Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Supporting information for

Controllable design of multi-metallic aerogels as efficient electrocatalysts for methanol fuel cells

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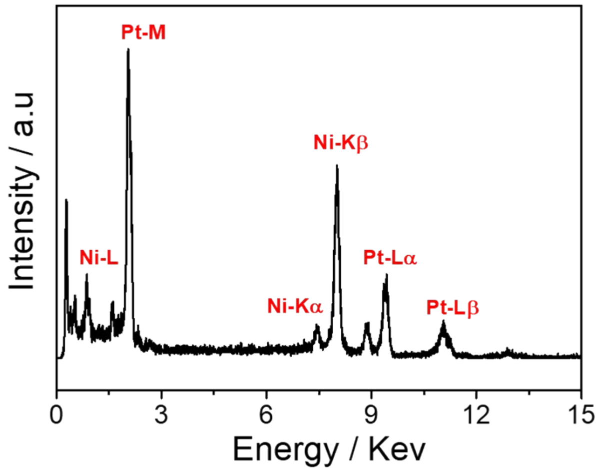

Figure S1. Energy dispersive spectrum (EDS) of PtNi nanotubular aerogels.

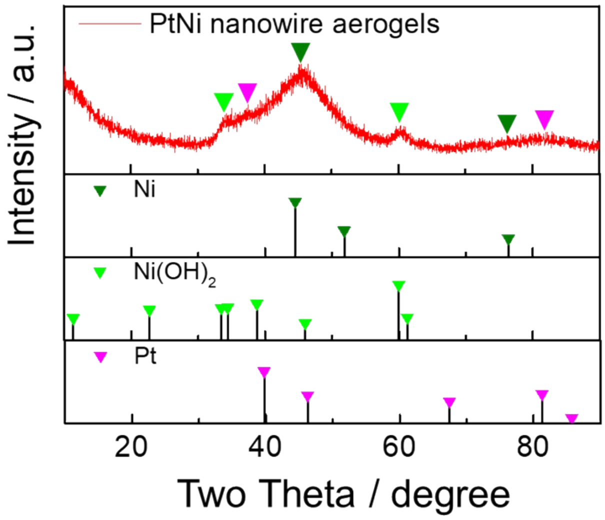

Figure S2. XRD spectrum of PtNi nanowire aerogels.

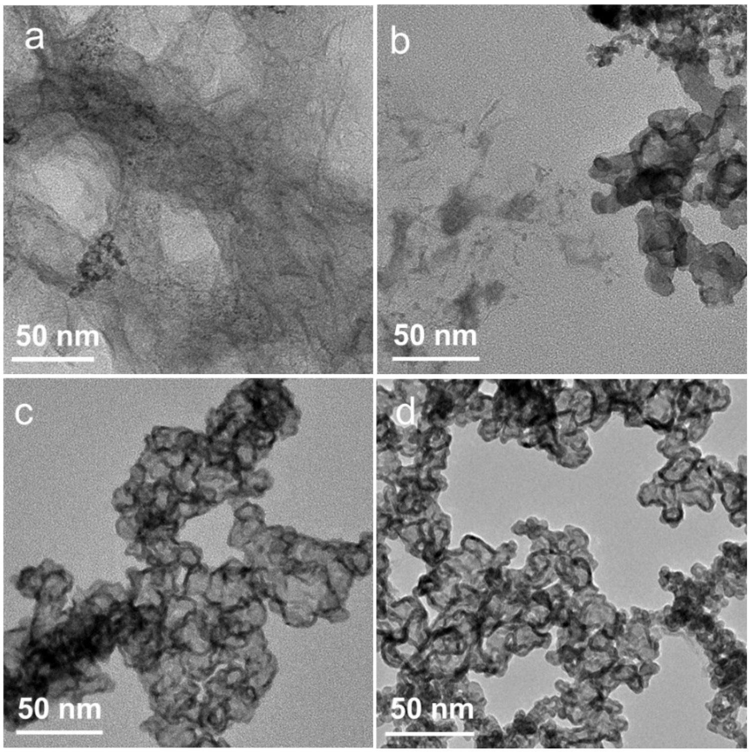

Figure S3. Effect of HCl concentration with (a) 5, (b) 10, (c) 20, (d) 60 mM on the nanotubular structure during the post treatment.

