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Speeding up the production of renewable fuels

Until now, there has been no cheap and efficient way to produce hydrogen from renewable energy. Oscar Díaz-Morales tackled part of this problem by designing novel oxygen evolution catalysts that enhance the electrolysis of water. He published his discovery in *Nature Communications*, and a patent has been granted to the catalysts and the techniques to produce them.

By Willy van Strien

OSCAR DÍAZ-MORALES was trained as a chemist in Caracas, Venezuela. He came to Leiden University for a PhD project, after completion of which he stayed for another year for a joint project with the Japanese company Hitachi. He then transferred to Stockholm University as a postdoctoral researcher.

Increasing amounts of energy are harnessed from sunlight and wind. The challenge now is to store all this energy, so that it can be used when and where it will be needed. One of the most promising storage options is to convert energy into a current which is passed between two electrodes in an electrochemical cell, which is then used to split water. At the negative electrode, hydrogen gas is formed, which is a renewable fuel. However, until now, this process has not been cost-effective as at the positive electrode, oxygen gas evolves as a by-product. Not only is this process slow, it also limits the rate of water splitting. Therefore, the oxygen evolution should be catalysed on the electrode surface. The problem, however, is that the state-of-the-art catalyst iridium oxide is expensive, as iridium is scarce.
To solve this problem, Oscar Díaz-Morales set to devising a new type of catalyst. He opted for compounds in which iridium atoms are embedded in a framework of cheaper materials. He tried 'iridium double perovskites': oxides consisting of a combination of barium, iridium and a third metal. These combinations contain three times less iridium than iridium oxide. When testing several of these compounds, a surprise awaited him: some of them exhibited a catalytic activity that was more than three times higher than that of the benchmarking iridium oxide. 'We still don't know why,' Díaz-Morales says. 'It has to do with the crystal structure. While iridium oxide is rigid, iridium double perovskites are able to "breathe", which probably facilitates oxygen absorption.'
New catalysts must not only be active, they must also retain their activity during long-term use. The best candidates for the third metal in the compounds are yttrium and praseodymium, metals which are classified as rare earth elements. Does it make sense to replace iridium with one of these to make catalysts cheaper? 'The funny thing is that, although yttrium and praseodymium belong to the rare earth elements, they are not rare at all. They are more common than iridium and, accordingly, they are cheaper.'