Supporting Information

One-step integration of amorphous RuBx and crystalline Ru nanoparticles into N-doped porous carbon polyhedrals for robust electrocatalytic activity towards HER in both acidic and basic media

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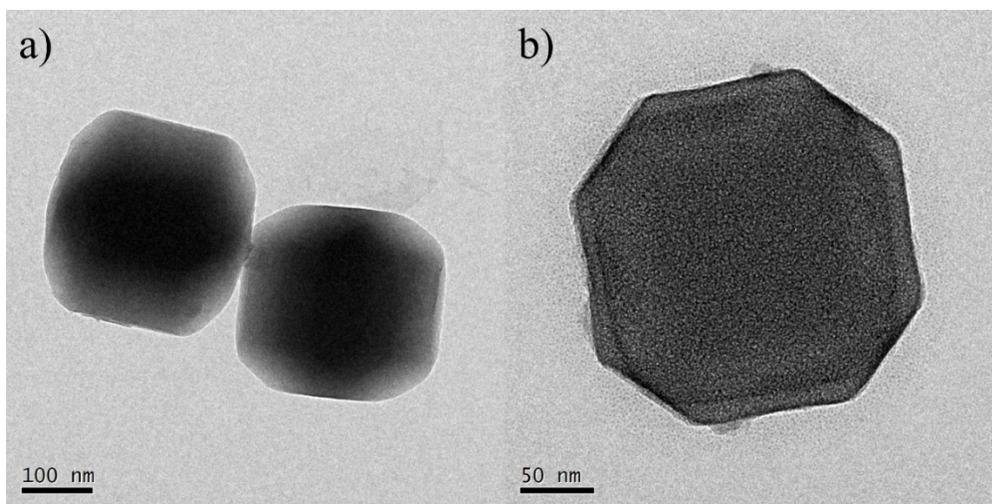
Figure S1. TEM images for a) ZIF-8 and b) NPCH
