Supplementary Information

Improvement of chlorine evolution stability and activity of RuO_2-TiO_2/IrO_2-Ta_2O_5 electrode with low iridium content by alternating coating thermal decomposition method

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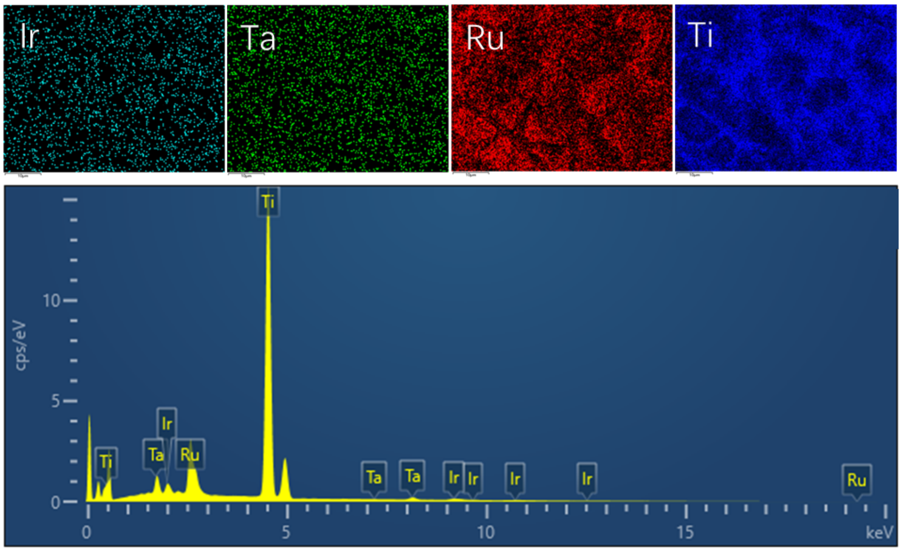

Figure S1 The SEM mapping of RuTi/LC-IrTa electrode.

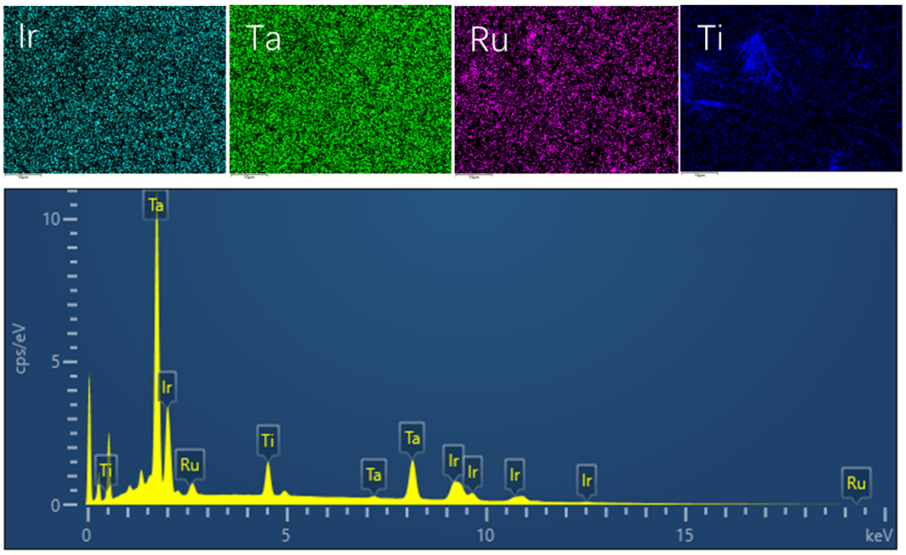

Figure S2 The SEM mapping of RuTi/HC-IrTa electrode.

