Electronic Supplementary Material (ESI) for Nanoscale.

One-step synthesis of ultrathin Pt_xPb nerve-like nanowires as robust catalysts for enhanced methanol electrooxidation

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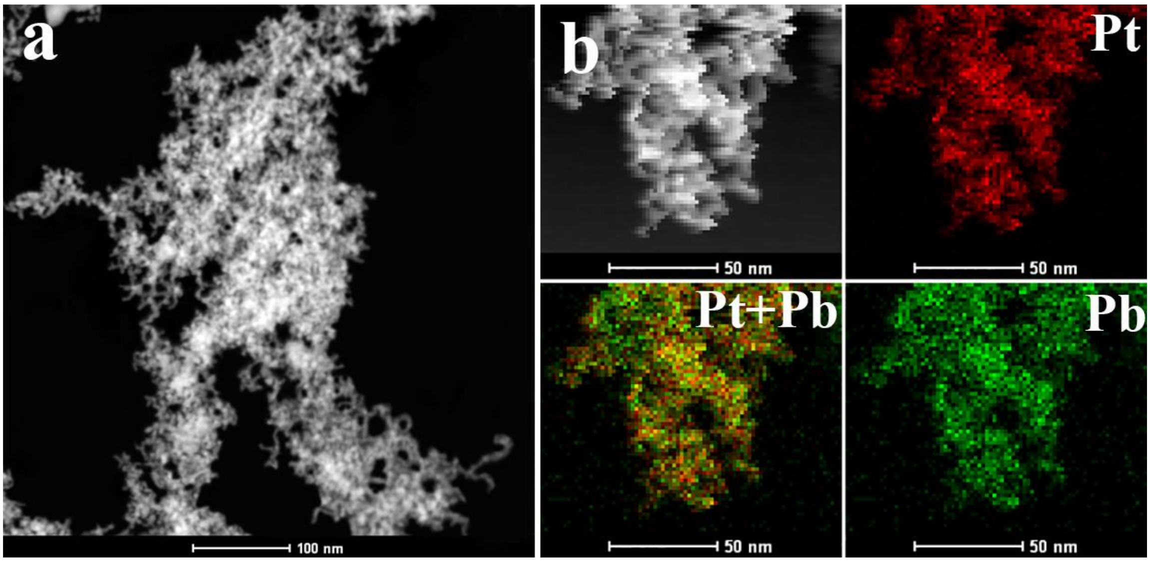

Fig. S1 Additional (a) HAADF-STEM image and (b) EDX mapping images of the $Pt_{3.5}Pb$ NNWs.

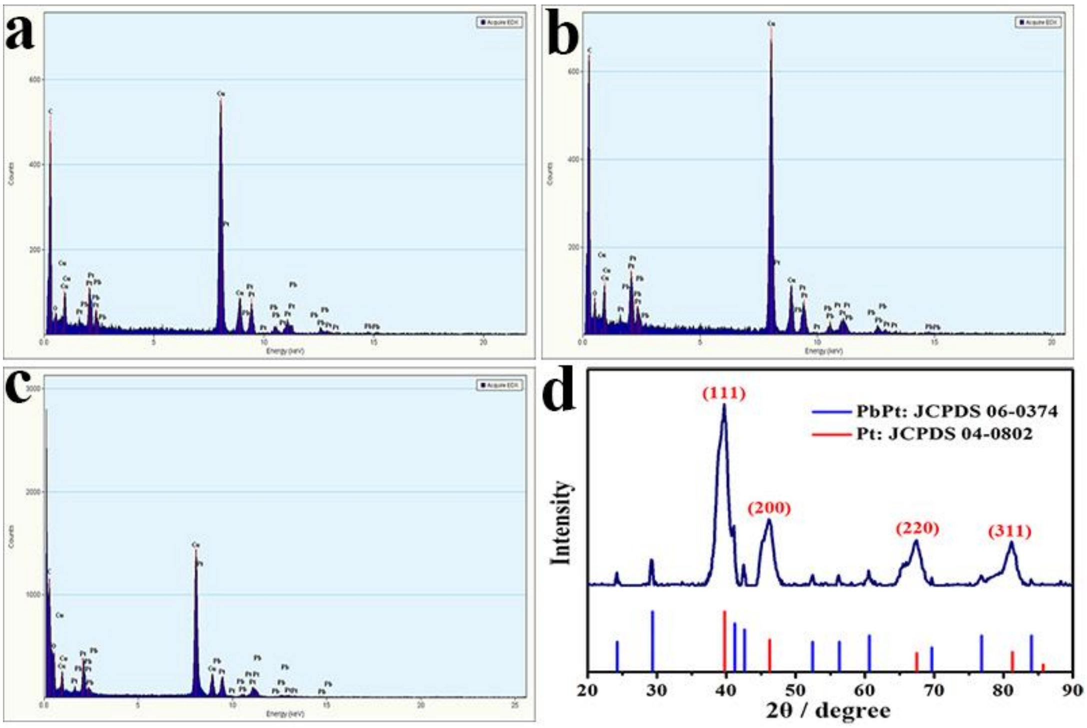

Fig. S2 TEM-EDX of the Pt_3Pb NNWs (a), $Pt_{3.5}Pb$ NNWs (b), Pt_4Pb NNWs (c), and the ratio of Pt/Pb are 3:1, 3.5:1 and 4:1, respectively. (d)XRD pattern of the Pt_4Pb NNWs.

