

NiRu nanoparticles encapsulated in nitrogen-doped carbon matrix as a highly efficient electrocatalyst for hydrogen evolution reaction

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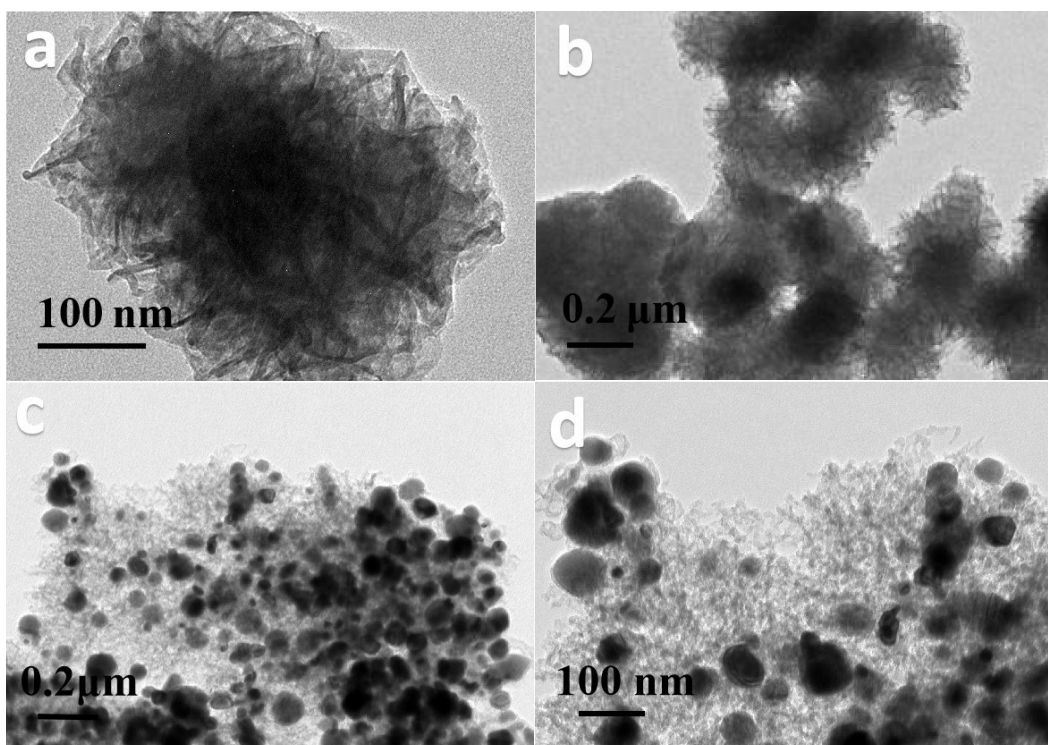


Figure S1. (a and b) TEM images of Ni-based MOFs and (c and d) Ni@NC.

