Electronic Supplementary Information (ESI):

'Casting' nanoporous nanowires: revitalizing the ancient process for designing advanced catalysts

Ying Wang,[1] Tianyi Kou,[2] Hui Gao,[1] Jiazheng Niu,[1] Jie Zhang,[1] Lanfen Lv,[1] Zhangquan Peng,[3] Zhonghua Zhang[1,*]

[1]Key Laboratory for Liquid-Solid Structural Evolution and Processing of Materials (Ministry of Education), School of Materials Science and Engineering, Shandong University, Jingshi Road 17923, Jinan, 250061, P.R. China

[2]Department of Chemistry and Biochemistry, University of California, Santa Cruz, California 95064, United States

[3]State Key Laboratory of Electroanalytical Chemistry, Changchun Institute of Applied Chemistry, Chinese Academy of Sciences, Changchun, Jilin 130022, P.R. China

*Corresponding author. Email: zh_zhang@sdu.edu.cn (Z. Zhang)

Figure S1. Photographs of (a) $Al_{97.7}Ni_2Pd_{0.2}Pt_{0.1}$ alloy ingot, (b) $Al_{97.7}Ni_2Pd_{0.2}Pt_{0.1}$ alloy ribbons, and (c) PdPtNi NPNWs catalyst after dealloying.

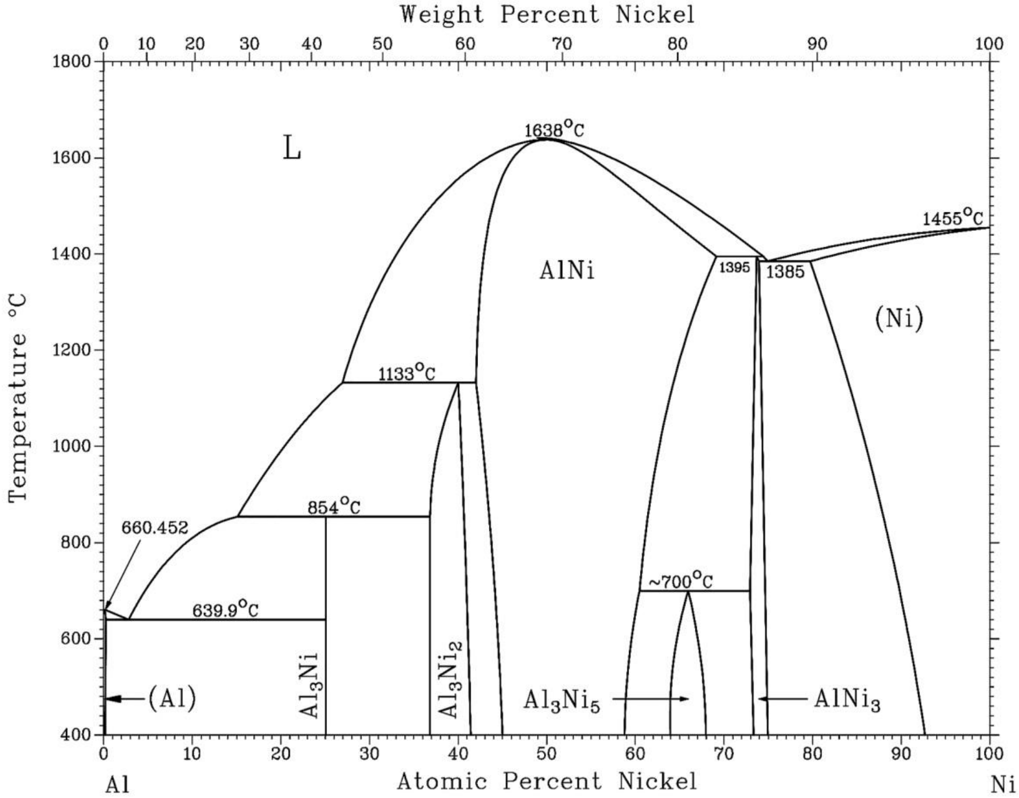

Figure S2. Al-Ni binary alloy phase diagram.[1]