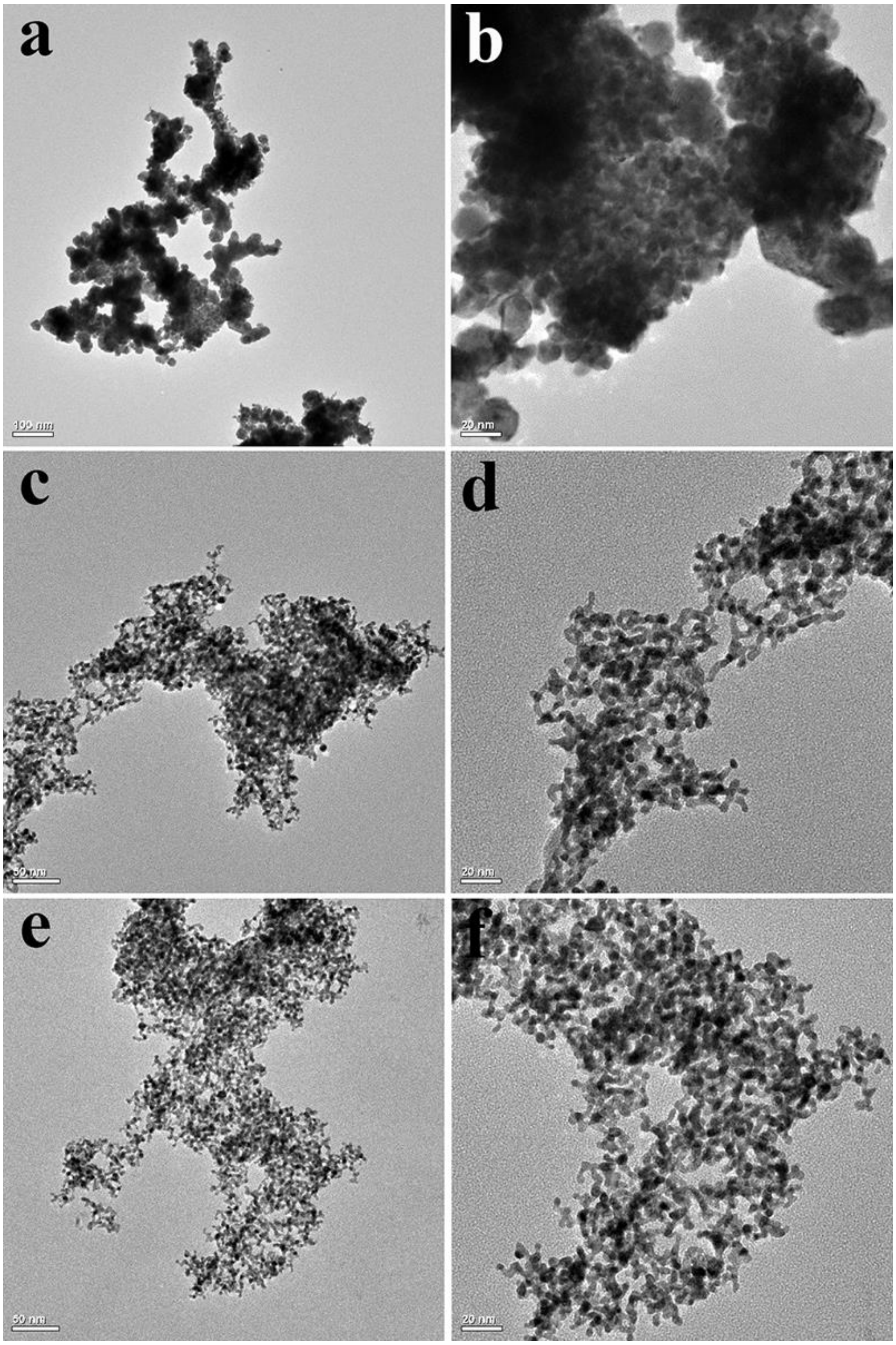

Fig. S3 Representative TEM images of the products with the same reaction conditions as those of the $Pt_{3.5}Pb$ NNWs except the use of (a, b) 0.006 mmol, (c, d) 0.0048 mmol and (e, f) 0.0035 mmol of $Pb(acac)_2$.

