Supporting information

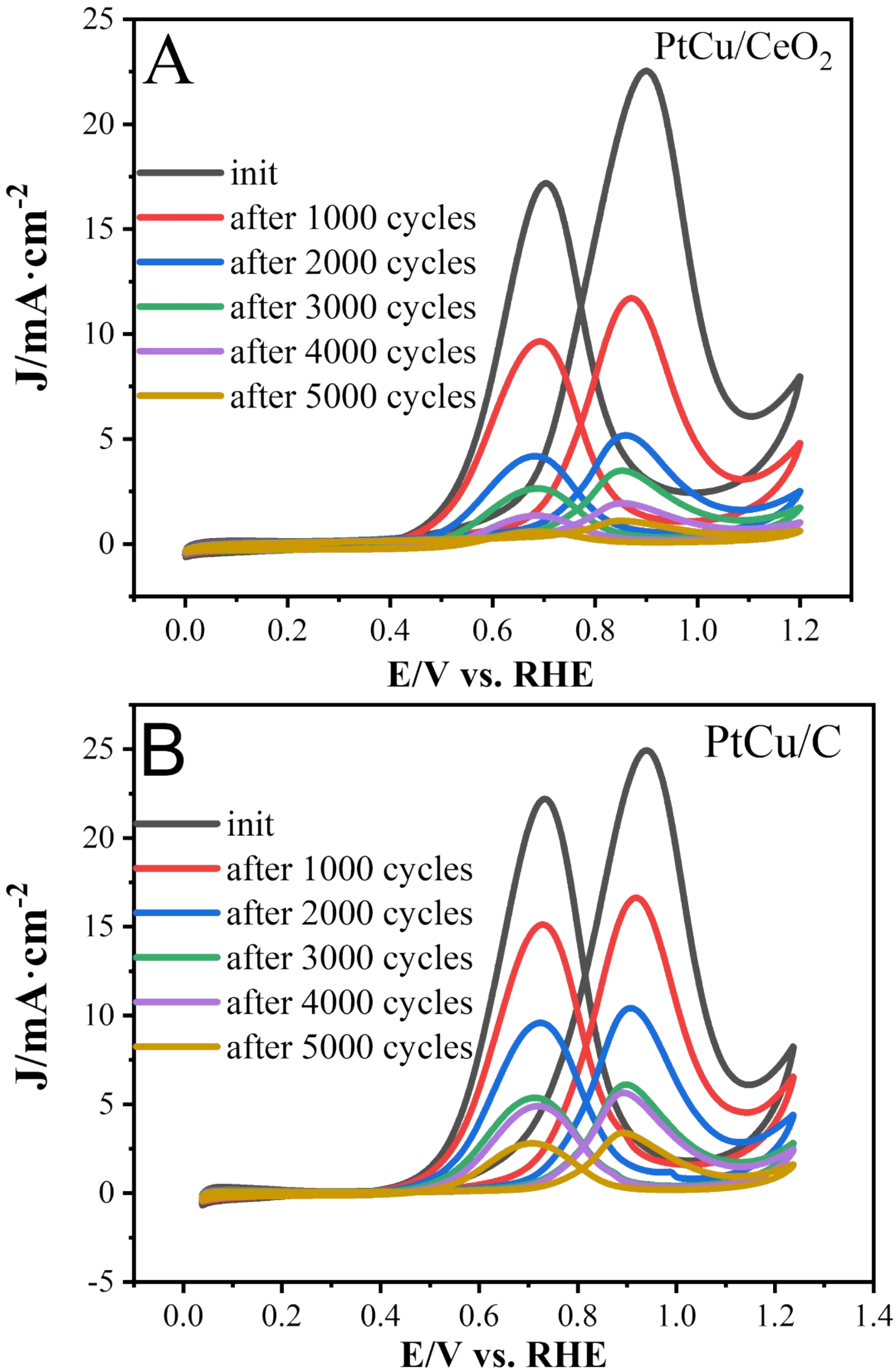
The ultra-thin order-disordered CeO_2 nanobelts as the non-carbon support of PtCu catalyst towards methanol oxidation and oxygen reduction reactions

Han Zhi[a], Boda Dong[a], Xingxing Guo[b], Feng Xu[ab1]

[a] School of Advanced Manufacturing, Fuzhou University

[b] College of Materials Science and Engineering, Fuzhou University

[1] Corresponding author at: College of Materials Science and Engineering, Fuzhou University, Fuzhou, China.
Email address: xufeng@fzu.edu.cn.



