Supporting Information

Highly Efficient and Durable P, Ru-CeO2 Self-supporting Electrodes Toward Industrial-level Hydrogen Production

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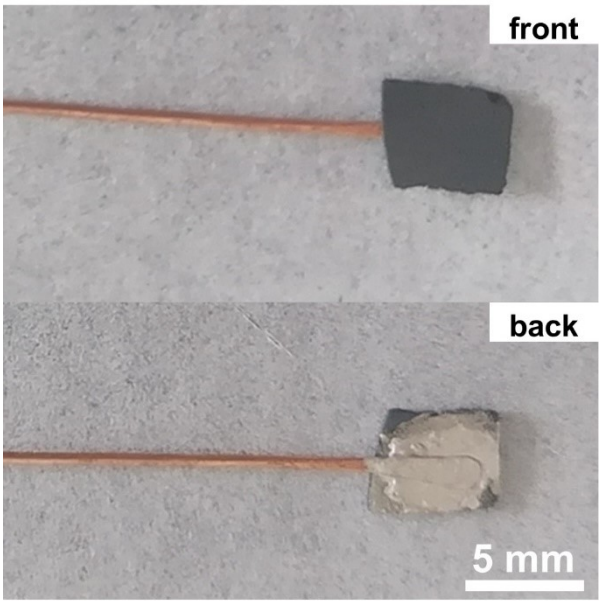

Figure S1. The optical photo of the P, Ru-CeO_2 self-supporting electrode.

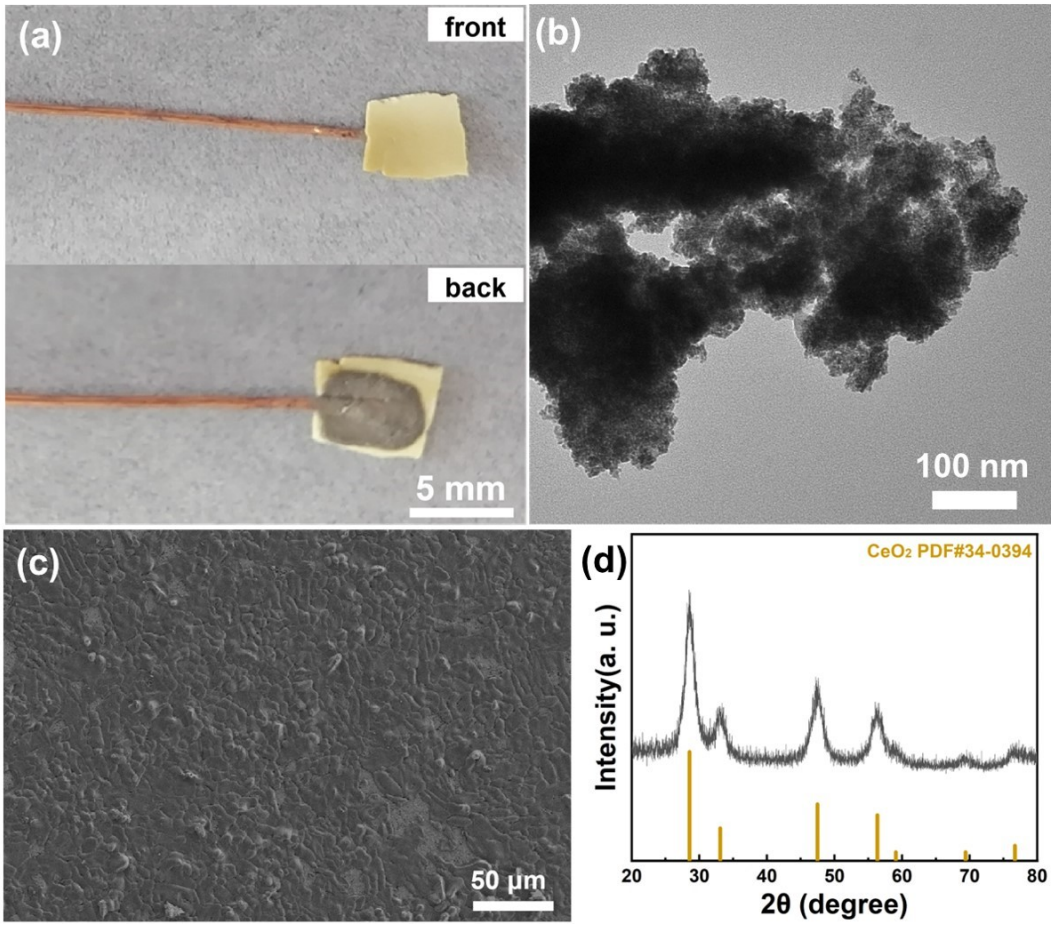

Figure S2. (a) Optical photo, (b) TEM image, (c) TEM image and (d) XRD pattern of the pristine CeO_2 self-supporting electrode.