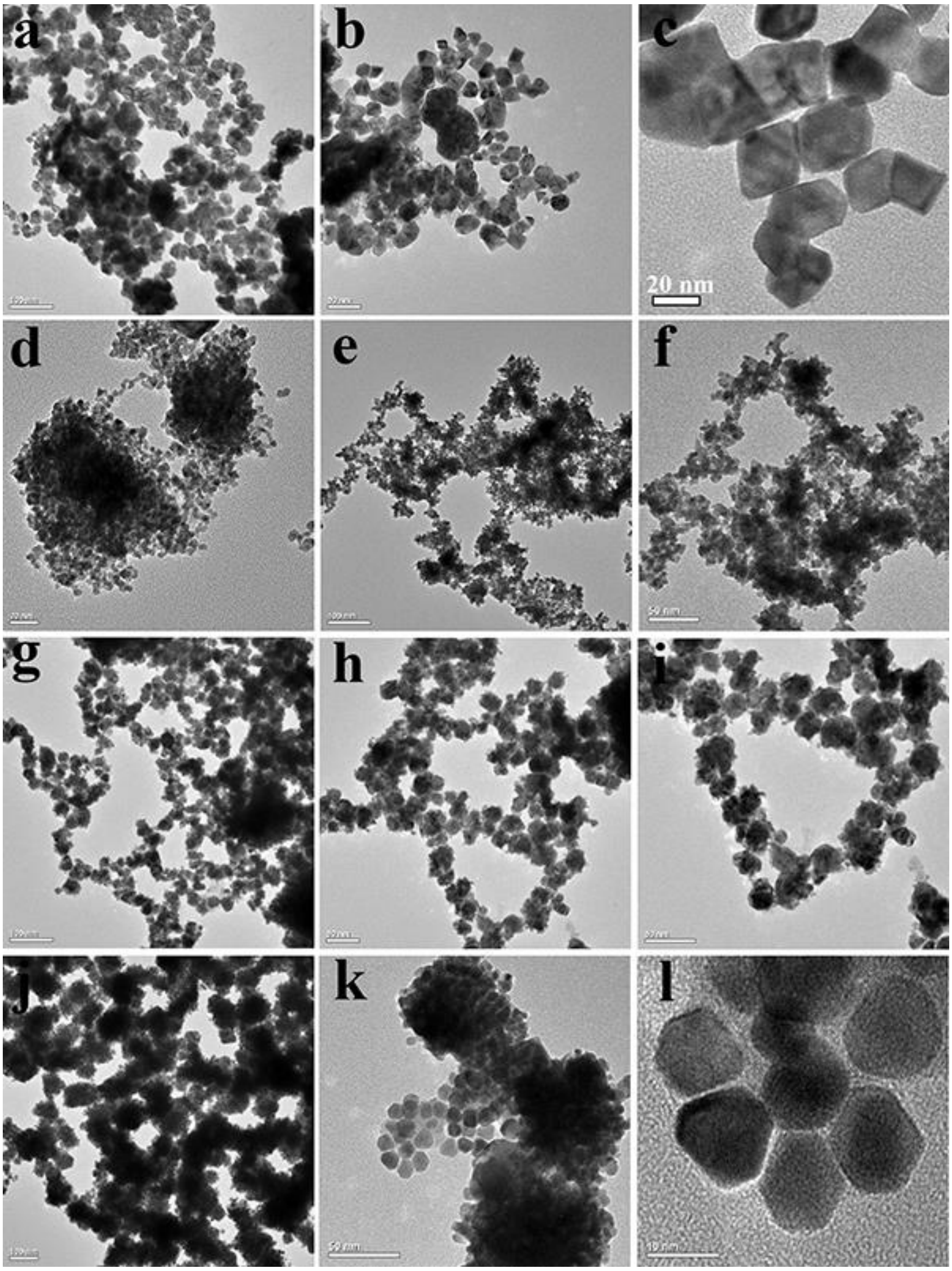

Fig. S4 Representative TEM images of the products with the same reaction conditions as those of the $Pt_{3.5}Pb$ NNWs except the use of (a, b, c) 0 μL, (d, e, f) 100 μL, (g, h, i) 500 μL and (j, k, l) 1 mL OAm.

