Electronic Supplementary Material (ESI) for Materials Chemistry Frontiers.

Supplemental Information For:

Designing Binary Electrocatalysts for Hydrogen Evolution in Saline Electrolyte Using Rapid Synthesis on Carbon Paper Supports

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Supporting Figures

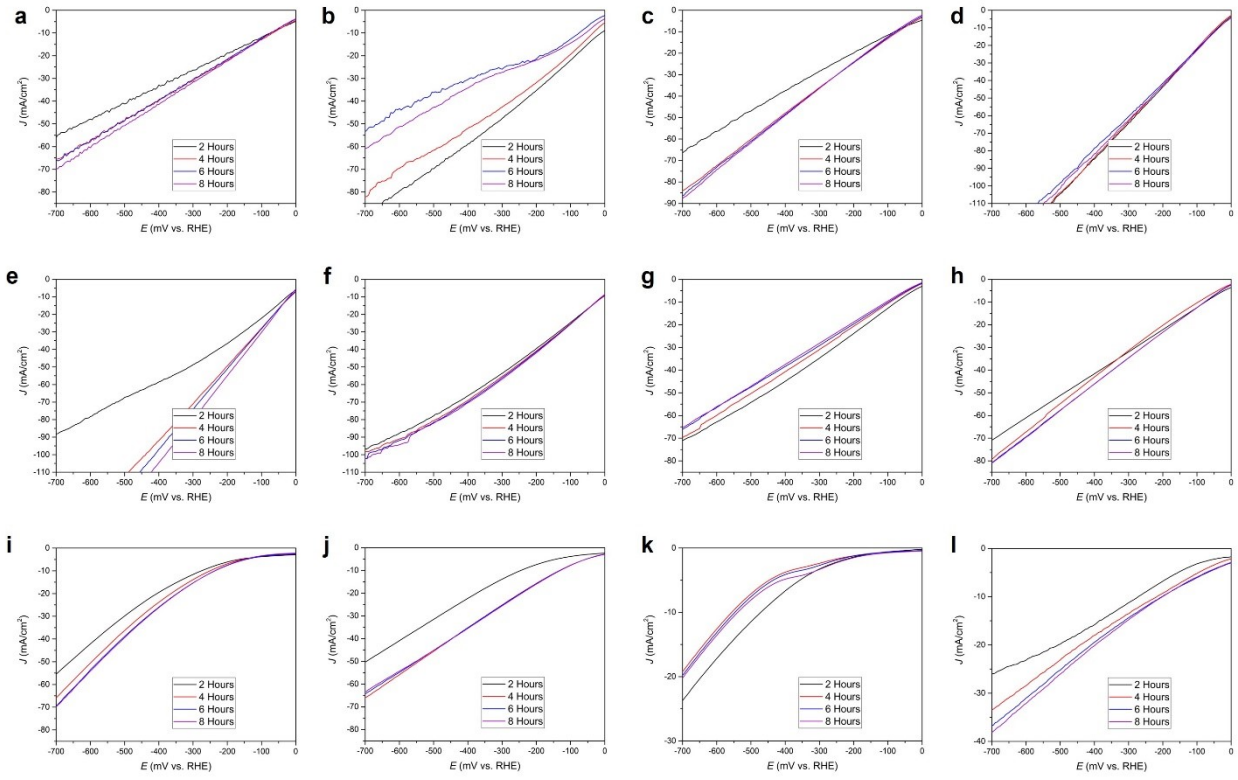

Figure S1. Eight hour linear sweep voltammetry experiments for the six standout catalysts to look at the stability of each catalyst in both electrolytes. (a.) Pt in control **(b.)** Pt in saline **(c.)** Rh in control **(d.)** Rh in saline **(e.)** Ni:Pt in control **(f.)** Ni:Pt in saline **(g.)** Ni:Rh in control **(h.)** Ni:Rh in saline **(i.)** Ni:Au in control (**j.)** Ni:Au in saline **(k.)** Fe:Co in control **(l.)** Fe:Co in saline

