Organometallic Synthesis of High-density Pt Single Atom Catalyst on Nickel for Alkaline Hydrogen Evolution Reaction

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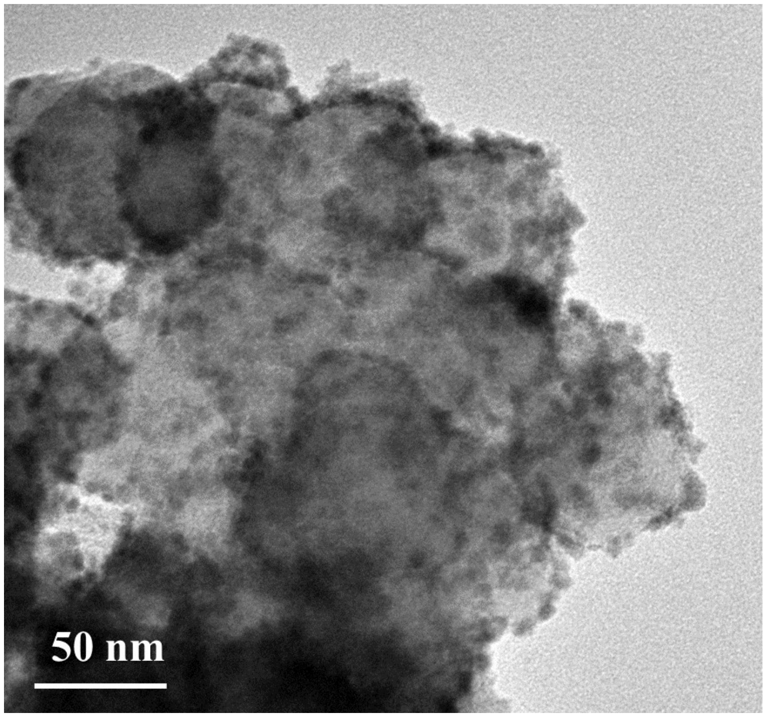