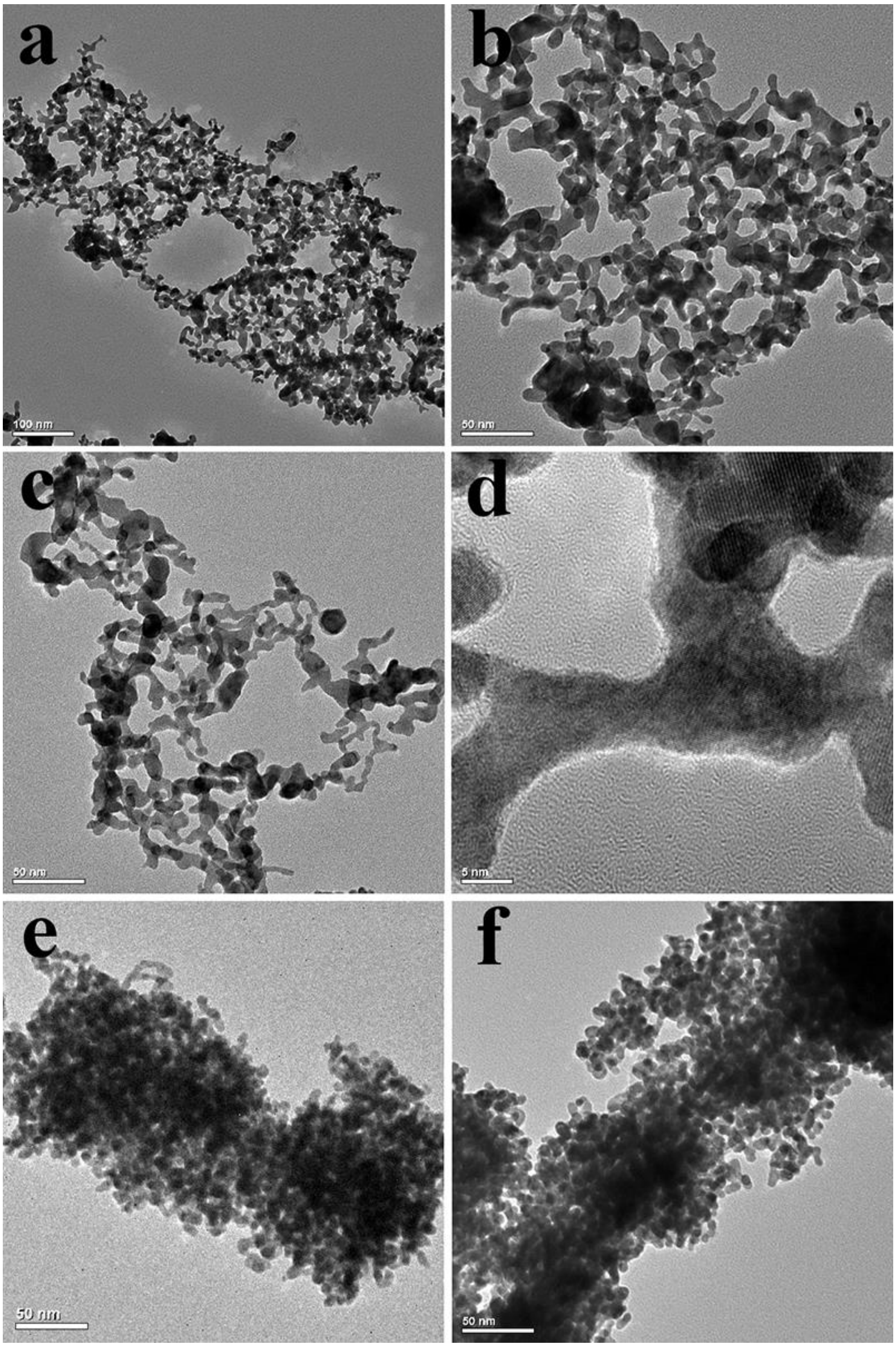

Fig. S5 TEM images of the products with the same reaction conditions as those of the $Pt_{3.5}Pb$ NNWs except changing $Pb(acac)_2$ with $Pb(ac)_2$ (a-d) and in absence of $Pb(acac)_2$ (e, f).

