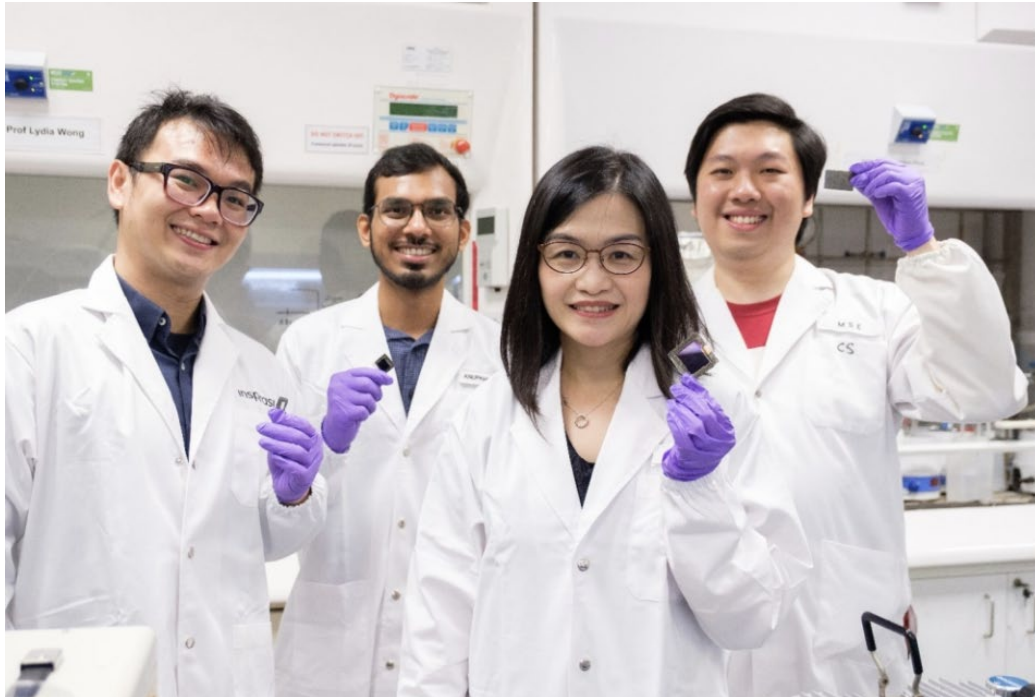




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Perovskite-based device generates H₂ and removes pollutants



NTU team develops 'artificial leaf' that generate clean hydrogen from seawater and simultaneously degrades hydrazine, a toxic contaminant

Scientists from Nanyang Technological University, Singapore, inspired by leaves, have designed a perovskite-based device that harvests sunlight to generate clean hydrogen from seawater and simultaneously degrade hydrazine, a highly toxic contaminant from industrial wastewater.

The study 'Self-powered artificial leaf using perovskite photocathode for solar hydrogen production and hydrazine degradation' was published in Nature Communications (2026)

Producing hydrogen from electrolysis of seawater instead of freshwater improves its sustainability as additional steps to remove salt from the seawater are not required. However, seawater presents many challenges. Chloride ions in seawater interfere with the reaction and reduce its efficiency. Additionally, corrosive and toxic chlorine compounds are also generated that can damage the electrodes.

To boost the efficiency of hydrogen production from seawater, the researchers, led by Lydia Wong of NTU's School of Materials Science and Engineering, designed the anode (positive cathode) containing a catalyst that breaks down hydrazine into hydrogen and nitrogen. This reaction requires less energy than the oxygen-producing reaction usually involved in water electrolysis. As a result, the sunlight-powered cathode can generate hydrogen from water more efficiently and with a lower energy requirement, while the anode removes hydrazine and produces additional hydrogen.

The catalyst, containing iron, cobalt and chromium, is also resistant to corrosion and its electrical, physical and chemical properties can be easily customised. At the same time, the production of corrosive and toxic chlorine compounds is suppressed.

To generate the electricity required to power the device, the researchers fabricated the cathode from lead halide-based perovskites. The cathode was coated with a conductive epoxy resin containing silver and copper particles as well as titanium foil to protect it from degradation.

In simulated and real seawater samples, the device generated a stable electric current from light. The photocurrent density (25 mA cm^{-2}) – the amount of current generated per illuminated area of the device – was also one of the highest reported for lead-based perovskite cathodes, an indication of the device's effectiveness at converting sunlight to electricity.

The device maintained a stable performance for over 72 hours at an illumination equivalent to the intensity of sunlight that reaches the Earth's surface on a clear day, generating hydrogen at a high rate of $466 \text{ } \mu\text{mol cm}^{-2} \text{ h}^{-1}$, comparable with similar solar power-driven devices. It effectively degraded hydrazine without the need for separation from water within 30 hours, reducing its concentration from 0.5 M (equivalent to about 1.6% by weight) to 0.5 parts per billion (ppb), more than 20 times below the US Environmental Protection Agency's permissible limit of 10 ppb.

"This dual-function device represents a major leap forward for environmental technology. By efficiently harvesting solar energy to break down a toxic industrial pollutant while simultaneously harvesting clean fuel, we are solving both an energy problem and a pollution problem," said Prof Wong.

"The breakthrough here lies not simply in producing solar hydrogen but in demonstrating a practical route towards multifunctional photoelectrochemical systems. Such dual-purpose approaches are likely to play an increasingly important role in the future deployment of solar fuels technologies, where economic value and environmental impact must go hand in hand," said James Durrant, professor of Photochemistry and Sustainable Energy in the Department of Chemistry at the University of Oxford, who was not involved in the research.

The researchers are now working to develop catalysts that can expand the device's applications beyond hydrazine degradation, including the treatment of other pollutants and the conversion of waste materials into useful products such as fuels and industrial chemicals.

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