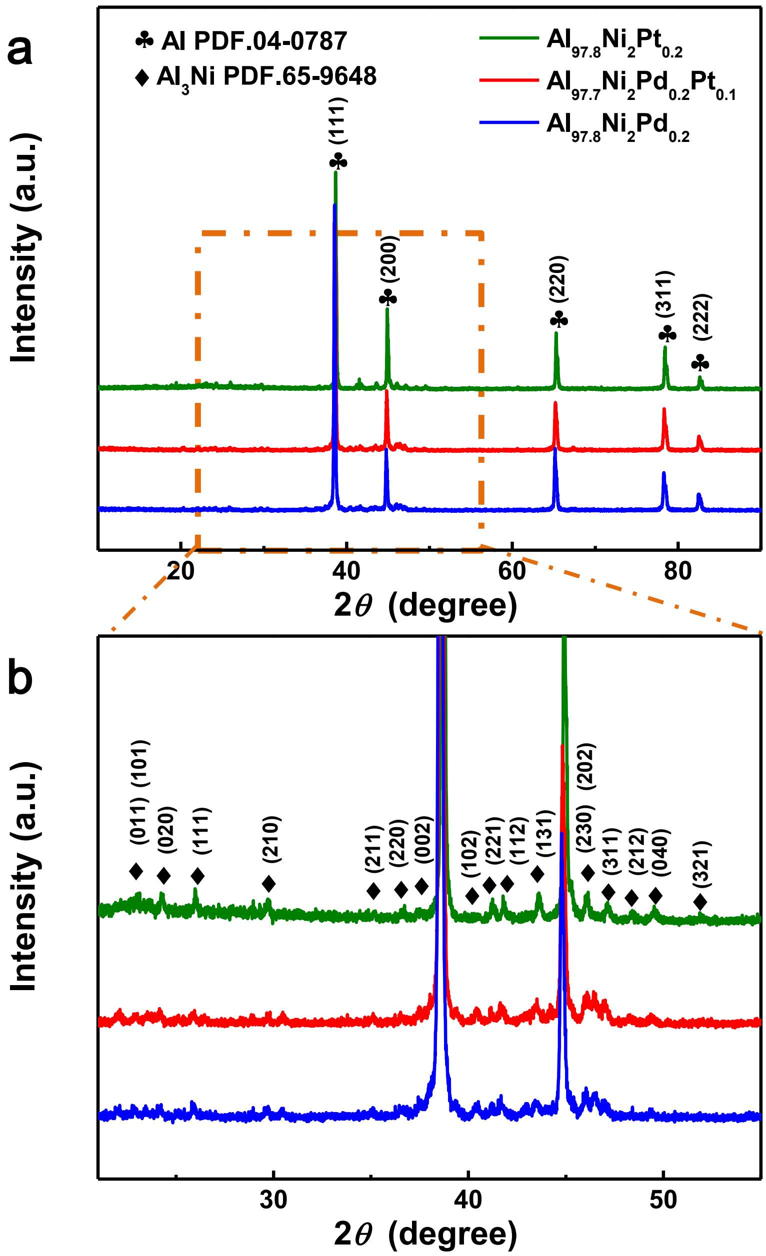

Figure S3. (a) XRD patterns and (b) magnified XRD patterns with the 2θ angle ranging from 21° to 55° of the $Al_{97.8}Ni_2Pt_{0.2}$, $Al_{97.7}Ni_2Pd_{0.2}Pt_{0.1}$ and $Al_{97.8}Ni_2Pd_{0.2}$ alloy ribbons.