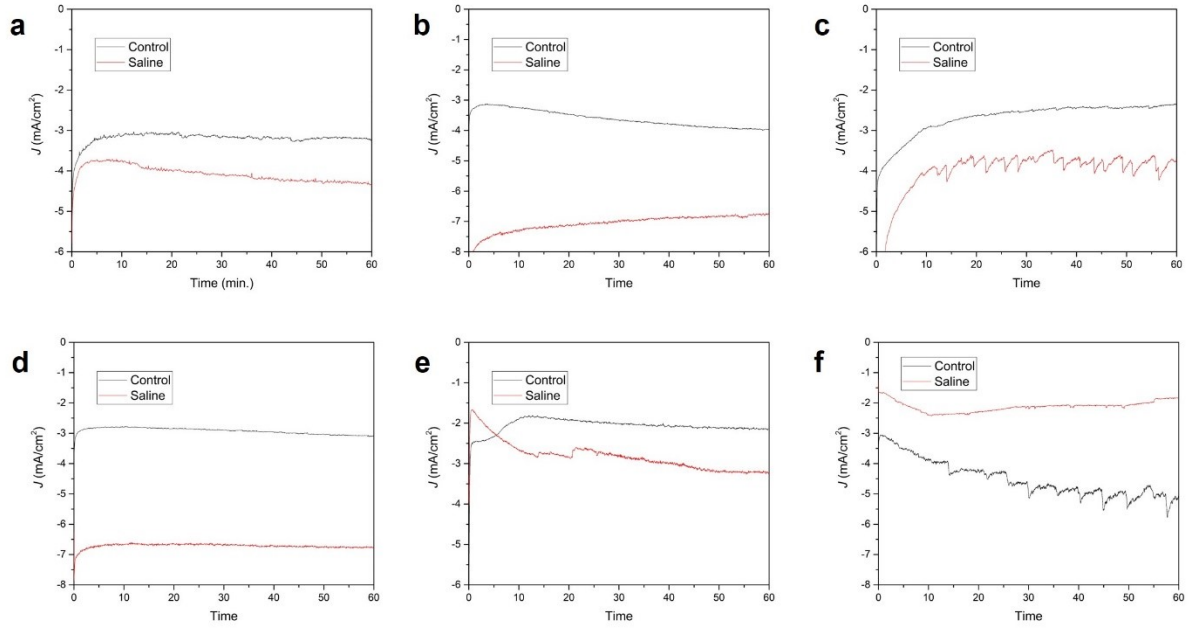

Figure S2. One-hour chronoamperometry experiments for the six standout catalysts to look at the stability of each catalyst in both conditions. Experiments performed at -0.79 V vs. RHE. (a.) Platinum nanoparticles, **(b.)** Rhodium nanoparticles, **(c.)** Ni:Pt nanoparticles, **(d.)** Ni:Rh nanoparticles, **(e.) 1**Ni:1Au nanoparticles, and **(f.)** Fe:Co nanoparticles.