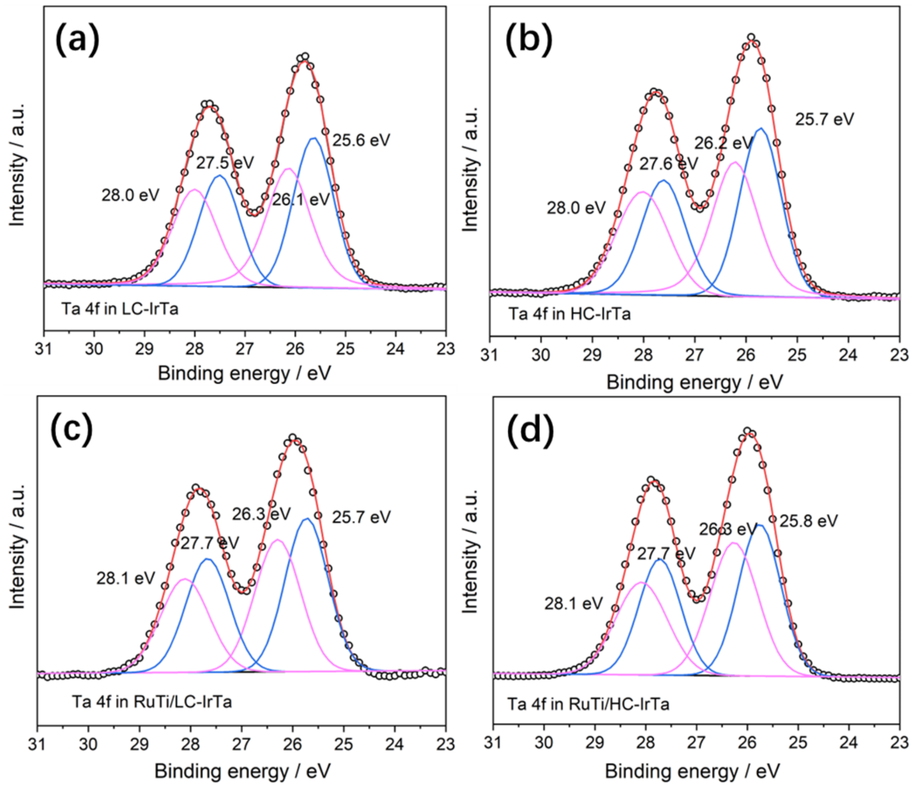

Figure S3 The XPS core-level spectra of Ta 4f obtained from LC-IrTa(a), HC-IrTa(b), RuTi/LC-IrTa(c) and RuTi/HC-IrTa(d).

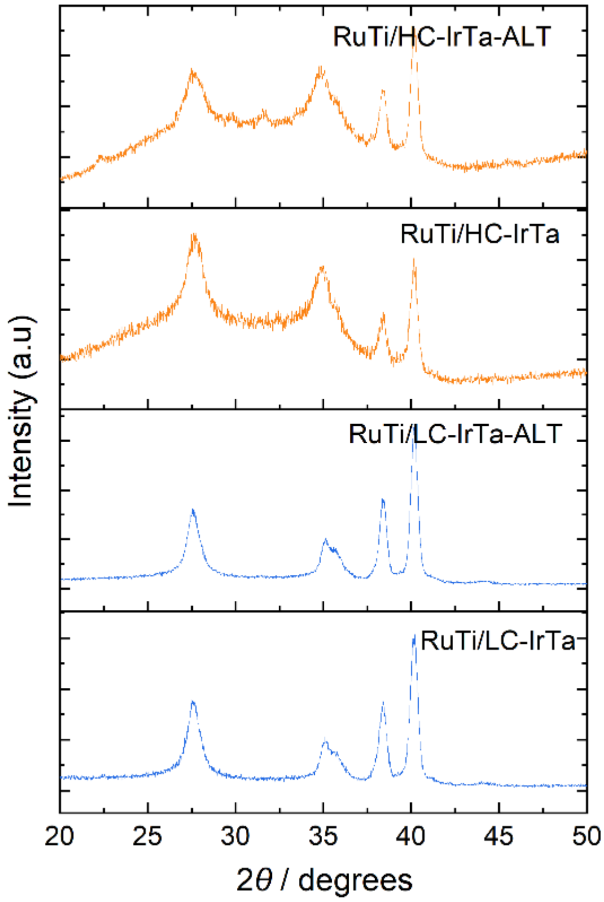

Figure S4 The X-ray diffraction patterns of RuTi/LC-IrTa and RuTi/HC-IrTa electrodes before and after ALT.

