Supporting information

Promoting effect of nickel hydroxide on electrocatalytic performance of Pt in alkaline solution

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The Calculation method of Scherrer equation:

The Scherrer equation, in X–ray diffraction and crystallography, is a formula that relates the size of sub–micrometre particles, or crystallites, in a solid to the broadening of a peak in a diffraction pattern. The Calculation method of Scherrer equation is follows:

$$\mathbf{D=K\cdot\gamma/B\cdot\cos\theta}$$

Where D is the mean size of the ordered (crystalline) domains, K=0.89, is Scherrer constant, γ=0.154056 nm, is the X–ray wavelength, B is the line broadening at half the maximum intensity (FWHM), θ is the Bragg angle. All angles are converted to radians.

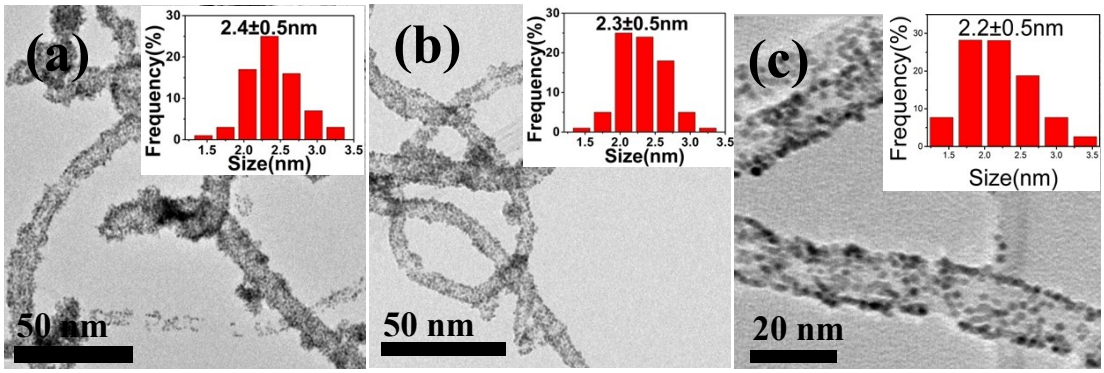

Figure S1. TEM images of (a) 10:1–Pt/Ni(OH)$_2$/N–CNTs, (b) 10:5–Pt/Ni(OH)$_2$/N–CNTs and (c) Pt/N–CNTs catalysts.

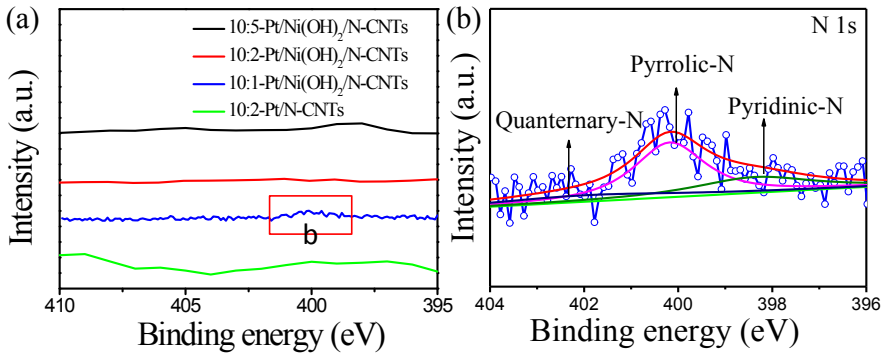

Figure S2. (a) XPS patterns of the N 1s of all nanomaterials. (b) Enlarged N 1s pattern of 10:1-Pt/$Ni(OH)_2$/N–CNTs.

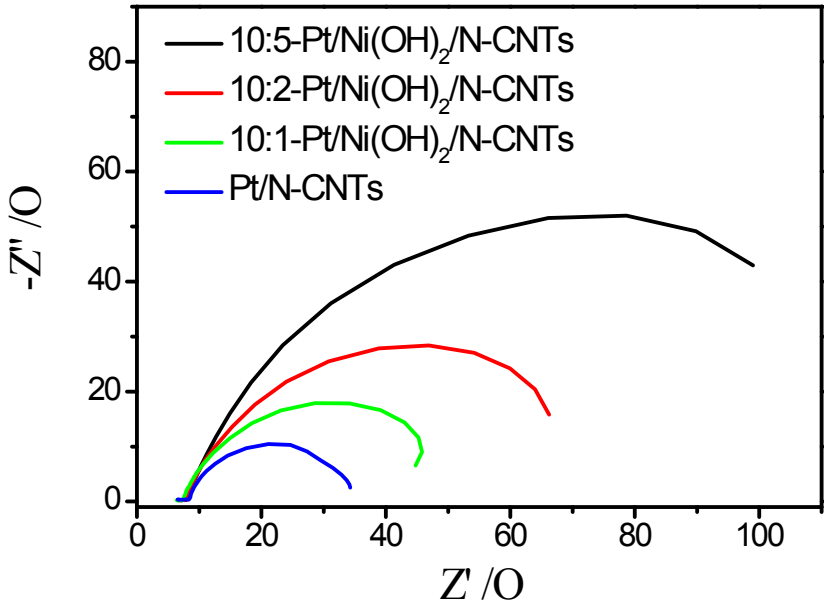

Figure S3. Nyquist plots of electrochemical impedance spectra (EIS) for 10:5–Pt/Ni(OH)$_2$/N–CNTs, 10:2–Pt/Ni(OH)$_2$/N–CNTs, 10:1–Pt/Ni(OH)$_2$/N–CNTs and Pt/N–CNTs in 0.1 M NaOH solution.