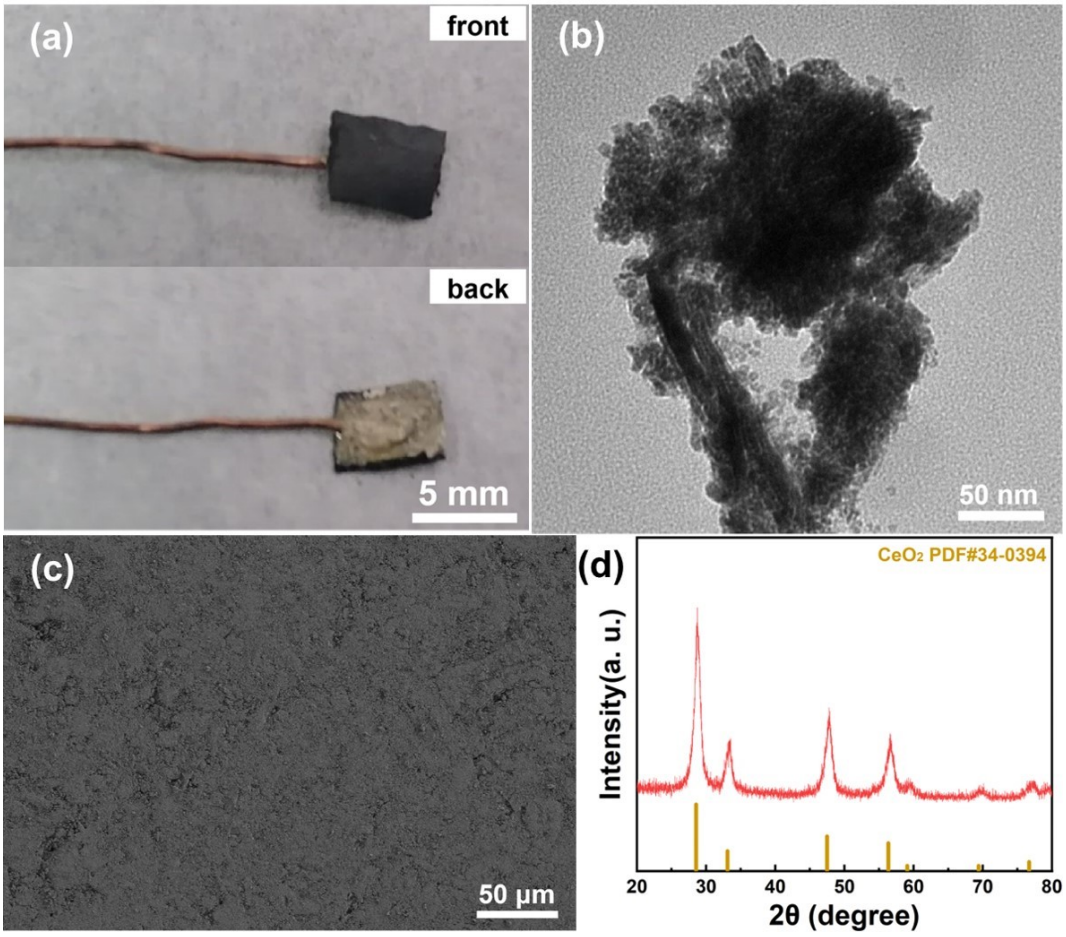

Figure S3. (a) Optical photo, (b) TEM image, (c) TEM image and (d) XRD pattern of the Ru-CeO_2 self-supporting electrode.

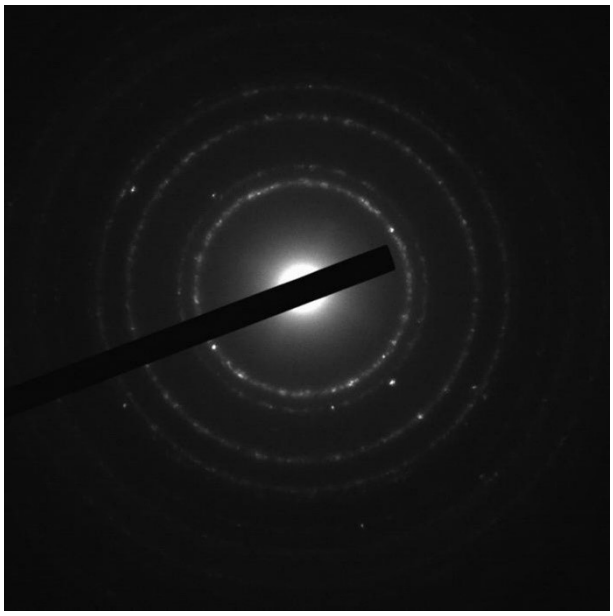

Figure S4. SAED pattern of the P, Ru-CeO_2 catalyst.

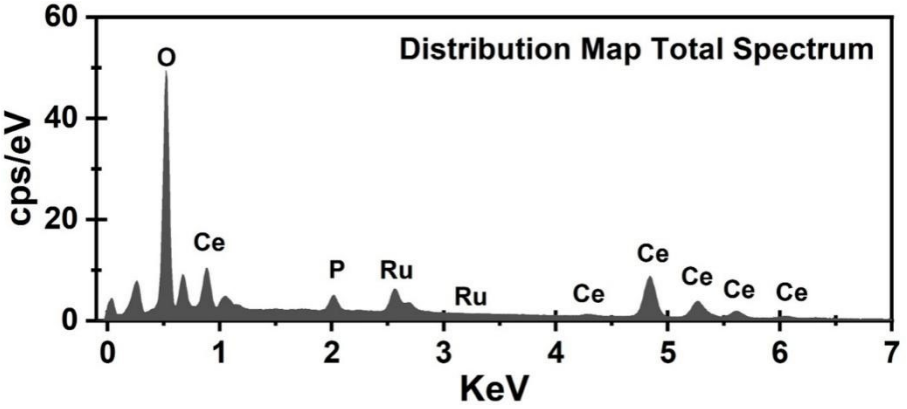

Figure S5. EDX spectrum of the P, Ru-CeO_2 self-supporting electrode.

Distribution Map Total Spectrum				
element	**Line Type**	**Weight%**	**wt% Sigma**	**Atomic%**
O	K	17.03	0.10	54.05
P	K	1.48	0.03	2.49
Ru	L	6.66	0.10	3.43
Ce	M	71.57	0.18	26.62
Other	-	3.26	-	13.41
total	_	100	_	100

Table S1. Relative proportions of main elements, corresponding to Figure S5.

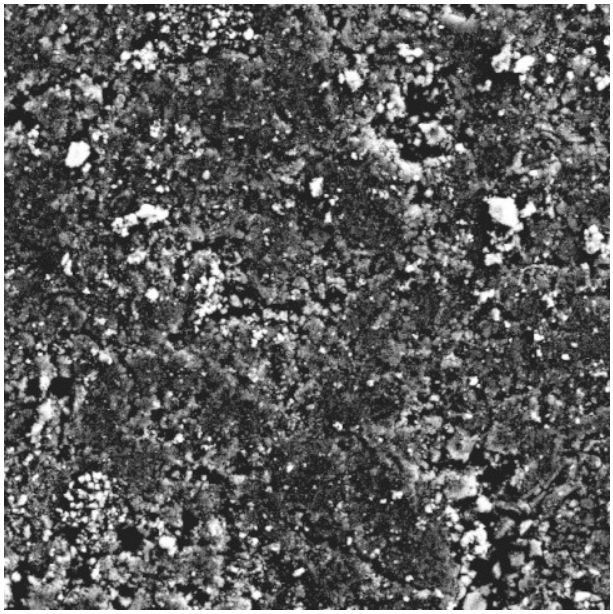

Figure S6. The SEM image for elemental mapping of the P, Ru-CeO_2 self-supporting electrode.

