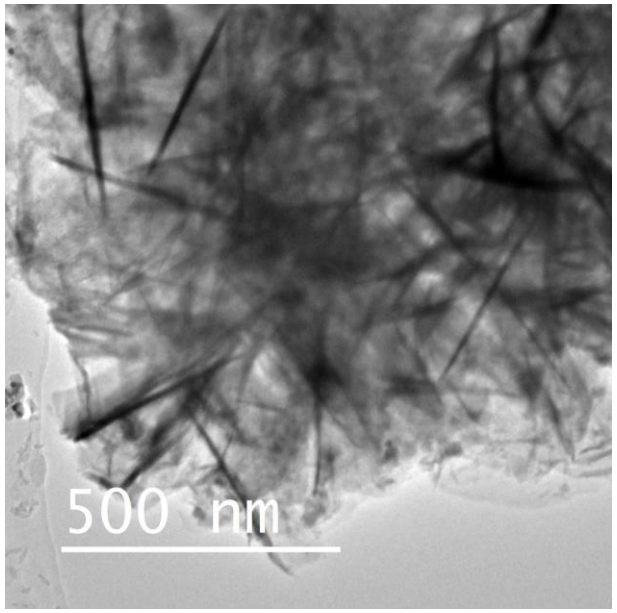


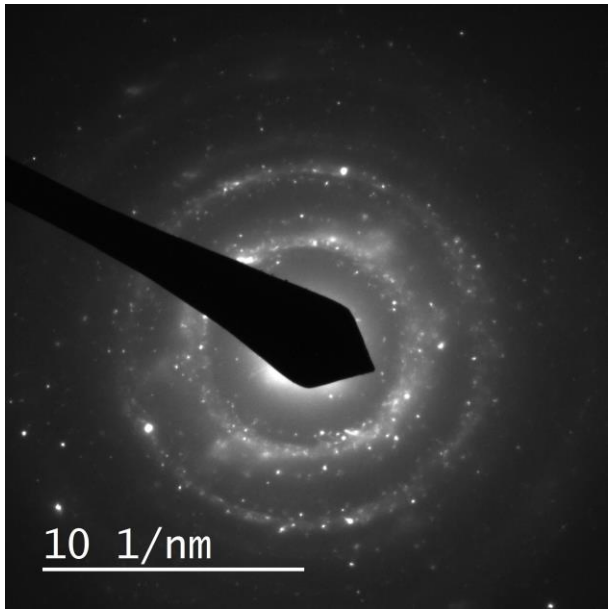




NiFe0.95Ce0.05







NiFe-LDH