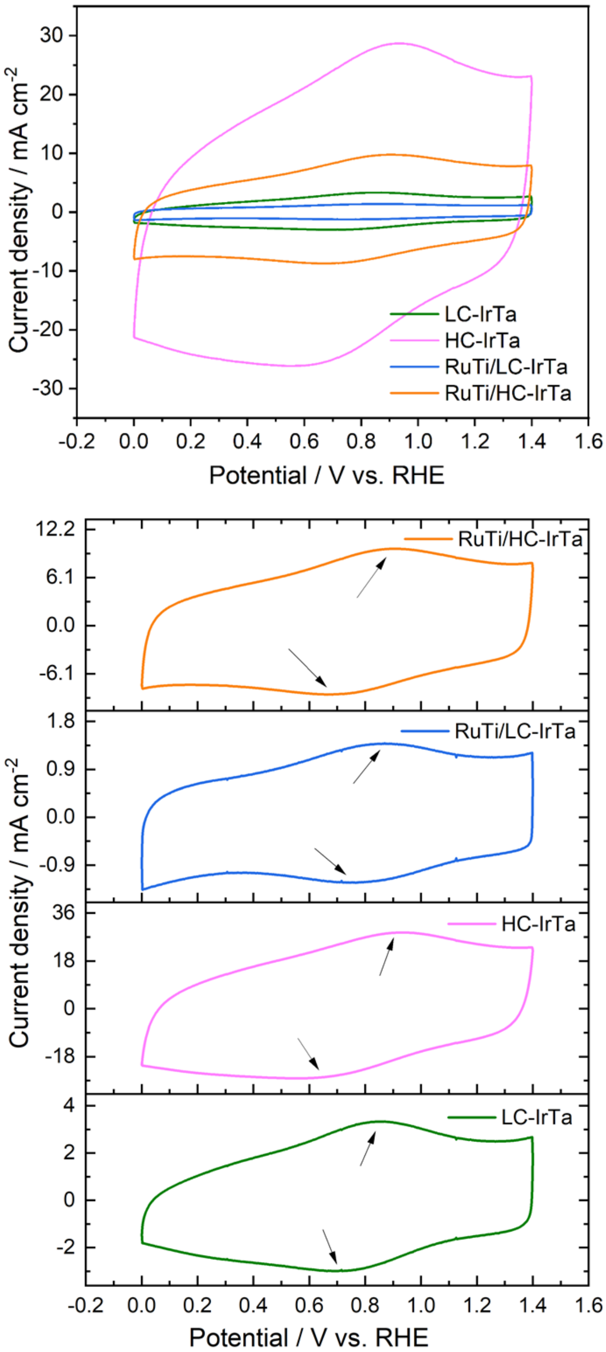

Figure S5 The cyclic voltammograms of LC-IrTa, RuTi/LC-IrTa, HC-IrTa and RuTi/HC-IrTa electrodes with a potential scan rate of 100 mV s^{-1} in 0.5 mol L^{-1} H_2SO_4 solution.