A
PtCu/CeO2
init
after 1000 cycles
after 2000 cycles
after 3000 cycles
after 4000 cycles
after 5000 cycles
J/mA·cm-2
E/V vs. RHE
0
5
10
15
20
25
0.0
0.2
0.4
0.6
0.8
1.0
1.2
B
PtCu/C
init
after 1000 cycles
after 2000 cycles
after 3000 cycles
after 4000 cycles
after 5000 cycles
J/mA·cm-2
E/V vs. RHE
-5
0
5
10
15
20
25
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4

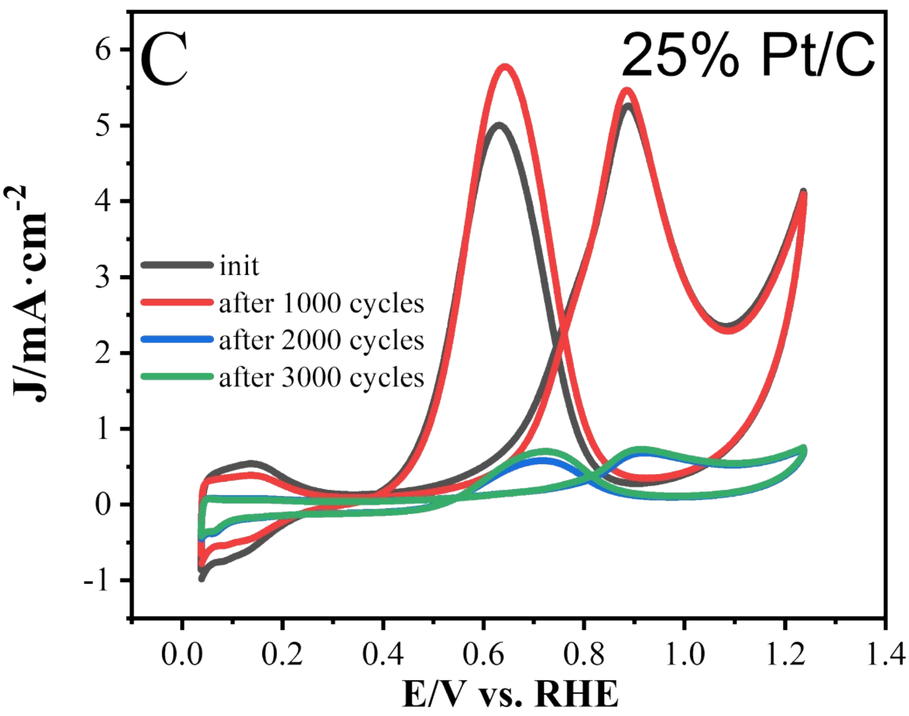


Figure S1 The ADT cycling of $PtCu/CeO_2$ (A), PtCu/C (B), and Pt/C (C).

The durability is also an important issue. Figure S1 shows the MOR curves of Pt/C, PtCu/C, and $PtCu/CeO_2$ after 5000 cycles and their MA losses. The forward scan current of Pt/C after 1000 cycles was already lower than the negative scanning current value, which indicated that the Faraday efficiency of Pt/C decreases dramatically after 1000 cycles. While the forward scan current of PtCu/C and $PtCu/CeO_2$ are always higher than negative one, illustrating the high Faraday efficiency. The degradation of catalytic activity was directly observed by the MA loss. The activity of Pt/C catalyst decreases sharply after 2000 ADT cycles. The MA of $Pt_{0.15}Cu/CeO_2$ and PtCu/C after 5000 cycles retain 17.04% and 14.21%, respectively, due to the better durability of the PtCu alloy, the CeO_2 in the former gives a slight improvement in durability.

