Electronic Supplementary Material

Multi-functional layered double hydroxides supported by nanoporous gold towards overall hydrazine splitting

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Experimental section

1. Chemicals

Cobalt nitrate hexahydrate ($Co(NO_3)_2 \cdot 6H_2O$, ≥99.0%), cobalt acetate tetrahydrate ($Co(OAc)_2 \cdot 4H_2O$, ≥98.0%), 2-methylimidazole (2-MIM, ≥98.0%) and potassium hydroxide (KOH) (≥85 %) were purchased from Shanghai Aladdin Biochemical Technology Co. Ltd. Ferric nitrate nonahydrate ($Fe(NO_3)_3 \cdot 9H_2O$, ≥98.0%), cupric nitrate trihydrate ($Cu(NO_3)_2 \cdot 3H_2O$, ≥98.0%), nickel nitrate hexahydrate ($Ni(NO_3)_2 \cdot 6H_2O$, ≥98.0%), nitric acid (HNO_3, 65.0 ~ 68.0%), hydrochloric acid (HCl, 36.0 ~ 38.0%), hydrazine hydrate ($N_2H_4 \cdot H_2O$, 85%) and ethanol (EtOH, ≥99.7%) were obtained from Sinopharm Chemical Reagent Co., Ltd. Iridium oxide (IrO_2, ≥98.0%) was received from Shanghai Haohong Biomedical Technology Co., Ltd. Platinum on carbon (Pt/C, 20 wt%) was acquired from Shanghai Hesen Electric Co., Ltd. Nafion solution (Dupont D520, 5wt%) was purchased from Shanghai Macklin Biochemical Technology Co., Ltd. Hexadecyl trimethyl ammonium bromide (CTAB, ≥99.0%) was obtained from Beijing Innochem Science & Technology Co., Ltd. Gold-based alloy foil (Au, 50 wt%) was received from Nanjing Yongbo metal materials Co., Ltd.

2. Characterizations

The morphology and structure were recorded by transmission electron microscope (TEM, JEM-2100 plus) and scanning electron microscope (SEM, Hitachi S-4800). The X-ray diffraction (XRD) patterns were characterized by Rigaku SmartLab 9KW. The high-angle annular dark-field scanning TEM (HAADF-STEM) and elemental mapping images were taken on a spherical probe corrected TEM (JEOL Arm200). The X-ray photoelectron spectroscopy (XPS) was carried out on Thermo Fisher Scientific ESCALAB 250Xi, and the XPS results were calibrated using C 1*s* (284.8 eV) data.

Figures

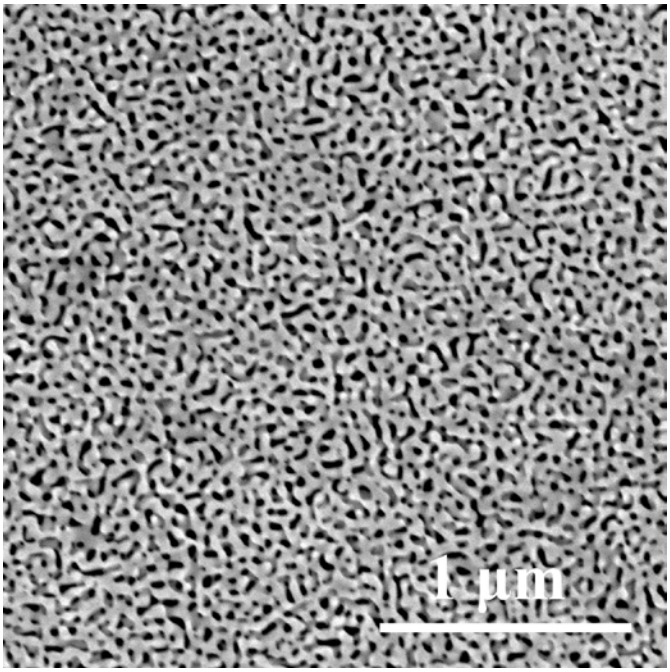

Figure S1. The SEM image of the NPG.

