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New Device Uses Sunlight to Make Green Hydrogen from Seawater and Treat Industrial Wastewater



Science & Technology (Commonwealth Union) – The splitting of Hydrogen for its extraction is generally quite an expensive process. Some of the key challenges in alternative energy sources have been cost and effectiveness, however with research improving and further refining previous techniques these challenges look less and less daunting.

Singapore based researchers at Nanyang Technological University (NTU), have developed an innovative device capable of using sunlight to produce clean hydrogen from seawater while simultaneously breaking down hydrazine, a highly toxic pollutant commonly associated with industrial wastewater.

The device directly absorbs sunlight and transforms it into electricity, which drives the chemical reaction without the need for an external energy source. The inspiration behind is the structure of leaves.

The study appeared recently in Nature Communications.

When it comes to electrolysis, it is known as the splitting water into hydrogen and oxygen with the utilization of electricity. An electric current moves via water between two electrodes (an anode and a cathode). For obtaining the result water molecules are split into hydrogen and oxygen.

Electrons travel to the cathode, or negative electrode, during electrolysis, where they combine with water molecules to create hydrogen gas.

By removing the requirement for additional desalination before electrolysis, using saltwater rather than freshwater to produce hydrogen could increase the process' sustainability.

However, there are also technical difficulties with seawater. Chloride ions have the potential to negatively impact electrochemical reactions and lower the efficiency of hydrogen production.

The process can also produce corrosive and potentially toxic chlorine-based compounds, which may damage the electrodes over time.

To improve the efficiency of hydrogen generation from seawater, researchers led by Prof Lydia Wong from NTU's School of Materials Science and Engineering developed an anode, the positive electrode, equipped with a catalyst capable of breaking down hydrazine into hydrogen and nitrogen. This reaction consumes less energy than the oxygen-evolution reaction that normally takes place during conventional water electrolysis.

By replacing the energy-intensive oxygen-producing reaction with the hydrazine reaction, the sunlight-powered system can produce hydrogen from water with lower energy requirements and greater efficiency. As the process occurs during the same time, the anode plays a role in assisting remove hydrazine from wastewater while generating additional hydrogen, making it a win-win process.

The catalyst, which is made from iron, cobalt and chromium, offers strong resistance to corrosion while allowing its electrical, physical and chemical characteristics to be readily adjusted for different applications.

Meanwhile, the process helps minimise the formation of corrosive and harmful chlorine-based compounds.

Researchers of the study indicated that to supply the electricity needed to operate the device, researchers developed the cathode using lead-halide perovskites, semiconductor materials capable of absorbing sunlight and converting it into electrical energy. The cathode was then protected with a conductive epoxy coating containing silver and copper particles, together with titanium foil, helping to prevent degradation.

In tests using both artificial and natural seawater, the device proved able to generate a steady electrical current when exposed to light. It achieved a photocurrent density of 25 mA cm⁻², which quantifies the amount of current generated per unit of illuminated surface area. This is one of the highest values reported for lead-based perovskite cathodes and shows the device's capacity to effectively convert solar energy into electricity.

Professor Wong indicated that this dual-function device demonstrates a crucial step forward for atmospheric technology. By successfully extracting solar energy to break down a toxic industrial substance while simultaneously producing clean fuel, they are bringing a solution to both an energy and pollution issue

At present the researchers of the study are engaged in forming catalysts that have the ability go further on the device's applications.

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