Supporting Information

Ruthenium-modified oxygen-deficient NiCoP catalysts for efficient electrocatalytic water splitting

Bo-yao Zhang[a,1], Song-lin Xu[a,1], Jia Li[a], Xin-Xin Zhao[a], Rong-da Zhao[a,*], Ming-chang Zhang[c,*], De-peng Zhao[b], Lihua Miao[d,*]

[a]School of Materials Science and Engineering, Liaoning University of Technology, Jinzhou, Liaoning 121000, China

[b]School of New Energy, Shenyang Institute of Engineering, Shenyang, Liaoning, 110136, P. R. China

[c]Institute of Science and Technology for New Energy, Xi'an Technological University, Xi'an 710021, P. R. China

[d]School of Medical Information Engineering, Shenyang Medical College, Shenyang, Liaoning, 110043, P. R. China

Correspondences should be addressed: Rongdazhaoln@126.com; hellodepeng@163.com; zhangmingchang@xatu.edu.cn

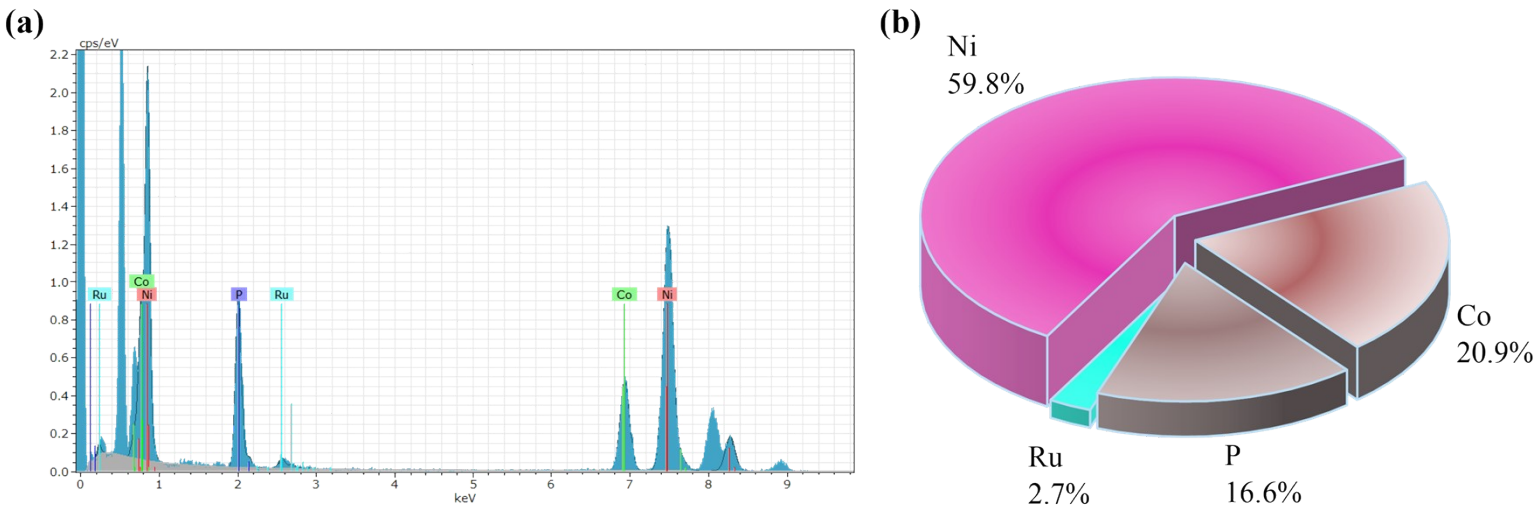

Figure S1 (a,b) Ru precursor percentage loading.

Materials	Area (mm^2)	Quality (mg)	Ru mass load (mg/mm^2)
Ru-NiCoP-O_v	25	10.9	0.02
NiCoP-O_v	25	10.4	

Table S1 Mass loading of Ru on a unit area electrode.