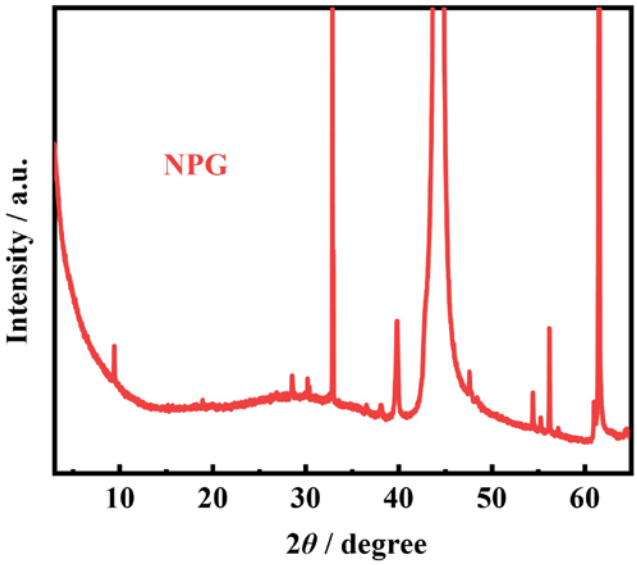

Figure S2. The XRD pattern of the NPG.

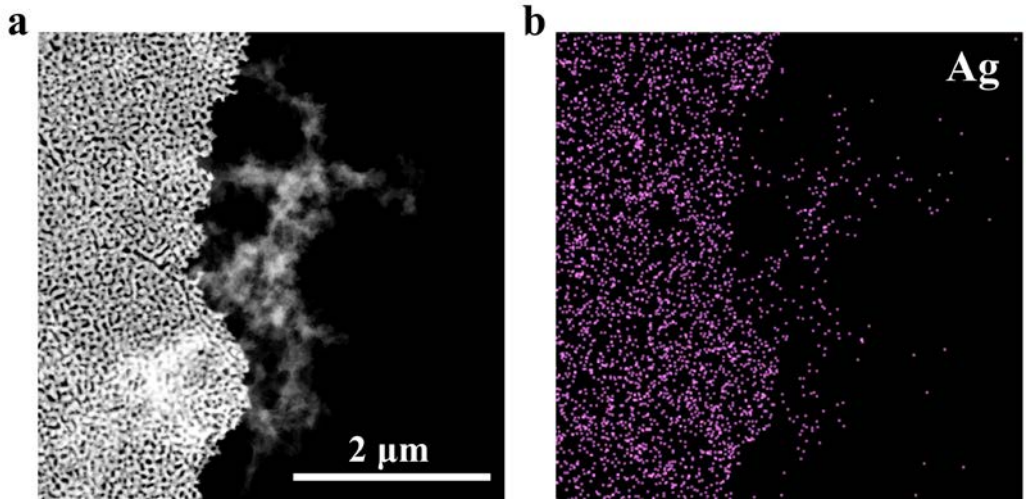

Figure S3. The HAADF-STEM image (a) and elemental mapping of Ag (b) of the NPG-HS-LDH.

Table S1. Atomic concentration (at%) of each element presented in the elemental mapping images of the NPG-HS-LDH.

	Atomic concentration (%) through elemental mapping test								
Element	**Ni**	**Co**	**Fe**	**Cu**	**C**	**N**	**O**	**Au**	**Ag**
Value	1.69	4	1.18	24.15	31.87	1.65	25.34	10	0.11

