

Electronic Supplementary Information

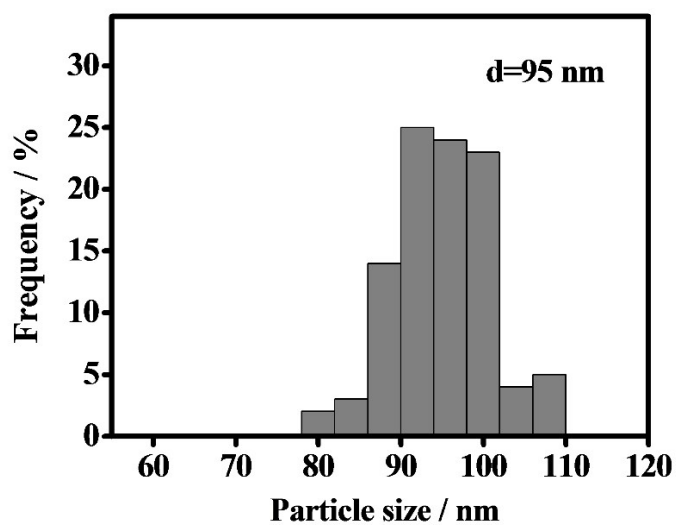


Fig. S1 Histogram of the particle size distribution of the PtPd MNs.

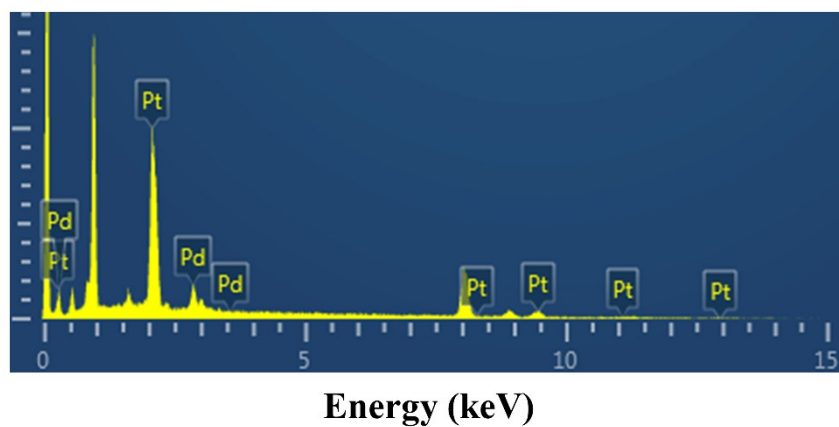


Fig. S2 EDX spectrum of the PtPd MNs.

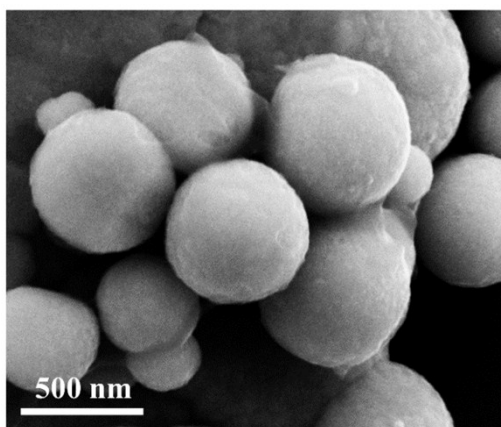


Fig. S3 SEM image of the PtPd nanoparticles prepared without adding F127 under the identical conditions used for the typical synthesis.

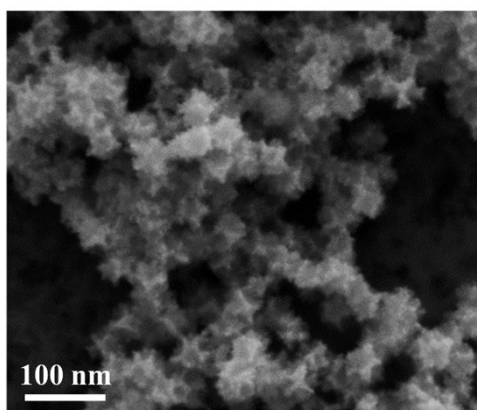


Fig. S4 SEM image of the PtPd nanoparticles prepared without adding HCl under the identical conditions used for the typical synthesis.