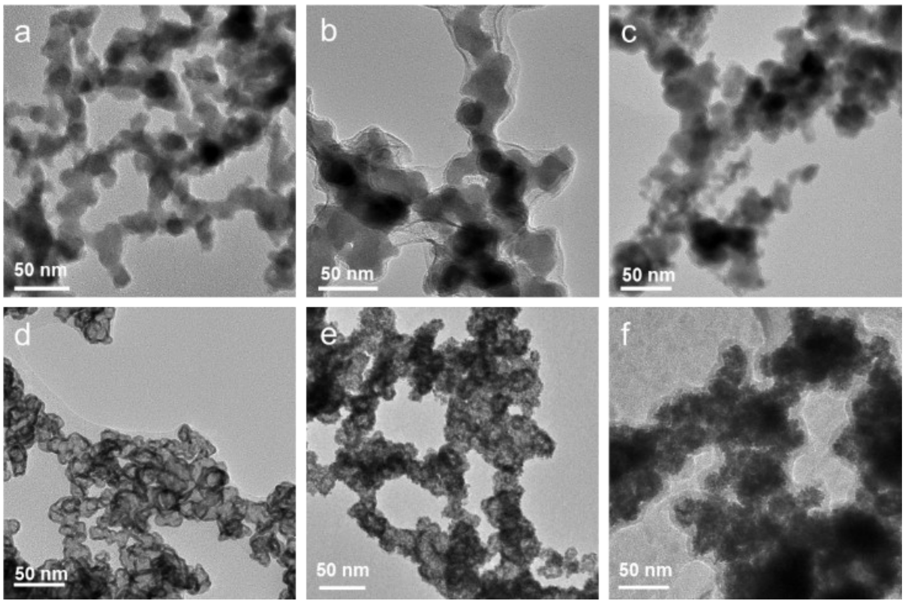

Figure S4. TEM images of samples before (a, b, c) and after (d, e, f) acid treatment when the molar ratio of Ni/Pt in the precursor is 9:1 (a, d), 36:1 (b, e) and pure Ni (c, f).

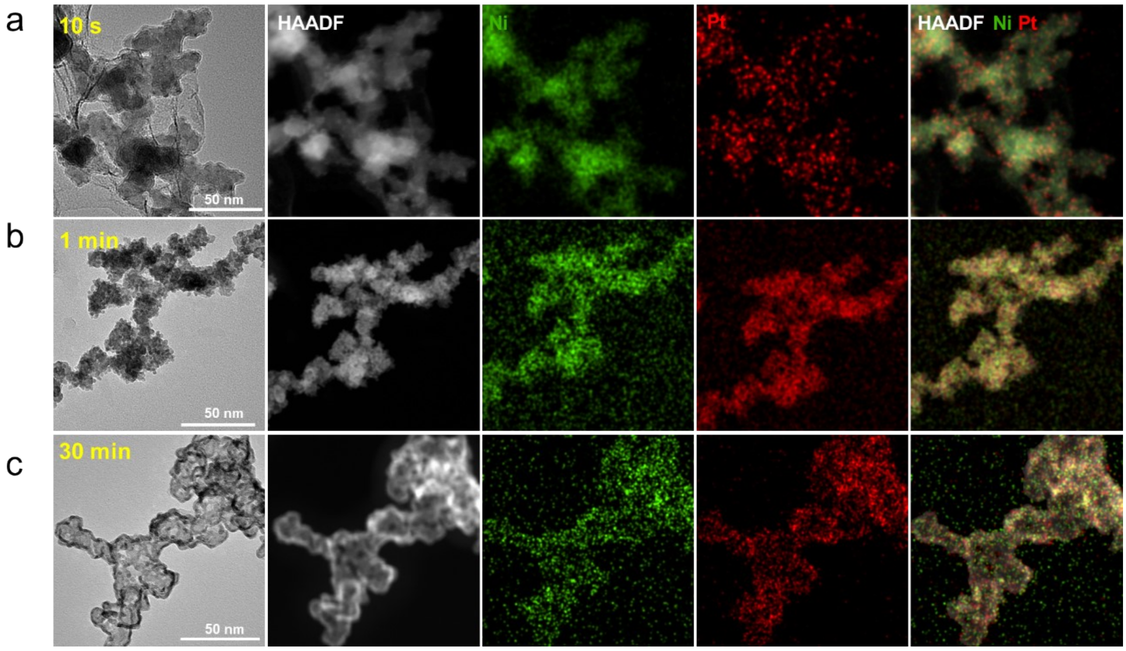

Figure S5. TEM images for growing pathway from the solid nanowire to the nanotubular structure of the PtNi-2 sample after post treatment of etching and replacing for (a) 10 s, (b) 1 min, and (c) 30 min.

