# Simple solution makes hydrogen production through solar water splitting more efficient and cheaper

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Researchers from Delft University of Technology (TU Delft, The Netherlands), in collaboration with colleagues from the École Polytechnique Fédéral de Lausanne (EPFL, Switzerland), have found a simple yet very effective solution to greatly increase the efficiency and stability of hydrogen production through solar-driven water splitting. By separating the positive and the negative electrodes using a bipolar membrane, they were able to create local optimal conditions for electrolysis. Furthermore, they achieved this using only Earth-abundant catalysts and solar cells, opening the way for more efficient and stable water-splitting systems at lower cost. They have published their findings in the latest *Advanced Energy Materials*.

The thought driving Associate Professor dr. Wilson Smith in his research at TU Delft, is that one hours' worth of sunlight reaching the Earth contains enough energy for one years' worth of current energy demand worldwide. One of the challenges is being able to store and transport part of that energy for later use. So-called solar fuels could offer a solution, for example by harvesting solar energy and converting it into hydrogen by means of water splitting.

## Electrolysis

Electrolysis is the process involved, and in order to realize efficient and long term water splitting, having a strong acid around the negative

cathode and a strong base around the positive anode would be best. Up until now, most of the commercially available electrolysers run in either a strong acid or a strong base electrolyte. In these systems, the highly corrosive environments limit the choice of catalysts, and they suffer from the constraint of finding a suitable pair of electrodes for the one electrolyte. So far only precious, and therefore expensive, metal catalysts can do that job.

## Simple solution

The seemingly simple solution of separating the two electrodes by a specialized membrane, allows for optimization of the process, by offering the electrodes their respective best environments. It also means that Earth-abundant catalysts can be used in the process, making it cheaper, more efficient, and more stable.

## Efficient process

The international research team, also including dr. David Vermaas from TU Delft, has shown that using a bipolar membrane in this manner can lead to a water splitting system efficiency of 12.7%. Natural photosynthetic processes in plants run at about 1% efficiency, while an efficiency of 10% is considered to be the starting point for potential commercial viability according to various techno economic analyses. An efficiency of 18% has been achieved for these types of processes, but only using precious metals and other very expensive (and unstable) materials. To be able to achieve this high efficiency while also using all Earth-abundant components in the solar cell and catalysts, makes the achievement an excellent demonstration for this technology. Smith: 'This is a strong scientific step that can help the transition from lab scale systems into practical devices.'

## Potential for other applications

The principle of separating the poles in these types of cells also looks very promising for other applications, according to Smith. 'Using this bipolar membrane for electrochemical systems, we are now able in theory to click together the optimal half reaction components for processes like pieces of Lego. This has a huge potential for other electrochemical reactions such as the production of ammonia and hydrocarbons, while separating the oxidation half reaction completely. In this next step, we can finally replicate nature and make a truly artificial photosynthetic system that goes well beyond the efficiencies in nature.'

**More information:** Jingshan Luo et al, Bipolar Membrane-Assisted Solar Water Splitting in Optimal pH, *Advanced Energy Materials* (2016). DOI: 10.1002/aenm.201600100

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