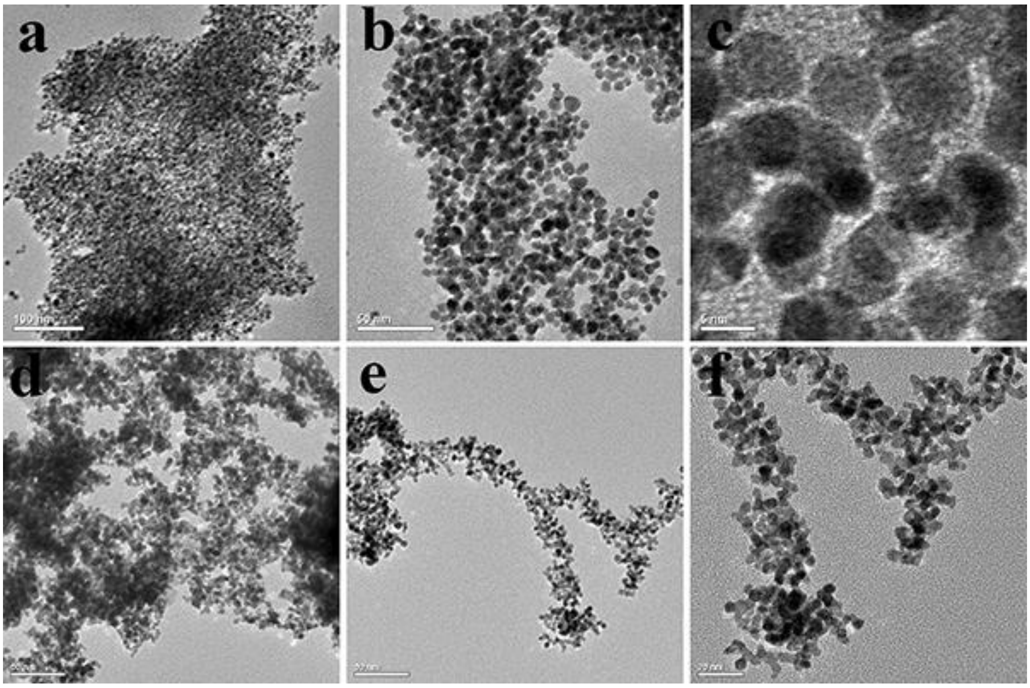

Fig. S6 Representative TEM images of the products with the same reaction conditions as those of the $Pt_{3.5}Pb$ NNWs except changing the reaction temperature to (a, b, c) 140℃ and (d, e, f) 160℃.

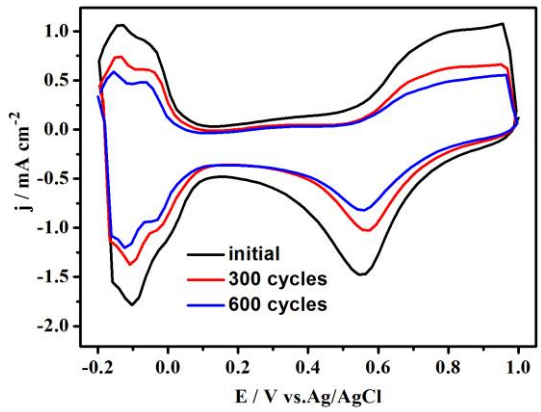

Fig. S7 CV curves before and after 600 potential cycles of the PtRu/C catalysts.

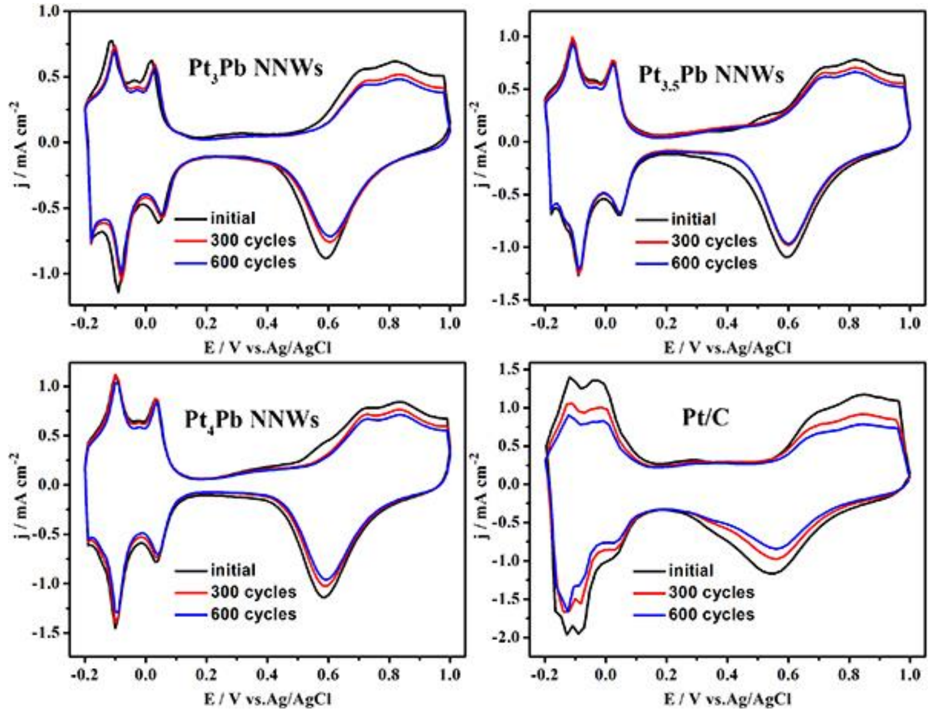

Fig. S8 CV curves before and after 600 potential cycles of the Pt_4Pb NNWs, $Pt_{3.5}Pb$ NNWs, Pt_3Pb NNWs and commercial Pt/C catalysts. The durability tests are carried out at room temperature in 0.5 M H_2SO_4 solution at a sweep rate of 50 mV s^{-1}.