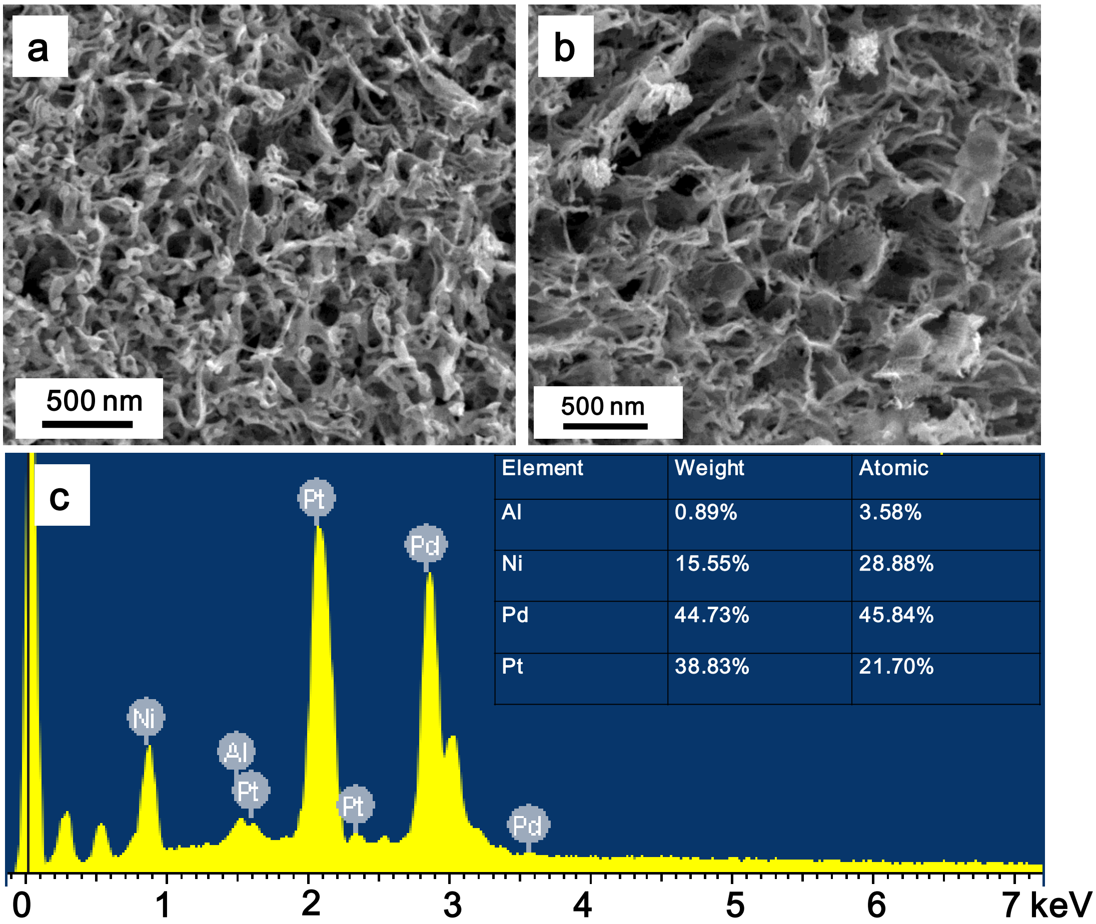

Figure S4. (a-b) SEM images and (c) typical EDX spectrum of the PdPtNi NPNWs obtained by the two-step dealloying method. The corresponding compositions are listed in Figure S4c.