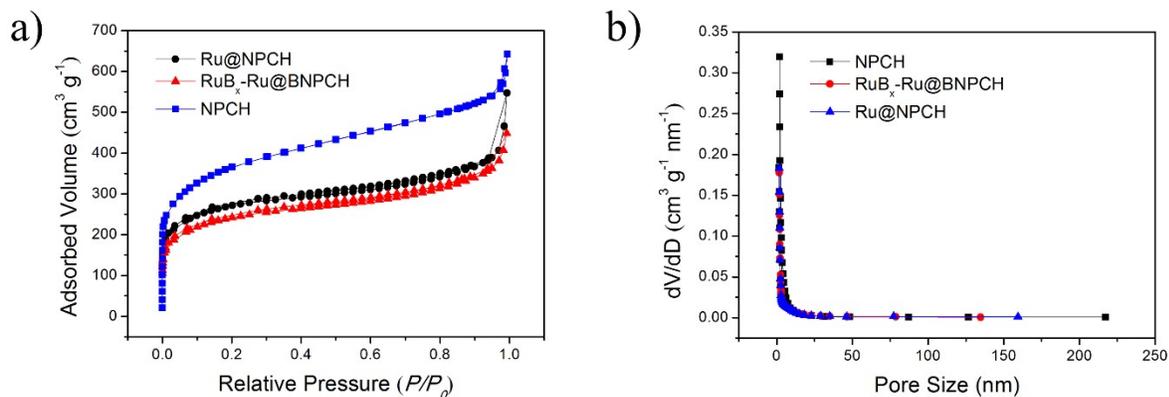
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RuB$_x$-Ru@BNPCH and Ru@NPCH
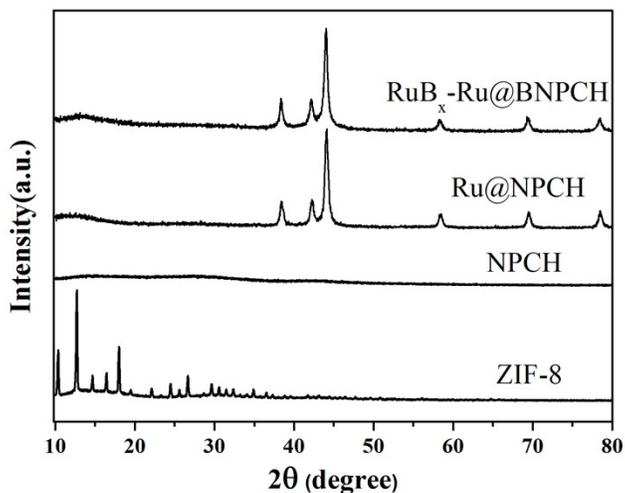
Figure S3. XRD patterns of ZIF-8, NPCH, RuB$_x$-Ru@BNPCH and Ru@NPCH
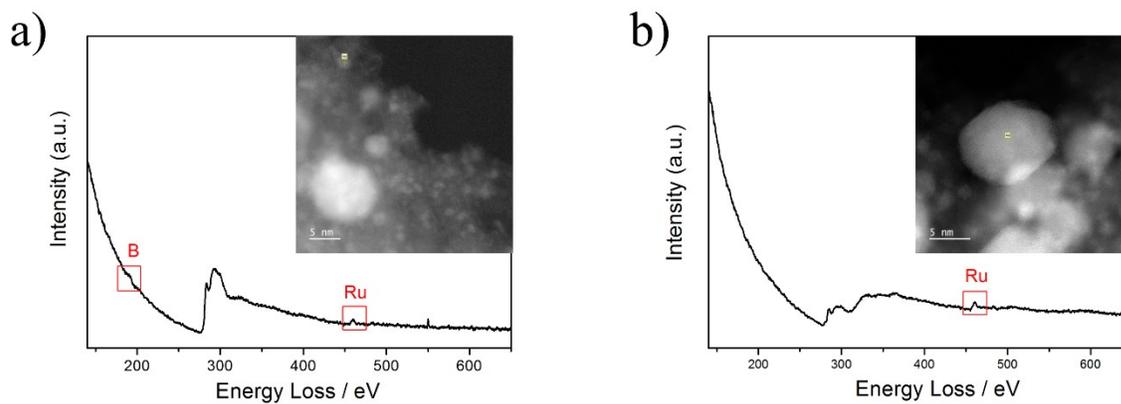
Figure S4. EELS spectra of RuBx-Ru@BNPCH (the insets are schematic for EELS acquisition