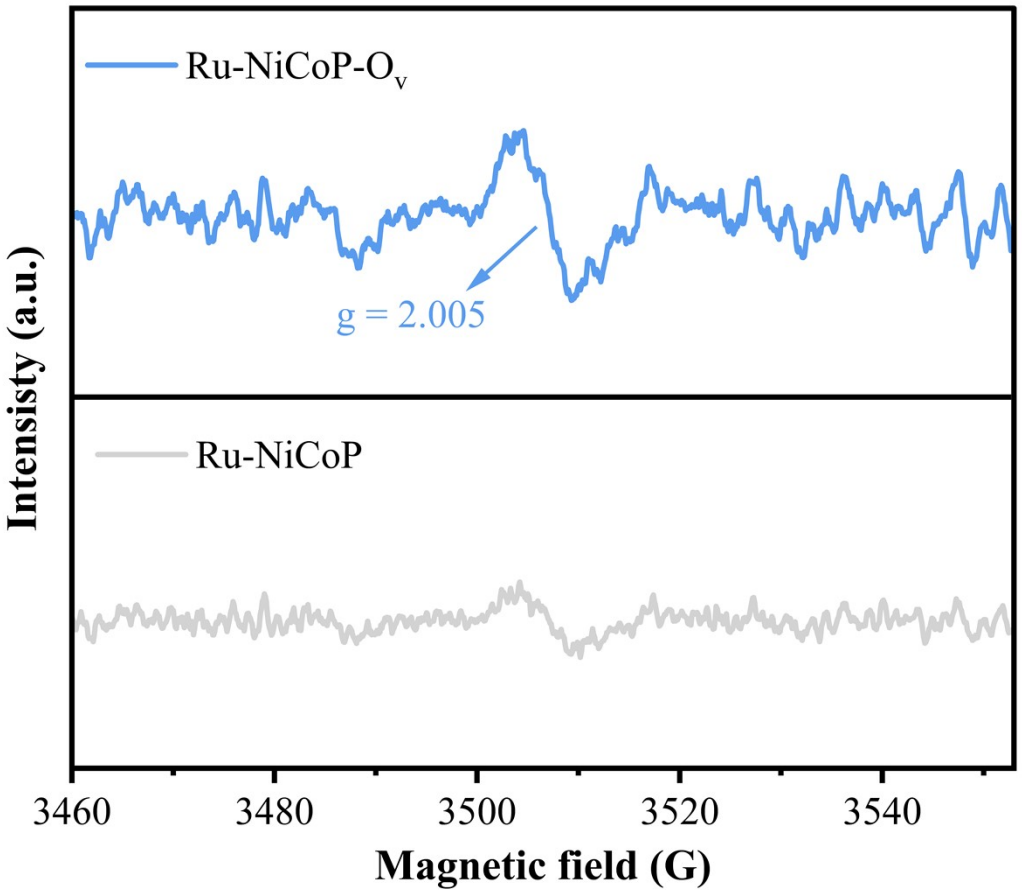

Figure S2 EPR characterizations of samples.