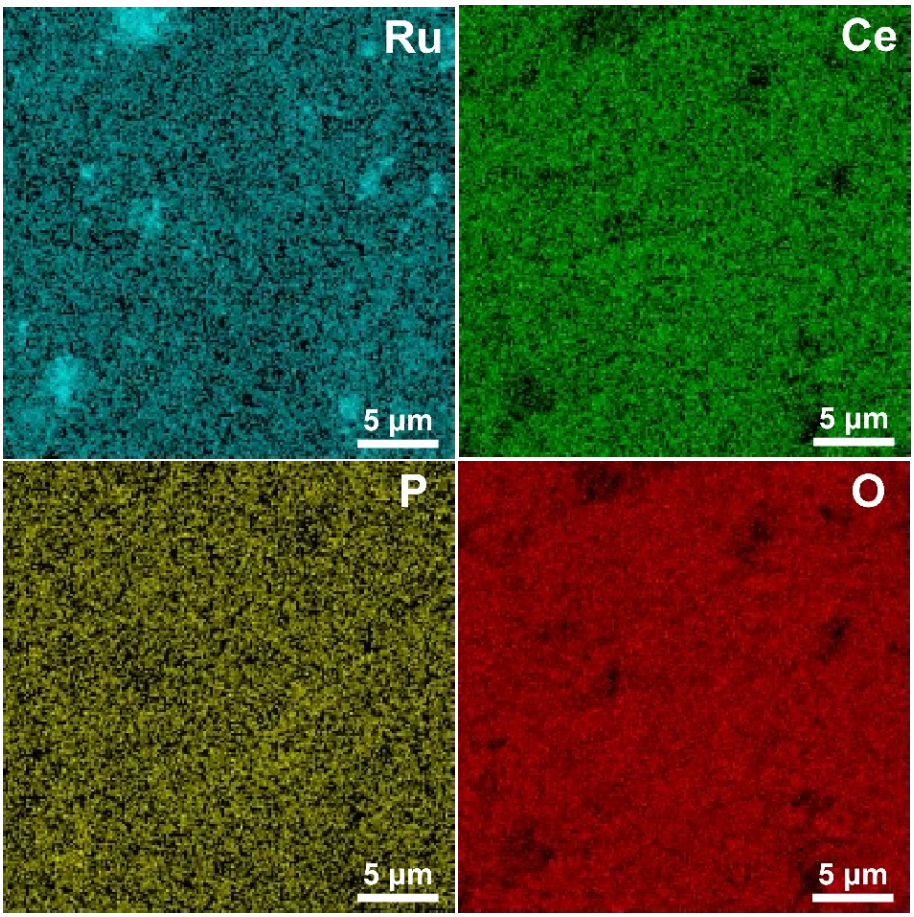

Figure S7. The corresponding elemental mapping image in Figure S5 of the P, Ru-CeO_2 self-supporting electrode.

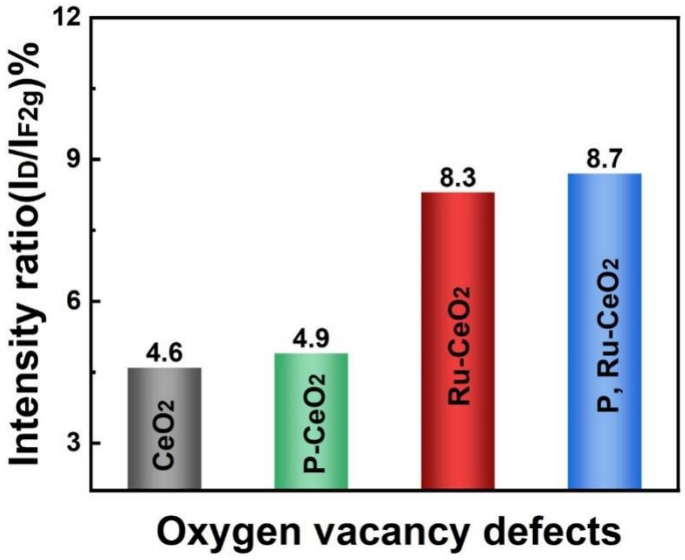

Figure S8. Peak intensity ratio of I_D/I_{F2g} over CeO_2, P-CeO_2, Ru-CeO_2 and P, Ru-CeO_2 catalysts.

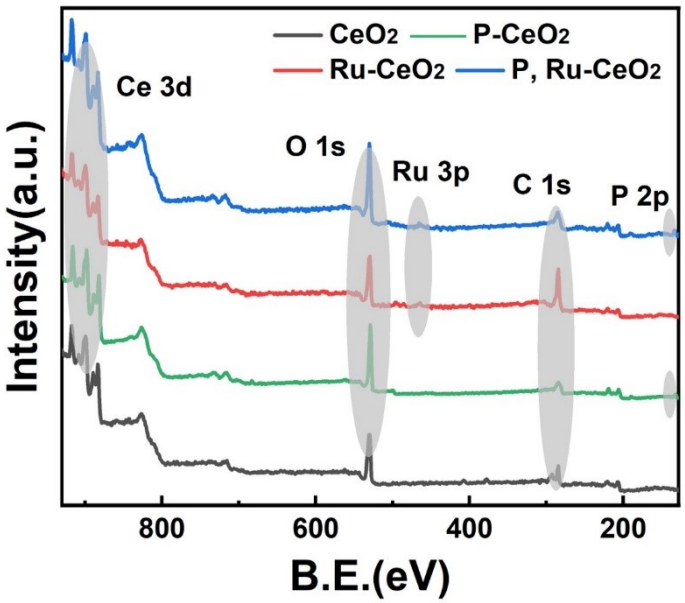

Figure S9. XPS survey scan spectrum of the pristine CeO_2, P-CeO_2, Ru-CeO_2 and P, Ru-CeO_2 catalysts.