regions and the points for a and b from amorphous particles and crystalline particles,

respectively, which were obtained by STEM).

Table S1 Comparison of HER catalystic activity between RuB_x-Ru@BNPCH product and other well-developed Ru-based and Transition metal boride based HER electrocatalysts in 1.0 M KOH solution.

Catalysts	$E_{(J=10mA\ cm^{-2})}$ (mV)	Tafel slope (mV dec^{-1})	Reference
RuB_x-Ru@BNPCH	5	22.2	**This work**
Pt/C	22	48.9	1
Ru_2B_3@BNC	14	53.9	1
RuB_2	28	28.7	2
Ru NCs/BNG	14	28.9	3
Ru_2B_3	14.6	27.3	4
$RuSe_2$	29.5	39.2	5
$RuIrO_x$	13	23	6
3D RuCu NCs	18	59	7
RuP_2@NPC	52	69	8
Co_2B-500/NG	127	92.4	9
FeB_2	61	87.5	10
Co-50Ni-B/CC	80	88.2	11
Co-B-P/NF	42	42.1	12
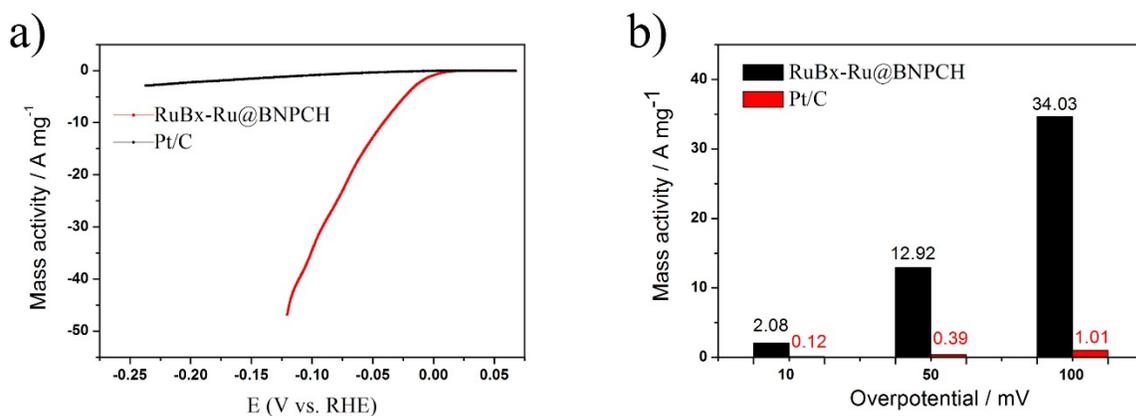
Figure S5. LSV curves of RuBx-Ru@BNPCH with the mass of Ru in 1M KOH and (b) histogram of mass activity at different overpotentials
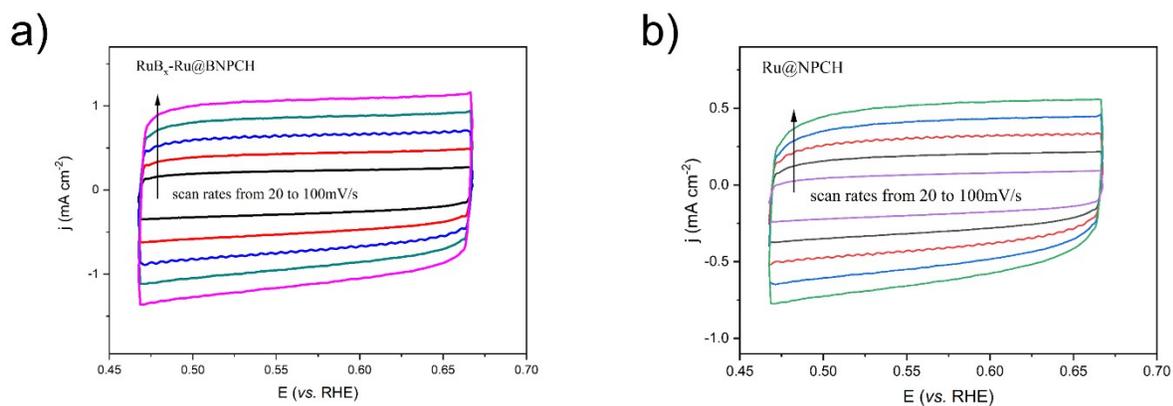
Figure S6. Cyclic voltammetry tests in a non-Faradaic region (0.46 to 0.66 V vs RHE) with different scan rates to determine the electrochemical double layer capacitance C_{dl}: the RuBx-Ru@BNPCH (a) and Ru@NPCH (b) in 1.0 M KOH.

Table S2. Comparison of HER catalystic activity between RuB_x-Ru@BNPCH product and other well-developed Ru-based and Transition metal boride based HER electrocatalysts in 0.5 M H_2SO_4 solution.