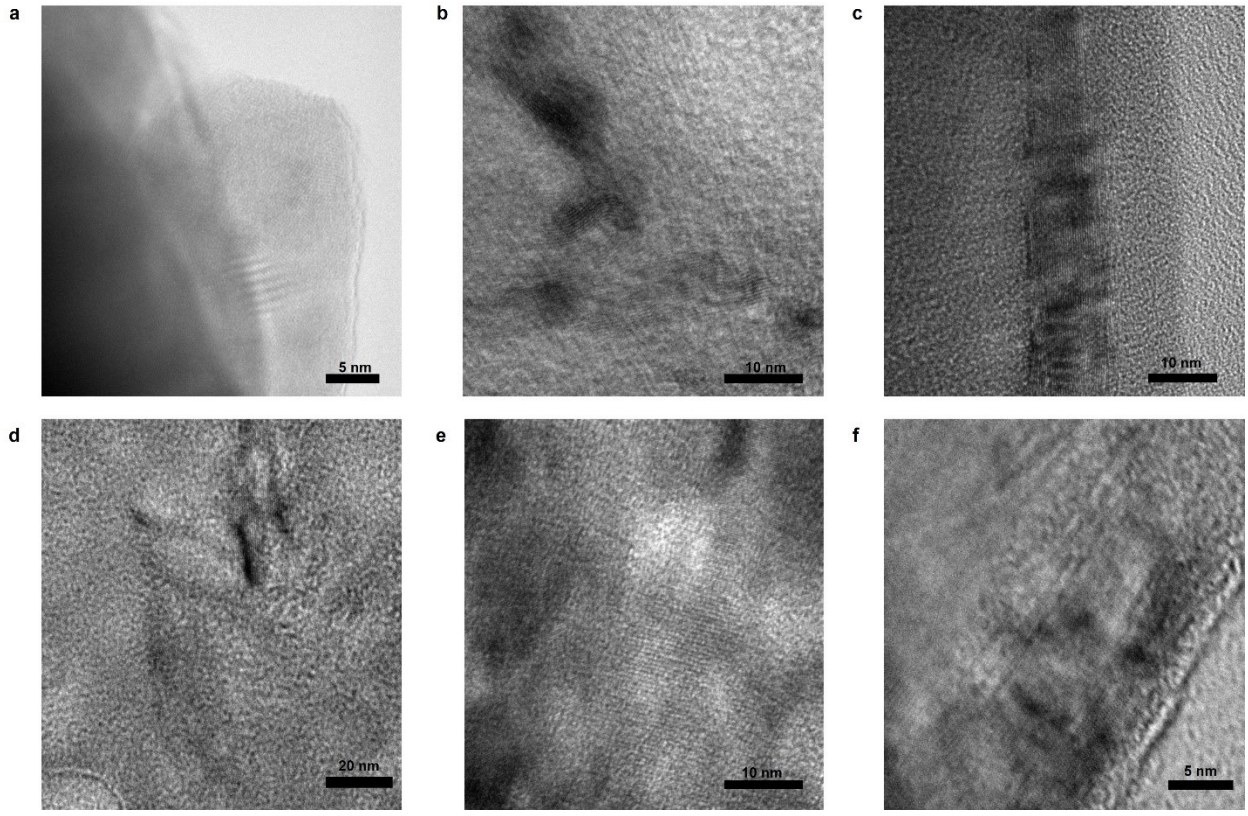

Figure S3. HR-TEM images of the six standout catalysts. (a.) Platinum nanoparticles, **(b.)** Rhodium nanoparticles, **(c.)** Ni:Pt nanoparticles, **(d.)** Ni:Rh nanoparticles, **(e.)** Ni:Au nanoparticles, and **(f.)** Fe:Co nanoparticles.