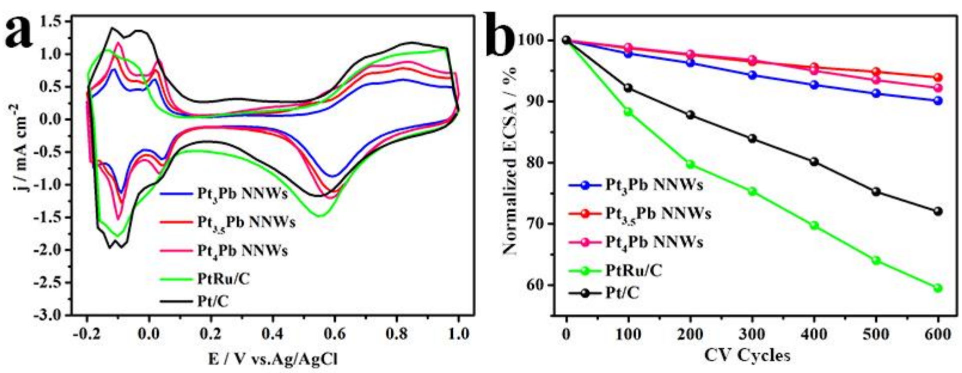

Fig. S9 (a) CV of different catalysts were recorded at room temperature in N_2-saturated 0.5 M H_2SO_4 solution with a sweep rate of 50 mV s^{-1}. (b) variation of normalized ECSA during 600 cycles for the Pt_xPb NNWs and the commercial Pt/C catalysts.

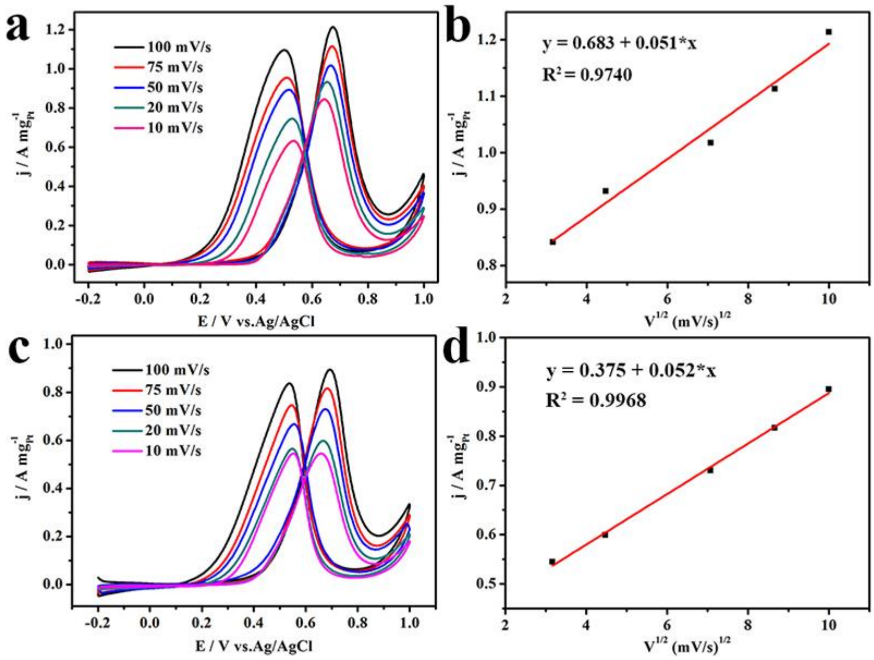

Fig. S10 CV of MOR on the Pt_3Pb NNWs and Pt_4Pb NNWs at different scan rates in acidic condition (a, c) and the corresponding plot of j_m versus the $v^{1/2}$ (b, d), respectively.

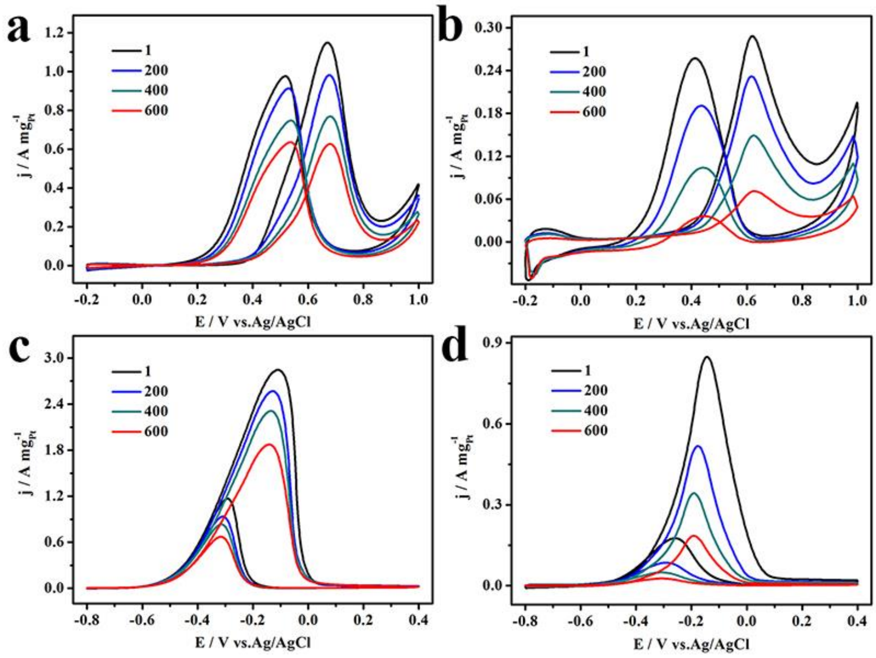

Fig. S11 CV of the $Pt_{3.5}Pb$ NNWs and commercial Pt/C catalysts for 600 cycles in acidic (a, b) and alkaline (c, d) conditions, respectively.