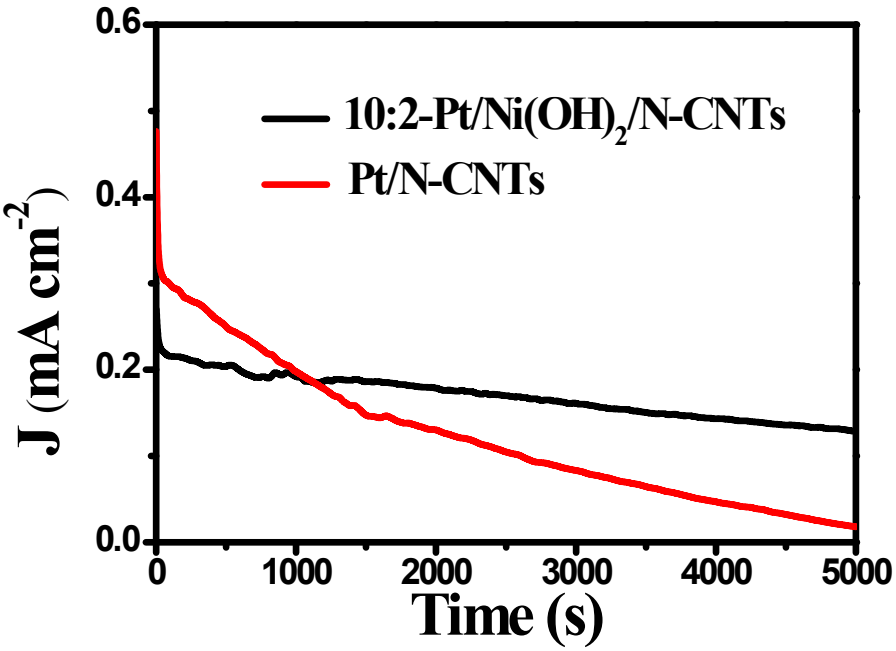

Figure S4. *i–t* curves (at 0.5 V vs. RHE) of MOR for 10:2–Pt/Ni(OH)$_2$/N–CNTs and Pt/N–CNTs catalysts.

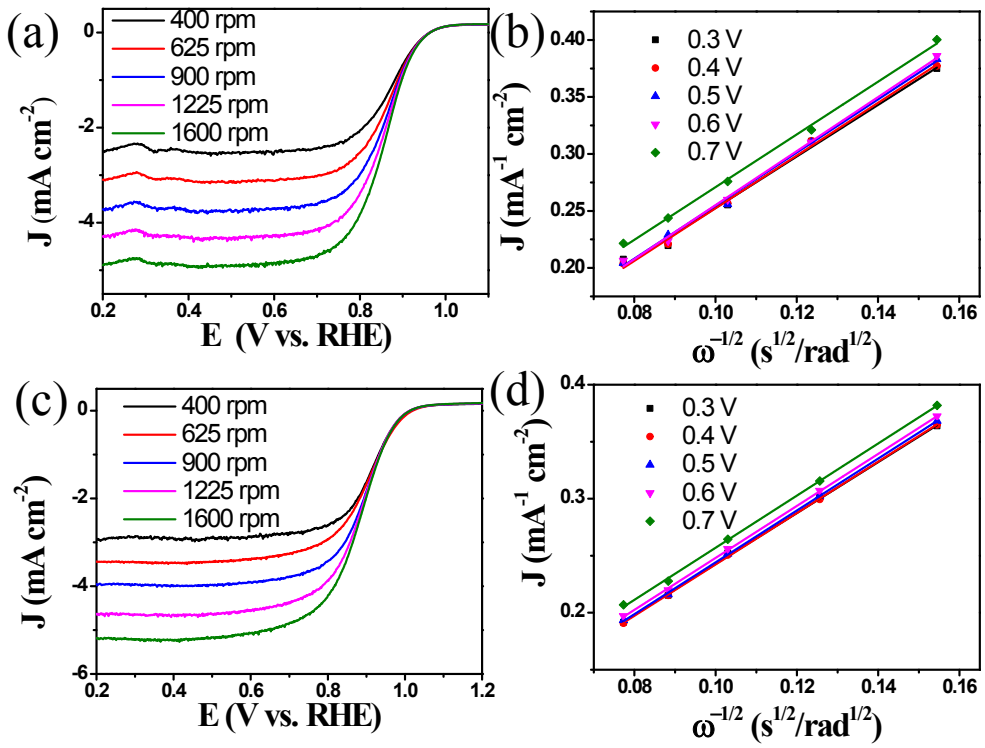

Figure S5. ORR polarization curves of (a) Pt/C and (c) Pt/CNTs in O_2-saturated 0.1 M NaOH solution at a scan rate of 10 mV s^{-1} and different rotation rates. Koutecky-Levich plots of (b) Pt/C and (d) Pt/CNTs at different potentials.

