Creating a top-tier, high-density tungsten single atom catalyst

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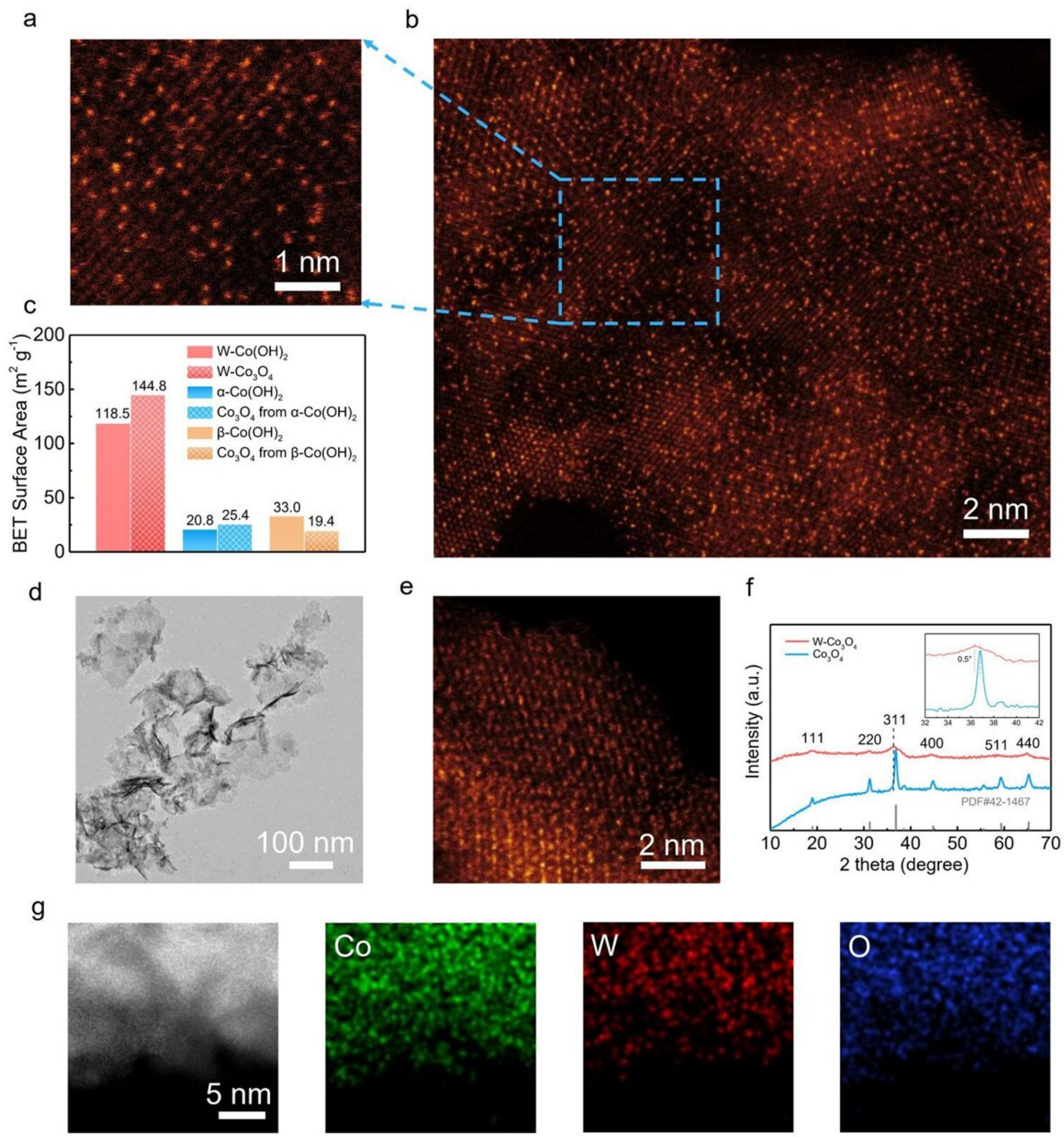


Characterizations of W-Co(OH) and W-CoO. (a, b) Aberration-corrected HAADF-STEM images of W-Co(OH). (c) BET areas of W-Co(OH), α-Co(OH), β-Co(OH) and their corresponding oxides. (d, e) TEM and aberration-corrected HAADF-STEM images of W-CoO. (f) XRD patterns of W-CoO and the pure CoO prepared from α-phase cobalt hydroxide. (g) EDS elemental mapping of W-CoO. Credit: *Journal of the American Chemical Society* (2025). DOI: 10.1021/jacs.5c12122

Designing a catalyst is incredibly difficult—yet researchers at Tohoku University have successfully created a catalyst that is ranked as one of the best. Their catalyst greatly speeds up the oxygen evolution reaction (OER), which is a typically slow-paced reaction that desperately needs a boost so that it can be used practically in environmentally friendly technologies.

