

Supplementary Materials: Atomic Pt-Clusters Decoration Triggers a High-Rate Performance on Ni@Pd Bimetallic Nanocatalyst for Hydrogen Evolution Reaction in Both Alkaline and Acidic Medium

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1. X-ray Photoelectron Spectroscopy of Ni@Pd-Pt NC at Pt-4f Orbital.

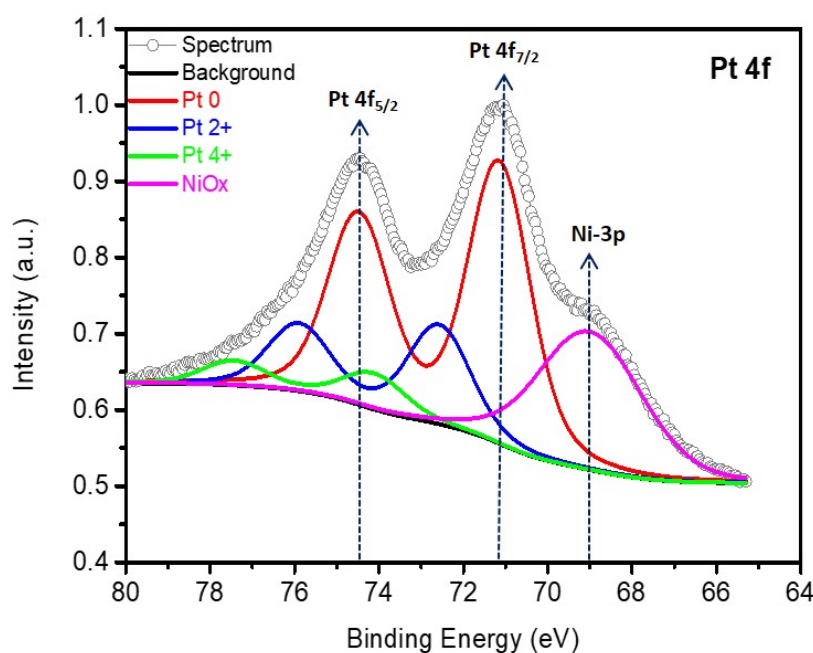


Figure S1. X-ray photoelectron spectroscopy of Ni@Pd-Pt NC at Pt-4f orbitals.

2. X-ray Photoelectron Spectroscopy of Ni@Pd-Pt NC at Pt-4f Orbital.

Figure S2 represents the XPS spectra of Ni@Pd NC at Ni-2p orbital. Accordingly, two peaks around at 855.6 and 873.4 eV are due to photoemissions from Ni²⁺- 2p_{3/2} and Ni²⁺- 2p_{1/2}, respectively. Meanwhile, two satellite peaks are observed at ~861 eV and ~880 eV, which are corresponding to the oxidation products. Besides, a suppressed peak centered at ~ 852.6 eV is the characteristic peak of metallic Ni (i.e. Ni (0)). Consequently, it can be said that in Ni@Pd majority of Ni-atoms are present in form of Ni-oxide.

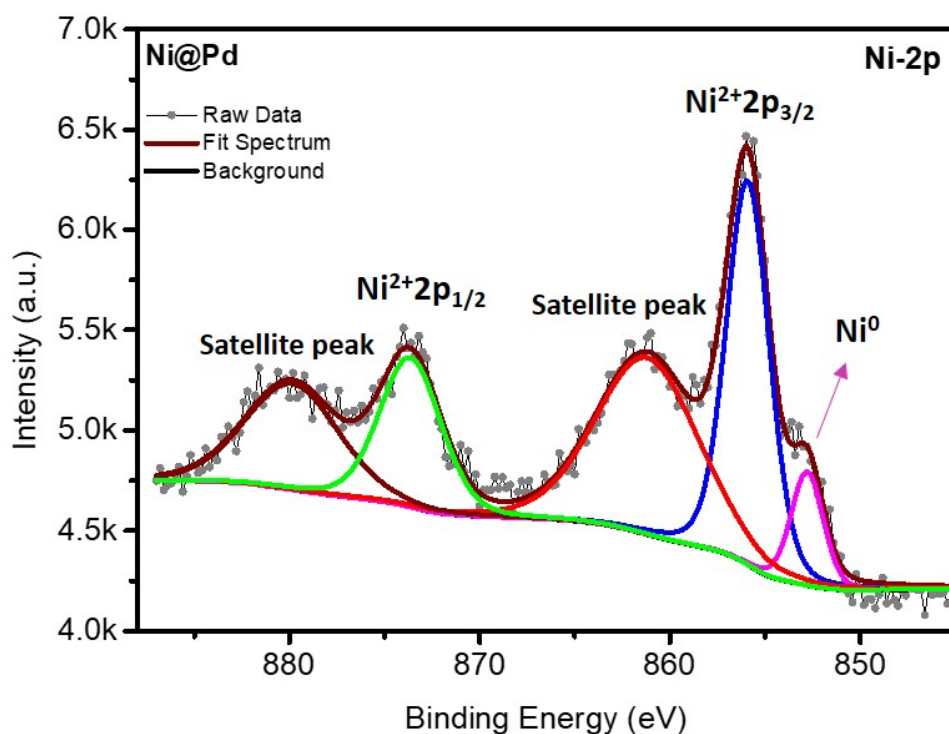


Figure S2. X-ray photoelectron spectroscopy of Ni@Pd NC at Ni-2p orbitals.