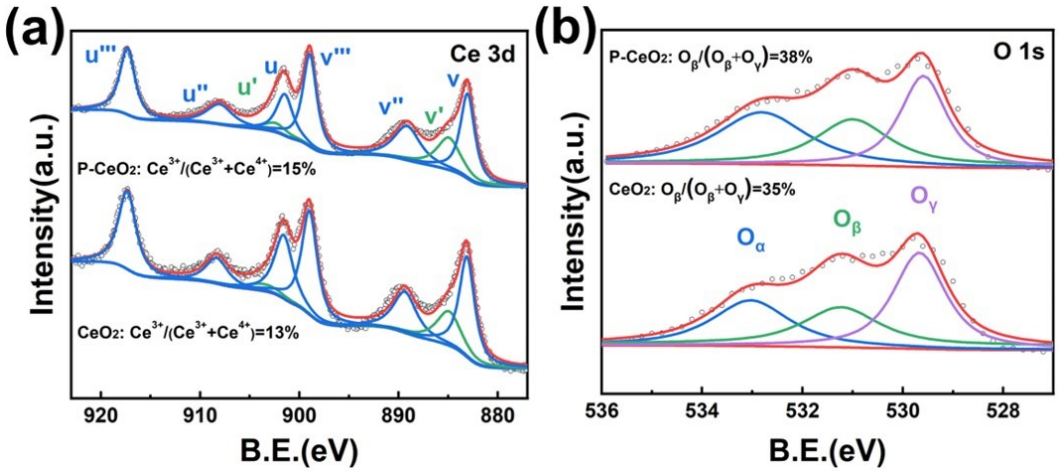

Figure S10. XPS of the pristine CeO_2, P-CeO_2 catalysts: (a) Ce 3d orbitals, (b) O 1s orbitals.

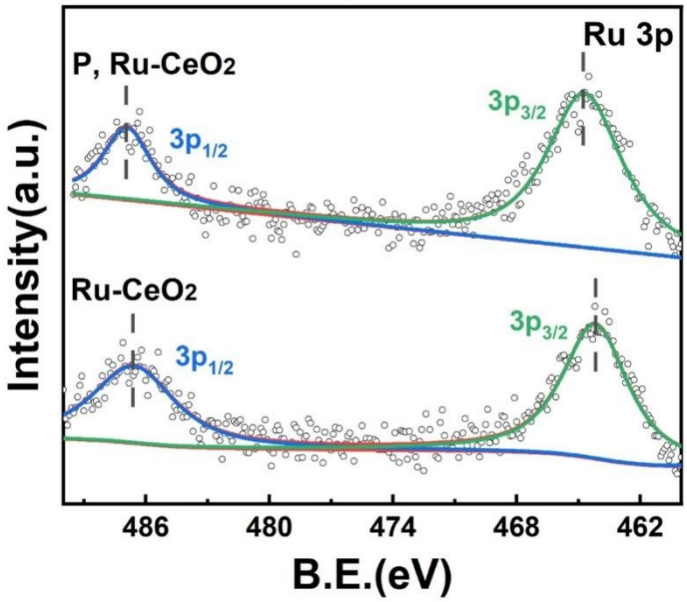

Figure S11. XPS of Ru-CeO_2 and P, Ru-CeO_2 catalysts: Ru 3p orbitals.

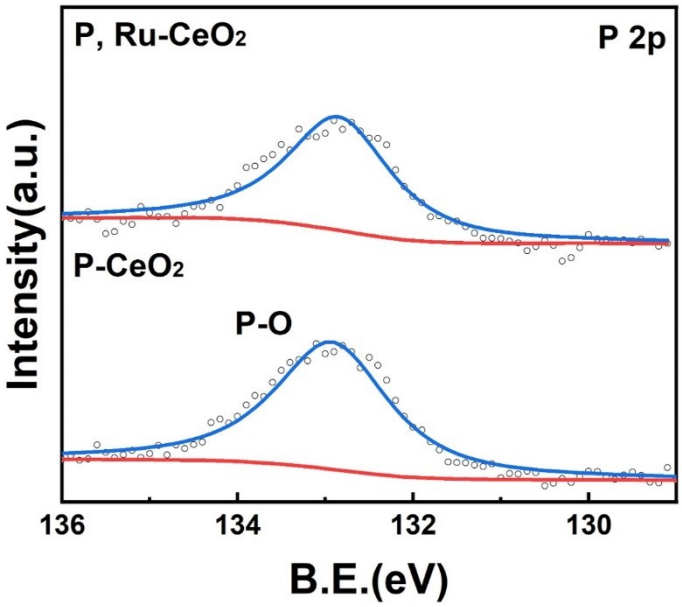

Figure S12. XPS of P-CeO_2 and P, Ru-CeO_2 catalysts: P 2p orbitals.