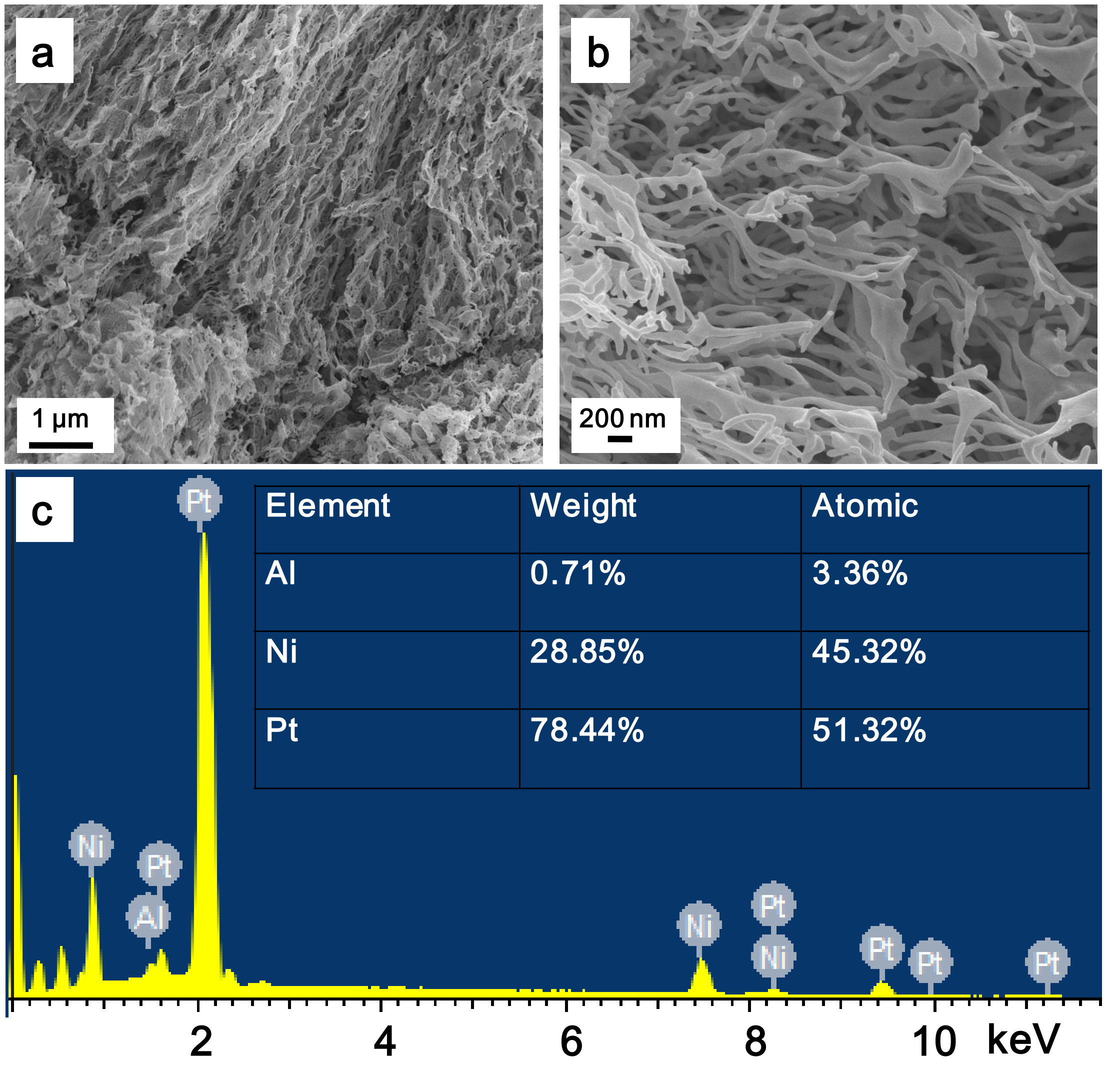

Figure S5. (a-b) SEM images and (c) typical EDX spectrum of the PtNi NPNWs obtained by the two-step dealloying method. The corresponding compositions are listed in Figure S5c.