3. ICP-OES Determined Composition Ratios of Experimental Nanocatalysts

Table S1. ICP-OES determined composition ratios of experimental nanocatalysts

Samples	Ni (wt.%)	Pd (wt.%)	Pt (wt.%)
Ni@Pd	8.598	15.68	0
Ni@Pd-Pt	9.287	16.95	1.964

4. Stability Test Results of Ni@Pd-Pt NC in Alkaline and Acidic Medium.

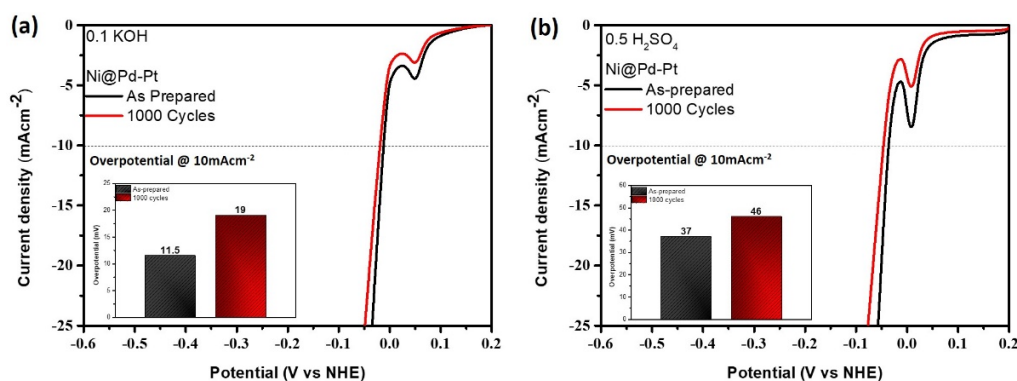


Figure S3. Comparative LSV curves of the as-prepared Ni@Pd-Pt NC and after 1000 cycles in (a) alkaline and (b) acidic medium

5. Benchmarks for HER Activity of Noble Metal-based Catalysts.

Table S2. Benchmarks for HER activity of noble metal-based catalysts.

Catalysts	Electrolyte	Overpotential@ 10 mAcm ⁻² (mV)	Tafel slope (mV/dec)	Ref.
Ni@Pd	0.1 M KOH	173	156	Current Study
Ni@Pd-Pt		11.5	42	
Ni@Pd	0.5 M H ₂ SO ₄	158	215	
Ni@Pd-Pt		37	47	
Pt/MoS ₂ /CFs	0.5 M H ₂ SO ₄	80	53.6	Electrochim. Acta, 2015, 166, 26–31
Pd ₆₅ Pt ₃₅	0.5 M H ₂ SO ₄	N/A	40	Int. J. Hydrog. Energy, 2015, 40, 6754–6762
Pd ₆₀ Pt ₄₀	0.5 M H ₂ SO ₄	130	N/A	Int. J. Hydrog. Energy, 2013, 38, 92–99
Pt-MoS ₂	0.5 M H ₂ SO ₄	80	40.0	Nat. Commun., 2013, 4, 1–8
Pt/NiS@Al ₂ O ₃	0.5 M H ₂ SO ₄	34	35.0	J. Mater. Chem. A, 2018, 6, 11783–11789
AuPd-NCs	0.5 M H ₂ SO ₄	29	47	J. Hydrog. Energy, 2016, 41, 8839–8846

6. Cyclic Voltammograms of Experimental NCs.

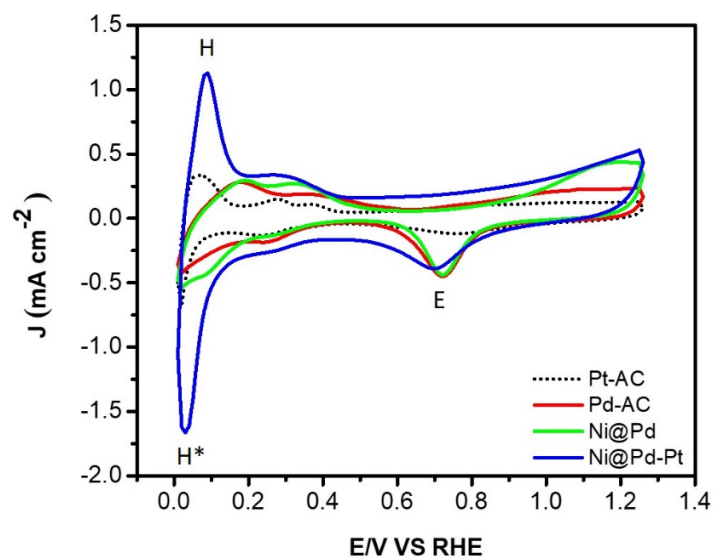


Figure S4. Superimposed Cyclic voltammograms of experimental NCs.