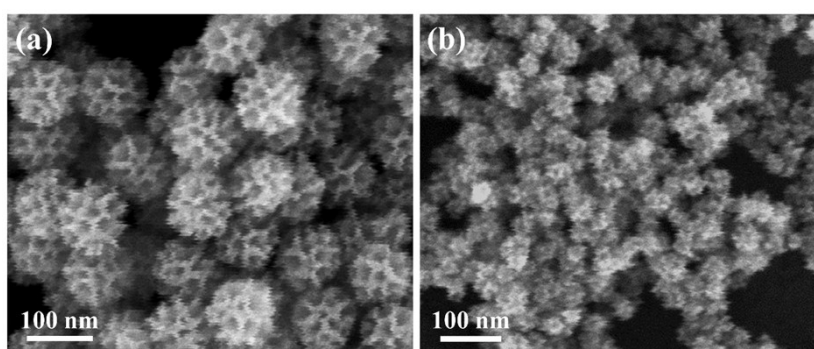


Fig. S5 SEM images of the PtPd samples obtained by introducing different molar ratio of $\text{H}_2\text{PtCl}_6/\text{Na}_2\text{PdCl}_4$: (a) $\text{H}_2\text{PtCl}_6/\text{Na}_2\text{PdCl}_4=4/1$ (PtPd-1); (b) $\text{H}_2\text{PtCl}_6/\text{Na}_2\text{PdCl}_4=1/1$ (PtPd-2).

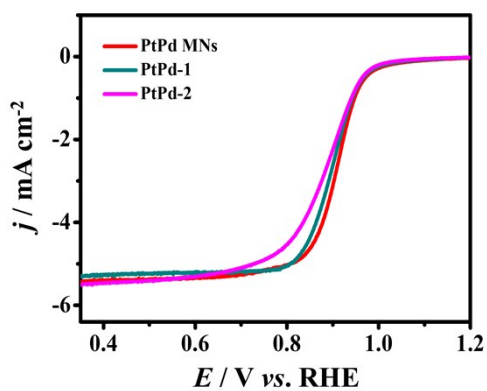


Fig. S6 ORR polarization curves of various PtPd catalysts.

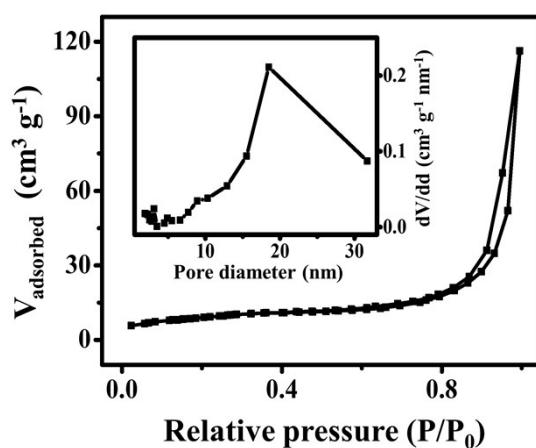


Fig. S7 N₂ adsorption-desorption isotherms for the PtPdNiP MNs. The inset is the BJH pore-size distribution curve.

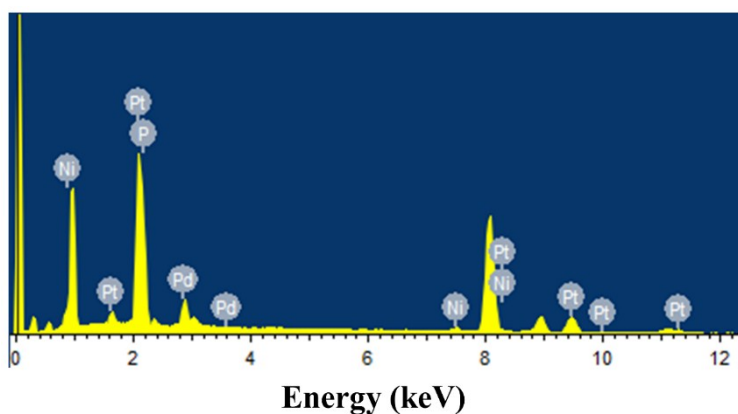


Fig. S8 EDX spectrum of the PtPdNiP MNs.