Figure S1. TEM image of NiPt-5/C

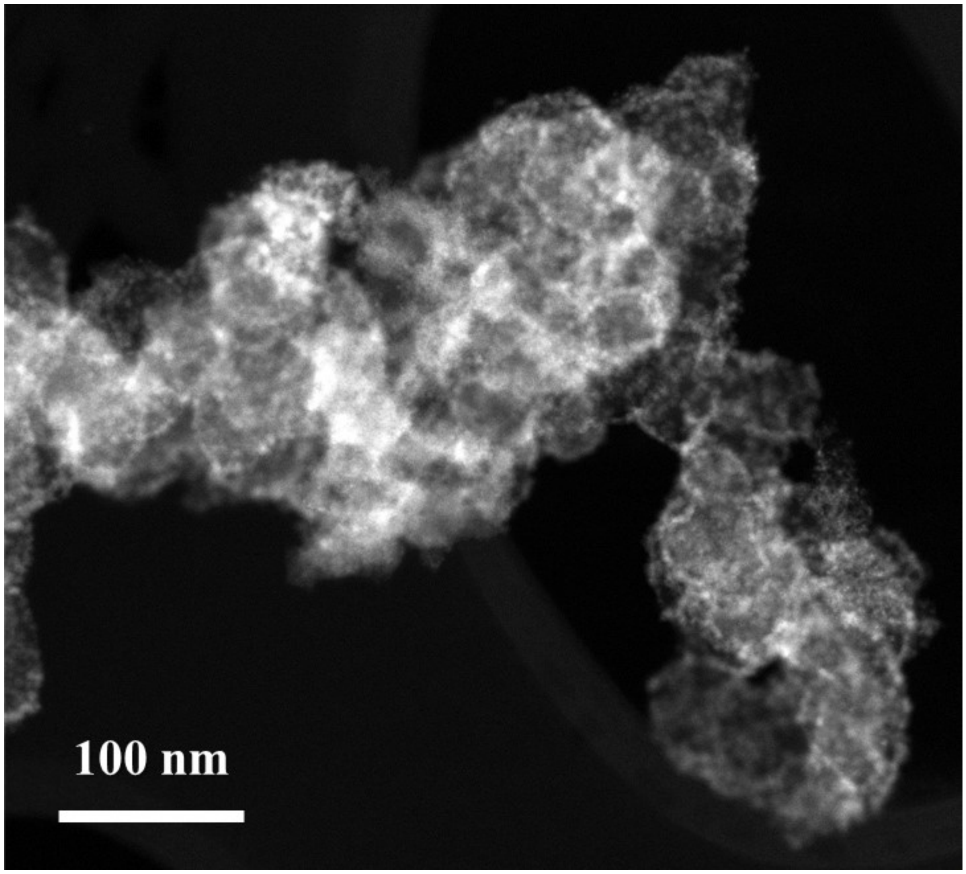

Figure S2. HAADF-STEM image of NiPt-10/C

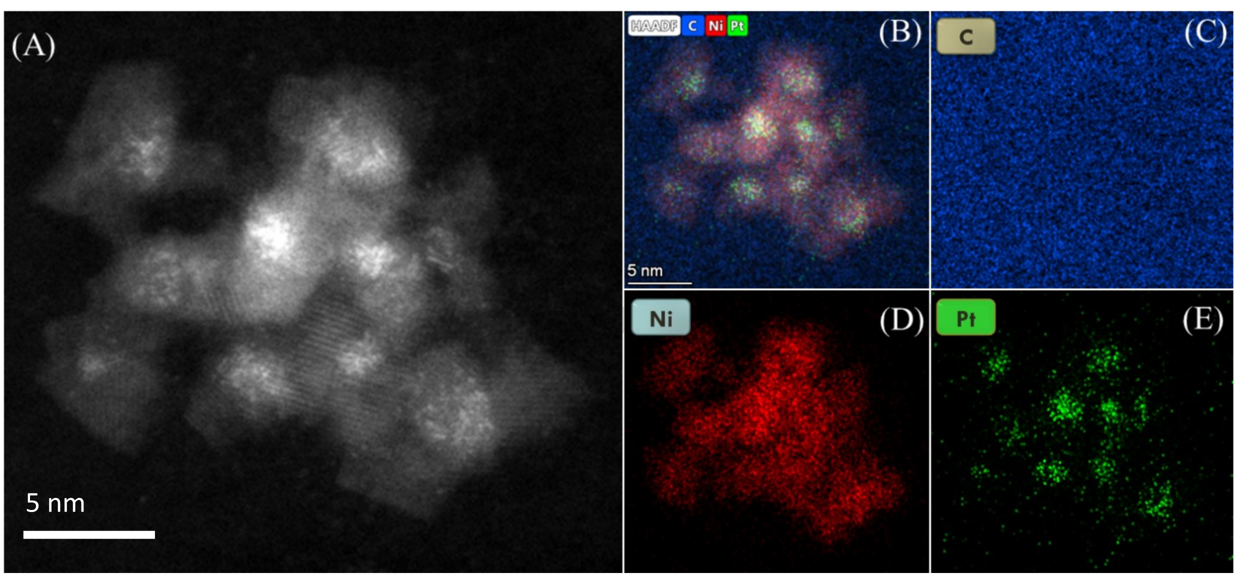

Figure S3. (A) HAADF image of NiPt-10/C (B-E) STEM –EDS mapping of different elements in NiPt-10/C