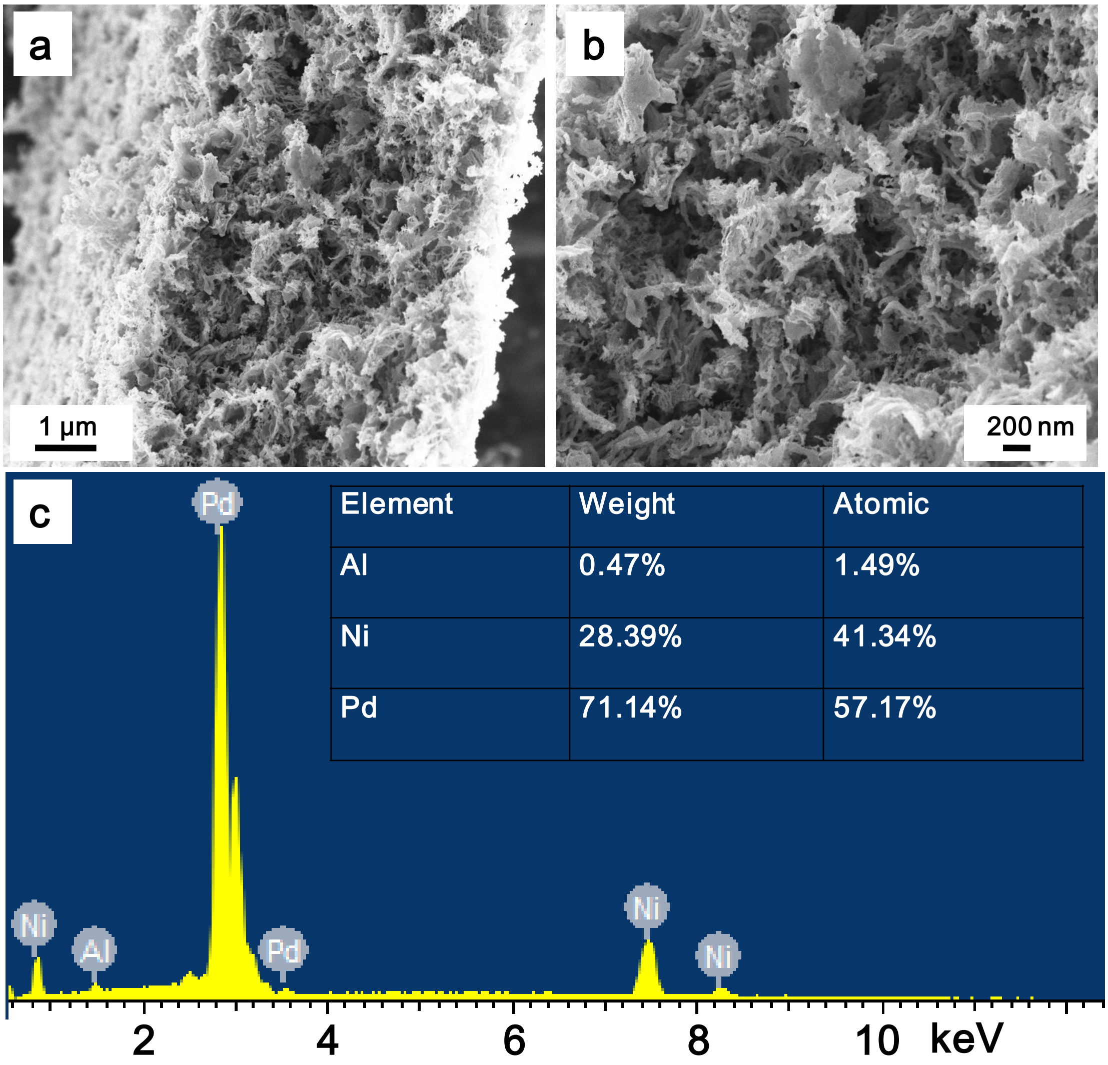

Figure S6. (a-b) SEM images and (c) typical EDX spectrum of the PdNi NPNWs obtained by the two-step dealloying method. The corresponding compositions are listed in Figure S6c.

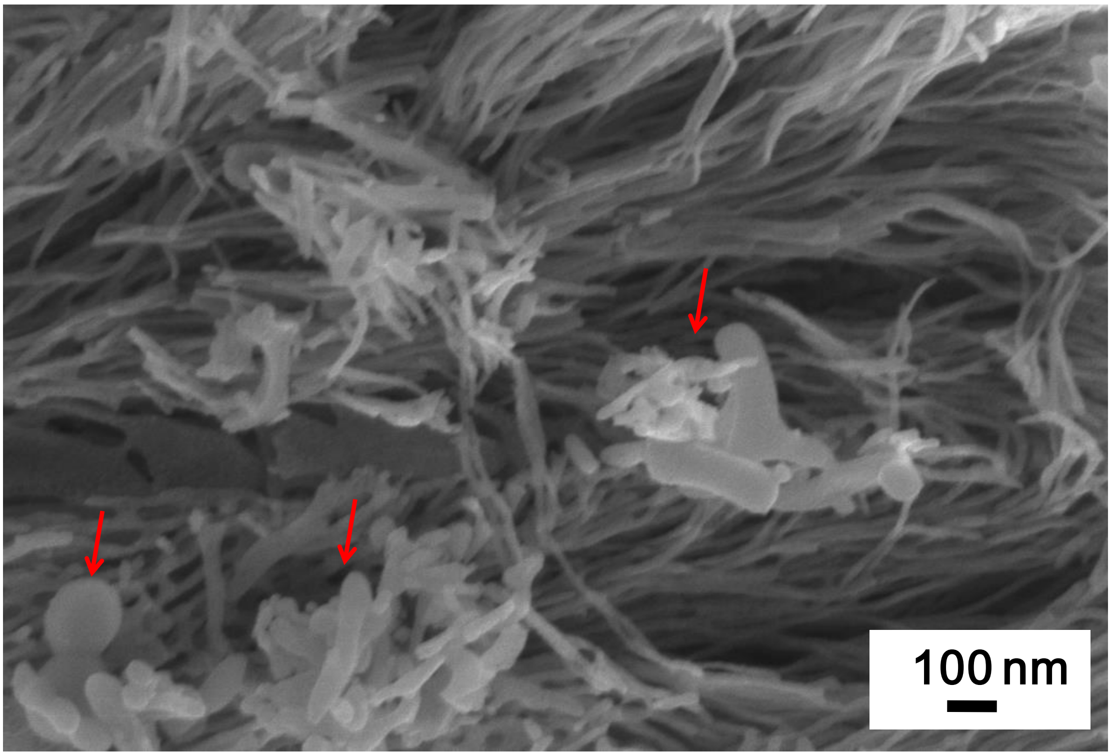

Figure S7. SEM image of the as-dealloyed $Al_{96}Ni_4$ sample after dealloying in 1 M NaOH solution. The sub-micron particles are highlighted by red arrows.