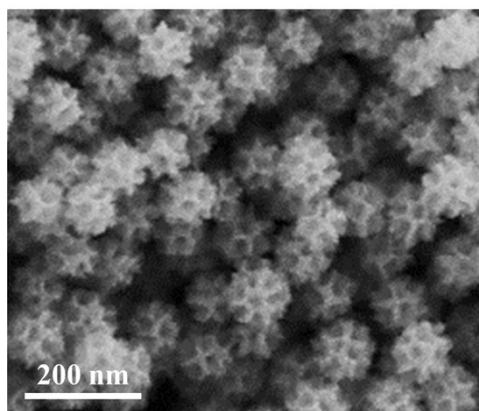


Fig. S9 SEM image of the PtPdP MNs.

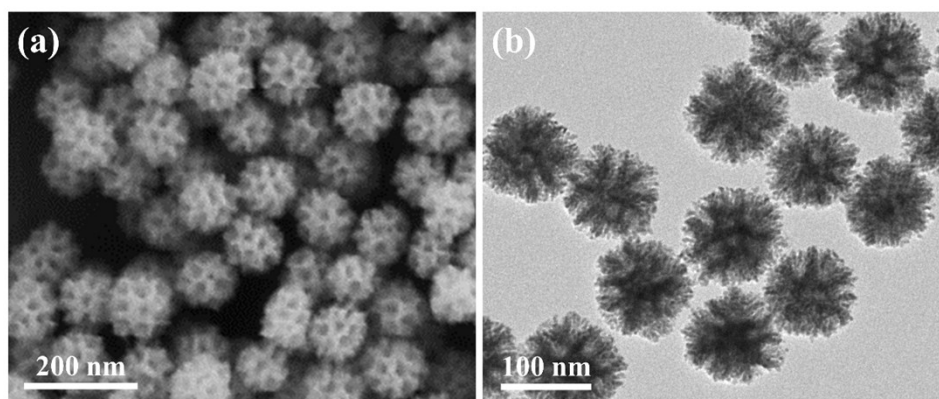


Fig. S10 (a) SEM and (b) TEM images of the PtPdNi MNs.

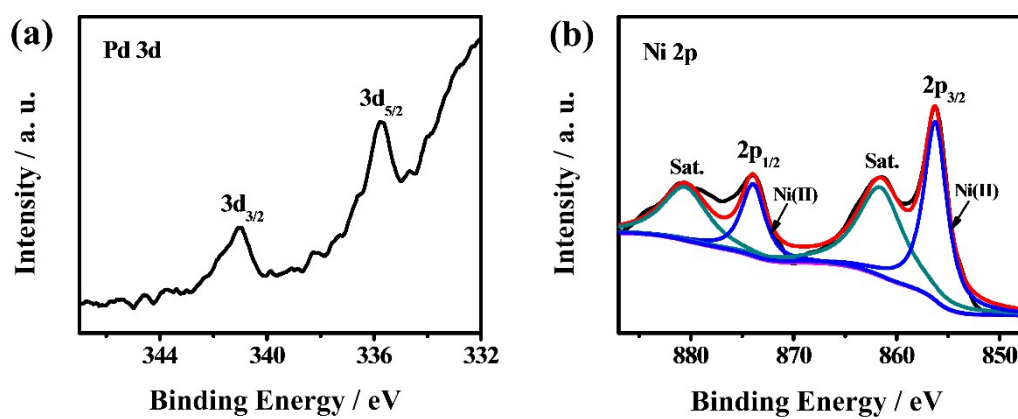


Fig. S11 XPS spectra of the (a) Pd 3d and (b) Ni 2p regions for the PtPdNiP MNs.

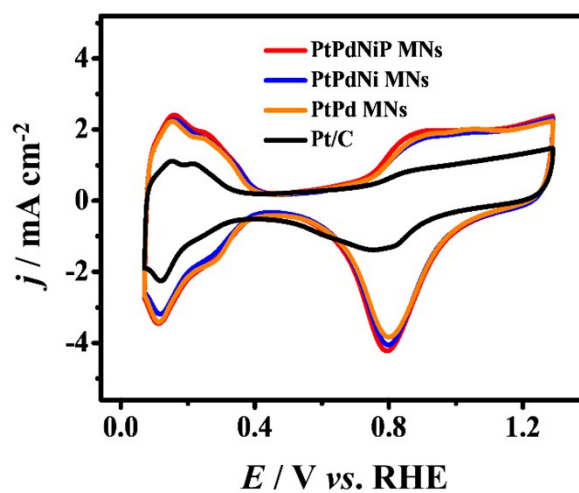


Fig. S12 CV curves of the catalysts in a N_2 -saturated 0.1 M HClO_4 solution at room temperature.

