New catalyst helps combine fuel cell, battery into one device

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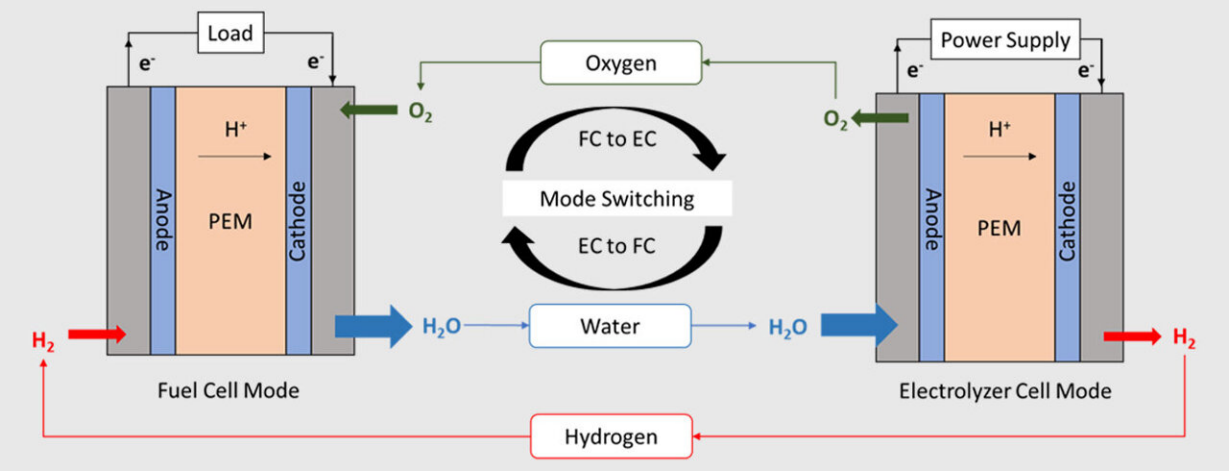

Credit: Washington University in St. Louis

A single device that both generates fuel and oxidant from water and, when a switch is flipped, converts the fuel and oxygen into electricity and water, has a host of benefits for terrestrial, space and military applications. From low environmental impact to high energy density, developing efficient unitized regenerative fuel cells, or URFCs as they are called, has been in researchers' sights for years now.

But to truly be efficient, an URFC needs bifunctional catalysts. This means, in electrolyzer mode, catalysts should facilitate the breakdown of water into hydrogen and oxygen, and, in fuel cell mode, facilitate their

recombination into water. Now, working in the lab of Vijay Ramani, the Roma B. & Raymond H. Wittcoff Distinguished University Professor, a team of researchers has found an excellent bifunctional catalyst for the oxygen electrode.

Their work was published in the journal *Proceedings of the National Academy of Sciences*.

"Unlike the hydrogen electrode, wherein platinum is an effective bifunctional catalyst, it is very challenging to identify a suitable catalyst for the oxygen electrode due to the sluggish kinetics of oxygen reduction and oxygen evolution," said Pralay Gayen, currently working at Intel, who was a postdoctoral research associate in Ramani's lab at the McKelvey School of Engineering at Washington University in St. Louis and served as the paper's first author.

Sulay Saha, a postdoctoral research associate in Ramani's laboratory, and Gayen's research was guided by first principles—taking into account the fundamental properties of different substances before heading to the lab to test potential catalysts.

Along with former undergraduate researcher and co-author Xinquan Liu, the team ultimately identified and developed Pt-Pyrochlore, a composite of platinum and a lead ruthenate pyrochlore, which yielded high bifunctionality.

The "bifunctionality index" is a measure of catalyst's ability to facilitate both the forward and reverse direction of a reaction. "We want the index to be low," said Kritika Sharma, a Ph.D. engineering student. "Zero, ideally." This new catalyst has a bifunctionality index of 0.56 volts—very low compared with other catalysts reported. When used in a URFC device developed by the laboratory, the catalyst enabled a round-trip energy efficiency (RTE) of 75%—the highest reported round-trip

efficiency in this type of URFC.

With such high efficiency, the URFCs developed are well suited for applications such as submersibles, drones, spacecrafts and space stations, as well as for off-grid energy storage.

More information: Vijay Ramani et al, High-performance AEM unitized regenerative fuel cell using Pt-pyrochlore as bifunctional oxygen electrocatalyst, *PNAS*, DOI: 10.1073/pnas.2107205118 , www.pnas.org/content/118/40/e2107205118

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