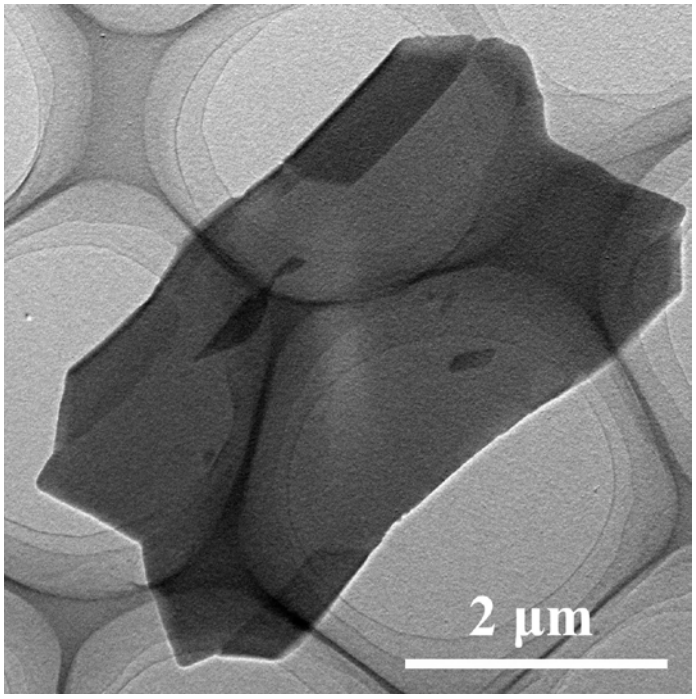

Figure S4. The TEM image of the HS-ZIF-67.

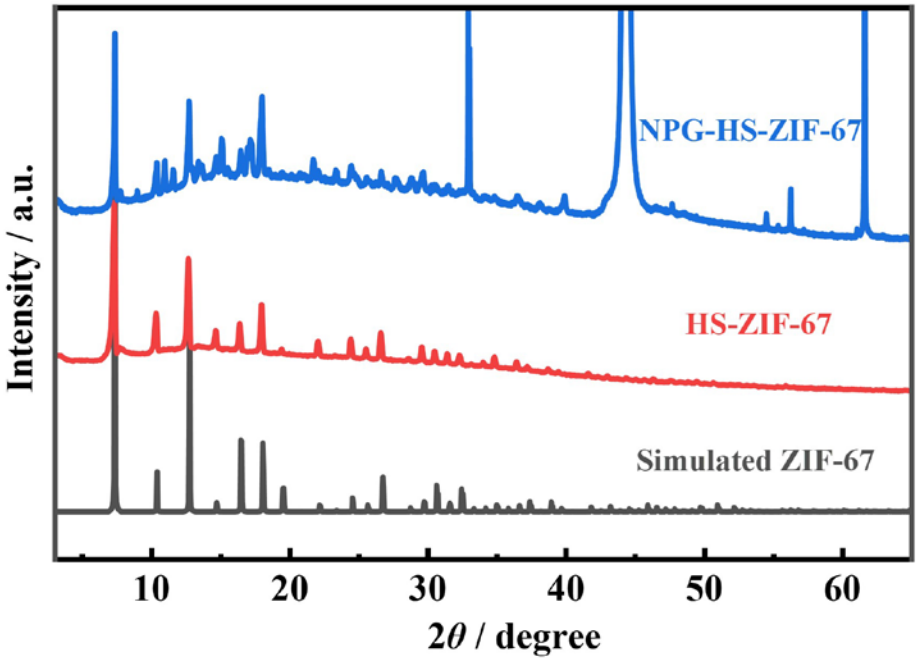

Figure S5. The XRD patterns of the NPG-ZIF-67, HS-ZIF-67 and simulated data.

