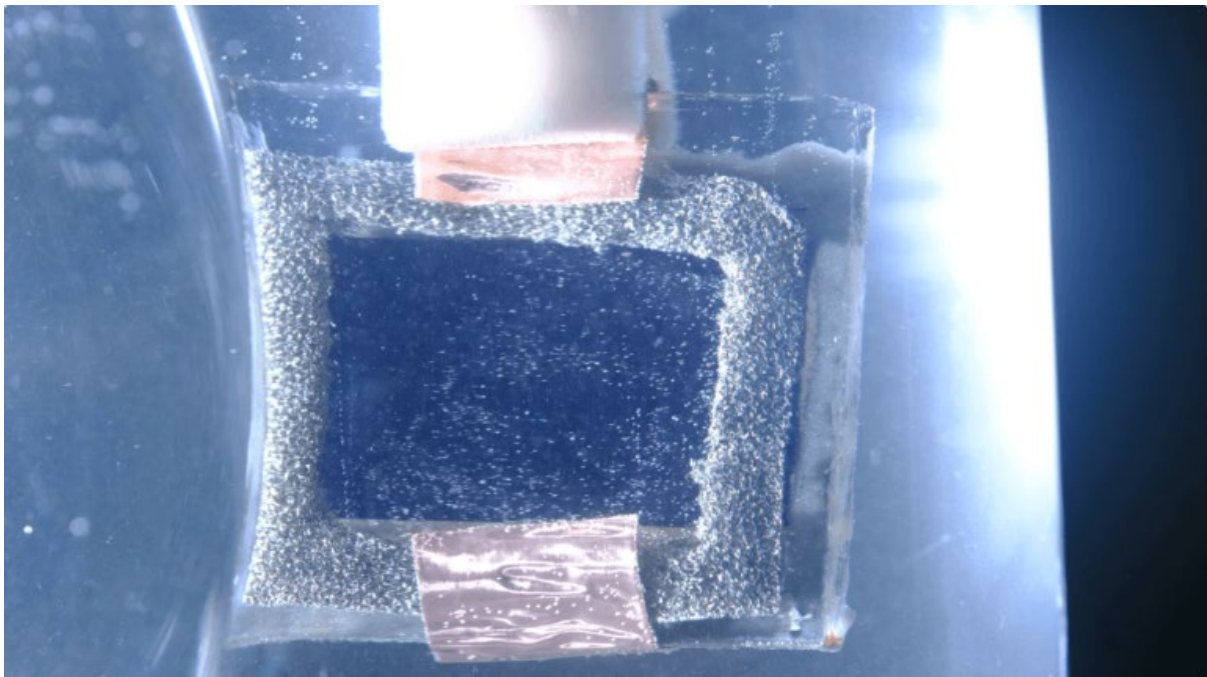


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Translated from Dutch

Hydrogen directly from the sea and cleaner water as a bonus: this is how this new solar cell works



The experimental solar cell with which researchers produce hydrogen from seawater and simultaneously break down toxic pollution. © NTU Singapore

Producing hydrogen using nothing but sunlight and seawater, while simultaneously eliminating a highly toxic waste product. Researchers in Singapore have developed an 'artificial leaf' that combines both processes – thereby cleverly circumventing a persistent problem of hydrogen production from the sea.

Researchers at Nanyang Technological University (NTU) in Singapore have developed a solar cell-like system that tackles two problems at once. The device produces green hydrogen directly from seawater and simultaneously breaks down hydrazine, a highly toxic substance that can be found in industrial wastewater, among other places.

