

Supporting information for:

Ni nanoparticles assembled on the surface of biomass-derived porous carbon as competitive candidates for hydrogen evolution reaction

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Characterization

X-ray diffraction (XRD) measurements were implemented by a powder X-ray diffraction system (Rigaku, TTR-III). The X-ray photoelectron spectroscopy (XPS) measurements were implemented by a Thermo ESCALAB 250Xi spectrometer with monochromatic Al K α radiation ($h\nu=1486.6$ eV). The structure was investigated by scanning electron microscope (FE-SEM) (Hitachi, SU8000) and a transmission electron microscopy (TEM) (JEOL, JEM-2010, 200 kV). Nitrogen adsorption-desorption experiments were carried out at 77.35 K by means of an Autosorb-1 (Quantachrome Instruments) analyzer.

Electrochemical measurements

The measurements on the electrochemical performances were performed using a CHI 660E electrochemical workstation in a standard three-electrode mode. All electrochemical performance tests were performed in 1 M KOH (pH=14) solution. The Ni foam was firstly immersed in 1 M diluted acetone solution in an ultrasound bath for 50 min, then washed thoroughly with ethyl alcohol, water successively for twice, and finally dried. Then, the working electrode was prepared by passing the slurry containing Ni-PC-4 (85 wt.%) with acetyleneblack (10 wt.%) and PTFE (5 wt.%) in 10 mL absolute ethanol. After that, the electrode was made by heating at 60 °C for 40 min. The as-synthesized Ni-PC-4 slurry was coated onto the preprocessed Ni foam by applying suitable compressive force. The working electrode, reference electrode, and counter electrode are self-supporting electrode carrying electrocatalysts (1 cm \times 1 cm), saturated calomel electrode and graphite rods, respectively. The HER potentials used in this work

are corrected with a reversible hydrogen electrode according the following equation:

$$E(\text{RHE})=E(\text{SCE})+0.059\times\text{pH}+0.245 \quad (1)$$

The following well-known equation was used to calculate the Tafel slope of the catalysts.

$$\eta=b \log j + a \quad (2)$$

where “b” is the Tafel slope, “j” is the current density, and “a” is a constant. Before the linear scanning voltammetry (LSV) test, the electrocatalyst needs to be activated. Cyclic voltammetry (CV) technology is used and the scan rate is 100 mV/s until a stable CV curve appears. The linear sweep voltammetry test has a scan rate of 5 mV/s.

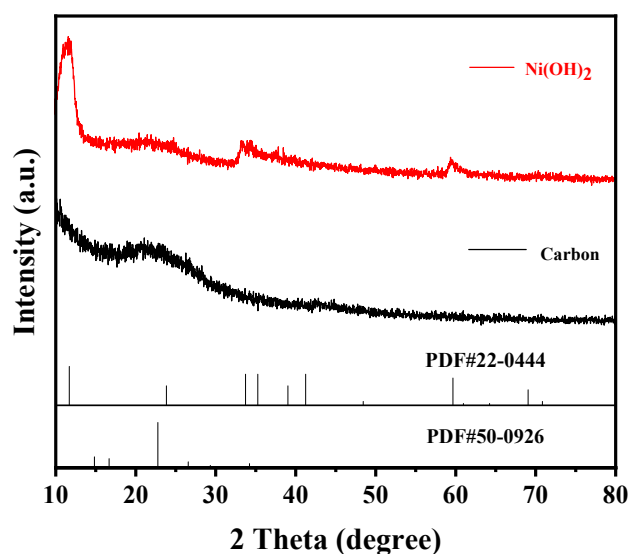
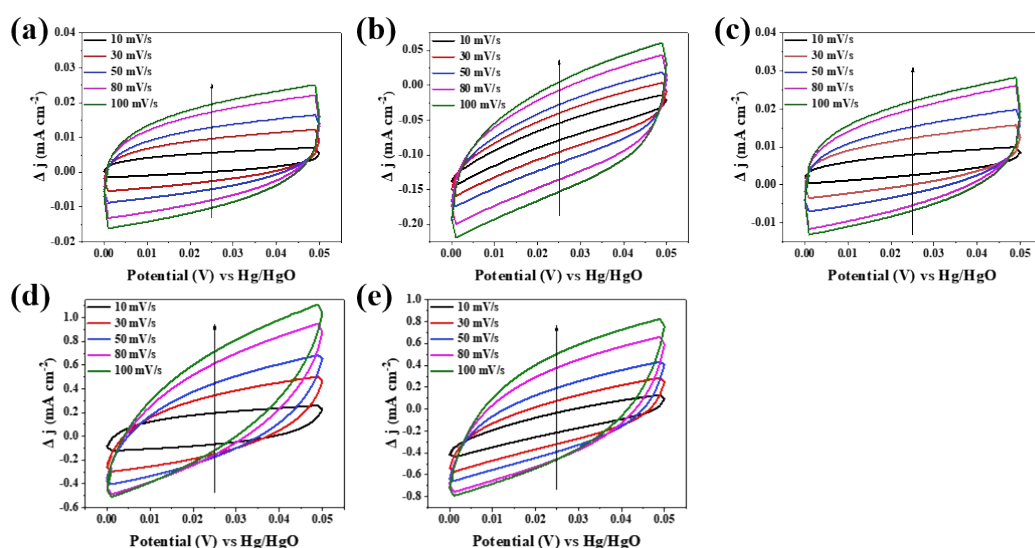