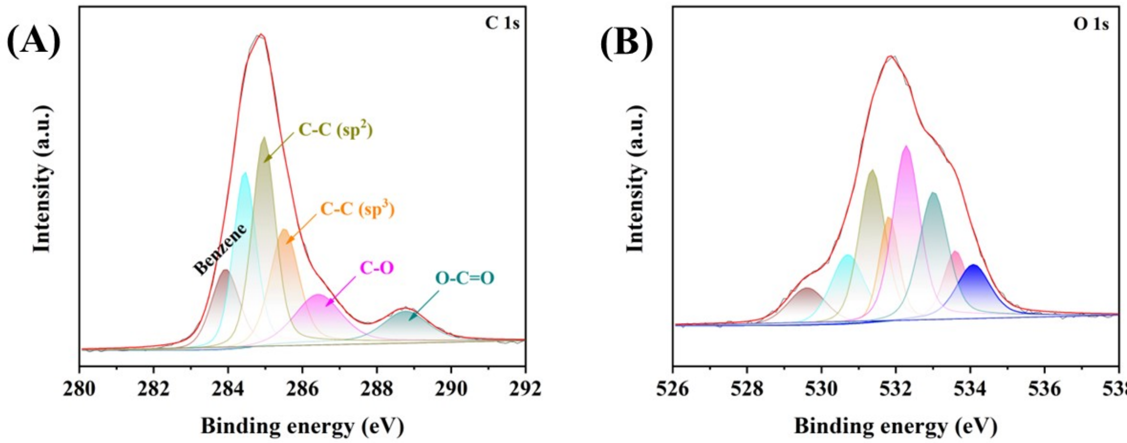

Figure.S4. XPS spectrum of NiPt-10/C. (a) C1s, and (b) O1s

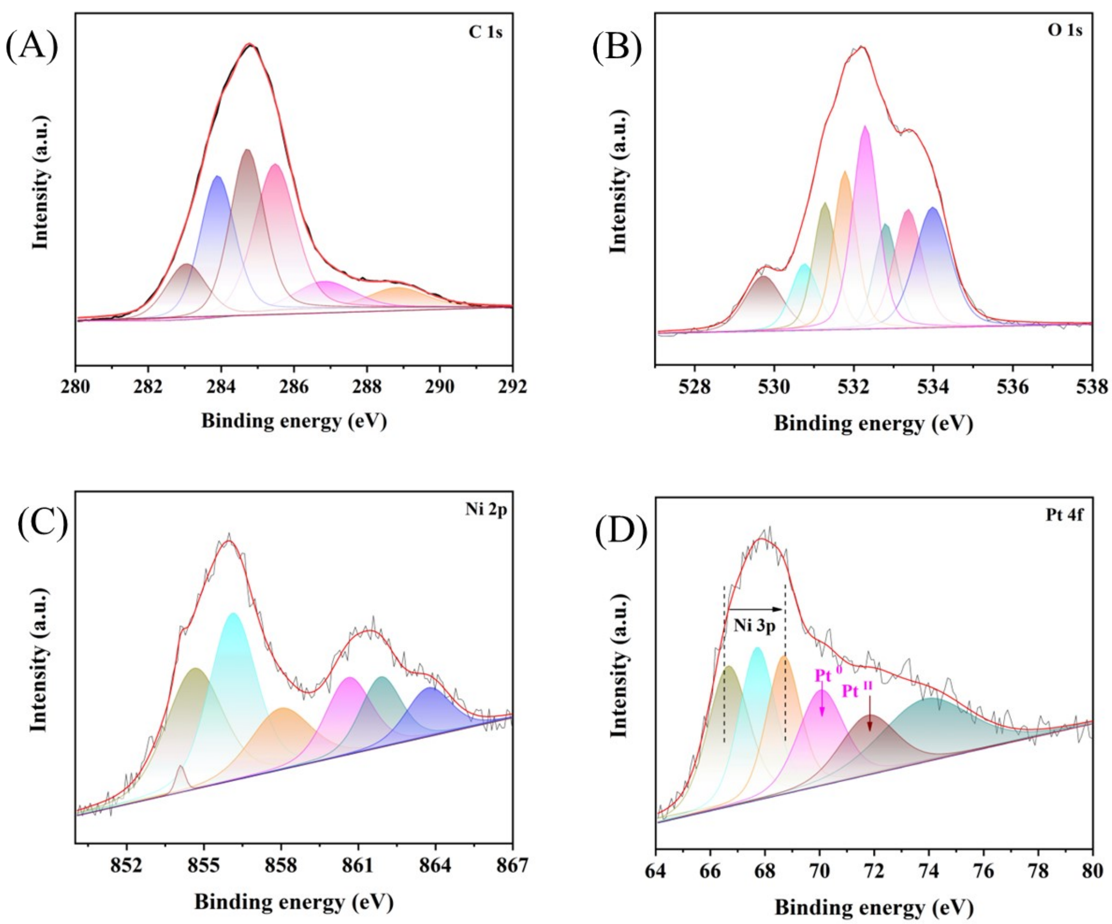

Figure.S5. XPS spectrum of NiPt-5/C. (a) C1s, (b) O1s, (c) Ni 2p and (d) Pt 4f