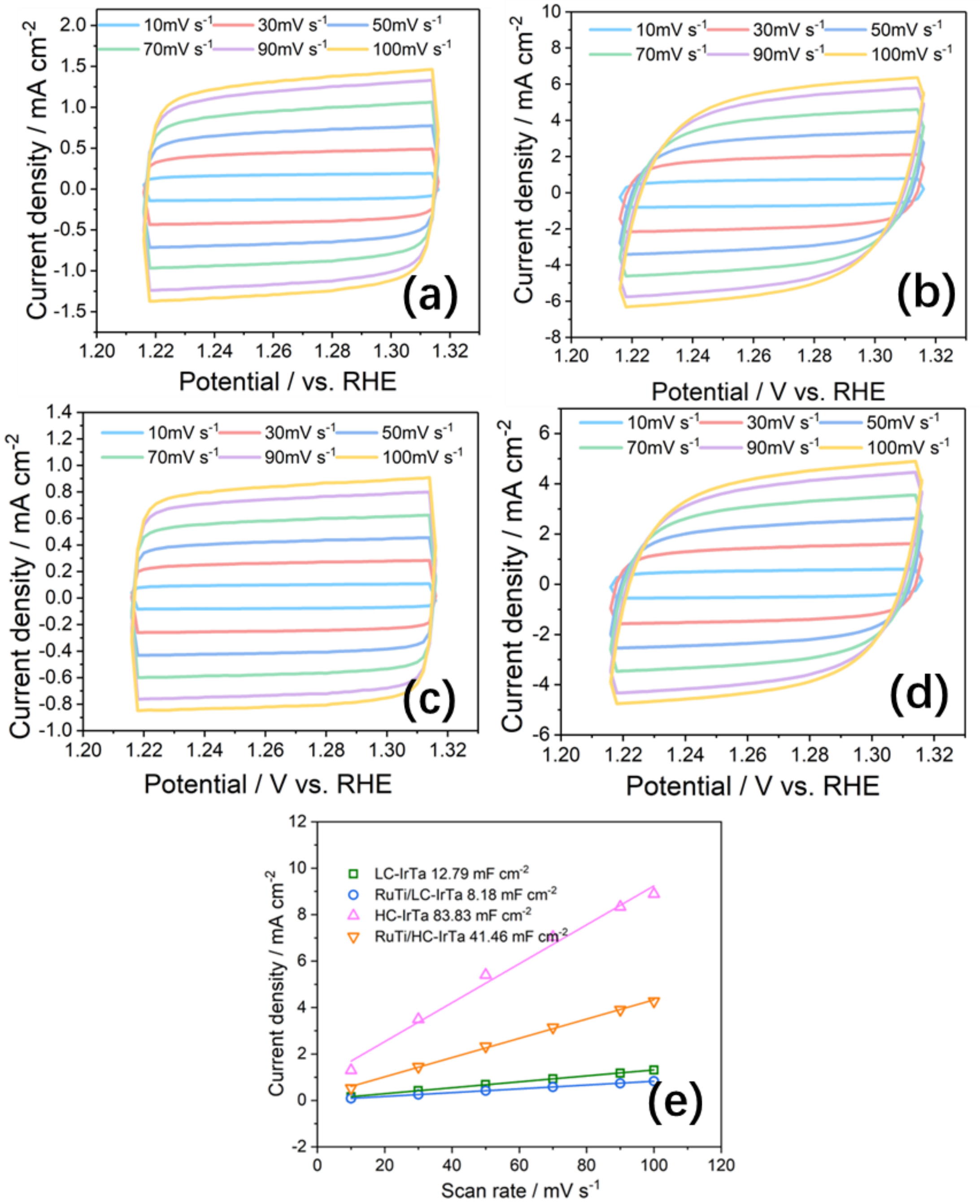

Figure S6 The cyclic voltammograms of LC-IrTa (a), HC-IrTa (b), RuTi/LC-IrTa (c) and RuTi/HC-IrTa (d) electrodes with different scan rate at potential of 1.216 ~ 1.316 V. Double-layer capacitances of LC-IrTa, HC-IrTa, RuTi/LC-IrTa and RuTi/HC-IrTa electrodes (e).