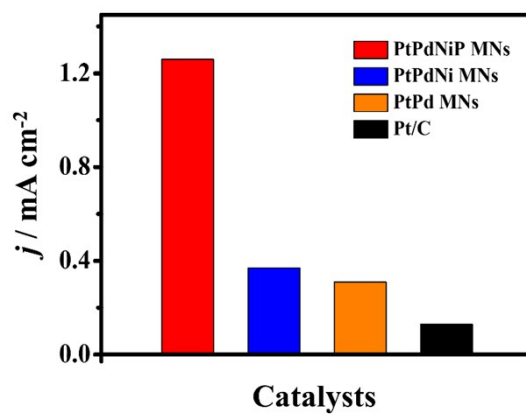


Fig. S13 Specific activities of the catalysts at 0.9 V obtained by normalizing the ORR currents to the BET surface areas.

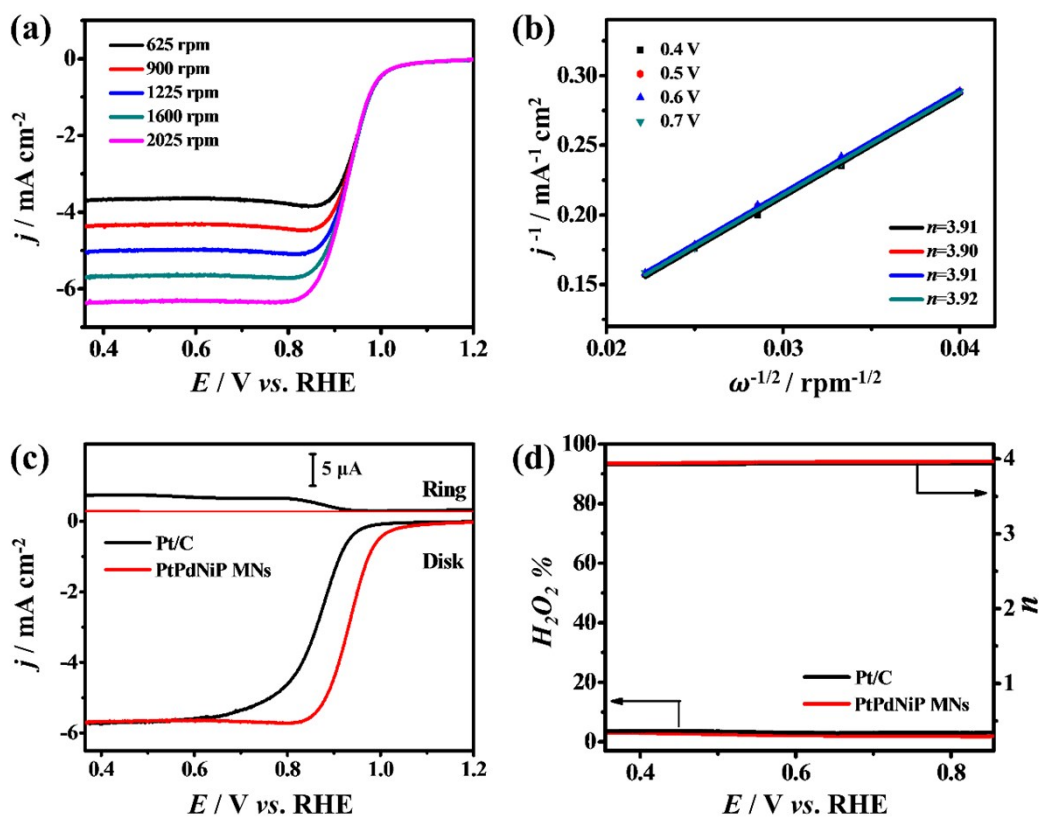


Fig. S14 (a) ORR polarization curves of the PtPdNiP MNs with different RDE rotation rates. The currents were normalized to the geometric area of the rotating disk electrode. (b) The electron transfer numbers at different potentials. (c) RRDE test of the ORR on the catalysts and (d) peroxide percentages and electron transfer numbers of the catalysts tested by the RRDE in an O₂-saturated 0.1 M HClO₄ solution.

