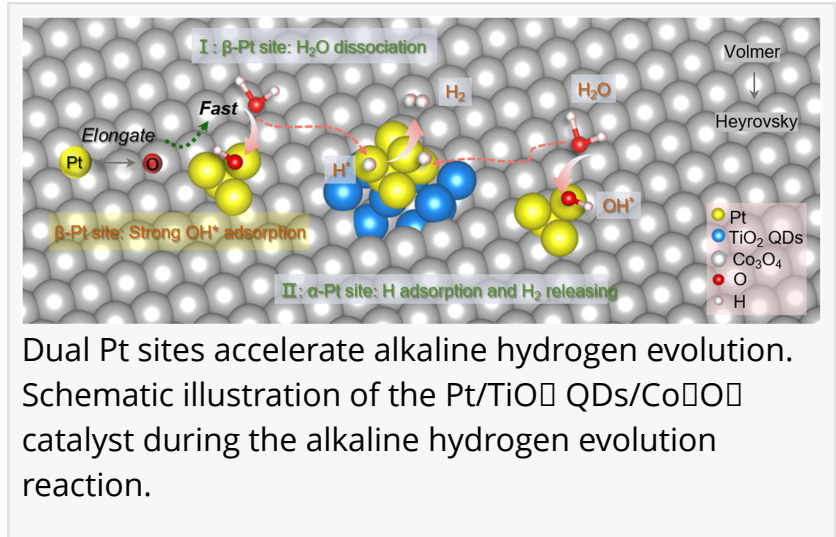


Tuning platinum for cleaner hydrogen

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/EINPresswire.com/ -- Clean hydrogen production depends on catalysts that can split water efficiently while using precious metals more wisely. A new catalyst design addresses one of the long-standing barriers in alkaline water electrolysis: the slow breakdown of water molecules on platinum (Pt) surfaces. By placing [Pt clusters](#) on a symbiotic oxide support made from titanium dioxide quantum dots and cobalt oxide (TiO₂ QDs/Co₃O₄), the study reshapes the electronic state of Pt and creates paired active sites. These sites separately accelerate water dissociation and hydrogen adsorption, enabling faster hydrogen evolution reaction (HER) activity, stronger stability, and a clearer path toward more efficient alkaline electrolyzers.



Alkaline water electrolysis is attractive for large-scale hydrogen production because it can use less corrosive electrolytes and may be compatible with lower-cost device components. However, even platinum (Pt), the benchmark HER catalyst, performs much more slowly in alkaline media than in acidic conditions because water molecules must first be dissociated before hydrogen can form. Conventional catalyst design often focuses on single active sites, making it difficult to balance water activation and hydrogen binding at the same time. Due to these challenges, further research is needed to regulate the electronic structure of Pt and design multifunctional oxide supports for alkaline hydrogen production.

A research team from Jilin University, Xi'an Technological University, the University of Waterloo, the University of Saskatchewan, and the Institute of High Energy Physics, Chinese Academy of Sciences, reported the study, published (DOI: 10.1016/j.esci.2025.100461) online in May 2026, in eScience. The work presents a TiO₂ QDs/Co₃O₄ symbiotic oxide support that precisely regulates Pt clusters for alkaline HER, improving both catalytic activity and operational durability in an anion exchange membrane water electrolyzer (AEMWE).

The team introduced TiO₂ QDs into a Co₃O₄-based support and then anchored Pt clusters onto the resulting oxide-oxide interface. Spectroscopic analyses and density functional theory (DFT)

calculations showed that the strong interaction between TiO₂ QDs and Co₃O₄ redistributed electrons in the Pt 5d orbitals, producing two types of active sites. The β-Pt–O–Co sites promoted water adsorption and dissociation, while the α-Pt–O–Ti sites favored hydrogen adsorption and release. This division of labor helped overcome the usual trade-off between water splitting and hydrogen binding. Electrochemical tests in potassium hydroxide (KOH) solution showed that Pt/QDs/Co₃O₄ required only 19 mV overpotential at 10 mA cm⁻², lower than commercial Pt/C. At an overpotential of 200 mV, its Pt mass activity was 2.17 times higher than that of commercial Pt/C. In an AEMWE device, the catalyst reached 500 mA cm⁻² at 1.78 V and operated continuously for more than 500 hours.

The authors said the work shows that catalyst supports should not be treated as passive platforms. By engineering the oxide interface, they said, the electronic structure of Pt can be tuned with unusual precision, allowing different Pt sites to take on different tasks during hydrogen generation. They added that this strategy may help bridge the gap between atomic-level catalyst design and practical electrolyzer operation, especially under alkaline conditions where water activation remains a major kinetic bottleneck.

The findings point to a broader design principle for high-efficiency electrocatalysts: building supports that actively shape the electronic environment of metal sites. Because the same support concept also improved ruthenium (Ru)-based catalysts, the approach may extend beyond Pt and offer a general route for designing lower-loading, higher-performance hydrogen catalysts. For industry, the combination of high activity, long-term stability, and device-level validation is especially important. The study provides a practical framework for developing alkaline water electrolysis systems that use precious metals more efficiently while moving closer to durable, scalable clean hydrogen production.

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