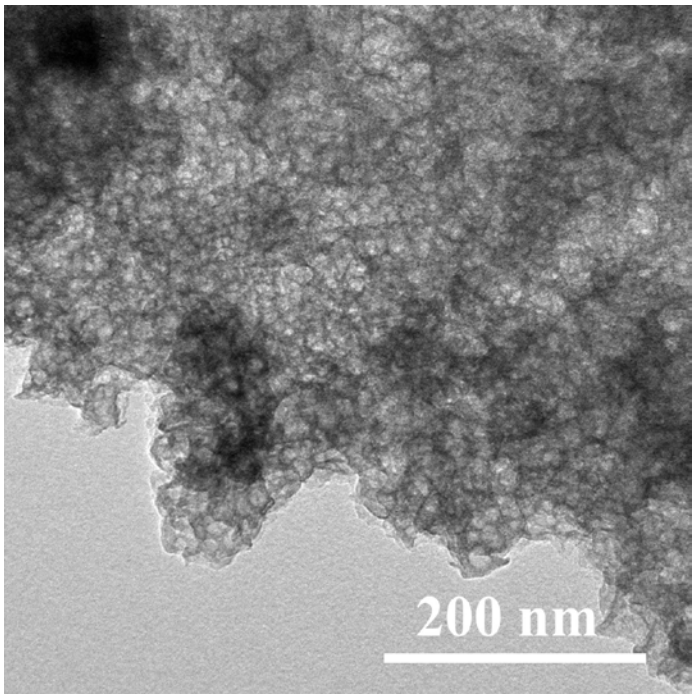

Figure S6. The TEM image of the HS-LDH.

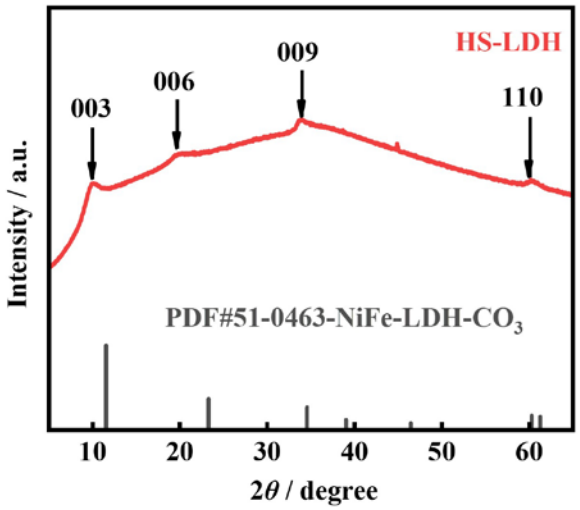

Figure S7. The XRD pattern of the HS-LDH.

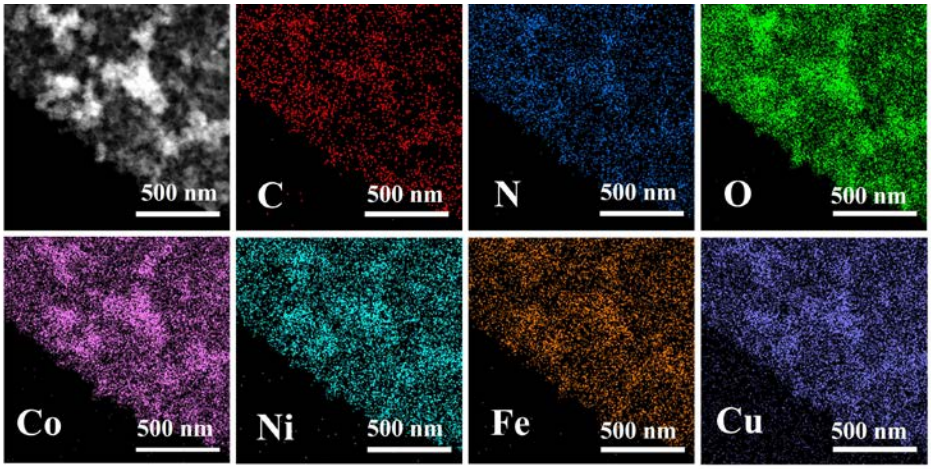

Figure S8. The HAADF-STEM and elemental mapping images of the HS-LDH.

Table S2. Atomic concentration (at%) of each element presented in the XPS survey spectrum of the NPG-HS-LDH.