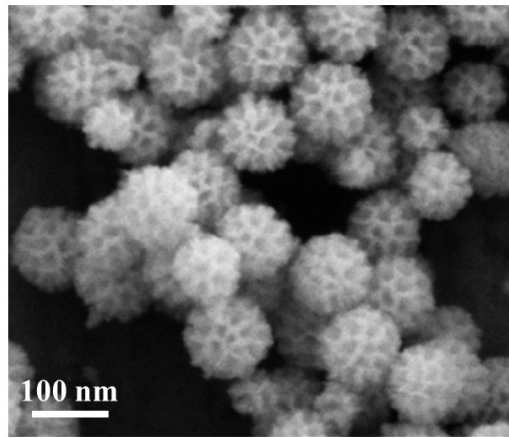


Fig. S15 SEM image of the PtPdNiP MNs after catalytic stability testing.

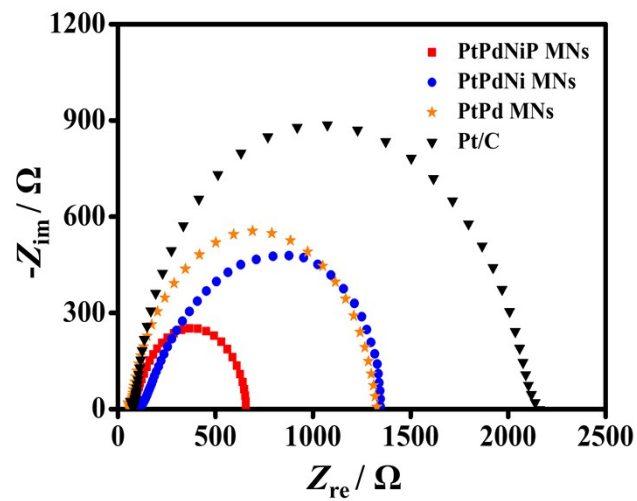


Fig. S16 Nyquist plots for the PtPdNiP MNs, PtPdNi MNs, PtPd MNs and Pt/C recorded in an O_2 -saturated 0.1 M $HClO_4$ solution at 0.9 V (vs RHE) with a rotation rate of 1600 rpm. The frequency ranges from 100 kHz to 0.01 Hz.

Table S1. The BET surface areas of various samples.

Samples	BET Surface Area / m² g⁻¹
PtPdNiP MNs	35.68
PtPdNiP nanospheres ^a	17.31
PtPdNi MNs	34.96
PtPd MNs	35.43
Pt/C	84.22

^a The sample was obtained by using PtPd solid nanospheres (shown in Fig. S3) as the precursor for Ni- and P-incorporation.

Table S2. The element contents in different samples.

Samples	Pt / at%	Pd / at%	Ni / at%	P / at%
PtPdNi MNs	57.07	30.85	12.08	--
PtPdNiP MNs	40.85	22.36	8.63	28.16
PtPdP MNs	60.88	33.56	--	5.56

Table S3. The comparisons of specific and mass activities of PtPdNiP MNs for ORR with some recently reported Pt-based catalysts.

Catalysts	Electrolyte	Specific activity (mA cm ⁻²)	Mass activity (mA μg _{Pt} ⁻¹)	Ref.
PtPdNiP MNs	0.1 M HClO ₄	0.89	0.45	This work
PtCuCoNi nanotubes	0.1 M HClO ₄	0.180	0.190	[1]
Nanoporous PtCuTi alloy	0.1 M HClO ₄	0.840	0.256	[2]
PtNi hollow nanochains	0.1 M HClO ₄	0.480	0.340	[3]
PtNi nanoporous nanowires	0.1 M HClO ₄	0.990	0.333	[4]
Nanoporous PtPd Alloy	0.1 M HClO ₄	0.390	0.250	[5]
PtPd@MCF-C	0.1 M HClO ₄	0.611	0.443	[6]
Pd@Pt tetrapods	0.1 M HClO ₄	--	0.381	[7]
Pt-Pd-Ag alloy nanoflowers	0.1 M HClO ₄	0.526	0.206	[8]
mesoporous Au-Pd-Pt nanoflowers	0.1 M HClO ₄	0.479	0.212	[9]

References

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