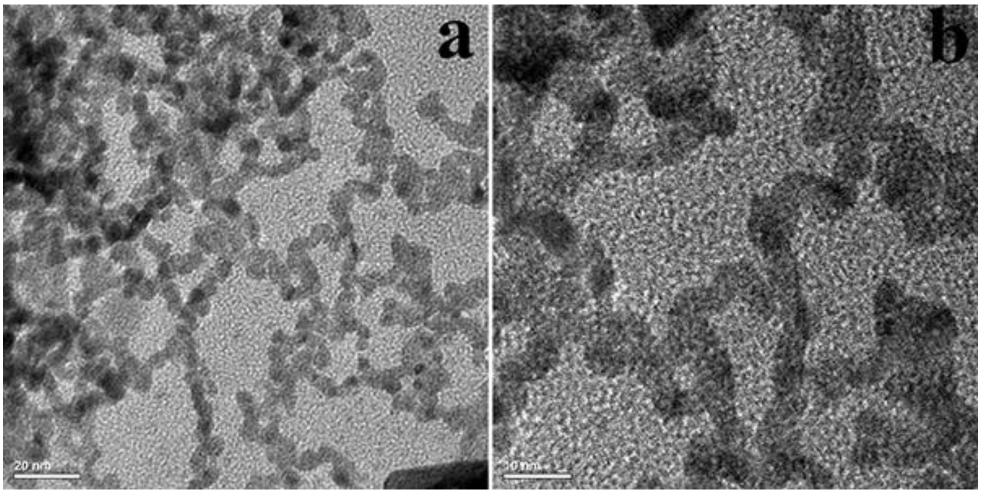

Fig. S12 (a) low-magnification and (b) high-magnification TEM image of the $Pt_{3.5}Pb$ NNWs after 600 potential cycles.

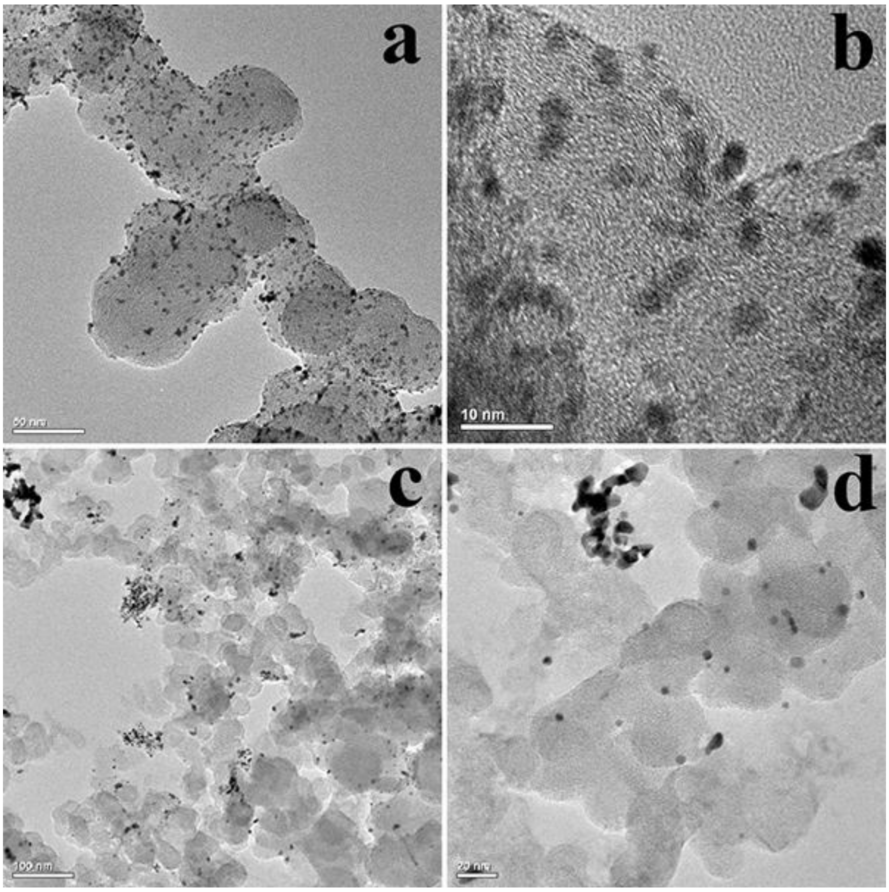

Fig. S13 Representative TEM images of the commercial Pt/C catalysts (a, b) before and (c, d) after 600 potential cycles.