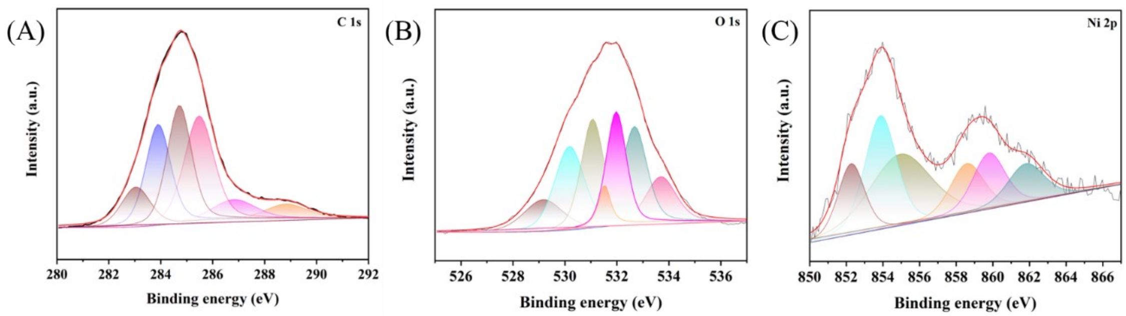

Figure S6. XPS spectrum of Ni/C. (a) C1s, (b) O1s and (c) Ni 2p

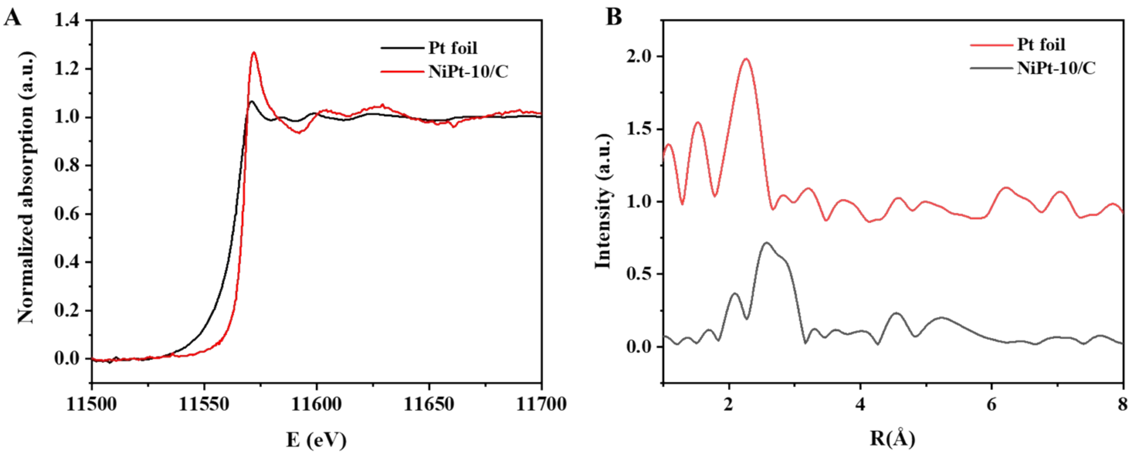

Figure S7. (A) XANES spectra of Pt foil and NiPt-10/C (B) EXAFS spectra of Pt foil and NiPt-10/C