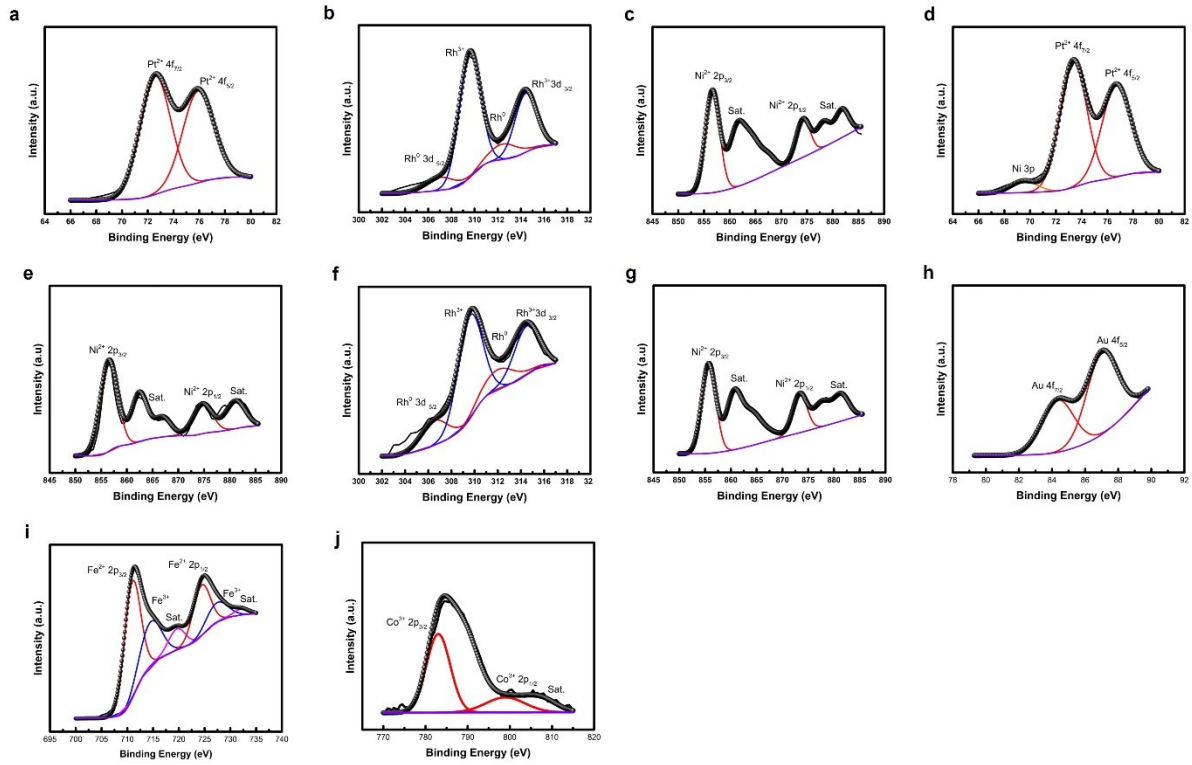

Figure S4. Elemental XPS analysis of the six standout catalysts. (a.) Platinum **(b.)** Rhodium **(c.)** Nickel on Ni:Pt nanoparticles, (**d.**) Platinum on Ni:Pt nanoparticles, **(e.)** Nickel on Ni:Rh nanoparticles, **(f.)** Rhodium on Ni:Rh nanoparticles, **(g.)** Nickel on Ni:Au nanoparticles, **(h.)** Gold on Ni:Au nanoparticles, **(i.)** Iron on Fe:Co nanoparticles, and **(h.)** Cobalt on Fe:Co nanoparticles.