Catalysts	$E_{(J=10mA\ cm^{-2})}$ (mV)	Tafel slope (mV dec^{-1})	Reference
RuB_x-Ru@BNPCH	33	37.8	**This work**
Ru_2B_3@BNC	41	60.7	1
$RuTe_2$-M	35.7	46.6	5
RuP_2@NPC	38	38	8
RuB_2	52	66.9	13
Pt/C	34	31.2	13
RuP@NPC	51	46	14
RuP-475	47	39	15
α-MoB_2	120	74.2	16
Ni_3B	79	85.32	17
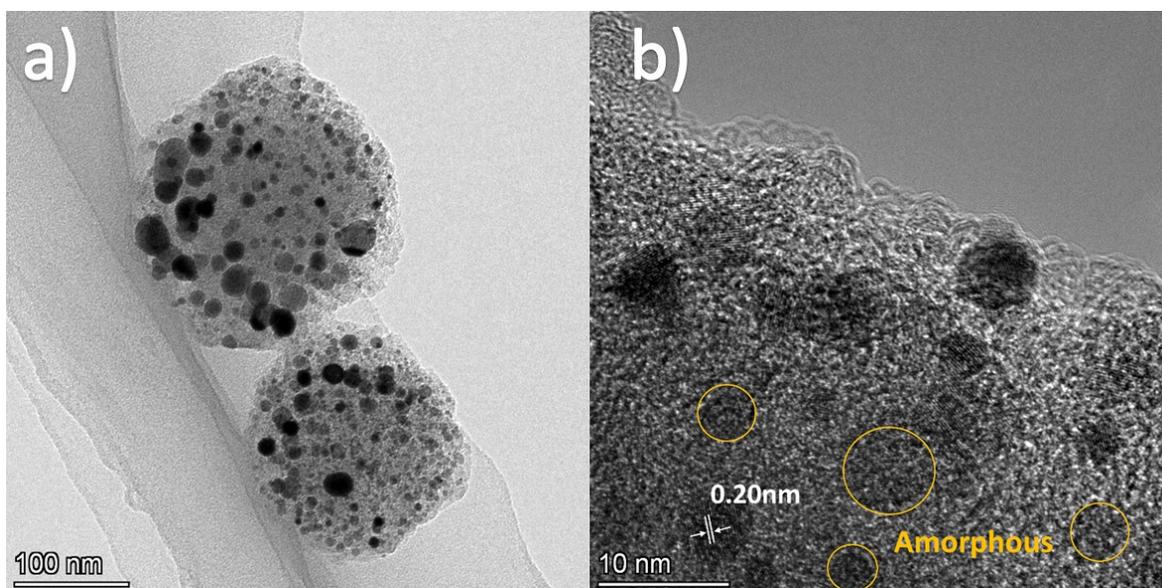
Figure S7. TEM a) and HRTEM b) images for RuBx-Ru@BNPCH after the CV cycling test
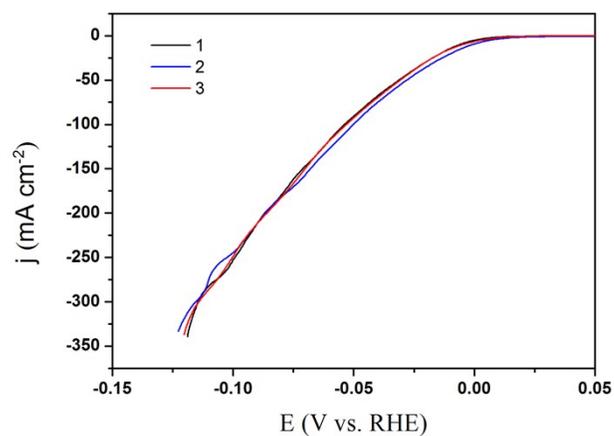
Figure S8. Polarization curves of RuBx-Ru@BNPCH for several batches of samples with the same

method
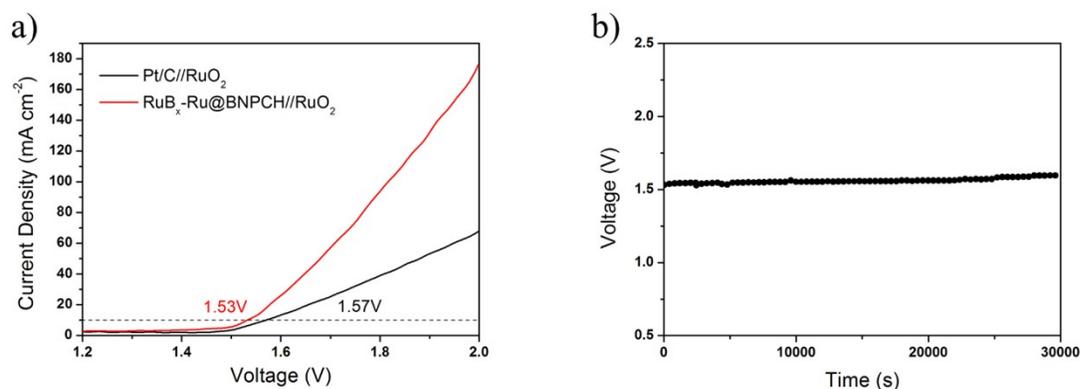
Figure S9. (a) LSV curves of water electrolysis for RuBx-Ru@BNPCH//RuO$_2$ and commercial Pt/C//RuO$_2$ at a scan rate of 5 mV s^{-1} in 1 M KOH, (b) Chronoamperometric curve for water electrolysis with constant current density of 10 mA cm^{-2} for RuBx-Ru@BNPCH//RuO$_2$ in 1 M KOH.

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