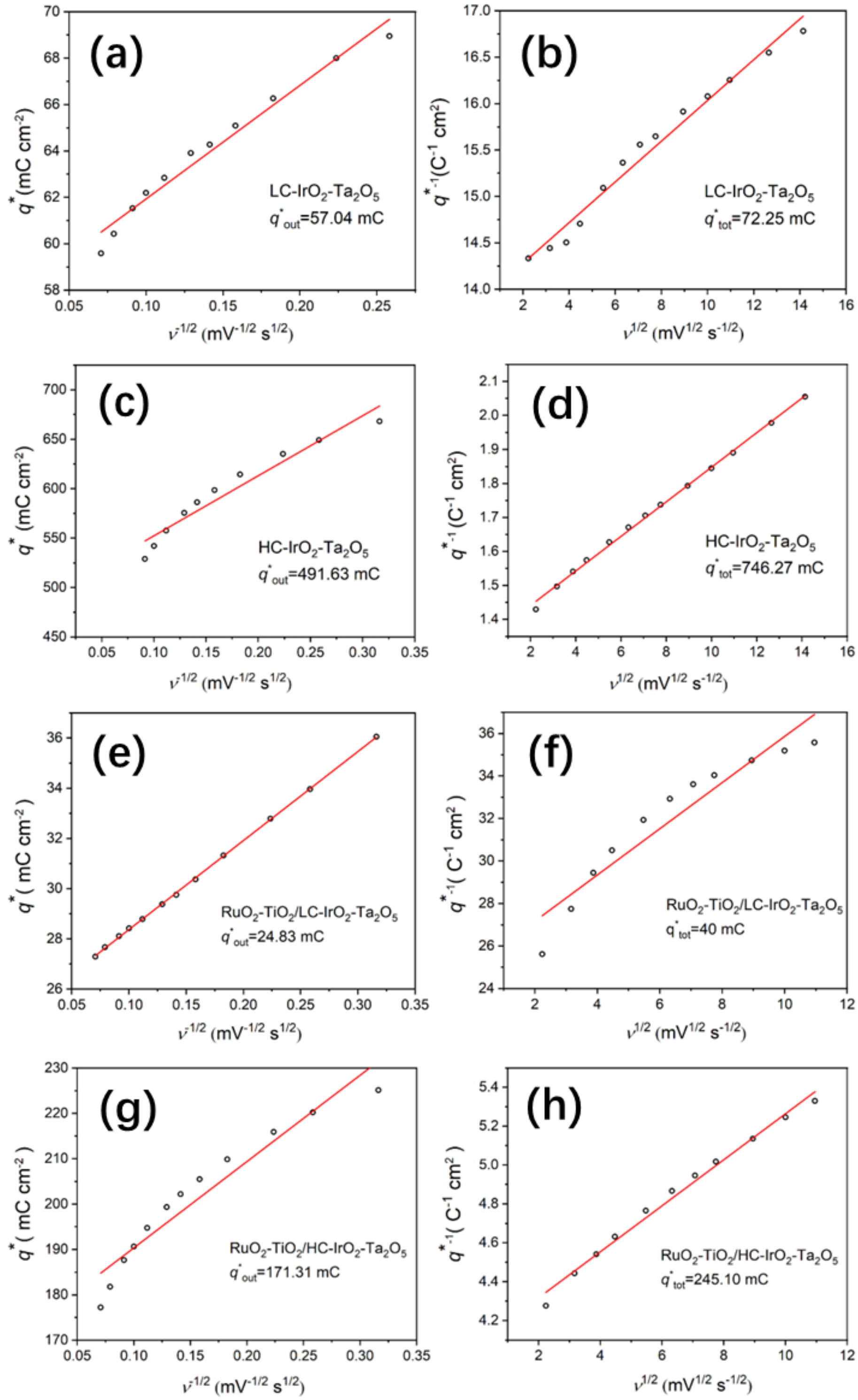

Figure S7 The total surface charges (q^*_{tot}) and outer surface charges (q^*_{out}) of LC-IrTa (a-b), HC-IrTa (c-d), RuTi/LC-IrTa (e-f) and RuTi/HC-IrTa electrodes (g-h).

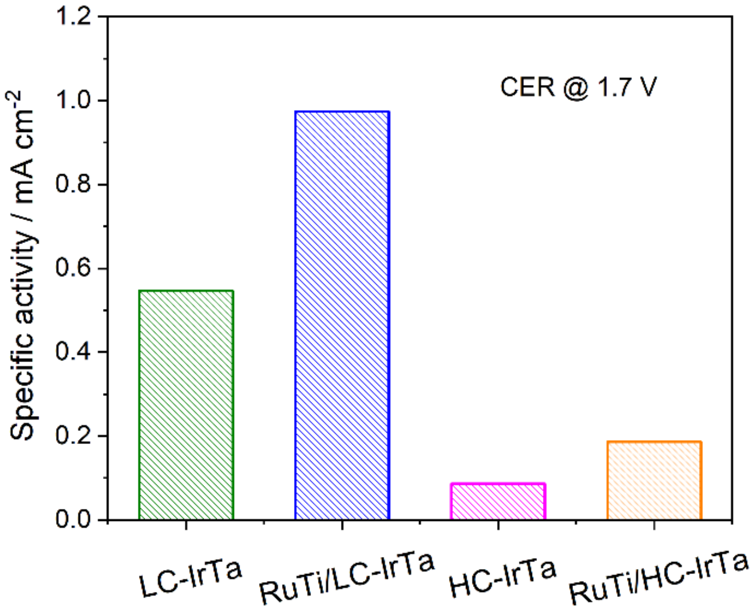

Figure S8 Specific activities of CER of LC-IrTa, RuTi/LC-IrTa, HC-IrTa and RuTi/HC-IrTa electrodes.

