Researchers report new, more efficient catalyst for water splitting

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Credit: George Hodan/public domain

University of Houston physicists have discovered a catalyst that can split water into hydrogen and oxygen, composed of easily available, low-cost materials and operating far more efficiently than previous catalysts.

That would solve one of the primary hurdles remaining in using water to produce hydrogen, one of the most promising sources of clean energy.

"Hydrogen is the cleanest primary energy source we have on earth," said Paul C. W. Chu, TLL Temple Chair of Science and founding director and chief scientist of the Texas Center for Superconductivity at UH. "Water could be the most abundant source of hydrogen if one could separate the hydrogen from its strong bond with oxygen in the water by using a catalyst."

Chu and colleagues including physicists Zhifeng Ren and Shuo Chen, both of whom also are principal investigators with the Texas Center for Superconductivity at UH, report their discovery - an efficient catalyst produced without the expensive precious metals most commonly used—this week in the *Proceedings of the Natural Academy of Sciences*.

Other researchers involved in the project include postdoctoral researchers Haiqing Zhou and Fang Yu, and graduate students Jingying Sun and Ran He.

The catalyst, composed of ferrous metaphosphate grown on a conductive nickel foam platform, is far more efficient than previous catalysts, as well as less expensive to produce.

"Cost-wise, it is much lower and performance-wise, much better," said Zhifeng Ren, M.D. Anderson professor of physics and lead author on the paper. The catalyst also is durable, operating more than 20 hours and 10,000 cycles in testing.

"Some catalysts are outstanding but are only stable for one or two hours," Ren said. "That's no use."

Although it is simple in theory, splitting water into hydrogen and oxygen is a complex process, requiring two separate reactions - a hydrogen evolution reaction and an oxygen evolution reaction, each requiring a separate electrode. While hydrogen is the more valuable component, it can't be produced without also producing oxygen. And while efficient hydrogen catalysts are available, Ren said the lack of an inexpensive and efficient oxygen catalyst has created a bottleneck in the field.

Hydrogen has a number of advantages. "Hydrogen (H2) produced from water splitting by an electrochemical process, called water electrolysis, has been considered to be a clean and sustainable energy resource to replace fossil fuels and meet the rising global energy demand, since water is both the sole starting material and byproduct when clean energy is produced by converting H2 back to water," the researchers wrote.

And unlike solar power, wind power and other "clean" energy, hydrogen can be easily stored.

Currently, most hydrogen is produced through steam methane reforming and coal gasification; those methods raise the fuel's carbon footprint despite the fact that it burns cleanly.

Chen said oxygen evolution reactions often depend upon an electrocatalyst using a "noble metal" - iridium, platinum or ruthenium. But those are expensive and not readily available.

"In this work, we discovered a highly active and stable electrocatalyst based on earth-abundant elements, which even outperforms the noble metal based ones," she said. "Our discovery may lead to a more economic approach for hydrogen production from water electrolysis."

Water splitting can be triggered either through electric current or through photocatalysis, using the power of the sun. Direct solar-powered water splitting is too inefficient, as water can absorb just a small portion of the light spectrum. Ideally, Ren said, solar power would be used to generate the electric power used to split water.

More information: Haiqing Zhou el al., "Highly active catalyst derived from a 3D foam of Fe(PO3)2/Ni2P for extremely efficient water oxidation," *PNAS* (2017). www.pnas.org/cgi/doi/10.1073/pnas.1701562114

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