Table. S1. NiPt based electrocatalysts for alkaline hydrogen evolution reaction

Catalysts	Electrolyte	Substrate	Mass activity at η = 100 mV	Enhancement factor compared to commercial Pt catalyst mass activity at η = 100 mV	Ref
Pt-Ni/rGO	0.1M KOH	GCE	0.39 A mg^{-1}_{pt}@100 mV	3.54	[1]
PtNi-NC-900	1M KOH	GCE	3.78 A mg^{-1}_{pt}@100 mV	3	[2]
Ni_3N-Pt	1M KOH	NF	NA	NA	[3]
Pt islands/Ni	0.1M KOH	GCE	NA	NA	[4]
Hcp-Pt-Ni	0.1M KOH	GCE	3.03 A mg_{pt}^{-1}@70mV	2.7	[5]
Pt-Ni heterostructure	0.1M KOH	GCE	NA	NA	[6]
Pt-Ni Alloy	0.1M KOH	GCE	NA	NA	[6]
Pt-Ni_5	1M KOH		6 A mg_{pt}^{-1} @70 mV	1.97	[7]
Pt_3Ni/C	0.1M NaOH	GCE	NA	NA	[8]
Pt-Ni SA	1M KOH	GCE	2.80 A mg_{pt}^{-1} @ 70 mV	3.2	[9]
PtNi-10/C	0.1M KOH	GCE	0.66 A mg_{pt}^{-1} @100 mV	8	This work

GCE- Glassy Carbon Electrode

NF- Ni Foam

NA- Not Available

References

1 Z. Du, Y. Wang, J. Li and J. Liu, *J. Nanoparticle Res.*,2019, 21, 1-15.

2 J. Guo, J. Liu, X. Zhang, X. Guan, M. Zeng, J. Shen, J. Zou, Q. Chen, T. Wang and D. Qian, *J. Mater. Chem. A*, 2022, **10**, 13727–13734.

3 Y. Wang, L. Chen, X. Yu, Y. Wang and G. Zheng, *Adv. Energy Mater.*, 2017, **7**, 1–7.

4 A. Alinezhad, L. Gloag, T. M. Benedetti, S. Cheong, R. F. Webster, M. Roelsgaard, B. B. Iversen, W. Schuhmann, J. J. Gooding and R. D. Tilley, *J. Am. Chem. Soc.*, 2019, **141**, 16202–16207.

5 Z. Cao, Q. Chen, J. Zhang, H. Li, Y. Jiang, S. Shen, G. Fu, B. A. Lu, Z. Xie and L. Zheng, *Nat. Commun.*, 2017, **8**, 15131.

6 C. Zhang, B. Chen, D. Mei and X. Liang, *J. Mater. Chem. A*, 2019, **7**, 5475–5481.

7 C. Zhang, X. Liang, R. Xu, C. Dai, B. Wu, G. Yu, B. Chen, X. Wang and N. Liu, *Adv. Funct. Mater.*,2021, 31(14), 2008298.

8 L. fan Shen, B. an Lu, X. ming Qu, J. yu Ye, J. ming Zhang, S. hu Yin, Q. hui Wu, R. xiang Wang, S. yu Shen, T. Sheng, Y. xia Jiang and S. gang Sun, *Nano Energy*, 2019, **62**, 601–609.

9 Z. Zhang, G. Liu, X. Cui, B. Chen, Y. Zhu, Y. Gong, F. Saleem, S. Xi, Y. Du, A. Borgna, Z. Lai, Q. Zhang, B. Li, Y. Zong, Y. Han, L. Gu and H. Zhang, *Adv. Mater.*, 2018, **30**, 1–7.