Figure S1 XRD pattern of Ni(OH)₂ and carbon.

Table S1 The overpotential at 10 mA cm⁻² and the value of uncompensated resistance (Ru) of all samples with and without iR compensation for HER.

Catalyst	Overpotential with iR compensation (mV)	Overpotential without iR compensation (mV)	The value of Ru (Ω)	Percentage of iR correction
Ni-PC-1	91.4	109.0	17.6	100%
Ni-PC-2	79.8	96.0	16.2	100%
Ni-PC-3	201.6	220.0	18.4	100%
Ni-PC-4	19.4	32.0	12.6	100%
Ni-PC-5	44.2	58.0	13.8	100%



Figure

Figure S2 The CV curves of the catalysts at different rates from 10 mV s⁻¹ to 100 mV s⁻¹ in 1.0 M KOH for (a) Ni-PC-1, (b) Ni-PC-2, (c) Ni-PC-3, (d) Ni-PC-4 and (e) Ni-PC-5.

Turnover frequency (TOF) could be calculated with the following equations.

For HER,

$$n \text{ (mol)} = Q / 2F \quad (1)$$

$$\text{TOF (s}^{-1}\text{)} = jA / 2nF \quad (2)$$

Where n is the number of active sites, which gathered from the CV measurements conducted at a scan rate of 50 mV s⁻¹ with the potential range of -0.2 to 0.6 V in 1.0 M phosphate buffer solution (PBS, pH=7) for HER; Q is the integral charges (cathodic

and anodic), which could be calculated by the above CV curves by deducting a blank value; F is the Faraday constant (96485 C mol^{-1}); and j is the current density at a given overpotential of the LSV and A is geometric area of the electrode.

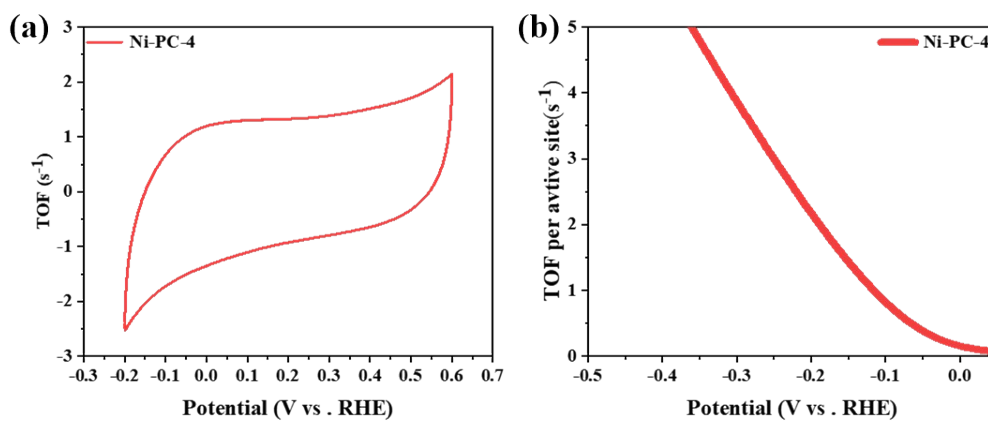


Figure S3 TOF plots of Ni-PC-4 during the HER process.