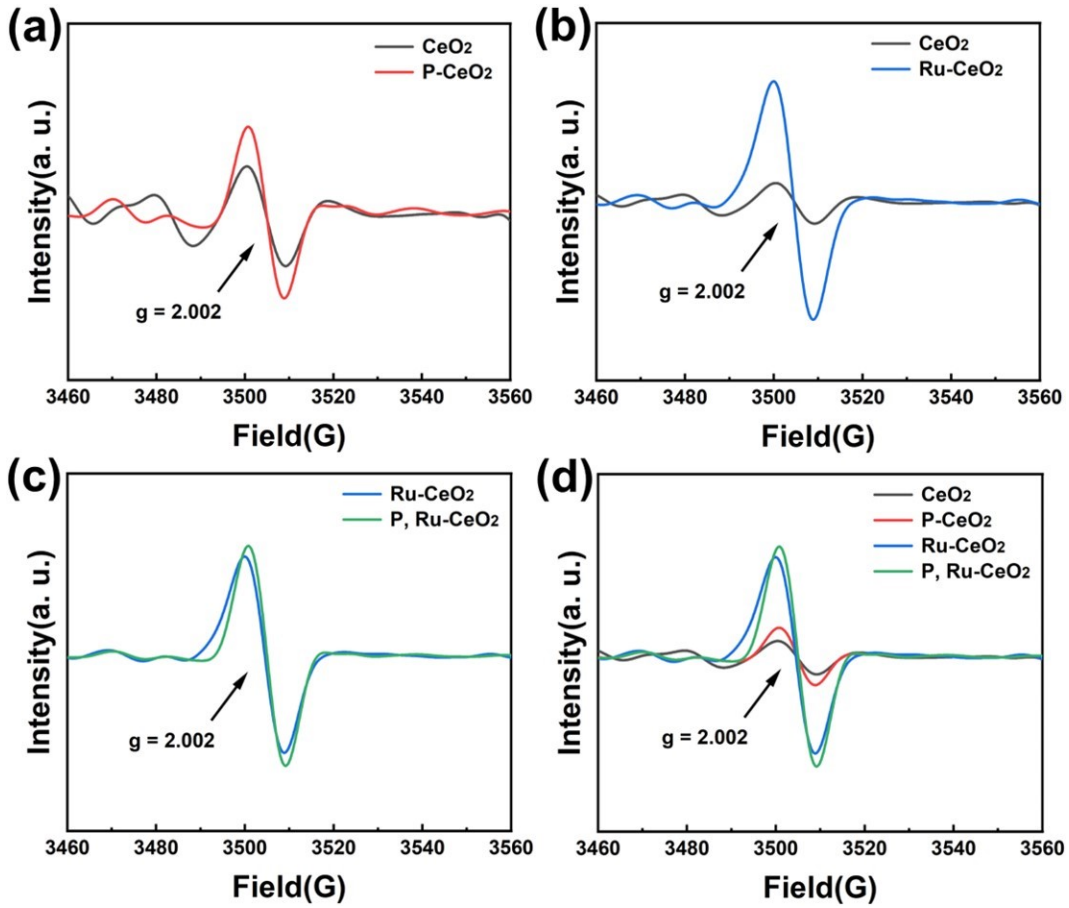

Figure S13. EPR spectrum of the catalysts: (a) CeO_2 and P-CeO_2, (b) CeO_2 and Ru-CeO_2, (c) Ru-CeO_2 and P, Ru-CeO_2, (d) CeO_2, P-CeO_2, Ru-CeO_2 and P, Ru-CeO_2.

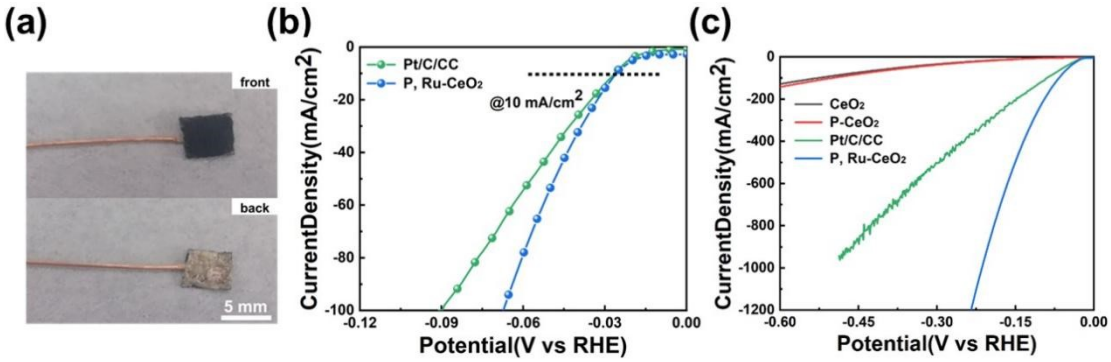

Figure S14. (a) Commercial Pt/C working electrode loaded on CC. iR-corrected polarization curves of the pure CeO_2, P-CeO_2, P, Ru-CeO_2 self-supporting working electrodes and commercial Pt/C/CC: (b) @low-current density; (c) @high-current density.

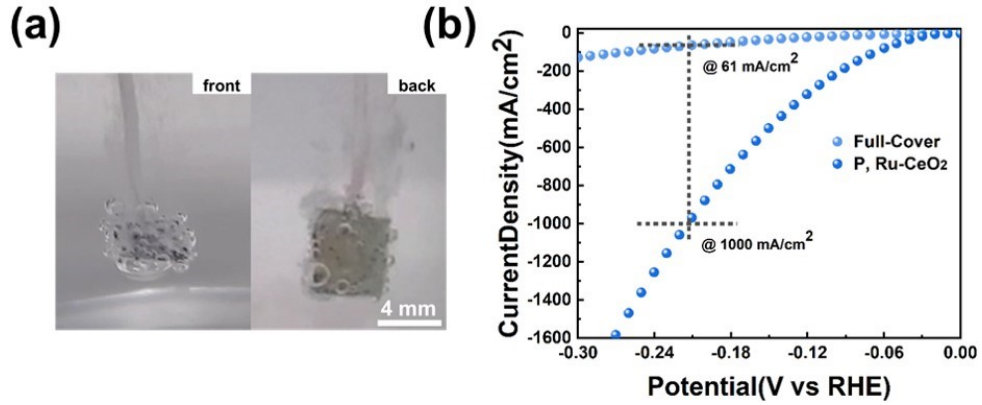

Figure S15. (a) the comparison between the front and back of the P, Ru-CeO_2 self-supporting working electrode. (b) iR-corrected polarization curves of the Full-Cover-P, Ru-CeO_2, P, Ru-CeO_2 self-supporting working electrodes.