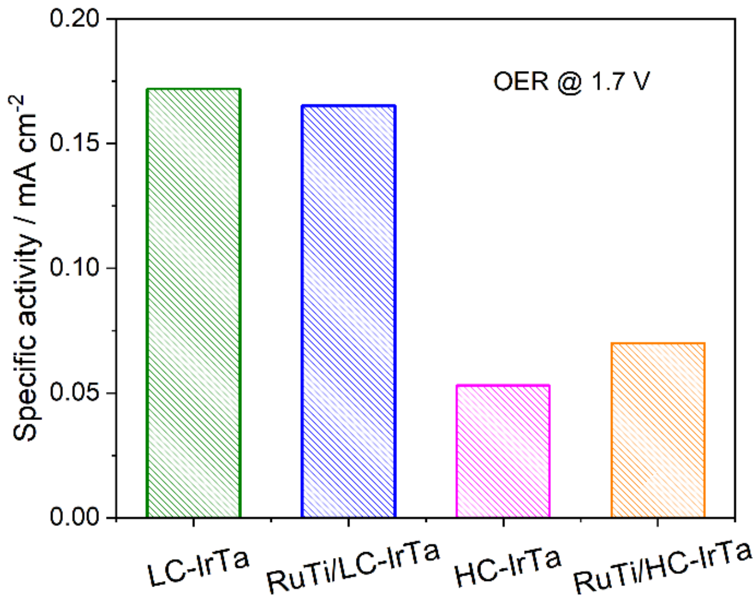

Figure S9 Specific activities of OER of LC-IrTa, RuTi/LC-IrTa, HC-IrTa and RuTi/HC-IrTa electrodes.

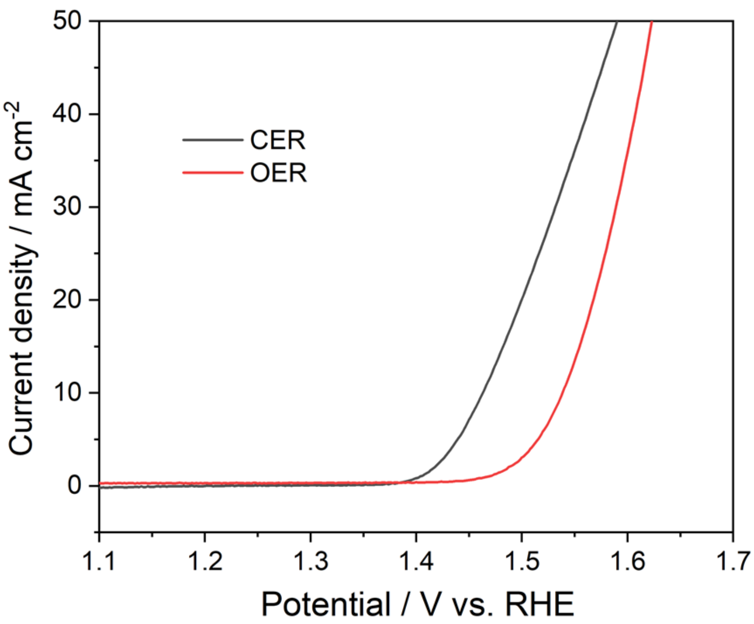

Figure S10 The CER apparent activities in 4.0 M NaCl (pH = 1.0) and the OER apparent activities in 0.5 M H_2SO_4 + 1.33 M Na_2SO_4 of RuTi-HC-IrTa electrode.

Table S1 The loading of Ir, Ta and Ru of RuTi, LC-IrTa, HC-IrTa, RuTi/LC-IrTa, RuTi/HC-IrTa and RuTi-HC-IrTa electrodes by XRF.

Electrodes	Ir/μg cm^{-2}	Ta/μg cm^{-2}	Ru/μg cm^{-2}	Ir:Ta/mol:mol
RuTi	---	---	180.3	---
LC-IrTa	56.3	65.2	---	45:55
HC-IrTa	680.4	846.0	---	43:57
RuTi/LC-IrTa	30.3	35.8	62.1	44:56
RuTi/HC-IrTa	373.6	463.2	82.5	43:57
RuTi-HC-IrTa	350.5	440.3	97.1	43:57

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Table S2 Als and SLs of RuTi, LC-IrTa, HC-IrTa, RuTi/LC-IrTa, RuTi/HC-IrTa and RuTi-HC-IrTa electrodes.