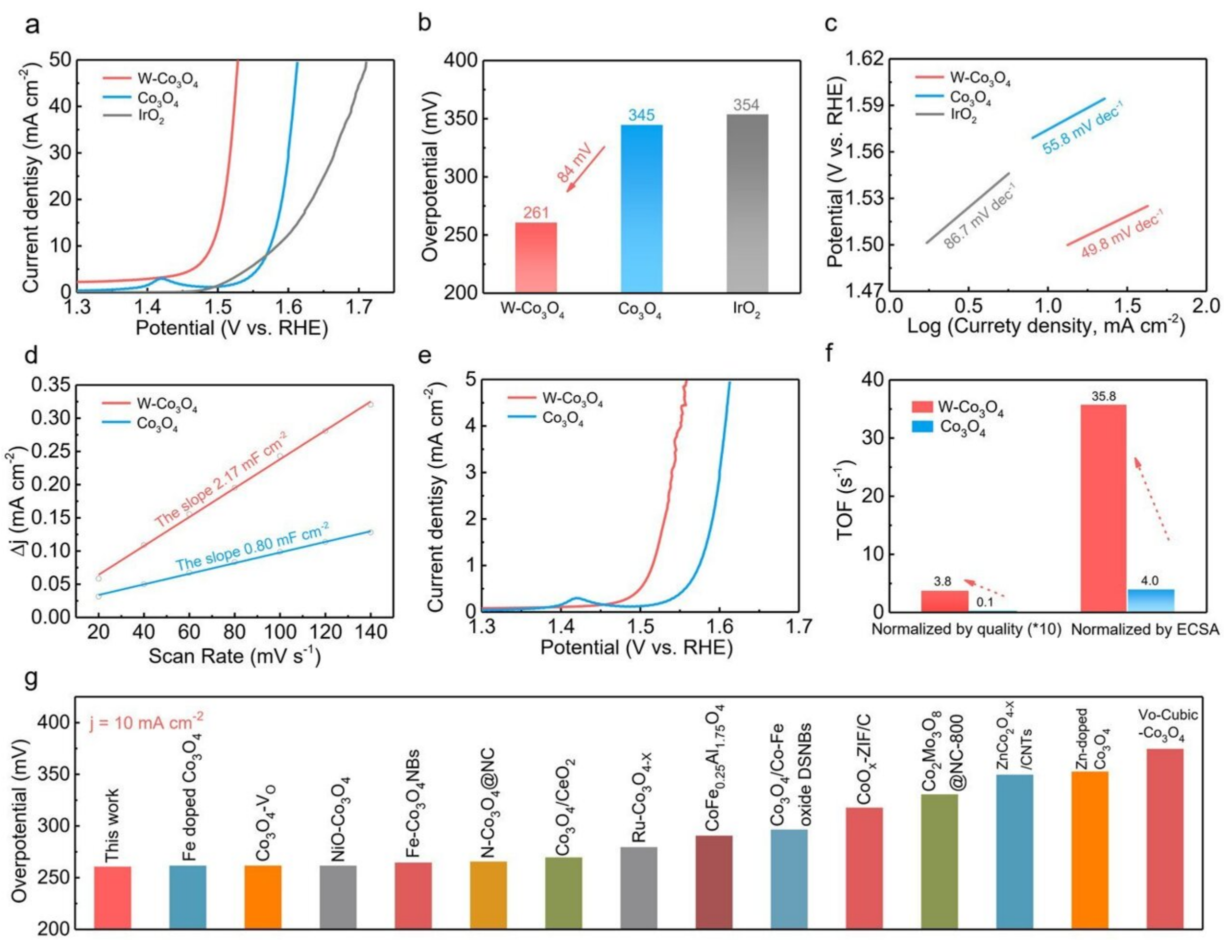
This result combines low overpotential, long-term stability, and practicality into a catalyst that has a promising future helping to combat climate change.

The findings were published in the *Journal of the American Chemical Society*.

What makes designing catalysts so difficult is obtaining the right balance of traits that speeds up the OER as much as possible while minimizing negative trade-offs. For example, while more active sites are desirable, too many can compromise the composition and structure of the catalyst—making it unstable.

The key to their success was tungsten (W) and a general oxygen-vacancy anchoring strategy. Their method enabled the high-density and stable incorporation of W single atoms into transition-metal hydroxides/oxides. This stabilizes ultrathin structures, while also allowing for more active sites that speed up the reaction. This technique breaks the conventional trade-off between activity and stability.

"This research is important as it contributes to the development of more efficient and cost-effective catalysts for water electrolysis, a key process for producing clean hydrogen fuel," explains Professor Hao Li (WPI-AIMR).



