Green hydrogen: MXenes show talent as catalyst for oxygen evolution reaction

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The surface of a Vanadium carbide MXene has been examined by Scanning Electron Microscopy. The beautiful structures are built by cobalt copper hydroxide molecules. Credit: B. Schmiedecke/HZB

The MXene class of materials has many talents. An international team led by HZB chemist Michelle Browne has now demonstrated that

MXenes, properly functionalized, are excellent catalysts for the oxygen evolution reaction in electrolytic water splitting. They are more stable and efficient than the best metal oxide catalysts currently available. The team is now extensively characterizing these MXene catalysts for water splitting at the Berlin X-ray source BESSY II and Soleil Synchrotron in France.

The findings are published in the *Journal of Materials Chemistry A*.

Green hydrogen is seen as one of the energy storage solutions of the future. The gas can be produced in a climate-neutral way using electricity from the sun or wind by electrolytic water splitting. While hydrogen molecules are produced at one electrode, oxygen molecules are formed at the other. This oxygen evolution reaction (OER) is one of the limiting factors in electrolysis. Special catalysts are needed to facilitate this reaction.

Among the best candidates for OER catalysts are—for example—nickel oxides, which are inexpensive and widely available. However, they corrode quickly in the alkaline water of an electrolyzer and their conductivity also leaves much to be desired. This is currently preventing the development of low-cost, high-performance electrolyzers.

MXenes as catalysts

A new class of materials could offer an alternative: MXenes, layered materials made of metals, such as titanium or vanadium, combined with carbon and/or nitrogen. These MXenes have a huge internal surface area that can be put to fantastic use, whether for storing charges or as catalysts.

Ph.D. student Bastian Schmiedecke chemically "functionalized" the MXenes by docking copper and cobalt hydroxides onto their surfaces. In preliminary tests, the catalysts produced in this way proved to be significantly more efficient than the pure metal oxide compounds. What's more, the catalysts showed no degradation and even improved efficiency in continuous operation.

Measurements at BESSY II

Measurements at the BESSY II X-ray source, with Namrata Sharma and Tristan Petit, showed why this works so well: "We were able to use the Maxymus beamline there to find out how the outer surfaces of the MXene samples differ from the inside," explains Schmiedecke. The researchers combined scanning electron microscopy (SEM/TEM), X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), X-ray transmission microscopy (STXM) and X-ray absorption near-edge structure (XANES) to gain further insights into the material.

"We have been able to show that MXenes have great potential for use as catalysts in electrolyzers," says Michelle Browne. The collaboration with partner teams from Trinity College, Dublin, Ireland, and the University of Chemistry and Technology, Prague will continue. In addition to further chemical variations of MXene catalysts, the team also plans to test such catalysts in conventional electrolyzers in continuous operation.

More information: Bastian Schmiedecke et al, Enhancing the oxygen evolution reaction activity of CuCo based hydroxides with V2CTx MXene, *Journal of Materials Chemistry A* (2024). DOI: 10.1039/D4TA02700K

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