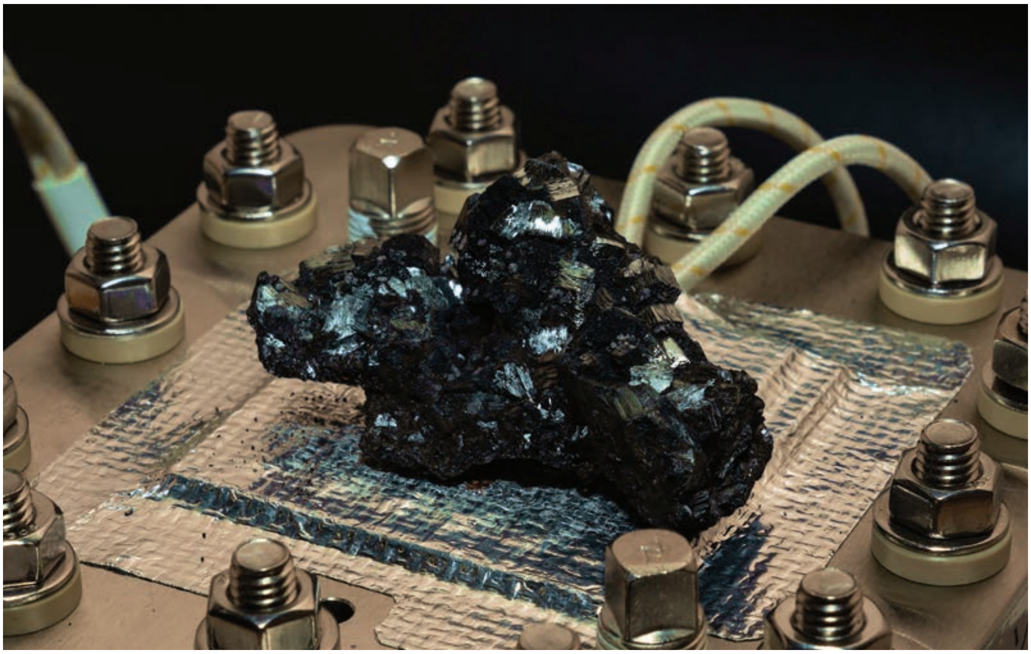

A water electrolyzer with a proton exchange membrane (PEM). The PEM contains a longer-lasting, Earth-abundant catalyst based on manganese oxide.

ELECTROCATALYSIS

Longer lasting and more sustainable production of green hydrogen

A more stable catalyst will help efforts to produce hydrogen from water on an industrial scale

RIKEN researchers have improved on their green and sustainable method of extracting hydrogen from water by using a custom-made catalyst for the chemical reaction[1]. The achievement will aid efforts to realize a sustainable hydrogen-based economy.

Splitting water into oxygen and hydrogen using a proton exchange membrane (PEM) is a green electrochemical process for producing hydrogen fuel, a clean alternative to fossil fuels.

However, one limitation preventing the widespread industrial adoption of PEM electrolysis is that the best catalysts for it are rare Earth metals, such as iridium.

"Scaling up PEM electrolysis to the terawatt scale would require 40 years' worth of iridium, which is certainly impractical and highly unsustainable," says Ryuhei Nakamura of the RIKEN Center for Sustainable Resource Science (CSRS).

Previously, Nakamura's team developed a PEM-electrolysis process that did not rely on rare Earth metals. However, the process was too unstable for use in a PEM electrolyzer.

The team has now developed a longer-lasting, Earth-abundant catalyst that is a form of manganese oxide.

The key finding was that reaction stability could be increased by more than 40-fold by altering the catalyst's lattice structure.

Oxygen in the 3D lattice structure of manganese oxide comes in two configurations: planar and pyramidal. The planar version forms stronger bonds with manganese, and the researchers discovered that increasing the amount of planar oxygen in the lattice significantly enhanced catalytic stability.

The manganese oxide catalyst with the highest achievable percentage of planar oxygen (94%) could sustain the oxygen evolution reaction for one month at 1,000 milliamperes per square centimeter and the total amount of charge transferred was 100 times more than anything achieved in previous studies.

When this catalyst was tested in a PEM electrolyzer, water electrolysis could be sustained for about 6 weeks at 200 milliamperes per square centimeter. The total amount of hydrogen produced was 10 times more than has been achieved in the past with other non-rare metal catalysts.

"Surprisingly, the improved stability did not come at a cost in activity, which is usually the case," says Shuang Kong, also of CSRS. "A PEM water electrolyzer that generates hydrogen with an Earth-abundant catalyst at a rate of 200 milliamperes per square centimeter is highly efficient."

The researchers believe that real-world applications will eventually be possible and contribute to carbon neutrality.

"We will continue to modify catalyst structure to increase both current density and catalyst lifetime," says Nakamura. "In the long term, our efforts should help achieve the ultimate objective for all stakeholders—to conduct PEM water electrolysis without the use of iridium." ●

Reference

1. Kong, S., Li, A., Long, J., Adachi, K., Hashizume, D., Jiang, Q., Fushimi, K., Ooka, H., Xiao, J. & Nakamura, R. Acid-stable manganese oxides for proton exchange membrane water electrolysis. *Nature Catalysis* **7,** 252–261 (2024).