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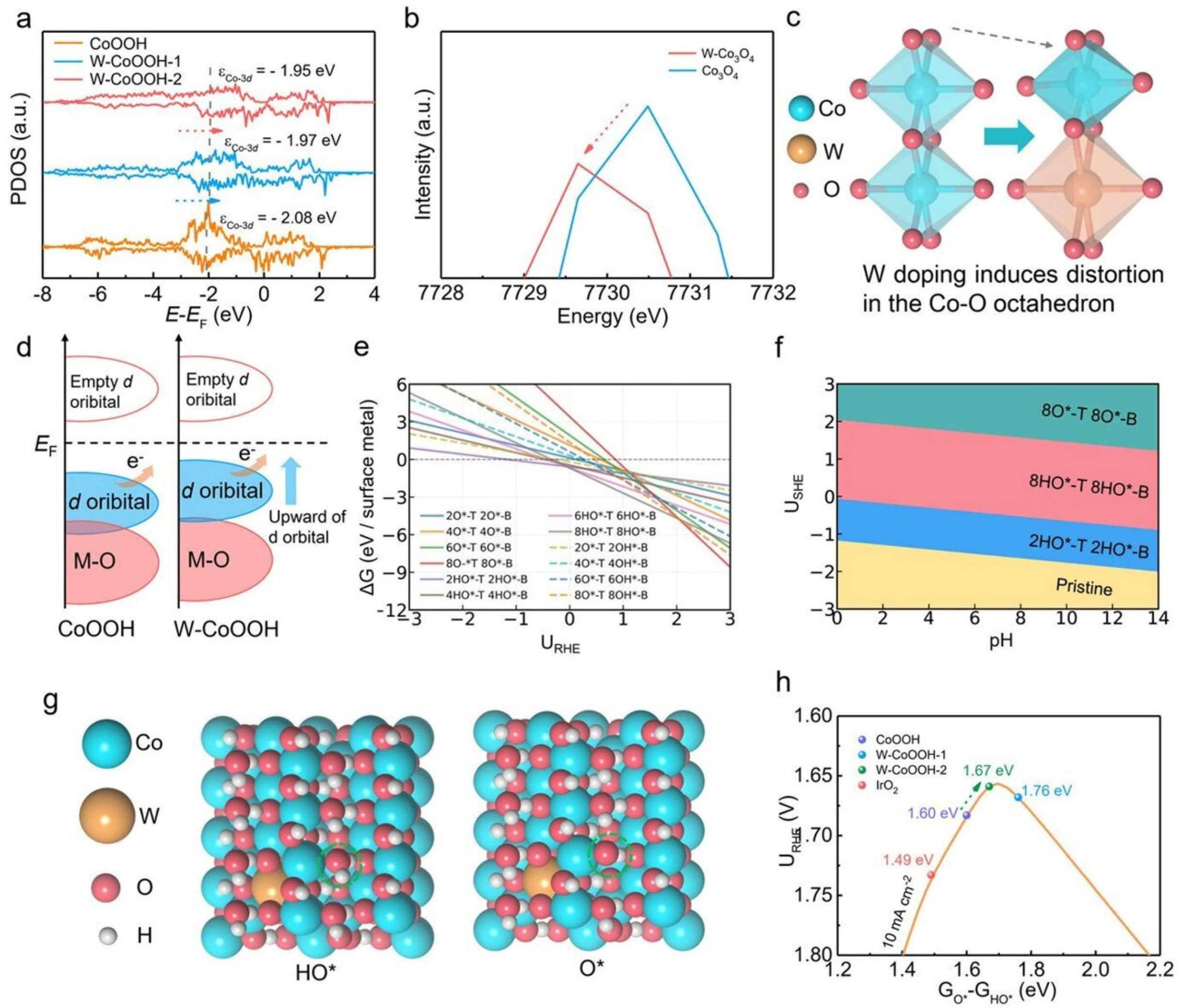

Theoretical analyses of OER activity on W-CoOOH. (a) Projected density of states of CoOOH, W-CoOOH-1 and W-CoOOH-2 (E: Fermi level; ε: Co 3d band center). (b) The white line intensities in the Co K-edge XANES spectra. (c) Illustration of the Co-O octahedron distortion in W-CoOOH and CoOOH. (d) Schematic band diagrams of CoOOH and W-CoOOH. (e) Stability of O* and HO* on W-CoOOH-2. (f) 2D surface Pourbaix diagram of W-CoOOH-2. (g)

Optimized adsorption structures for HO* and O* (top view) on W-CoOOH-2 pre-covered by hydroxyls. (h) Microkinetic OER volcano at the current density of 10 mA cm, with the points indicating the OER potentials. Credit: *Journal of the American Chemical Society* (2025). DOI: 10.1021/jacs.5c12122

This work provides a low-cost, robust, and efficient alternative that does not depend on expensive noble metals or unstable Fe-based systems. The research team says their next steps will further evaluate the long-term stability of the catalysts under industrially relevant current densities, and explore their performance in practical applications such as Anion Exchange Membrane Water Electrolysis and Zn-air batteries.

These efforts will accelerate the translation of our findings into cost-effective, durable OER catalysts for renewable energy conversion and storage technologies.

More information: Yong Wang et al, High-Density W Single Atoms in Two-Dimensional Spinel Oxide Break the Structural Integrity for Enhanced Oxygen Evolution Catalysis, *Journal of the American Chemical Society* (2025). DOI: 10.1021/jacs.5c12122

Provided by Tohoku University

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