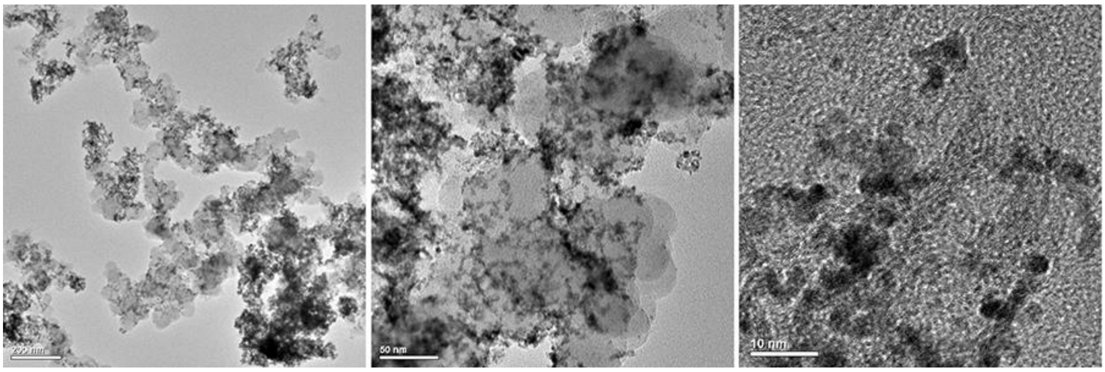

Fig. S14 TEM images of the PtRu/C catalysts.

Table S1. MOR performance of various electrocatalysts

Catalysts	Electrolyte solution	Peak current potential (V)*	Mass activity (A mg^{-1})	Specific activity (mA cm^{-2})	Ref.
$Pt_{3.5}Pb$ NNWs	0.5 M H_2SO_4 + 1 M CH_3OH	0.66	1.18	2.78	This work
Pt_3Ti/C	0.1 M $HClO_4$ + 1 M CH_3OH	0.70	0.149	0.307	S1
Pt_3V/C		0.72	0.200	0.384	
Pt-Sn	0.5 M H_2SO_4 + 0.5 M CH_3OH	--	0.346	2.30	S2
Pt_3Co	0.1 M $HClO_4$ + 0.1 M CH_3OH	0.71	1.02	1.95	S3
Pt-Au	0.1 M $HClO_4$ + 0.5 M CH_3OH	0.82	0.80	2.25	S4
Pt-Ru	0.5 M H_2SO_4 + 0.5 M CH_3OH	0.71	0.074	0.76	S5
Pt-Ru/C	0.5 M H_2SO_4 + 1 M CH_3OH	--	0.44	--	S6
$Pt_{3.5}Pb$ NNWs	0.5 M KOH + 1 M CH_3OH	-0.11	2.84	6.51	This work
Pt_1Pb_1/C	1 M NaOH + 1 M CH_3OH	0.1	1.93	4.30	S7
Pd-Ni-Pt	0.1 M KOH + 0.05 M CH_3OH	--	--	1.55	S8
Au/Pt-Cu	1 M KOH + 1 M CH_3OH	-0.06	1.50	--	S9
Pt-Ru/TiO_2	0.5 M NaOH + 0.5 M CH_3OH	-0.10	--	3.438	S10
Pt-Ru/C		0.1	--	3.20	

* The peak current potential were corresponding to Ag/AgCl (saturated KCl) electrode.

Reference

(S1) Z. Cui, H. Chen, M. Zhao, D. Marshall, Y. Yu, H. Abruna and F. J. DiSalvo, *J. Am. Chem. Soc.*, 2014, **136**, 10206-10209.

(S2) Q. Chen, Y. Yang, Z. Cao, Q. Kuang, G. Du, Y. Jiang, Z. Xie and L. Zheng, *Angew. Chem., Int. Ed.*, 2016, **128**, 9167-9171.

(S3) L. Bu, S. Guo, X. Zhang, X. Shen, D. Su, G. Lu, X. Zhu, J. Yao, J. Guo and X.

Huang, *Nat. Commun.*, 2016, **7**, 11850.

(S4) H. You, F. Zhang, Z. Liu and J. Fang, *ACS Catal.*, 2014, **4**, 2829-2835.

(S5) Z. Lin, W. Chen, Y. Jiang, T. Bian, H. Zhang, J. Wu, Y. Wang and D. Yang, *Nanoscale*, 2016, **8**, 12812-12818.

(S6) E. Lee, A. Murthy and A. Manthiram, *J. Electroanal. Chem.*, 2011, **659**, 168-175.

(S7) Q. Jiang, L. Jiang, J. Qi, S. Wang and G. Sun, *Electrochim. Acta*, 2011, **56**, 6431-6440.

(S8) B. T. Sneed, A. P. Young, D. Jalalpoor, M. C. Golden, S. Mao, Y. Jiang, Y. Wang and C. K. Tsung, *ACS Nano*, 2014, **8**, 7239-7250.

(S9) W. Hong, J. Wang and E. Wang, *Small*, 2014, **10**, 3262-3265.

(S10) Y. Hu, A. Zhu, C. Zhang, Q. Zhang and Q. Liu, *Inter. J. Hydrogen Energy*, 2015, **40**, 15652-15662.