	Atomic concentration (%) through XPS test								
Element	**Ni**	**Co**	**Fe**	**Cu**	**C**	**N**	**O**	**Au**	**Ag**
Value	5.56	4.34	3.94	0.85	45.56	2.04	36.32	1.4	trace

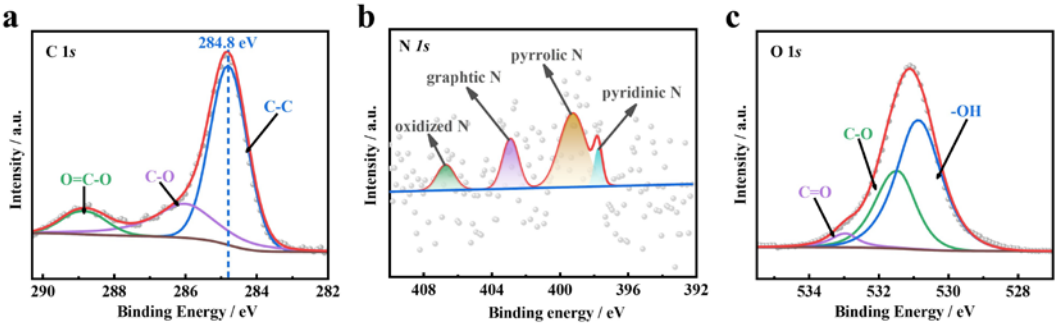

Figure S9. HR-XPS of C 1*s*, N 1*s* and O 1*s* of the NPG-HS-LDH.

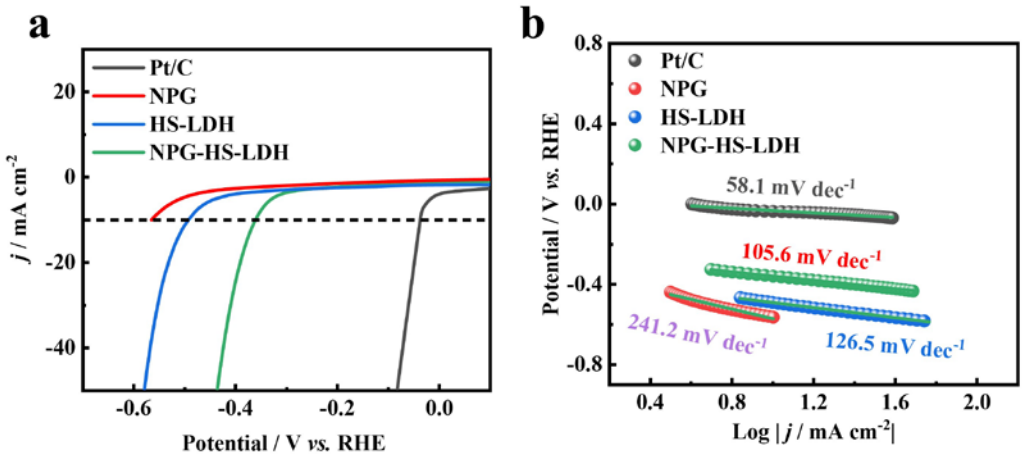

Figure S10. The HER performances of the NPG-HS-LDH and commercial Pt/C: (a) polarization curves; (b) the corresponding Tafel slopes.