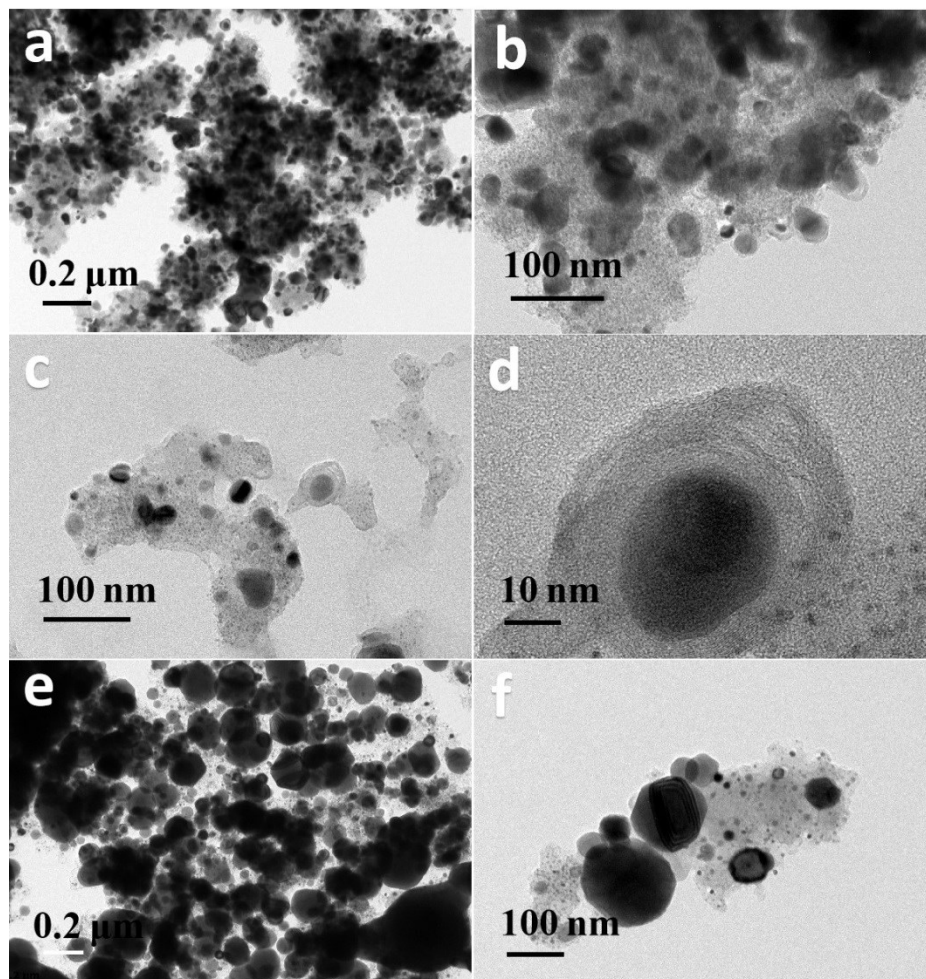


Figure S2. TEM images of (a and b) NiRu₂@NC-600, (c and d) NiRu₁@NC-600, and NiRu₂@NC-800.

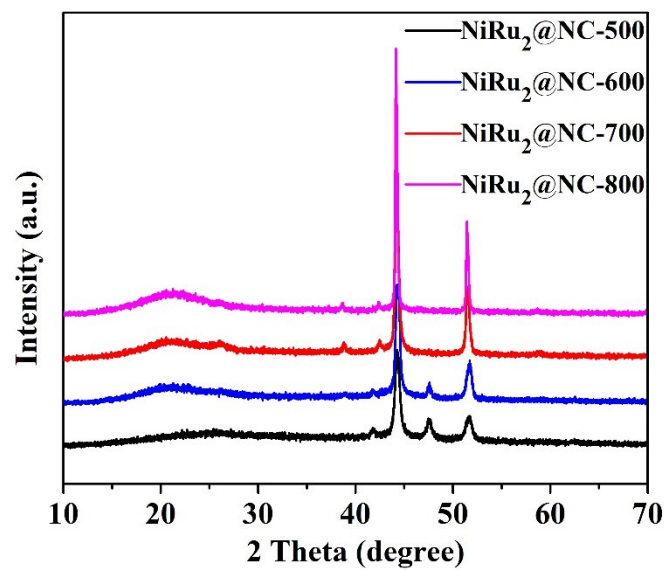


Figure S3. The XRD patterns of electrocatalysts obtained at different carbonization temperatures.

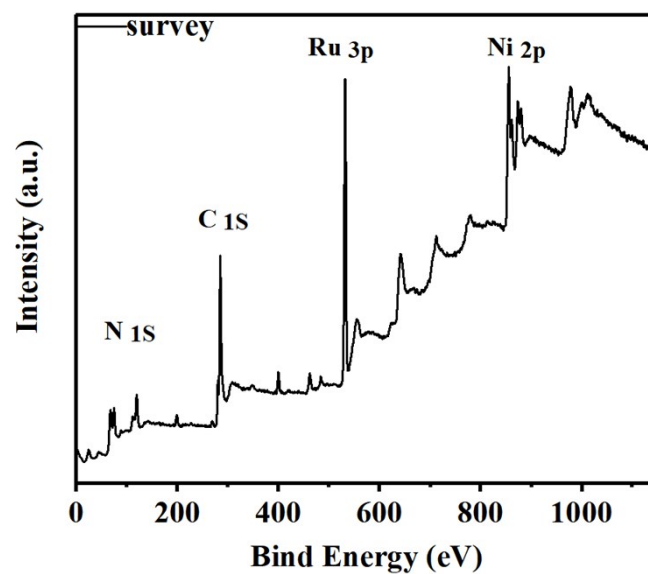


Figure S4. XPS spectrum of NiRu₂@NC-600.

