

Researchers design efficient iridium catalyst for hydrogen generation

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Tantalum Oxide-Supported Iridium Catalyst for Highly Efficient Oxygen Evolution Reaction

Proton exchange membrane water electrolysis (PEMWE) converts electric energy into transportable hydrogen energy

However, its widespread application is restricted by:

- Sluggish oxygen evolution reaction (OER) kinetics
- High loading levels of precious metal oxide catalysts

How can OER catalysts be made both efficient and cost-effective?

Electron-rich iridium (Ir) nanostructure supported on mesoporous tantalum oxide (Ta₂O₅) as an OER catalyst

- Ir uniformly dispersed on Ta₂O₅ support
- Ir amount decreased to 0.3 mg_{Ir} cm⁻² in PEMWE MEA

Higher electrical conductivity | Enhanced Ir utilization | Large electrochemically active surface area

X-ray photoelectron and X-ray absorption spectroscopies | Strong metal-support interaction between Ir and Ta | Density functional theory | Charge transfer from Ta to Ir enhanced the activity of Ir/Ta₂O₅

Novel features of the Ir/Ta₂O₅ OER catalyst

- High OER activity with an overpotential of 288 ± 3.9 mV at 10 mA cm⁻²
- Mass activity of 876.1 ± 125.1 A g⁻¹ of Ir at 1.55 V
- Stability >120 hours during single cell operation

The newly developed Ir/Ta₂O₅ catalyst can make PEMWE both low-cost and efficient by improving catalytic activity, Ir utilization, and stability

Electron-rich Ir nanostructure supported on mesoporous Ta₂O₅ for enhanced activity and stability of oxygen evolution reaction
Baik et al. (2023)
Journal of Power Sources | 10.1016/j.jpowsour.2023.233174

Gwangju Institute of Science and Technology

Researchers from Korea and USA develop a novel iridium catalyst with enhanced oxygen evolution reaction activity, facilitating a cost-effective proton exchange membrane water electrolysis for hydrogen production. Credit: Chanhoo Pak from Gwangju Institute of Science and Technology

The energy demands of the world are ever increasing. In our quest for clean and eco-friendly energy solutions, transportable hydrogen energy offers considerable promise. In this regard, proton exchange membrane

water electrolyzers (PEMWEs) that convert excess electric energy into transportable hydrogen energy through water electrolysis have garnered remarkable interest.

However, their widescale deployment for hydrogen production remains limited due to slow rates of oxygen evolution reaction (OER)—an important component of electrolysis—and high loading levels of expensive metal oxide catalysts, such as iridium (Ir) and ruthenium oxides, in electrodes. Therefore, developing cost-effective and high-performance OER catalysts is necessary for the widespread application of PEMWEs.

Recently, a team of researchers from Korea and U.S., led by Professor Chanho Pak from Gwangju Institute of Science and Technology in Korea, has developed a novel mesoporous tantalum oxide (Ta_2O_5)-supported iridium nanostructure catalyst via a modified formic acid reduction method that achieves efficient PEM water electrolysis.

Their study was published in the *Journal of Power Sources*. The study was co-authored by Dr. Chaekyung Baik, a post-doctoral researcher at Korea Institute of Science and Technology (KIST).

"The electron-rich Ir nanostructure was uniformly dispersed on the stable mesoporous Ta_2O_5 support prepared via a soft-template method combined with an ethylenediamine encircling process, which effectively decreased the amount of Ir in a single PEMWE cell to 0.3 mg cm^{-2} ," explains Prof. Pak. Importantly, the innovative Ir/ Ta_2O_5 catalyst design not only improved the utilization of Ir but also facilitated higher electrical conductivity and a large electrochemically active surface area.

Additionally, X-ray photoelectron and X-ray absorption spectroscopies revealed strong metal–support interaction between Ir and Ta, while density functional theory calculations indicated a charge transfer from

Ta to Ir, which induced the strong binding of adsorbates, such as O and OH, and maintained Ir (III) ratio in the oxidative OER process. This, in turn, led to the enhanced activity of Ir/Ta₂O₅, with a lower overpotential of 0.385 V compared to a 0.48 V for IrO₂.

The team also demonstrated high OER activity of the catalyst experimentally, observing an overpotential of 288 ± 3.9 mV at 10 mA cm^{-2} and a mass activity of $876.1 \pm 125.1 \text{ A g}^{-1}$ of Ir at 1.55 V, significantly higher than the corresponding values for Ir Black. In effect, Ir/Ta₂O₅ exhibited excellent OER activity and stability, as further confirmed through membrane electrode assembly single cell operation of over 120 hours.

The proposed technology offers the dual benefit of reduced Ir loading levels and an enhanced OER efficiency. "The improved OER efficiency complements the cost-effectiveness of the PEMWE process, enhancing its overall performance. This advancement has the potential to revolutionize the commercialization of PEMWEs, accelerating its adoption as a primary method for [hydrogen production](#)," speculates an optimistic Prof. Pak.

More information: Chaekyung Baik et al, Electron-rich Ir nanostructure supported on mesoporous Ta₂O₅ for enhanced activity and stability of oxygen evolution reaction, *Journal of Power Sources* (2023). [DOI: 10.1016/j.jpowsour.2023.233174](https://doi.org/10.1016/j.jpowsour.2023.233174)

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