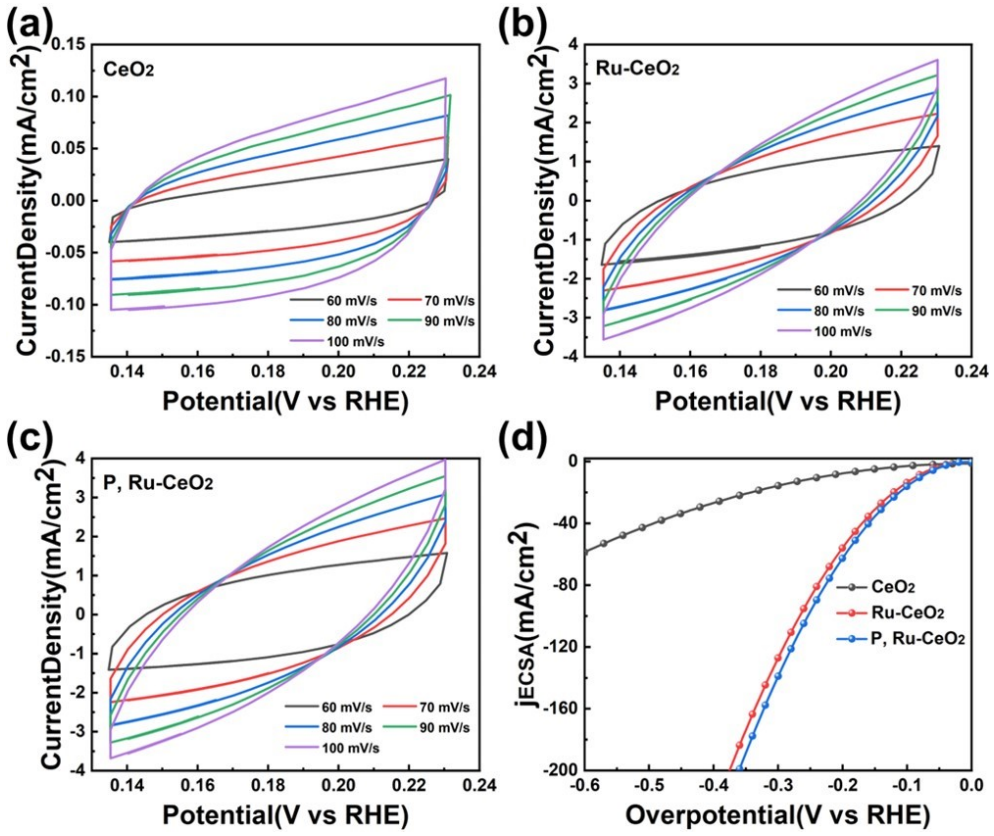

Figure S16. Electrochemical double-layer capacitance measurements at different scan rates for HER. Cyclic voltammograms of (a) pure CeO_2, (b) Ru-CeO_2 and (c) P, Ru-CeO_2 self-supporting working electrodes. (d) HER polarization curves normalized by the electrochemical double-layer capacitance.

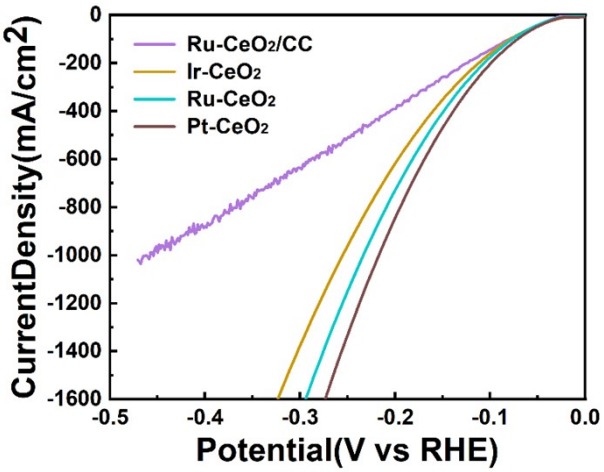

Figure S17. iR-corrected polarization curves of the Ir-CeO_2, Ru-CeO_2, Pt-CeO_2 self-supporting working electrodes, and the Ru-CeO_2/CC.

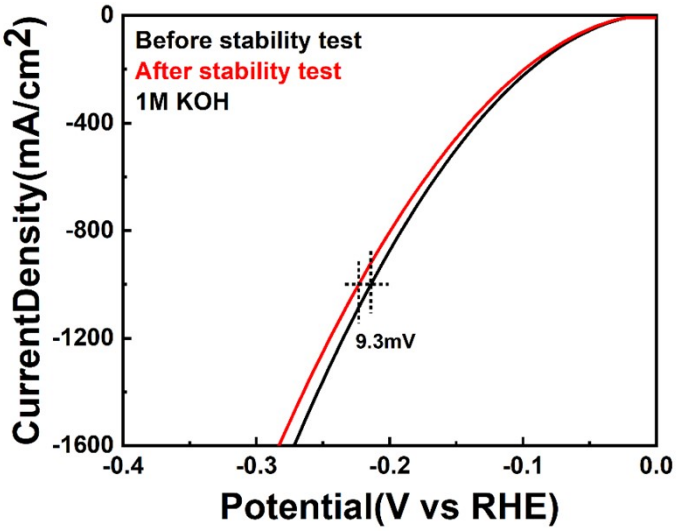

Figure S18. iR-corrected polarization curves of the P, Ru-CeO_2 self-supporting electrode before and after 5000 CV cycles in 1 M KOH.

materials	η_{HER}(mV)	Tafel(mV/dec)	Reference
This work	215	25	—
$Pt/TiO_2/Ni(OH)_2/NF$	227	39	Ref.1[1]
$NiCo@RuO_2$ HNAs/NF	236	69	Ref.2[2]
$FeNiZn/FeNi_3@NiFe$	245	45	Ref.3[3]
$Ru\text{-}CoO_x/NF$	252	28	Ref.4[4]
$Ni\text{-}W_2N@NF$	276	46	Ref.5[5]
Sr_2RuO_4 bulk SC	278	26	Ref.6[6]
Co-SA/CC	294	97	Ref.7[7]
Ni-Co-P/CFP	295	31	Ref.8[8]
Self-Standing Pt NC/CF	331	61	Ref.9[9]
$Cu_3P\text{-}FeP@CC$	338	84	Ref.10[10]

Table S2. Comparison of the HER performance of the P, $Ru\text{-}CeO_2$ self-supporting working electrode with the similar catalysts at 1000 $mA \cdot cm^{-2}$ in 1.0 M KOH.

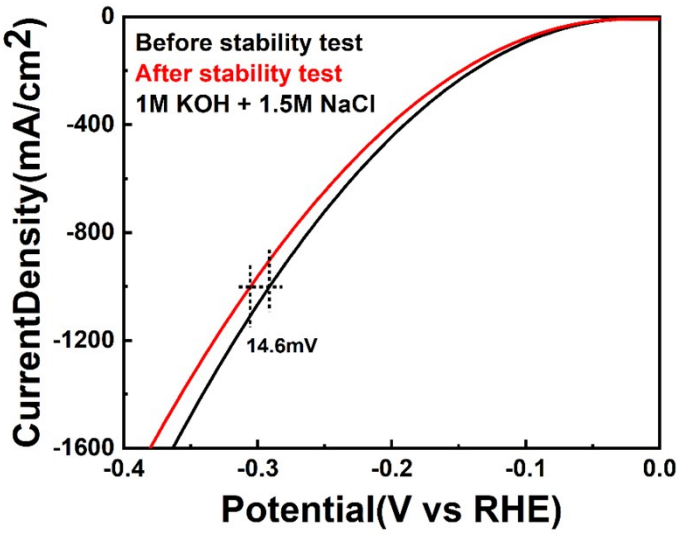

Figure S19. iR-corrected polarization curves of the P, $Ru\text{-}CeO_2$ self-supporting electrode before and after 5000 CV cycles in 1 M KOH+1.5 M NaCl.