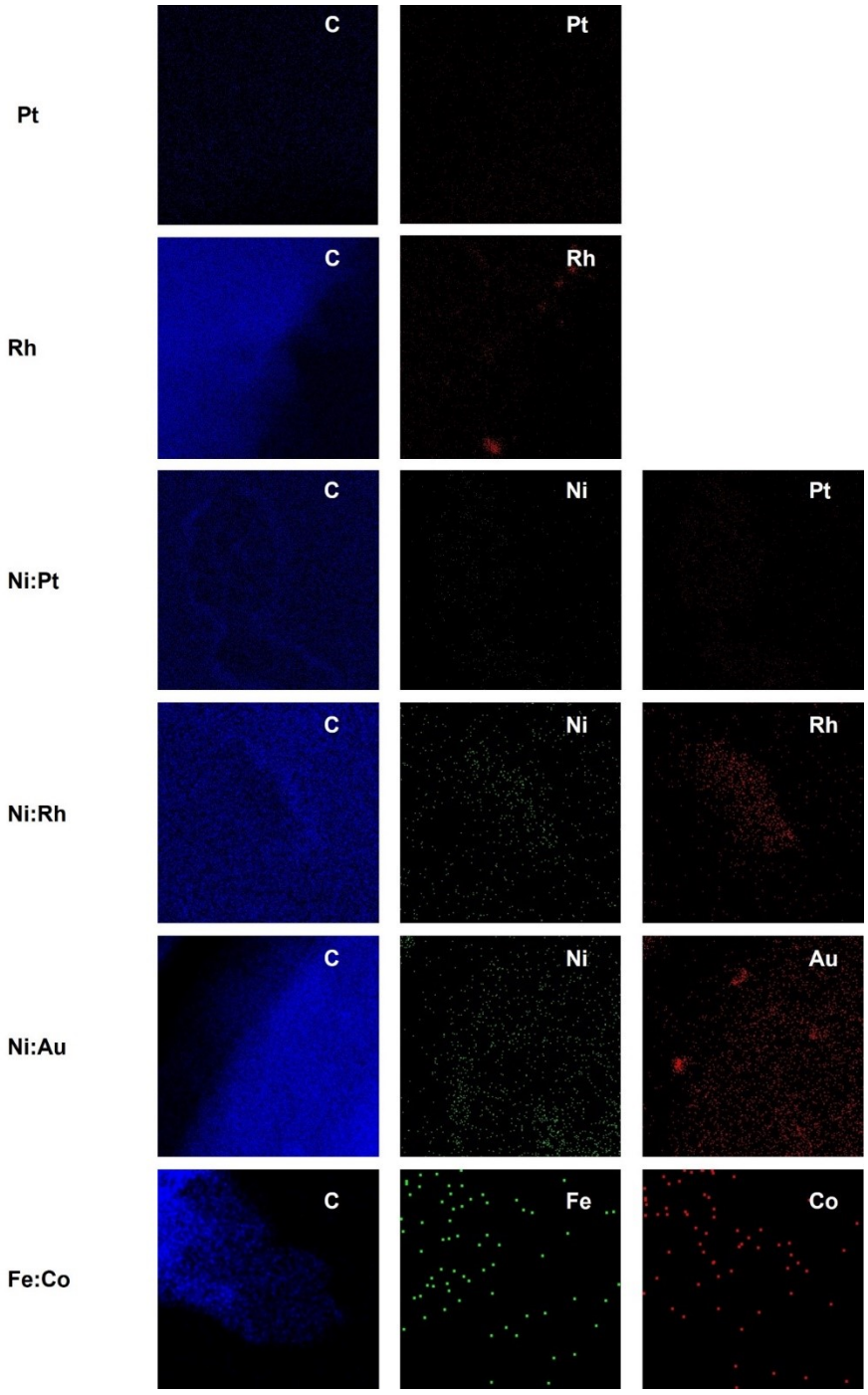

Figure S5. Elemental mapping of the six standout catalysts. (a.) Platinum nanoparticles, **(b.)** Rhodium nanoparticles, **(c.)** Ni:Pt nanoparticles, **(d.)** Ni:Rh nanoparticles, **(e.)** Ni:Au nanoparticles, and **(f.)** Fe:Co nanoparticles.

Supporting Tables

Table S1. This table shows the overpotentials of all the unary metal catalysts.

Unary Metal Catalysts	Control (mV)	Saline (mV)
Co	455	450
Cu	430	550
Fe	635	455
Au	290	370
Ni	505	515
Pd	180	150
Pt	35	60
Rh	55	100
Ag	300	425

Table S2. Table of the overpotentials of all binary metal catalysts.

Binary Combination	Control (mV)	Saline (mV)
1Pt:1Rh	40	90
1Ni:1Pt	40	50
1Pt:1Au	45	70
1Pt:1Fe	55	90
1Ag:1Pt	60	85
1Pt:1Pd	65	90
1Pt:1Co	65	80
1Pt:1Cu	85	100
1Ni:1Rh	110	120
1Rh:1Au	110	105
1Rh:1Pd	120	135
1Rh:1Fe	125	100
1Rh:1Co	130	125
1Ag:1Rh	135	115
1Rh:1Cu	160	150
1Fe:1Co	270	294
1Ni:1Au	220	275
1Fe:1Pd	235	370
1Ag:1Ni	235	350
1Pd:1Cu	240	295
1Co:1Pd	255	280
1Fe:1Au	280	465
1Ag:1Pd	290	255

1Pd:1Au	295	300
1Pd:1Ni	340	240
1Cu:1Co	345	395
1Cu:1Fe	355	385
1Co:1Au	365	355
1Au:1Ag	375	405
1Au:1Cu	375	425
1Co:1Ni	390	395
1Co:1Ag	415	425
1Ag:1Fe	445	400
1Cu:1Ag	480	495
1Cu:1Ni	580	460
1Ni:1Fe	610	540

Table S3. Table of the change in overpotentials of all binary metal catalysts.

Binary Metal Catalysts	Control (mV)	Saline (mV)
1Pt:1Rh	5	10
1Ni:1Pt	5	5
1Pt:1Au	0	35
1Pt:1Fe	5	20
1Ag:1Pt	25	15
1Pt:1Pd	0	20
1Pt:1Co	5	15
1Pt:1Cu	10	65
1Ni:1Rh	30	5
1Rh:1Au	5	35
1Rh:1Pd	0	5
1Rh:1Fe	5	40
1Rh:1Co	5	5
1Ag:1Rh	5	55
1Rh:1Cu	40	55
1Fe:1Co	40	115
1Ni:1Au	70	70
1Fe:1Pd	20	40
1Ag:1Ni	65	25
1Pd:1Cu	40	10
1Co:1Pd	5	10
1Fe:1Au	130	190
1Ag:1Pd	20	75
1Pd:1Au	80	85

1Pd:1Ni	40	0
1Cu:1Co	75	50
1Cu:1Fe	65	45
1Co:1Au	10	55
1Au:1Ag	120	30
1Au:1Cu	40	50
1Co:1Ni	50	0
1Co:1Ag	0	50
1Ag:1Fe	55	15
1Cu:1Ag	0	15
1Cu:1Ni	5	25
1Ni:1Fe	15	35

Table S4. Quantitative data from XPS analysis of six standout catalysts.

Standout Electrocatalysts	Atomic Concentration
Pt	100.00
Rh	100.00
Ni:Pt	40.09 : 59.91
Ni:Rh	43.30 : 56.70
Ni:Au	32.91 : 67.09
Fe:Co	22.83 : 77.17