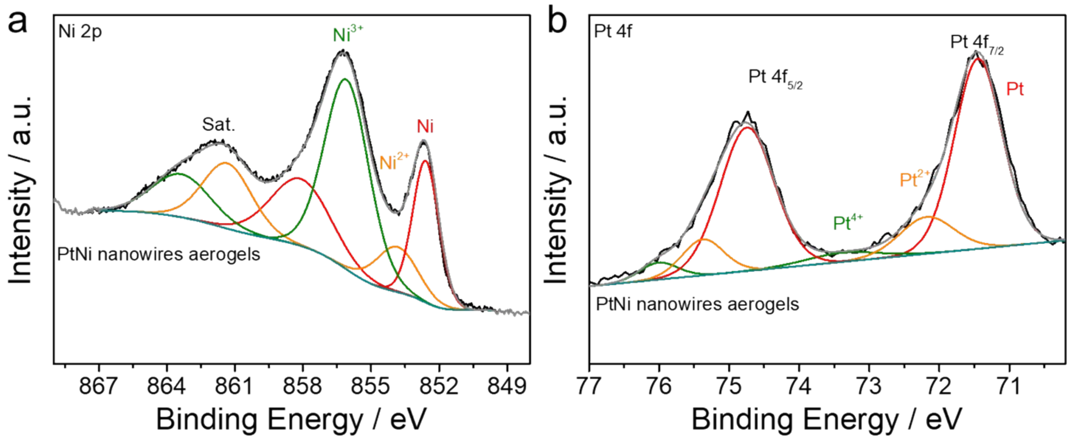

Figure S6. High-resolution XPS spectra for (a) Ni 2p and (b) Pt 4f in PtNi nanowire aerogels.

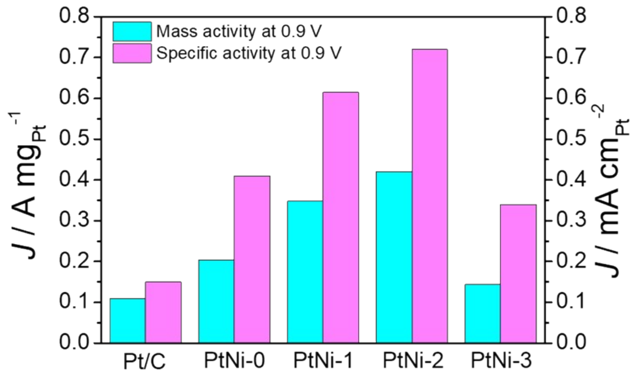

Figure S7. Mass activities and specific activities of commercial Pt/C and as-prepared PtNi-x aerogels at 0.9 V in ORR process.

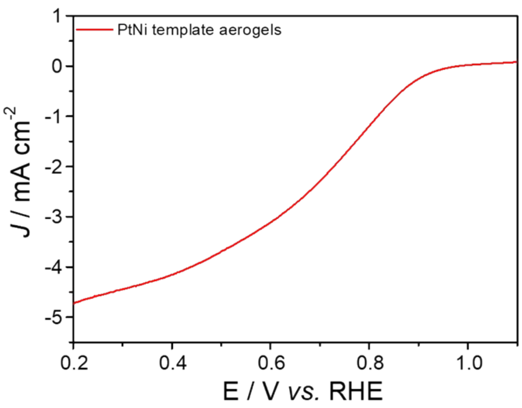

Figure S8. LSV curves of PtNi template aerogels in 0.1 M KOH solution.

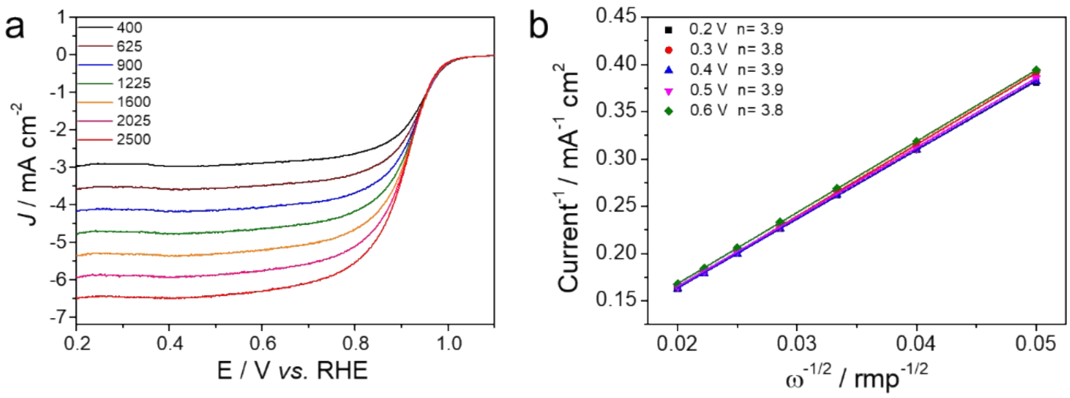

Figure S9. (a) Polarization curves of PtNi-2 aerogels at a set of rotation rates (400, 625, 900, 1225, 1600, 2025 and 2500 rpm), (b) Koutecky–Levich plots for the oxygen reduction on PtNi-2 aerogels at different potentials (0.2V, 0.3 V, 0.5 V, 0.6 V) in O_2-saturated 0.1 M KOH solution.