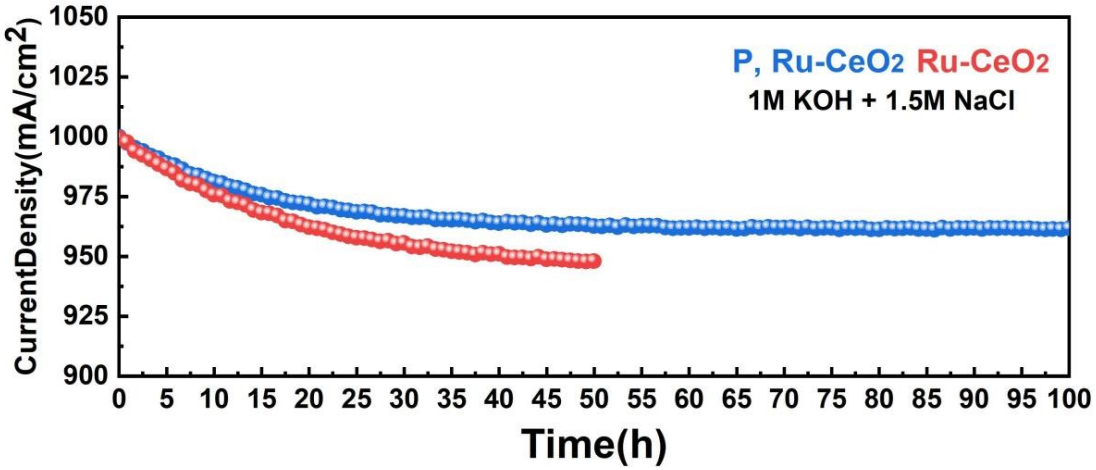

Figure S20. Chronoamperometric curves of the Ru-CeO_2 self-supporting electrodes and the P, Ru-CeO_2 self-supporting electrodes.

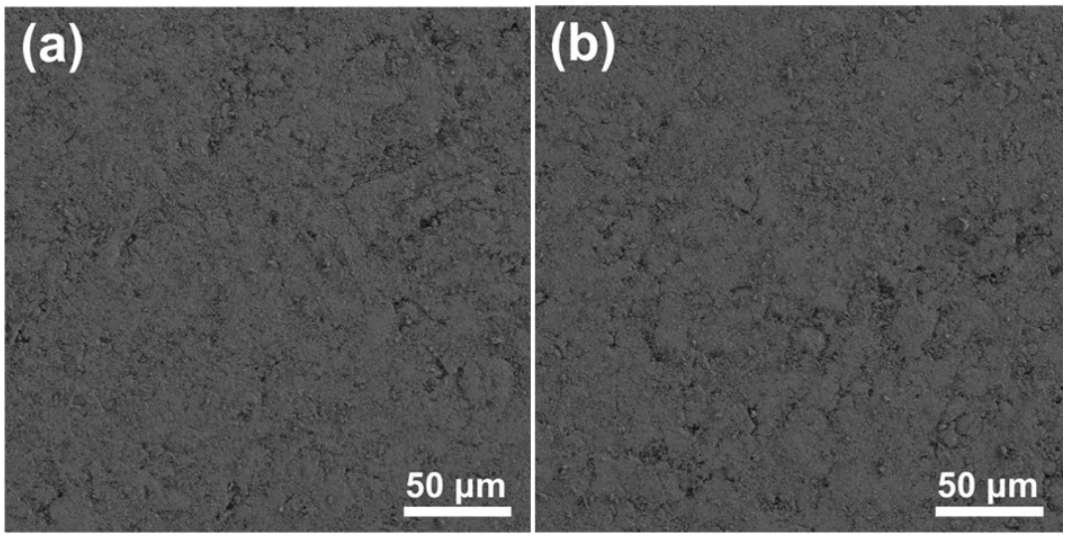

Figure S21. SEM images of the P, Ru-CeO_2 self-supporting electrode (a) before and (b) after durability test in 1 M KOH+1.5 M NaCl.

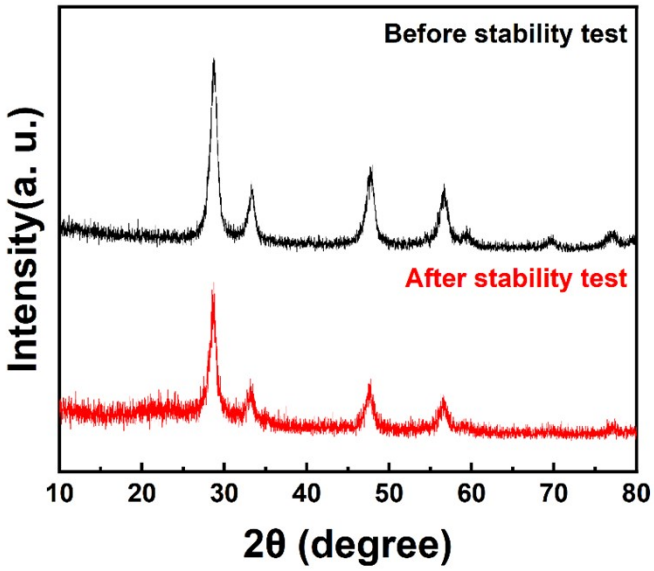

Figure S22. XRD pattern of the P, Ru-CeO_2 catalyst after durability test in 1 M KOH+1.5 M NaCl.