Electrodes	Accelerated Lifetime (AL) / h (i_a = 2 A cm^{-2})	service Lifetime (SL) / years (i_n = 0.2 A cm^{-2})
RuTi	5	0.06
LC-IrTa	38	0.43
HC-IrTa	245	2.80
RuTi/LC-IrTa	178	2.03
RuTi/HC-IrTa	602	6.87
RuTi-HC-IrTa	41	0.47

$SL = AL\ (i_{AL} / i_{SL})^n$,   n=2.0

Table S3 Comparison of ALs of RuTi/HC-IrTa and previously reported CER catalysts

Electrode	Loading/mg cm^{-2}	Electrolyte	Current density/ A cm^{-2}	AL/h	Ref.
RuO_2:TiO_2 (30:70)		0.5 M NaCl	1.2	1.8	*Catal. Sci. Technol.*, 2018, 8, 4957-4974.
RuO_2:TiO_2 (30:70)	0.3	0.5 M NaCl	0.7	31	*J. Electroanal. Chem.*. 2005, 579, 67–76.
RuO_2:TiO_2	2	2.0 M H_2SO_4	1.5	16	*J. Appl. Electrochem.*, 1997, 27, 1283–1289.
$Ir_{0.3}Ru_{0.3}Ti_{0.4}O_2$	2	3.0 M H_2SO_4	2	9	*Prog. Nat. Sci. Mater.*, 2014, 24, 134-141.
TiO_2–RuO_2–IrO_2–SnO_2 (60:25:5:10)		0.5 M NaCl	1	9	*J. Sol-Gel Sci. Techn.*, 2019, 89, 553–561.
$Ru_{0.25}Ir_{0.25}Ti_{0.5}O_2$	4	1.0 M H_2SO_4	2	100	*Ionics*, 2013, 19. 113–125.
40IrO_2-30RuO_2-15Ta_2O_5-15TiO_2	1.5	1.0 M Na_2SO_4	0.1	200	*J. Mater. Eng. Perform.*, 2019, 28, 5595–5604.
38IrO_2-36RuO_2-21TiO_2-5Ta_2O_5		1.0 M NaCl	2	98	*Corros. Sci.*, 2023, 214, 111005.
36RuO_2-38IrO_2-26TiO_2		1.0 M NaCl	2	120	*Corros. Sci.*, 2022, 206, 110481.
IrO_2-RuO_2-SiO_2	1.5	0.5 M H_2SO_4	2	175	*Corros. Sci.*, 2020, 170, 108662.
Ta_2O_5-IrO_2 (20:80)	1.35	1.0 M NaCl + 2.0 M $HClO_4$	2	272	*Mater. Sci. Appl.*, 2011, 2, 237-243.
IrO_2–Ta_2O_5 (70:30)	0.8	0.5 M H_2SO_4	2	799	*Corros. Sci.*, 2002, 44, 1655–1668.
IrO_2–Ta_2O_5 (70:30)		0.5 M H_2SO_4	4.24	93	Electrochim. Acta, 2018, 263, 353-361.

IrO_2–Ta_2O_5 (70:30)		1.0 M H_2SO_4	2	450	*Corros. Sci.*, 2003, 45, 2729–2740.
Ta_2O_5-IrO_2-rGO		1.0 M H_2SO_4	2	787	*J. Electrochem.Soc.*, 2020 167 146506
IrO_2–Ta_2O_5		1.0 M H_2SO_4 + 0.5 M Na_2SO_4	2	108	Sur. Coat. Tech., 2017, 320, 270-278.
IrO_2(35%)-Ta_2O_5 (30%)-SiO_2 (35%)		0.5 M H_2SO_4	1.5	230	Mater. Chem. Phys., 2022, 285, 126086.
RuTi/HC-IrTa	**0.37**	**0.5 M H_2SO_4**		**602**	**This work**

Table S4 Fitting parameters of equivalent circuits of LC-IrTa, HC-IrTa, RuTi/LC-IrTa, RuTi/HC-IrTa and RuTi-HC-IrTa electrodes

Reaction	Electrodes	$R_s/\Omega\ cm_2$	$R_{ct}/\Omega\ cm^2$
CER	LC-IrTa	0.41	0.28
	HC-IrTa	0.39	0.22
	RuTi/LC-IrTa	0.41	0.33
	RuTi/HC-IrTa	0.38	0.46
OER	LC-IrTa	0.41	3.37
	HC-IrTa	0.40	0.46
	RuTi/LC-IrTa	0.43	3.54
	RuTi/HC-IrTa	0.39	1.89