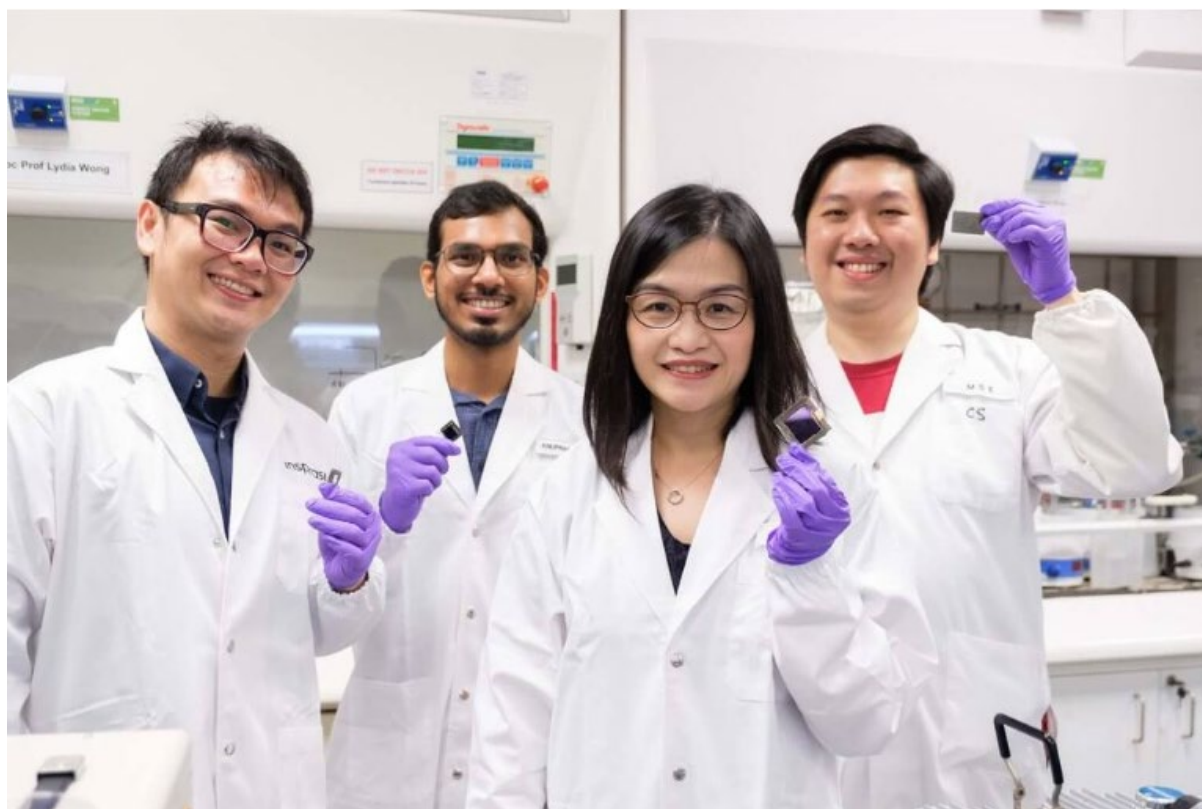
The system draws its energy directly from sunlight and therefore requires no external power source. The results have been published in *Nature Communications*.

Seawater makes electrolysis difficult

Producing hydrogen via electrolysis is simple in principle: electric current splits water into hydrogen and oxygen. Using seawater as a raw material is attractive because it does not require scarce fresh water and prior desalination can be avoided.

However, salt water presents a significant problem. Chloride ions can cause competing reactions, producing corrosive and toxic chlorine compounds. These not only reduce efficiency but can also corrode electrodes.

The NTU team led by materials scientist Lydia Wong therefore opts for a different chemical route. At the anode, no oxygen is formed, but hydrazine is broken down into nitrogen and hydrogen.



The researchers behind the new solar cell, from left to right: Stener Lie, Anupam Sadhu, Lydia H. Wong, and Hao Zhe Chun. © NTU Singapore

Waste reduces energy consumption

This results in a remarkable win-win situation. The oxidation of hydrazine requires less energy than the usual oxygen formation in electrolysis. The pollutant thus indirectly acts as an aid to make hydrogen production more energetically attractive.

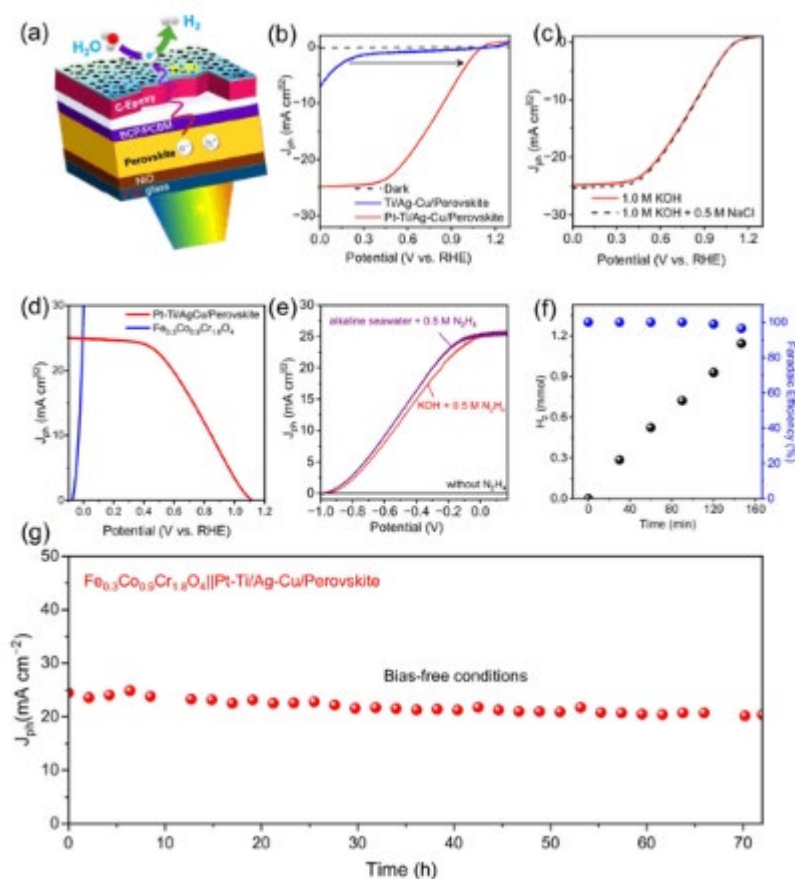
The anode contains a catalyst based on iron, cobalt, and chromium. This is resistant to corrosion and simultaneously suppresses the unwanted formation of chlorine compounds.