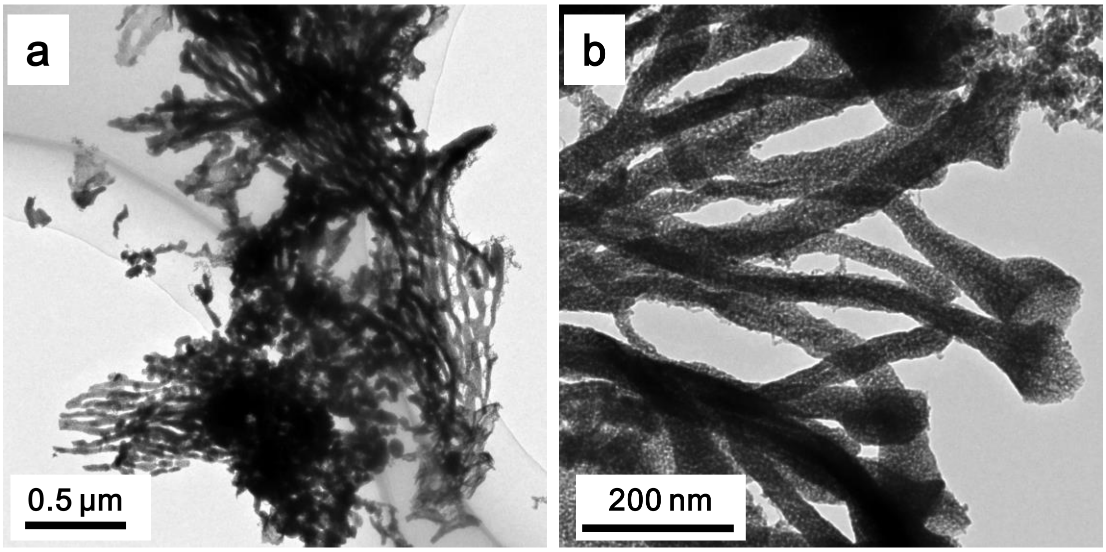

Figure S8. TEM images showing the microstructure of the PdPtNi NPNWs.

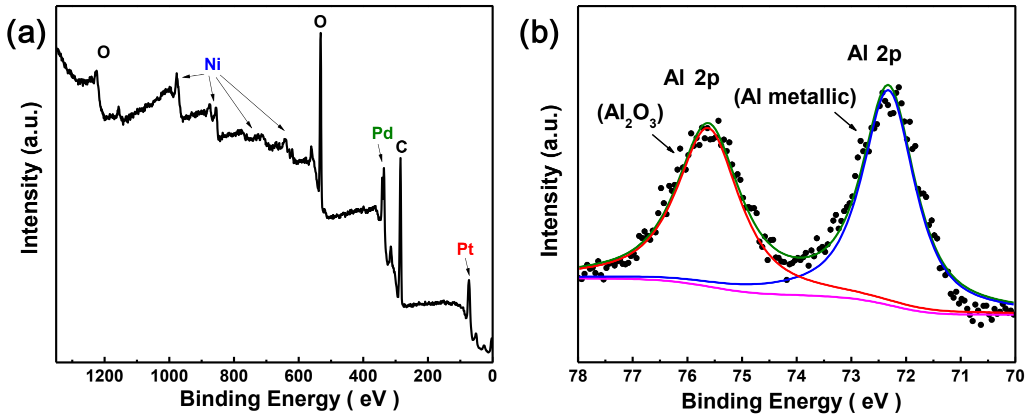

Figure S9. (a) XPS broad scan spectrum of the PdPtNi NPNWs catalyst. (b) XPS spectrum of Al 2p for the PdPtNi NPNWs catalyst.