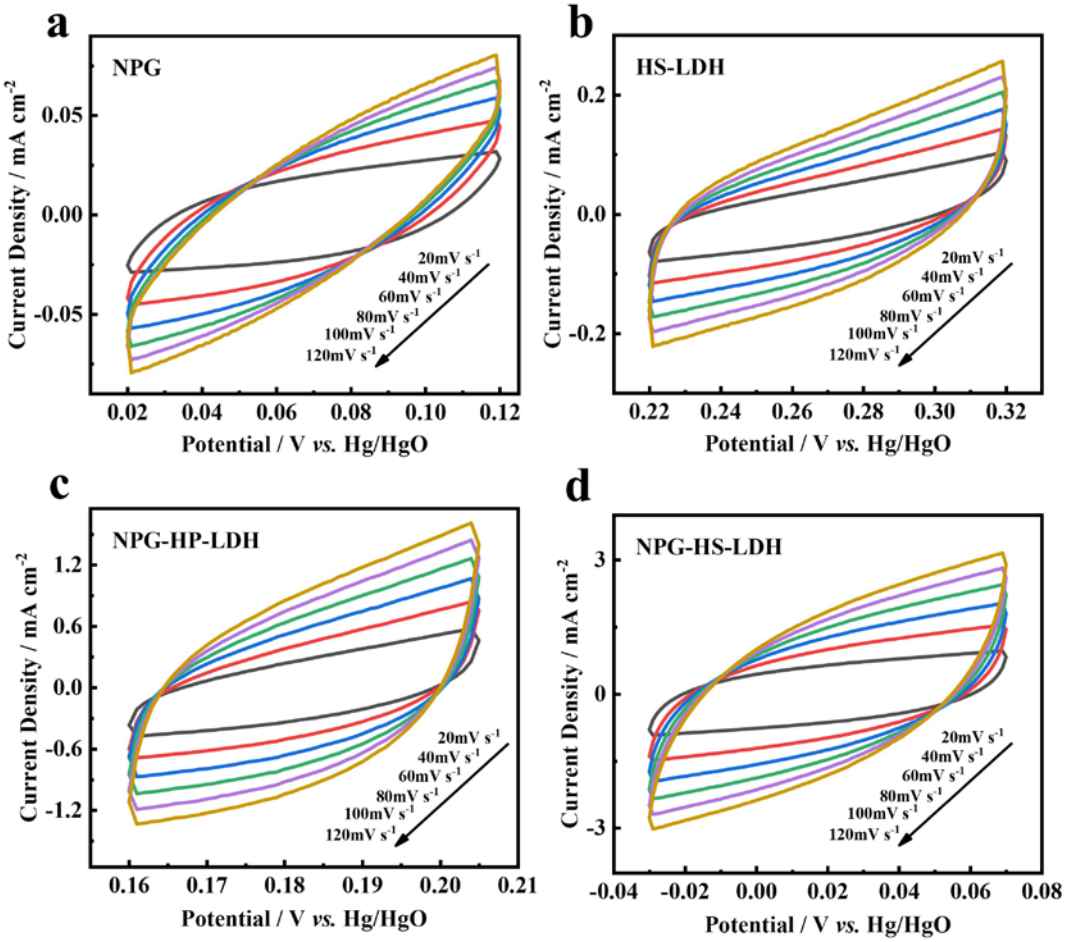

Figure S11. The electrochemical surface area (ECSA) tests of the as-prepared samples in 1 M KOH.