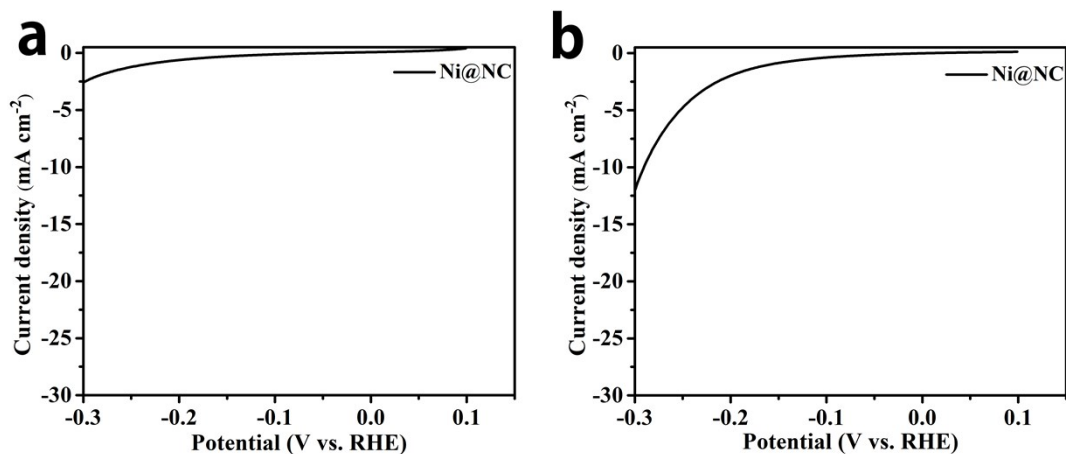


Figure S5. HER polarization curves of Ni@NC in (a) 0.5 M H₂SO₄ and (b) 1.0 M KOH.

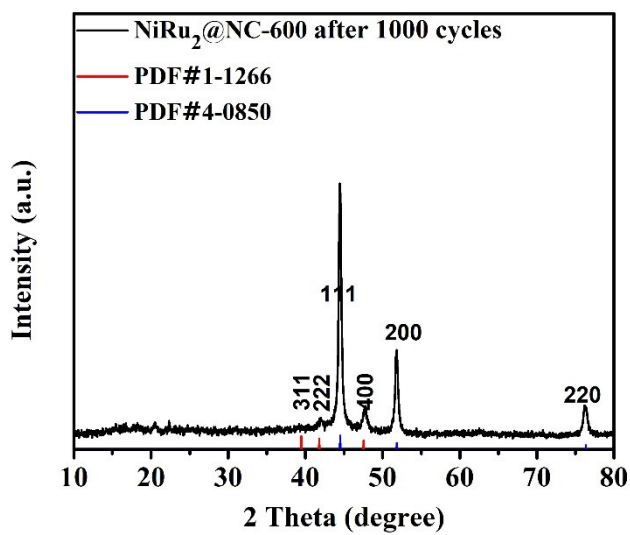


Figure S6. The XRD pattern of NiRu@NC-600 after 1000 cycles in 0.5 M H₂SO₄.

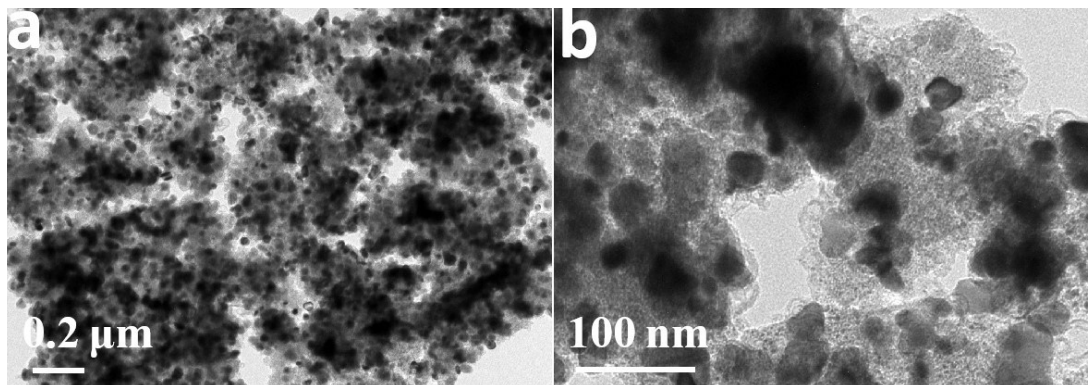


Figure S7. TEM images of NiRu@NC-600 after 1000 cycles in 0.5 M H₂SO₄.