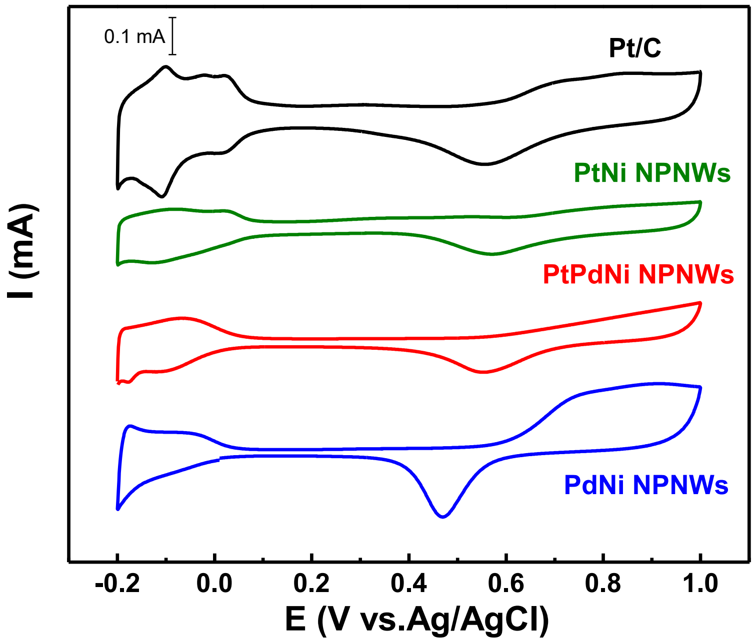

Figure S10. CVs of the Pt/C and M (M=Pt, Pd or PdPt)-Ni NPNWs catalysts in the N_2-purged 0.5 M H_2SO_4 solution. (Scan rate: 50 mV s^{-1})

Table S1. Comparison of the EGOR activity of our NPNWs catalysts with those of previously reported state-of-the-art EGOR electrocatalyst.

Sample	*ref*	EGOR j_{ECSA} (mA cm^{-2})	j_{mass} (A mg^{-1})	*solution*	Scan rate (mV s^{-1})
Our PdPtNi NPNWs	--	**126**	**3.9**	0.5 M EG + 0.5M KOH	50
Our PtNi NPNWs	--	**76**	**2.4**	0.5 M EG + 0.5M KOH	50
Our PdNi NPNWs	--	**71**	**2.3**	0.5 M EG + 0.5M KOH	50
$Pd_{55}Pt_{30}$ nanowire networks	2	86	3.38	0.5 M EG + 0.5M KOH	50
$Pt_{77}Cu_{54}Co_{23}$hollow nanospheres	3	92	1.8	0.5M EG + 0.5M NaOH	50
$Pd_{62}Au_{21}Ni_{17}$ nanosponges	4	90	6.36	0.5M EG + 0.5M KOH	50
PtPd multipods	5	72	~0.77	1.0M EG + 1.0M KOH	50
PdPt nanodendrites	6	139	1.64	0.5M EG + 1.0M KOH	50
PdCo nanodendrites	6	72	0.8	0.5M EG + 1.0M KOH	50
PdNi nanodendrites	6	34	0.46	0.5M EG + 1.0M KOH	50
PdAg/CNT	7	--	2.1	0.1M EG + 1.0M KOH	50
SF-MWCNT–$PdSn_{mix}$	8	51.9	--	0.5M EG + 0.5M KOH	50
PdAu HNT	9	--	4.6	0.5M EG + 0.5M KOH	50
Ag@Pt core–shell nanospheres	10	120	--	0.75M EG + 1.0M KOH	50
PtAg nanotubes	11	--	2.2	0.5M EG + 0.5M NaOH	50
AuPt@Pt NCs/rGO	12	--	1.85	0.5M EG + 0.5M KOH	50

Table S2. Comparison of the GOR activity of our NPNWs catalysts with those of previously reported state-of-the-art GOR electrocatalyst.

Sample	*ref*	GOR			
		j_{ECSA} (mA cm^{-2})	j_{mass} (A mg^{-1})	*solution*	Scan rate (mV s^{-1})
Our PdPtNi NPNWs	--	**48.2**	**1.5**	0.1M Gly + 1.0M KOH	50
Our PtNi NPNWs	--	**21.4**	**0.69**	0.1M Gly + 1.0M KOH	50
Our PdNi NPNWs	--	**35.9**	**1.15**	0.1M Gly + 1.0M KOH	50
$Pd_{55}Pt_{30}$ nanowire networks	2	46	1.8	0.1M Gly + 1.0M KOH	50
PdCu nanocrystals	13	21.6	--	0.5M Gly + 0.5M KOH	50
Porous Pd_4Bi catalyst	14	~130	~0.75	0.1M Gly + 1.0M KOH	100
Pd-CB	15	--	~1.15	0.5M Gly + 0.5M KOH	50
Pd_1Sn_1 nanoparticules	16	--	1.05	0.1M Gly + 1.0M KOH	20
FeCo@Fe@Pd/MWCNT-COOH	17	11	--	0.5M Gly + 1.0M KOH	50
PdAg CNT	18	43	--	0.1M Gly + 1.0M KOH	50
PtAg NCs	19	77.9	1.3	0.5M Gly + 0.5M KOH	50
PtAg nanotubes	11	--	1.58	0.5M Gly + 0.5M KOH	50
$Pd_{63}Ag_{37}$ nanocorals	20	6	1.6	0.5M Gly + 1.0M KOH	50
CuPd nanowire networks	21	54	1.2	0.1M Gly + 1.0M KOH	50
CuPt nanowire networks	21	45	1.05	0.1M Gly + 1.0M KOH	50

