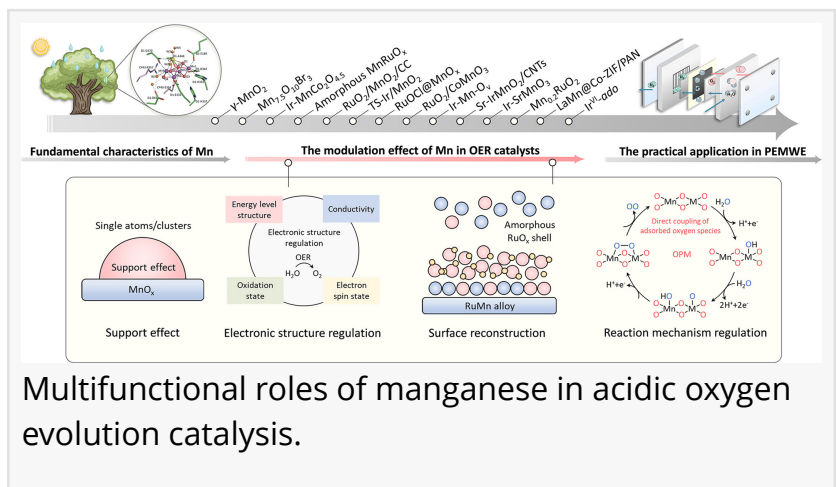


Can manganese unlock affordable green hydrogen in acidic water electrolysis?

GA, UNITED STATES, February 4, 2026 /EINPresswire.com/ -- Producing green hydrogen efficiently and affordably remains a major challenge for the global energy transition, particularly in acidic water electrolysis systems where catalyst stability is critical. Recent research highlights manganese-containing electrocatalysts as a promising pathway to address this challenge. Benefiting from low cost, natural abundance, and exceptional resistance to corrosion, manganese-based materials offer an alternative strategy to reduce dependence on scarce precious metals. The study synthesizes current understanding of how manganese contributes to oxygen evolution reactions under acidic conditions, outlining its potential not only as an active component but also as a stabilizing and performance-enhancing element in next-generation hydrogen production technologies.



[Proton exchange membrane water electrolysis](#) is widely regarded as a key technology for large-scale green hydrogen production due to its high efficiency and rapid response to intermittent renewable power. However, its widespread deployment is constrained by the reliance on expensive and scarce iridium- and ruthenium-based catalysts for the oxygen evolution reaction. The harsh acidic operating conditions further narrow the range of viable catalyst materials, as many transition metals rapidly dissolve or deactivate. Manganese, an earth-abundant element in natural photosynthetic water oxidation, has emerged as a potential solution, yet its moderate intrinsic activity and complex reaction behavior require deeper investigation.

Researchers from Nankai University report new insights into manganese-containing electrocatalysts for acidic oxygen evolution in a comprehensive review published online in 2025 in the journal *eScience*. The work systematically analyzes the origin of the activity and the stability of manganese oxides and elucidates the modulating roles of manganese in composite catalysts for proton exchange membrane water electrolysis, including the support effect, electronic structure regulation, reaction mechanism alteration, and surface reconstruction. By analyzing recent experimental and theoretical advances, the authors identify key strategies

through which manganese can enhance performance and reduce reliance on precious metals, offering a clearer roadmap for developing sustainable catalysts for acidic water splitting.

First, this review delves into the natural inspiration for manganese-based catalysts: the manganese-calcium-oxo cluster in Photosystem II, which is highly efficient for oxidizing water in nature. Manganese oxides exhibit diverse crystal structures that directly influence their catalytic behavior, with Mn^{3+} species identified as a key factor for catalytic activity. Notably, manganese oxides demonstrate exceptional long-term stability thanks to a unique self-healing mechanism that redeposits dissolved Mn ions during operation. Although manganese oxides show modest OER activity, their structural stability makes them excellent catalyst carriers. When combined with noble metals such as iridium or ruthenium, manganese oxides can induce beneficial lattice strain, create oxygen vacancies, and enhance electron transfer at interfaces. These interactions improve both the activity and durability of supported catalysts.

Beyond acting as a catalyst carrier, manganese plays multiple roles in acidic oxygen evolution catalysis. It can modify the electronic structure of active metals through electron reservoir effects and spin polarization. Importantly, manganese also steers reaction mechanisms toward pathways that reduce lattice oxygen loss, thereby enhancing catalyst stability. In some systems, manganese even promotes beneficial surface reconstruction and self-healing behavior, leading to the in-situ formation of highly active and stable surface phases. Together, these findings position manganese as a versatile design element rather than a simple substitute for precious metals.

According to the authors, manganese offers a combination of abundance, chemical flexibility, and electrochemical stability that is particularly well suited for acidic water electrolysis. They emphasize that manganese should not be viewed solely as a low-cost replacement for noble metals, but as a functional component capable of regulating electronic structure, reaction mechanism, and surface reconstruction. By leveraging these properties, future catalyst designs can achieve higher efficiency and longer lifetimes with reduced precious-metal content, a critical step toward scalable and economically viable hydrogen production technologies.

The insights from this work have direct implications for the development of next-generation electrocatalysts for proton exchange membrane electrolyzers. Incorporating manganese into catalyst architectures could significantly lower material costs while improving operational durability under harsh acidic conditions. This approach may accelerate the commercialization of green hydrogen by alleviating supply-chain constraints associated with iridium and ruthenium. Beyond hydrogen production, the design principles outlined for manganese-enabled electronic regulation and self-healing behavior could inform broader applications in electrocatalysis and energy conversion technologies. As renewable energy deployment expands globally, manganese-containing catalyst strategies may play a key role in enabling sustainable, resilient, and cost-effective electrochemical systems.

References

DOI

[10.1016/j.esci.2025.100427](https://doi.org/10.1016/j.esci.2025.100427)

Original Source URL

<https://doi.org/10.1016/j.esci.2025.100427>

Funding information

This work was financially supported by the National Natural Science Foundation of China (52025013, 22121005), and the Fundamental Research Funds for the Central Universities.

Lucy Wang

BioDesign Research

[email us here](#)

This press release can be viewed online at: <https://www.einpresswire.com/article/889231898>

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