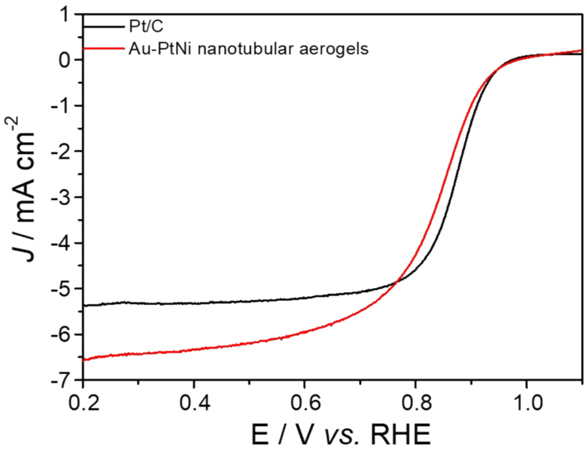

Figure S10. ORR performance of Pt/C and Au-PtNi nanotubular aerogels.

Figure S11. MOR performance of Pt/C and Au-PtNi nanotubular aerogels.

Table S1. ICP-OES results of PtNi-x aerogels

ICP results	Atomic ratio (Pt:Ni)	Pt (μg/mL)	Ni (μg/mL)
PtNi-0	1.76:1	6.93	1.21
PtNi-1	2.34:1	7.41	0.94
PtNi-2	2.88:1	7.26	0.77
PtNi-3	2.88:1	8.73	0.93

Table S2. Performance comparison of different catalysts towards ORR

Samples	Pt loading (μg)	Onset potential (V vs RHE)	Half-wave potential (V vs RHE)	j_k at 0.9 V (mA/cm^2)	Mass activity (A/mg_{Pt})	Specific activity (mA/cm_{pt}^2)
Pt/C	3.2	0.98	0.87	1.79	0.11	0.15
PtNi-0	5.78	1.02	0.90	5.89	0.20	0.41
PtNi-1	6.18	1.03	0.93	11.02	0.35	0.62
PtNi-2	6.05	1.03	0.93	12.95	0.42	0.72
PtNi-3	7.28	1.02	0.91	5.19	0.14	0.34

Table S3. Comparison for the electrochemical activities of the recent reported ORR electrocatalysts

Samples	Electrolyte	Half-wave potential (V vs RHE)	Mass activity (A mg^{-1}_{Pt})	Specific activity (mA cm^{-2}_{Pt})	Ref
PtNi nanotubular aerogel	0.1 M KOH	0.93	0.42 at 0.9 V vs RHE	0.72 at 0.9 V vs RHE	This work
Fe_3Pt/Ni_3FeN	0.1 M KOH	0.93	0.35 at 0.9 V vs RHE	/	[1]
Fe_3Pt/N@C	0.1 M KOH	0.89	0.43 at 0.9 V vs RHE	/	[2]
Au-Pd-Pt aerogels	0.1 M KOH	0.91	0.37 at 0.9 V vs RHE	0.88 at 0.9 V vs RHE	[3]
Pt-Ni@PtD/G	0.1 M $HClO_4$	0.83	0.061 at 0.9 V vs RHE	0.098 at 0.9 V vs RHE	[4]
Nanoporous Pt	0.1 M $HClO_4$	0.8*	0.3 at 0.8 V vs RHE	/	[5]
PtPd/CNWs	0.1 M $HClO_4$	0.87	0.23 at 0.9 V vs RHE	0.43 at 0.9 V vs RHE	[6]
PtCu RDNFs	0.1 M $HClO_4$	0.91	0.18 at 0.85 V vs RHE	0.48 at 0.85 V vs RHE	[7]
Pd4-s-Pt1/C	0.1 M $HClO_4$	0.90*	0.33 at 0.9 V vs RHE	0.74 at 0.9 V vs RHE	[8]
ZIF-67-Pt/RGO	0.5 M H_2SO_4	0.90*	0.21 at 0.9 V vs RHE	/	[9]
Pt@Co SAs-ZIF-NC	0.5 M H_2SO_4	0.92	0.48 at 0.9 V vs RHE	0.64 at 0.9 V vs RHE	[10]

* estimated value from the literature figures.

Reference:

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