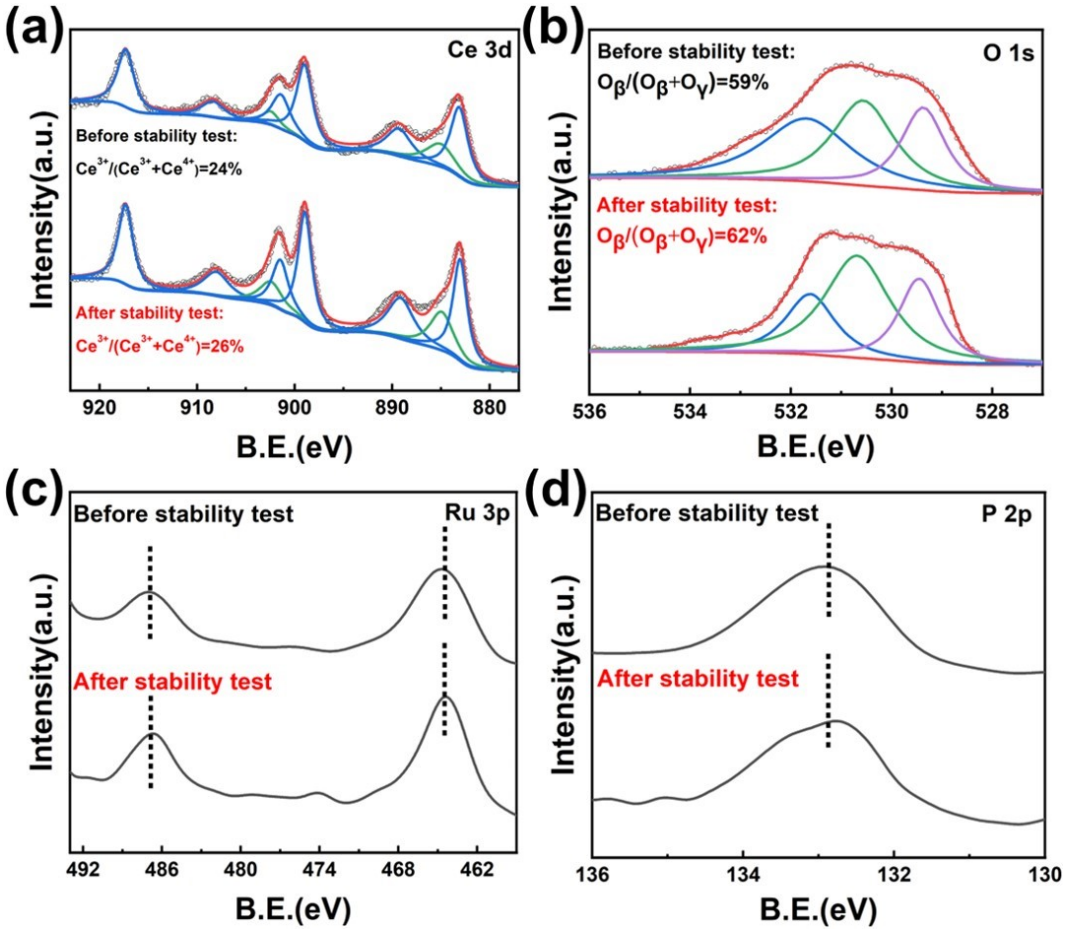

Figure S23. XPS of the P, Ru-CeO_2 catalyst after durability test in 1 M KOH+1.5 M NaCl. (a) Ce 3d. (b) O 1s. (c) Ru 3p. (d) P 2p.

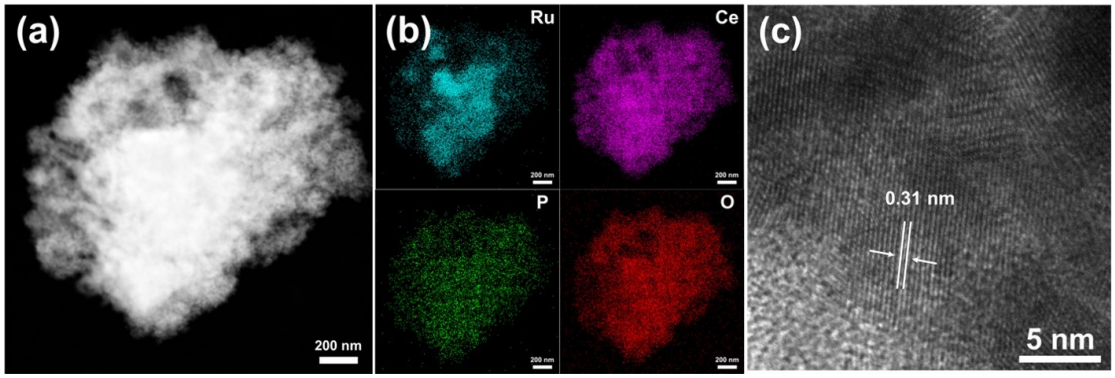

Figure S24. TEM images of the P, Ru-CeO_2 catalyst after durability test in 1 M KOH+1.5 M NaCl. (a) HADDF-STEM. (b) EDS. (c) HRTEM.

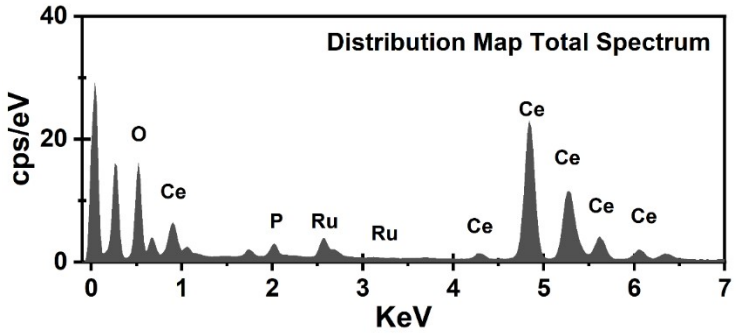

Figure S25. EDX spectrum of the P, Ru-CeO_2 catalyst, corresponding to **Figure S24**.

Distribution Map Total Spectrum			
element	**Line Type**	**Weight%**	**σ**
Ce	M	72.48	0.2
O	K	17.57	0.1
Ru	L	6.12	0.2
P	K	1.61	0.1
Other	-	2.22	-
total	_	100	_

Table S3. Relative proportions of main elements, corresponding to **Figure S25**.

References

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