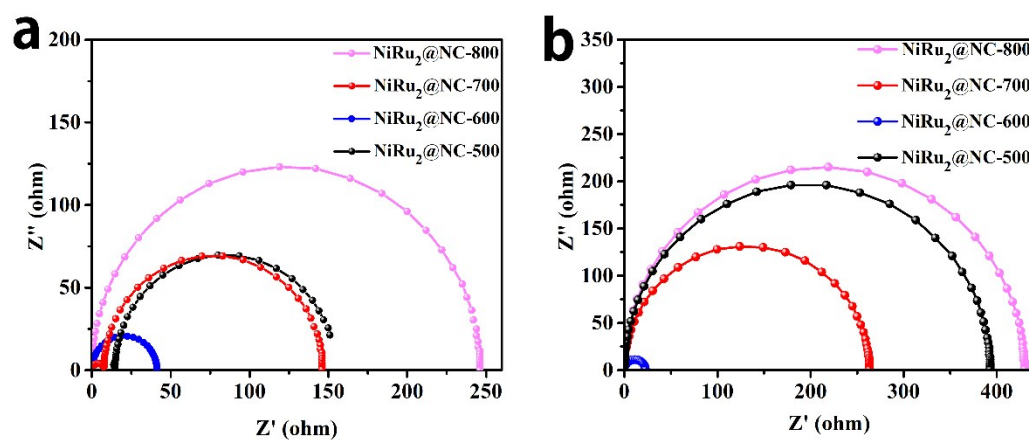


Figure S8. Nyquist curves for the catalysts in (a) 0.5 M H₂SO₄ and (b) 1.0 M KOH.

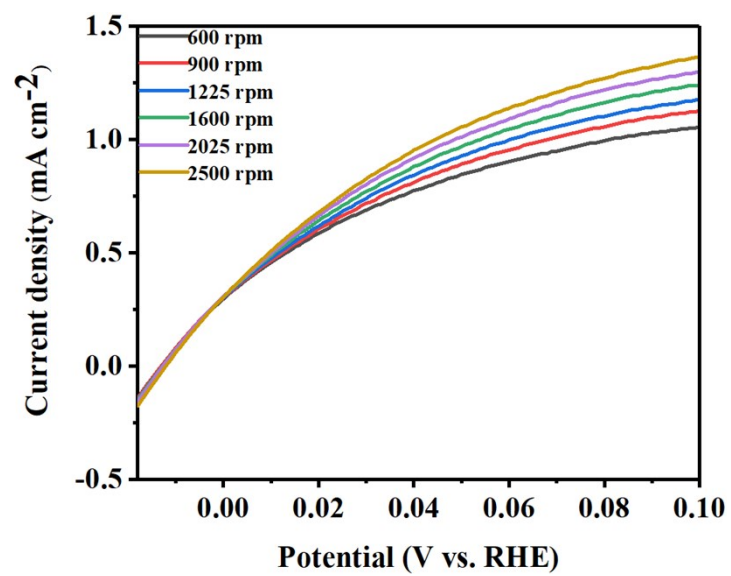


Fig S9. Polarization curves of NiRu₂@NC-600 at different rotation rates.

Table S1. The relation of Ru in the NiRu_x@NC-600 with initial addition content of RuCl₃ in the solution.

Samples	The initial amount of RuCl₃ (mg)	Ru content (atom %)
NiRu ₁ @NC-600	10	5.46 %
NiRu ₂ @NC-600	15	6.03 %
NiRu ₃ @NC-600	20	6.85 %

Table S2. Summary electrochemical performance of NiRu@NC samples.

Sample	Overpotential		Tafel slope	
	0.5 M H₂SO₄ (mV)	1.0 M KOH (mV)	0.5 M H₂SO₄ (mV dec⁻¹)	1.0 M KOH (mV dec⁻¹)
NiRu₂@NC-500	154	103	90.1	92.78
NiRu₂@NC-600	87	53	45.54	37.95
NiRu₂@NC-700	143	86	73.66	81.51
NiRu₂@NC-800	240	287	103.64	132.79
NiRu₁@NC-600	283	222	144.64	143.03
NiRu₃@NC-600	253	96	142.25	81.59