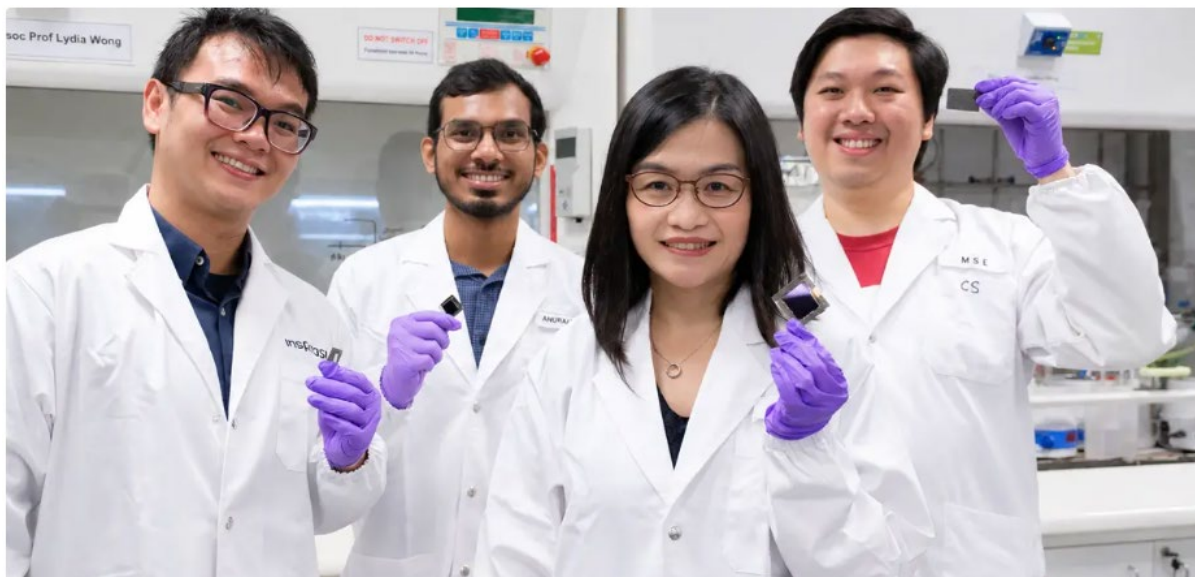


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Solar device makes hydrogen from seawater



Scientists at Nanyang Technological University (NTU Singapore) have developed a solar-powered device capable of producing clean hydrogen directly from seawater while simultaneously removing hydrazine, a highly toxic chemical commonly associated with industrial wastewater.

Inspired by the way leaves capture sunlight, the system converts solar energy directly into electricity to power chemical reactions without relying on an external electricity supply. The research, published in Nature Communications in May, demonstrates how solar hydrogen production could potentially be combined with wastewater treatment in a single technology.

A dual-purpose approach to green hydrogen

Hydrogen can be produced through electrolysis, a process in which electricity passes between two electrodes and drives chemical reactions that generate hydrogen.

At the cathode, or negative electrode, electrons participate in reactions that release hydrogen gas. Conventional water electrolysis typically requires another reaction at the anode to produce oxygen.

Using seawater rather than freshwater could make green hydrogen production more sustainable by reducing dependence on freshwater resources and potentially avoiding the need for desalination before hydrogen generation.

However, seawater electrolysis comes with significant technical challenges. High concentrations of chloride ions can interfere with electrochemical reactions, while unwanted chlorine-containing compounds may form during the process. These substances can be corrosive, potentially damaging electrodes and reducing the efficiency and lifespan of the system.

Turning a toxic pollutant into part of the solution

To overcome these challenges, a research team led by Professor Lydia Wong from NTU's School of Materials Science and Engineering developed an anode equipped with a specialized catalyst.

Instead of relying on the conventional oxygen-producing reaction, the catalyst promotes the breakdown of hydrazine into nitrogen and hydrogen.

This reaction requires less energy than oxygen evolution, allowing the system to produce hydrogen more efficiently. At the same time, the process destroys hydrazine in contaminated water and generates additional hydrogen as a useful product.

The catalyst is composed of iron, cobalt and chromium. According to the researchers, it offers strong corrosion resistance while allowing its electrical, chemical and physical characteristics to be adjusted for different applications.

Another important advantage is that the system suppresses the formation of harmful and corrosive chlorine compounds that can occur during conventional seawater electrolysis.

Perovskite technology converts sunlight into energy

To supply the electricity needed for the reactions, the researchers constructed the light-absorbing cathode using lead-halide perovskites.

Perovskites are semiconductor materials capable of absorbing sunlight and converting it into electrical energy. To improve durability in the challenging seawater environment, the researchers protected the cathode with several layers.

These included a conductive epoxy containing silver and copper particles, along with titanium foil designed to shield the sensitive photovoltaic material from degradation.

Tests using both simulated seawater and real seawater showed that the system could maintain a stable electrical current under illumination.

The device achieved a photocurrent density of approximately 25 mA cm^{-2} , which the researchers reported as among the highest values demonstrated for lead-based perovskite photocathodes. Photocurrent density measures the electrical current produced relative to the illuminated surface area and is an important indicator of solar-to-electricity performance.

Stable hydrogen production for more than 72 hours

The experimental system remained stable for more than 72 hours under illumination comparable to sunlight reaching Earth's surface on a clear day.

During testing, it achieved a hydrogen production rate of approximately $466 \mu\text{mol cm}^{-2} \text{ h}^{-1}$, a performance comparable with other solar-powered hydrogen technologies.

At the same time, the device demonstrated highly effective hydrazine removal.

Within 30 hours, hydrazine concentrations fell from 0.5 M, equivalent to roughly 1.6% by weight, to just 0.5 parts per billion (ppb). This concentration is more than 20 times below the U.S. Environmental Protection Agency benchmark of 10 ppb cited by the researchers.

Importantly, the pollutant could be degraded directly in the water without first requiring a separate hydrazine-removal stage.

Combining clean energy with pollution treatment

Professor Wong described the technology as a way to address two environmental challenges simultaneously: generating a clean fuel while eliminating a hazardous industrial contaminant.

Rather than using solar energy solely for hydrogen production, the system creates additional environmental value by integrating pollution treatment into the same process.

Professor James Durrant, Professor of Photochemistry and Sustainable Energy at the University of Oxford, who was not involved in the research, highlighted the broader potential of multifunctional photoelectrochemical technologies. Such systems could make solar fuel production more attractive by combining energy generation with other economically and environmentally valuable processes.

Researchers look beyond hydrazine

The NTU team is now investigating new catalysts that could expand the technology beyond hydrazine-contaminated wastewater.

Future versions could potentially target other industrial pollutants or transform waste materials into useful products, including fuels and chemical feedstocks.

If successfully scaled, this approach could contribute to a new generation of solar-powered systems that simultaneously produce green hydrogen, treat industrial wastewater and recover value from waste.

By combining renewable energy generation with pollution control, multifunctional photoelectrochemical technologies could help reduce the environmental footprint of both hydrogen production and industrial wastewater treatment.

<https://www.ecohubmap.com/the-news/solar-device-makes-hydrogen-from-seawater/4liylmubac4y7>