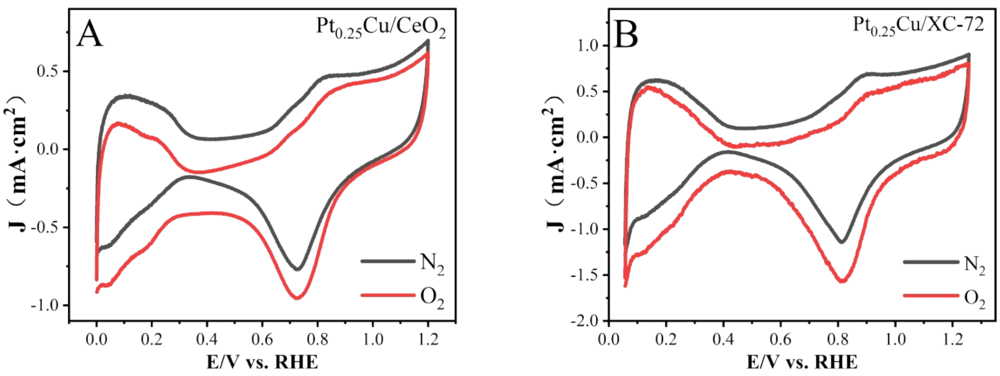


Figure S2 CV curves of $Pt_{0.25}Cu/CeO_2$, $Pt_{0.15}Cu/CeO_2$, and $Pt_{0.25}Cu$/XC-72 under N_2 and O_2 saturated solutions, respectively

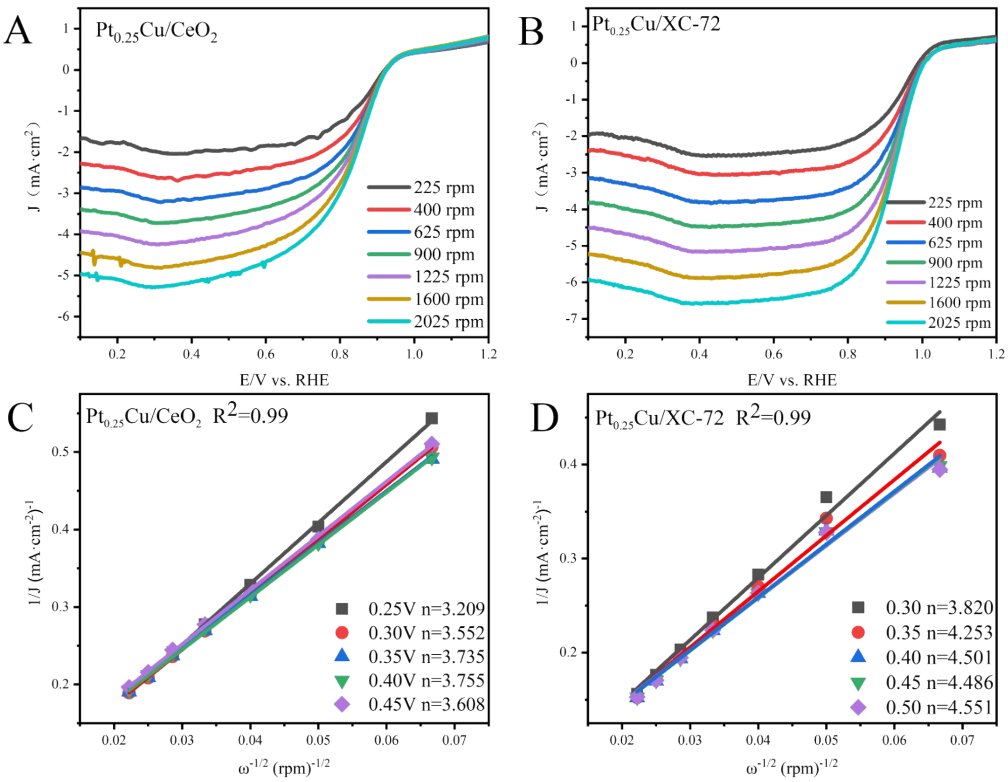


Figure S3 LSV curve and number of transferred electrons for each sample at different speeds