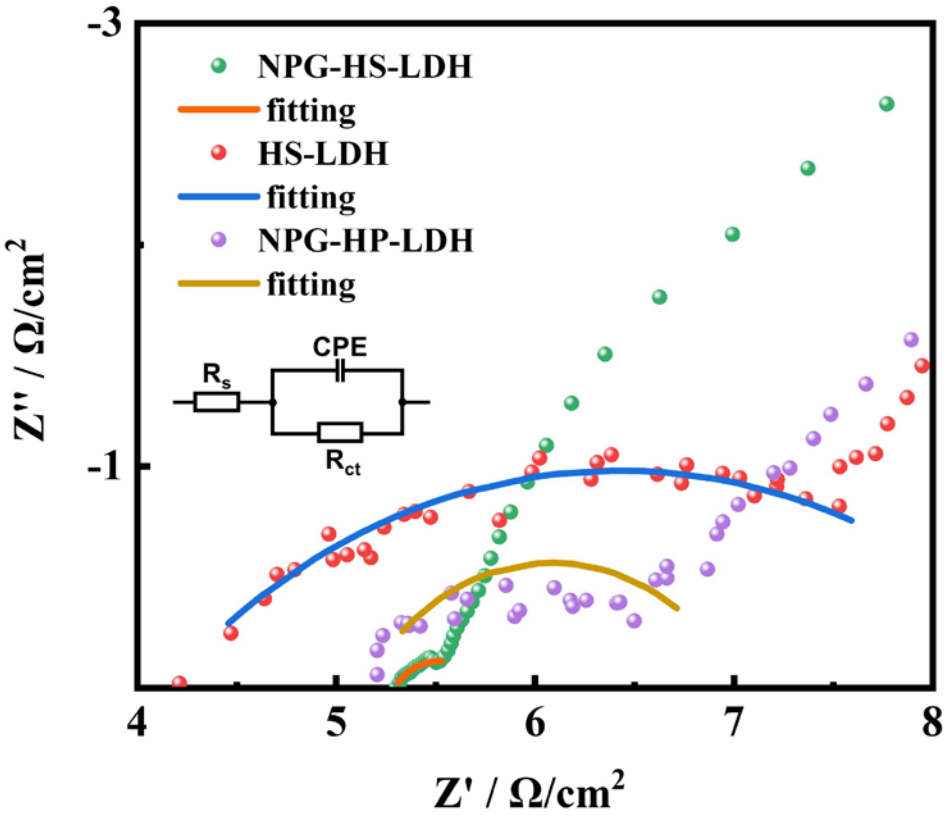

Figure S12. The EIS spectra of the as-prepared samples.

Table S3. Rs and Rct values obtained through fitting of the EIS spectra.

	NPG-HS-LDH	HS-LDH	NPG-HP-LDH
R_s/ Ω	5.297	4.146	5.148
R_{ct}/ Ω	0.456	4.558	1.877

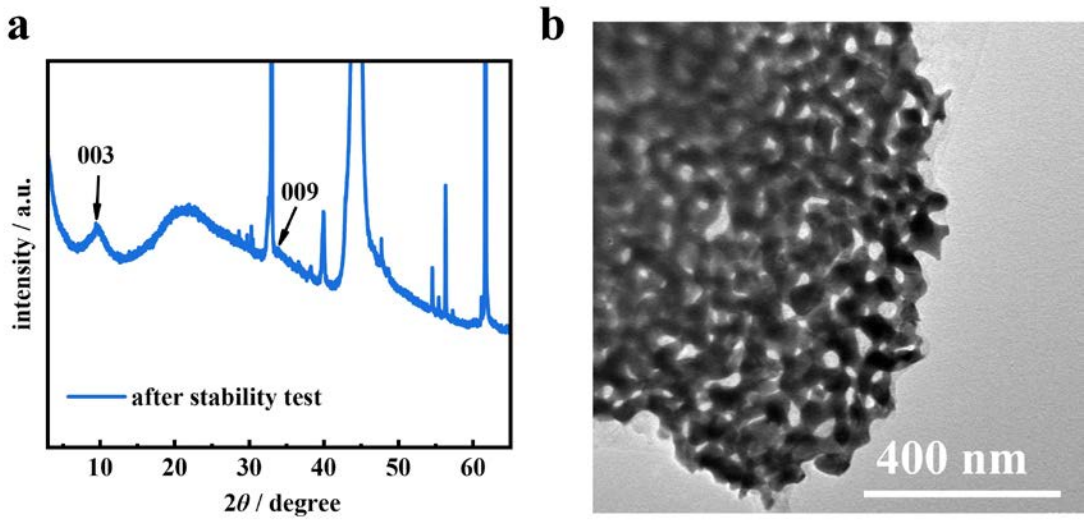

Figure S13. The XRD pattern (a) and TEM image (b) of the NPG-HS-LDH after stability test.

Table S4. Atomic concentration (at%) of each element presented in the XPS survey spectrum of the NPG-HS-LDH after stability test.