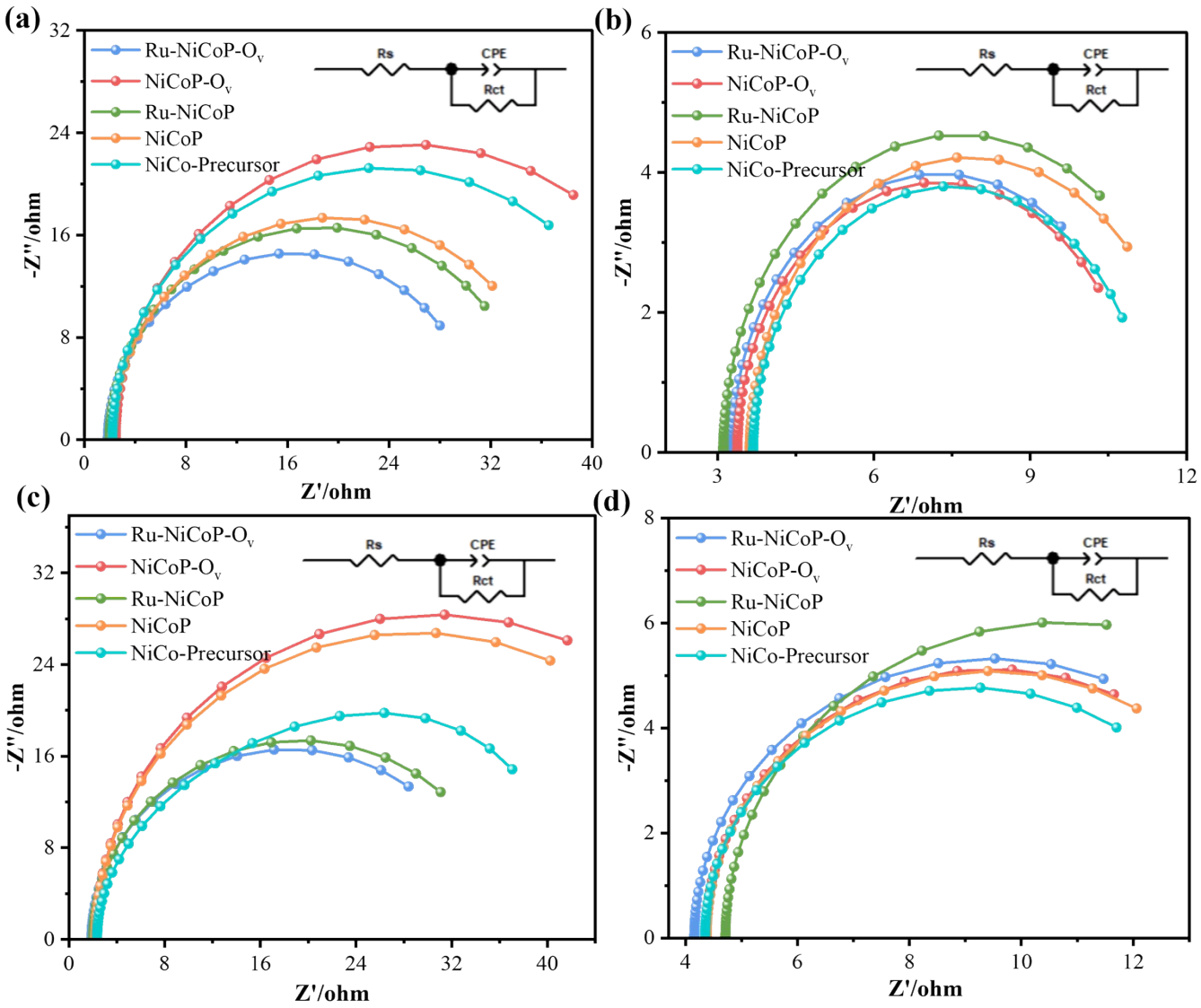

Figure S3 (a) Nyquist fitting curve of HER in 1M KOH solutions; (b) OER in 1M KOH solutions; (c) HER in alkaline seawater solutions; (d) OER in alkaline seawater solutions.

Electrolyte	Materials / η（mV）	Ru-NiCoP-O_v	NiCoP-O_v	Ru-NiCoP	NiCoP	NiCo
HER-KOH	-10 mA cm^{-2}	51.5 mV	124.7mV	70.7mV	107.7 mV	196.7mV
	-50 mA cm^{-2}	95.7 mV	194.7mV	137.7mV	173.7mV	301.7mV
HER-KOH-seawater	-10 mA cm^{-2}	68.1mV	134.9mV	71.9mV	104.9mV	116.9mV
	-50 mA cm^{-2}	124.9mV	220.7mV	153.3mV	176.5mV	245.1mV
OER-KOH	50 mA cm^{-2}	285.1mV	317.3mV	305.3mV	316.3mV	372.3mV
	100 mA cm^{-2}	323.3mV	357.3mV	339.7mV	365.3mV	411.4mV
OER-KOH-seawater	50 mA cm^{-2}	264.5mV	292.4mV	279.8mV	280.5mV	346.7mV
	100 mA cm^{-2}	291.5mV	322.2mV	307.5mV	311.1mV	373.5mV

Table S2 Overpotential comparison at different current densities.

