PRESS RELEASE

Gwangju Institute of Science and Technology Researchers Design Efficient Iridium Catalyst for Hydrogen Generation

The designed iridium nanostructure, supported on mesoporous tantalum oxide, enhances electrical conductivity, catalytic activity, and long-term stability

Proton exchange membrane water electrolyzers converts surplus electric energy into transportable hydrogen energy as a clean energy solution. However, slow oxygen evolution reaction rates and high loading levels of expensive metal oxide catalysts limit its practical feasibility. Now, researchers from Korea and USA have developed a new tantalum oxide-supported iridium catalyst that significantly boosts the oxygen evolution reaction speed. Additionally, it shows high catalytic activity and long-term stability in prolonged single cell operation.

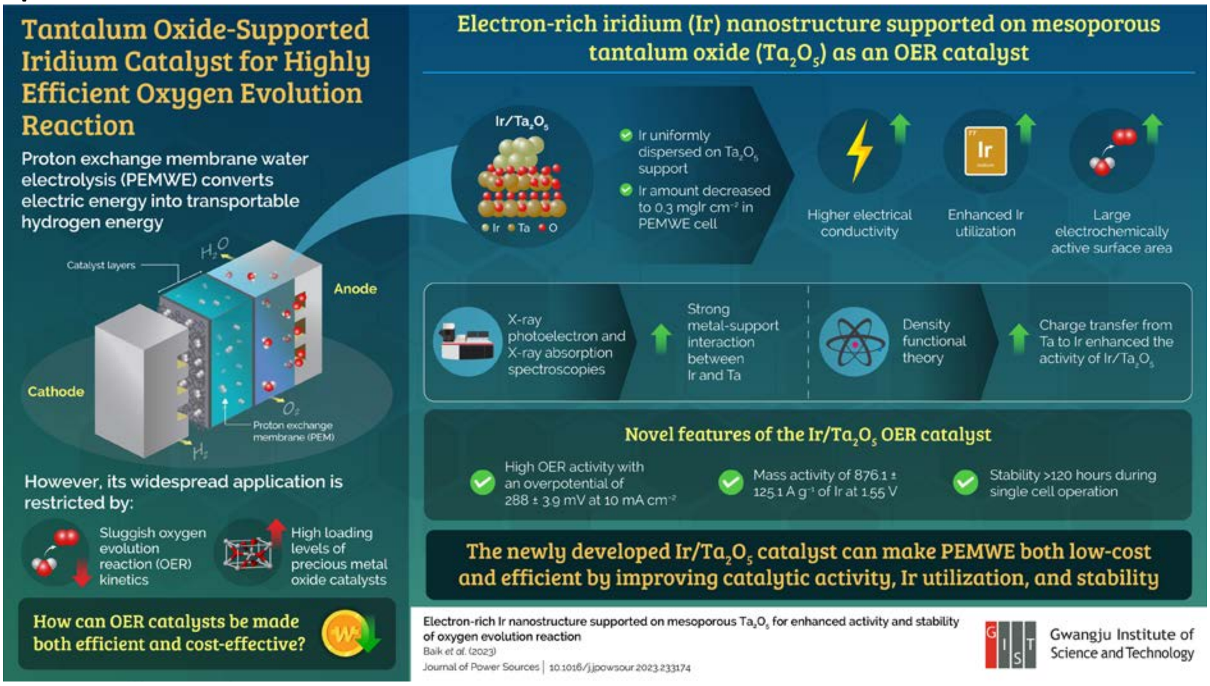

Image title: Novel tantalum oxide-supported iridium catalyst with high oxygen evolution reaction activity.

Image caption: 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.

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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 USA, 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 made available online on May 20, 2023 and will be published in Volume 575 of the *Journal of Power Sources* on August 15, 2023. 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/Ta_2O_5, with a lower overpotential of 0.385 V compared to a 0.48 V for IrO_2.

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 ± 125.1 A g^{-1} of Ir at 1.55 V, significantly higher than the corresponding values for Ir Black. In effect, Ir/Ta_2O_5 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.

Together, this development takes us one step closer to achieving a sustainable transportable hydrogen energy solution and, in turn, carbon neutrality.

Reference

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About the Gwangju Institute of Science and Technology (GIST)
The Gwangju Institute of Science and Technology (GIST) is a research-oriented university situated in Gwangju, South Korea. Founded in 1993, GIST has become one of the most prestigious schools in South Korea. The university aims to create a strong research environment to spur advancements in science and technology and to promote collaboration between international and domestic research programs. With its motto of "A Proud Creator of Future Science and Technology," GIST has consistently received one of the highest university rankings in Korea.

About the authors

Dr. Chanho Pak is a full professor at Gwangju Institute of Science and Technology (GIST) since August 2016. Before moving to GIST, he worked as a vice president at Samsung SDI and a master at SAIT of Samsung Electronics. He received his BS, MS, and Ph. D. degrees from the Department of Chemistry at KAIST in 1990, 1992, and 1995 respectively. His research currently focuses on developing catalytic materials for membrane electrode assembly in fuel cells and electrolysis using nanostructured carbon and hybrid metal oxide support. He has authored 126 research publications and 227 granted patents in his area of expertise.

Dr. Chaekyung Baik is a post-doctoral researcher at Korea Institute of Science and Technology (KIST). He worked on PEMWE OER catalysts and MEA development and is now focusing on ammonia oxidation reaction catalysts and devices. Before joining KIST in 2023, Chaekyung Baik received a Ph. D. in Energy Convergence from Gwangju Institute of Science and Technology.