References

1 K. Morsi, *Mater. Sci. Eng., A*, 2001, **299**, 1-15.

2 W. Hong, C. Shang, J. Wang and E. Wang, *Energy Environ. Sci.*, 2015, **8**, 2910-2915.

3 W. Hong, C. Shang, J. Wang and E. Wang, *Nanoscale*, 2015, **7**, 9985-9989.

4 S. Li, J. Lai, R. Luque and G. Xu, *Energy Environ. Sci.*, 2016, **9**, 3097-3102.

5 J. J. Lv, L. P. Mei, X. Weng, A. J. Wang, L. L. Chen, X. F. Liu and J. J. Feng, *Nanoscale*, 2015, **7**, 5699-5705.

6 J. N. Zheng, L. L. He, F. Y. Chen, A. J. Wang, M. W. Xue and J. J. Feng, *J. Mater. Chem. A*, 2014, **2**, 12899-12906.

7 J. Qi, N. Benipal, C. Liang and W. Li, *Appl. Catal., B*, 2016, **199**, 494-503.

8 T. Ramulifho, K. I. Ozoemena, R. M. Modibedi, C. J. Jafta and M. K. Mathe, *Electroanal. Chem.*, 2013, **692**, 26-30.

9 K. Cai, Y. Liao, H. Zhang, J. Liu, Z. Lu, Z. Huang, S. Chen and H. Han, *ACS Appl. Mater. Interfaces*, 2016, **8**, 12792-12797.

10 J. N. Zheng, J. J. Lv, S. S. Li, M. W. Xue, A. J. Wang and J. J. Feng, *J. Mater. Chem. A*, 2014, **2**, 3445-3451.

11 Y. Kim, H. Kim and W. B. Kim, *Electrochem. Commun.*, 2014, **46**, 36-39.

12 F. Q. Shao, X. X. Lin, J. J. Feng, J. Yuan, J. R. Chen and A. J. Wang, *Electrochim. Acta*, 2016, **219**, 321-329.

13 R. Wang, L. Y. Jiang, J. J. Feng, W. D. Liu, J. Yuan and A. J. Wang, *Int. J. Hydrogen Energy*, 2017, **42**, 6695-6704.

14 A. Zalineeva, A. Serov, M. Padilla, U. Martinez, K. Artyushkova, S. Baranton, C. Coutanceau and P. B. Atanassov, *J. Am. Chem. Soc.*, 2014, **136**, 3937-3945.

15 H. Wang, L. Thia, N. Li, X. Ge, Z. Liu and X. Wang, *ACS Catal.*, 2015, **5**, 3174-3180.

16 A. Zalineeva, A. Serov, M. Padilla, U. Martinez, K. Artyushkova, S. Baranton, C. Coutanceau and P. B. Atanassov, Appl. Catal., B, 2015, **176**, 429-435.

17 O. O. Fashedemi, H. A. Miller, A. Marchionni, F. Vizza and K. I. Ozoemena, *J. Mater. Chem. A*, 2015, **3**, 7145-7156.

18 N. Benipal, J. Qi, Q. Liu and W. Li, *Appl. Catal., B*, 2017, **210**, 121-130.

19 X. Weng, Q. Liu, A. J. Wang, J. Yuan and J. J. Feng, *J. Colloid Interface Sci.*, 2017, **494**, 15-21.

20 P. Song, J. J. Feng, F. Y. Guo and A. J. Wang, *J. Mater. Chem. A*, 2015, **3** 15920-15926.

21 W. Hong, J. Wang and E. Wang, *Nanoscale*, 2016, **8**, 4927-4932.