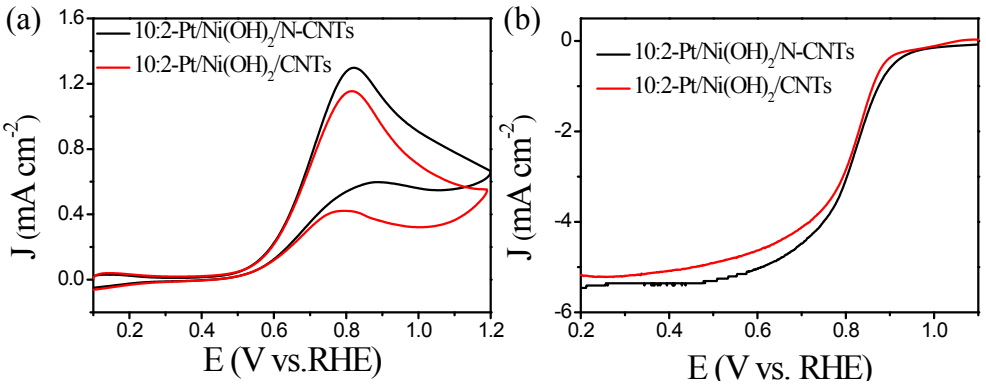

Figure S6. (a) MOR activity of 10:2–Pt/Ni(OH)$_2$/N–CNTs and 10:2–Pt/Ni(OH)$_2$/CNTs. (b) ORR activity of 10:2–Pt/Ni(OH)$_2$/N–CNTs and 10:2–Pt/Ni(OH)$_2$/ CNTs.

Table S1. The calculation results of Scherrer equation.

Sample	parameter			D /nm	D_{avg} /nm
	2θ /°	hkl	FWHM /rad		
10:5–Pt/Ni(OH)$_2$/N–CNTs	39.8	111	0.0595	2.17	2.14
	46.2	200	0.0586	2.15	
	67.7	220	0.0526	2.16	
	81.6	311	0.0496	2.09	
10:2–Pt/Ni(OH)$_2$/N–CNTs	39.8	111	0.0671	1.92	1.95
	46.2	200	0.0616	2.05	
	67.7	220	0.0667	1.71	
	81.6	311	0.0485	2.14	
10:1–Pt/Ni(OH)$_2$/N–CNTs	39.8	111	0.0535	2.41	2.01
	46.2	200	0.0608	2.07	
	67.7	220	0.0633	1.80	
	81.6	311	0.0585	1.77	
Pt/N–CNTs	39.8	111	0.0597	2.16	1.96
	46.2	200	0.0722	1.75	
	67.7	220	0.0601	1.90	
	81.6	311	0.0509	2.04	

Table S2. The compositions of the Pt/Ni(OH)$_2$/N–CNTs determined by TXRF.

Sample	Pt	Ni	N	C	Pt:Ni (mass ratio)
10:5–Pt/Ni(OH)$_2$/N–CNTs	1.194 mg	0.504 mg	0.038 mg	0.918 mg	2.36
10:2–Pt/Ni(OH)$_2$/N–CNTs	1.184 mg	0.201 mg	0.036 mg	0.910 mg	5.89
10:1–Pt/Ni(OH)$_2$/N–CNTs	1.215 mg	0.116 mg	0.042 mg	0.924 mg	10.47
Pt/N–CNTs	1.256 mg	/	0.041 mg	0.899 mg	/

Table S3. Performances of all catalysts and several representative results.

Sample	Based on CO-stripping			Based on H_{upd}[1]			MOR	ORR (0.9 V)
	ECSA m^2/g_{Pt}	MOR	ORR (0.9 V)	ECSA m^2/g_{Pt}	MOR	ORR (0.9 V)		
		Specific Activity (mA/mg_{Pt})	Specific Activity (mA/mg_{Pt})		Specific Activity (mA/mg_{Pt})	Specific Activity (mA/mg_{Pt})	Mass Activity (mA/mg_{Pt})	Mass Activity (mA/mg_{Pt})
10:5–Pt/$Ni(OH)_2$ /N–CNTs	22	1.02	0.22	20	1.13	0.24	344	142
10:2–Pt/$Ni(OH)_2$ /N–CNTs	24	1.28	0.30	24	1.30	0.31	368	191
10:1–Pt/$Ni(OH)_2$ /N–CNTs	20	1.06	0.32	22	0.97	0.30	237	164
Pt/ N–CNTs	21	1.18	0.18	19	1.32	0.19	261	91
Commercial Pt/C	12	0.50	0.16	13	0.47	0.15	56	114

H_{upd}[1] defined as the desorption of underpotentially deposited hydrogen.