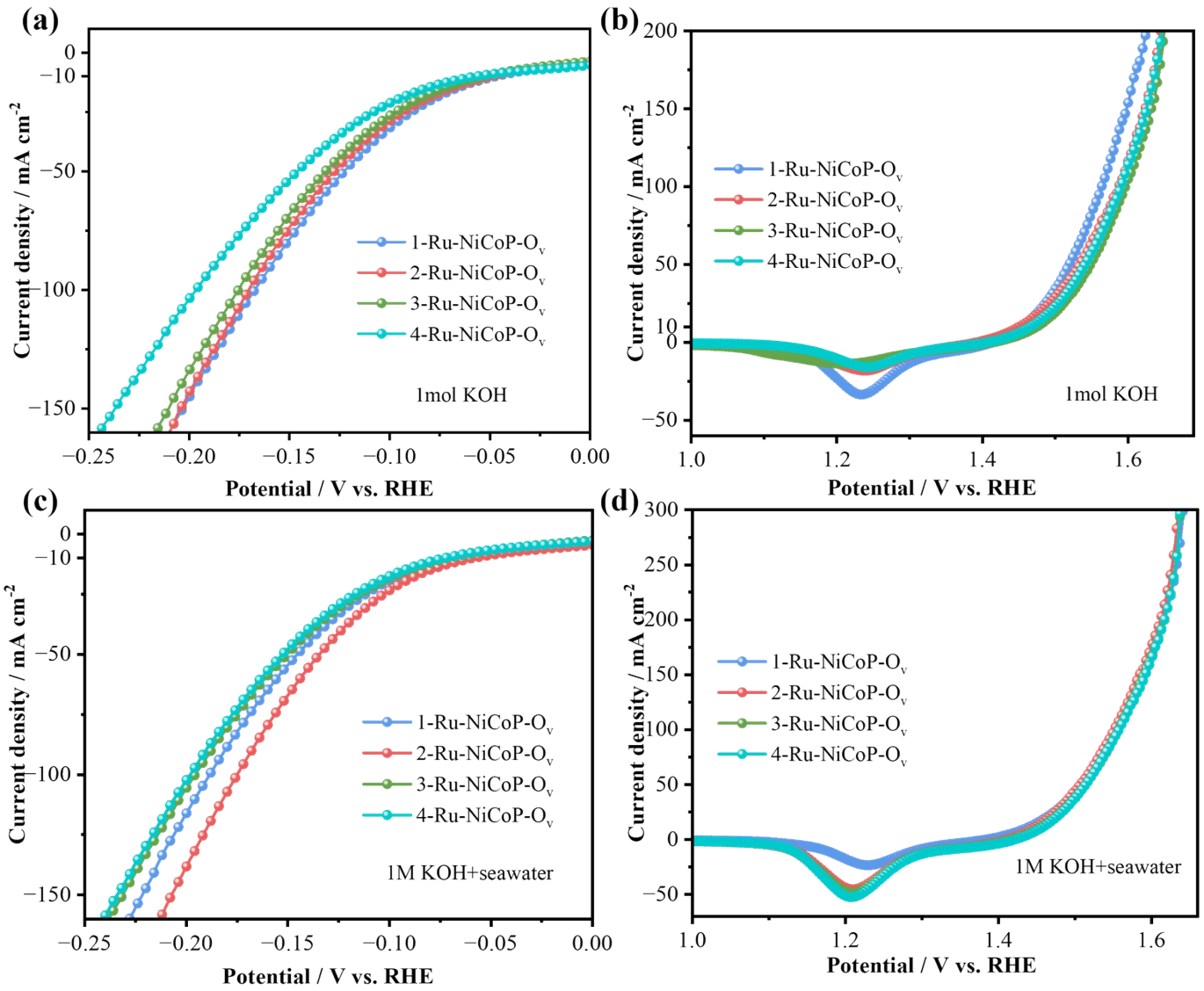

Figure S4 Repeatability verification of Ru-NiCoP-Ov preparation method (a-b) HER and OER performances in 1M KOH solutions; (c-d) HER and OER performances in alkaline seawater

η（mV） Materials	HER (-10 mA cm^{-2})	OER (10 mA cm^{-2})	HER-seawater (-10 mA cm^{-2})	OER-seawater (50 mA cm^{-2})
1-Ru-NiCoP-Ov	47 mV	224mV	68.9mV	279 mV
2-Ru-NiCoP-O_v	53.1 mV	221mV	58.6mV	277.2mV
3-Ru-NiCoP-O_v	49.1 mV	245.1 mV	71.1mV	284mV
4-Ru-NiCoP-O_v	56 mV	235.9mV	72.9mV	284.2 mV
Average value	51.3mV	239mV	67.7mV	281.1mV

Table S3 Performance repeatability verification.