For the light-absorbing cathode, the researchers use lead halide perovskite. A protective layer of conductive epoxy with silver and copper particles and titanium foil is intended to prevent the sensitive perovskite from degrading due to contact with the environment.

72 hours of stable hydrogen production

In tests with both artificial and real seawater, the system achieved a photocurrent density of 25 mA/cm^2 . According to the researchers, this is among the highest values reported for this type of perovskite photocathode.

Moreover, under illumination comparable to bright sunlight, the device continued to operate stably for more than 72 hours. Hydrogen production amounted to $466 \text{ } \mu\text{mol}$ per square centimeter per hour. At the same time, the hydrazine concentration dropped from 0.5 molar to only 0.5 ppb within thirty hours.



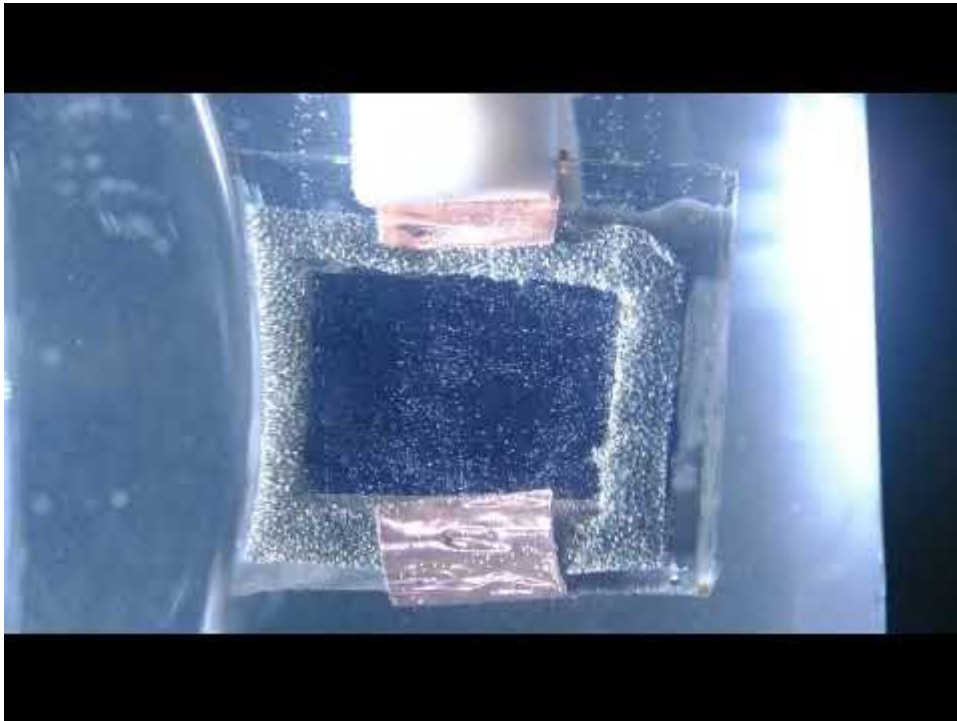
Solar cell performance under various conditions. The graphs show, among other things, the generated photocurrent, hydrogen production, and system stability under lighting comparable to sunlight. © Nature Communications / NTU Singapore

More than a small hydrogen generator

In conventional hydrogen production and wastewater treatment, energy production and pollution control are separate processes. Here, the chemical energy of an unwanted waste product is utilized to facilitate the production of a valuable energy carrier.

The researchers therefore want to extend the principle to other contaminants. The next step is the development of catalysts that can not only break down various waste streams but, where possible, also convert them into fuels or usable industrial chemicals.

With this, the artificial 'leaf cell' could eventually become more than a hydrogen generator: a solar-powered reactor that treats wastewater simultaneously as a problem and as a raw material.



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