Firstly, LSV curves of the samples were tested at 225, 400, 625, 900, 1225, 1600, and 2025 rpm, then take the limit current density values of potential 0.25V, 0.3V, 0.35V, 0.4V, and 0.45V (vs.RHE) in the limit diffusion area to draw the scatter plot, The number of transferred electrons reflected by ORR is calculated by the slope of the fitted curve. Fig S3 shows the results.

Table S1 Peak positions of PtCu in each catalyst, Pt and Cu standard elements

Sample	(111)	(200)	(220)	(311)
$Pt_{0.25}Cu/CeO_2$	39.81	46.29	67.52	81.34
Pt	39.54	45.99	67.06	80.75
Cu	43.32	50.45	74.12	89.94

Table S2 the value of Binding Energy of peak in XPS spectra for Pt, Cu and the proportion of zero-valence Pt atoms

Sample	Pt (eV)					Cu (eV)	
	Pt^0 $4f_{7/2}$	Pt^0 $4f_{5/2}$	Pt^{2+} $4f_{7/2}$	Pt^{2+} $4f_{5/2}$	Pt^0 (%)	Cu^0 $2p_{3/2}$	Cu^0 $2p_{1/2}$
$Pt_{0.25}Cu/CeO_2$	70.97	74.24	72.59	76.45	89.34	931.14	950.56
$Pt_{0.25}Cu$/XC-72	71.52	74.83	72.25	75.68	32.83	932.26	952.13

Table S3 ICP-AES results of samples

Sample	Pt (wt.%)	Cu (wt.%)	CeO_2 (wt.%)	Pt (at.%)	Cu (at.%)	CeO_2 (at.%)
$Pt_{0.25}Cu/CeO_2$	75.74	19.37	4.89	53.98	42.07	3.95
$Pt_{0.25}Cu$/XC-72	82.49	17.51	0	60.72	39.28	0

Table S4 Various performance values of the sample MOR test

Sample	I_f ($mA\cdot cm^{-2}$)	I_b ($mA\cdot cm^{-2}$)	I_f/I_b ($mA\cdot cm^{-2}$)	ECSA ($m^2\cdot gPt^{-1}$)	MA ($m^2\cdot gPt^{-1}$)	SA ($mA\cdot cm^{-2}$)
$Pt_{0.25}Cu/CeO_2$	37.24	30.01	1.24	8.91	0.32	0.36
25% Pt/C	5.23	5.00	1.05	8.36	0.03	0.04
$Pt_{0.25}Cu$/XC-72	24.93	22.19	1.12	11.39	0.2	0.18

Table S5 Various performance data of catalyst ORR test

Sample	E_{onset} (V)	$E_{1/2}$ (V)	J ($mA\cdot cm^{-2}$)	Tafel slope ($mV\cdot dec^{-1}$)	ECSA ($m^2\cdot gPt^{-1}$)	MA ($m^2\cdot gPt^{-1}$)
$Pt_{0.25}Cu/CeO_2$	0.92	0.82	4.82	242.90	5.19	0.21
$Pt_{0.25}Cu$/XC-72	0.94	0.86	5.88	268.20	8.58	0.24

Table S6 ORR performance values after endurance test

	5000 cycles			10000 cycles		
Sample	E_{onset}(V)	$E_{1/2}$(V)	J($mA\cdot cm^{-2}$)	E_{onset}(V)	$E_{1/2}$(V)	J($mA\cdot cm^{-2}$)
$Pt_{0.25}Cu/CeO_2$	0.93	0.83	4.51	0.90	0.72	4.30
$Pt_{0.25}Cu$/XC-72	0.94	0.86	5.84	0.94	0.85	5.63