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Singapore: NTU Smart Technology Opens New Path For Clean Hydrogen



Singapore researchers have developed a smart solar-powered technology that could address two environmental challenges simultaneously: clean hydrogen production and toxic industrial wastewater treatment. The “artificial leaf”, developed by scientists at Nanyang Technological University (NTU), uses sunlight to generate hydrogen from seawater while simultaneously breaking down hydrazine, a highly toxic industrial contaminant.

Combining Clean Energy And Pollution Treatment

The innovation reflects a broader shift towards technologies designed to deliver multiple sustainability benefits through a single system. Rather than relying on separate processes for energy generation and pollution treatment, the device combines both functions, potentially improving resource efficiency in future clean-energy systems.

Hydrogen production through electrolysis normally involves passing an electric current through water to separate it into hydrogen and oxygen. Using seawater could reduce the need for additional freshwater resources and avoid the desalination step required for conventional freshwater-based electrolysis.

However, seawater presents technical challenges. Chloride ions can interfere with the electrochemical reaction and lead to the formation of corrosive and potentially toxic

chlorine compounds. The NTU researchers designed their system to overcome these challenges while maintaining hydrogen production.

A Catalyst Designed For Seawater

The researchers developed an anode containing a catalyst made from iron, cobalt and chromium. Instead of producing oxygen through the conventional reaction, the catalyst breaks down hydrazine into hydrogen and nitrogen.

Because the reaction requires less energy, it can support more efficient hydrogen production while simultaneously removing the contaminant. The approach also suppresses the formation of corrosive chlorine compounds, helping protect the system from degradation.

The catalyst's electrical, physical and chemical properties can also be customised, creating potential opportunities to adapt the technology for different applications.

Turning Sunlight Into Hydrogen

The second major component is the solar-powered cathode. The researchers fabricated it using lead halide-based perovskites, semiconductor materials capable of capturing sunlight and converting it into electricity.

A protective coating incorporating silver and copper particles, together with titanium foil, was used to improve the cathode's durability. Tests using simulated and real seawater demonstrated that the device could generate a stable electric current under sunlight.

The system achieved a photocurrent density of 25 milliamperes per square centimetre, which NTU said was among the highest reported for lead-based perovskite cathodes. It also maintained stable performance for more than 72 hours under sunlight-equivalent illumination.

Treating Contaminated Water

The environmental treatment performance was similarly significant. In testing, the system reduced hydrazine concentrations from 0.5 M to 0.5 parts per billion within 30 hours, without requiring the contaminant to be separated from the water.

At the same time, the device generated hydrogen at a rate comparable with other solar-powered hydrogen systems. This combination of wastewater treatment and energy production is central to the technology's potential.

Expanding Sustainable Technology Applications

The research demonstrates how advanced materials and solar technologies can be combined to address energy and environmental challenges through multifunctional systems. For Singapore, where land and natural resources are constrained,

technologies capable of delivering several functions could have relevance as the country explores new approaches to sustainable infrastructure and resource management.

The researchers are now looking to extend the technology beyond hydrazine treatment. Future work includes developing catalysts capable of treating other pollutants and converting waste materials into useful products, including fuels and industrial chemicals.

The research was published in *Nature Communications*, adding to Singapore's research efforts in advanced materials, clean-energy technologies and sustainable engineering.

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