	Atomic concentration (%) after stability test via XPS								
Element	**Ni**	**Co**	**Fe**	**Cu**	**C**	**N**	**O**	**Au**	**Ag**
Value	1.72	6.95	3.09	0.82	54.12	1.5	31.8	trace	trace

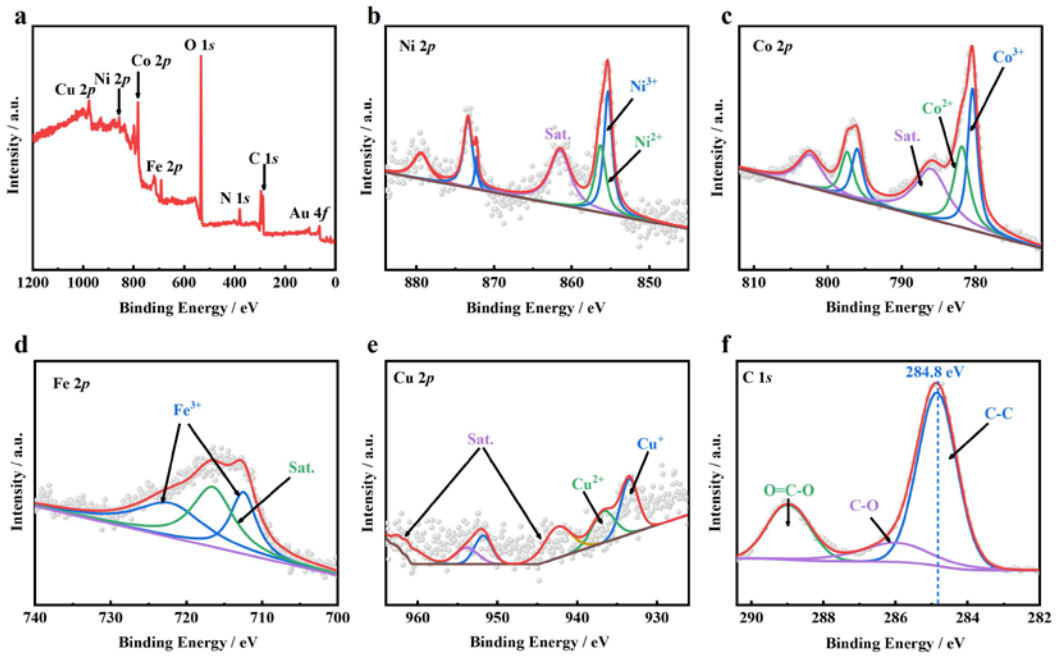

Figure S14. The XPS analysis of the NPG-HS-LDH after stability test.

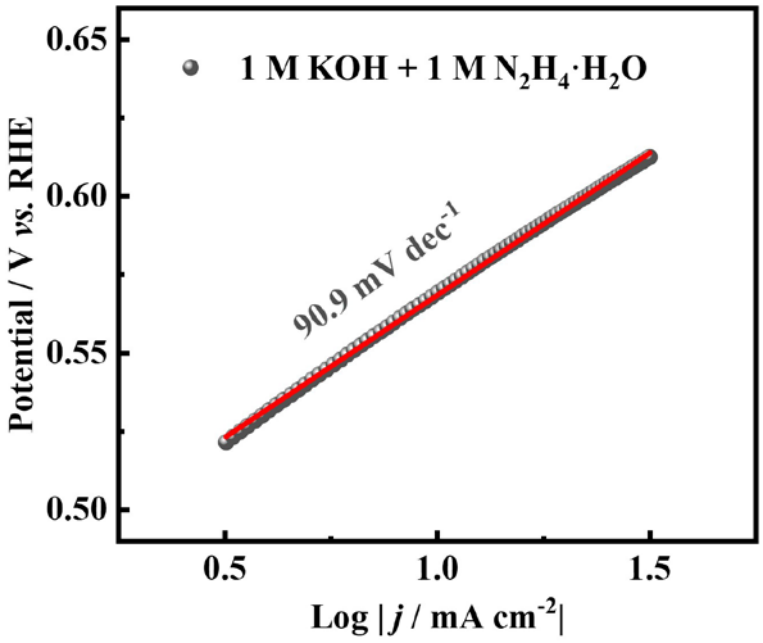

Figure 15. The corresponding Tafel slope of HzOR.