A bold new blueprint for economically viable solar hydrogen

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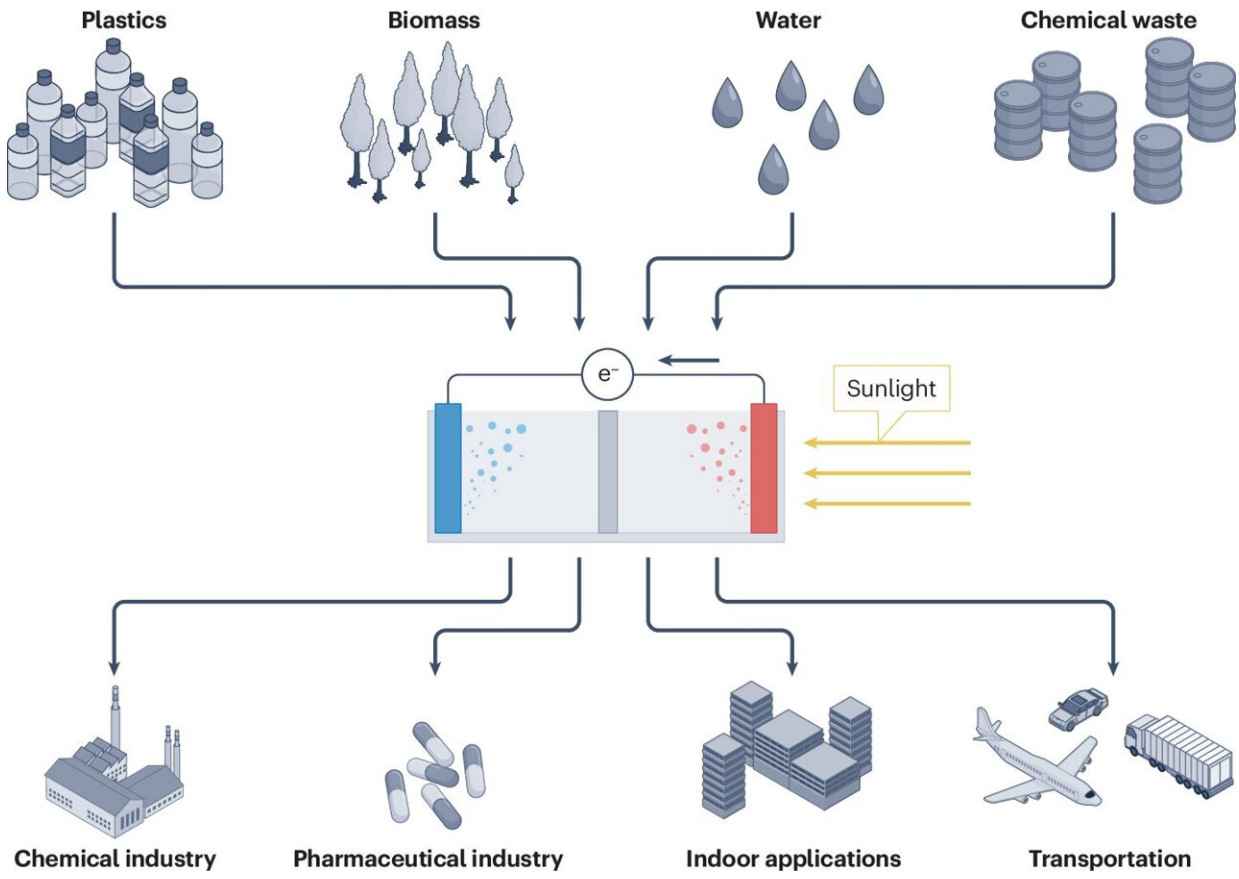


Renewable energy-driven (photo)electrochemical system. Credit: *Nature Reviews Clean Technology* (2025). DOI: 10.1038/s44359-025-00089-3

A review reimagines solar-driven water electrolysis not as a mere hydrogen production technology but instead as a relatively versatile

platform for sustainable chemical manufacturing, according to Professor Fatwa F. Abdi from the School of Energy and Environment at City University of Hong Kong (CityUHK).

This review article, published in *Nature Reviews Clean Technology*, argues that introducing high-value chemical syntheses into solar electrolysis systems could transform it from a cost-losing proposition into an economically compelling industry.

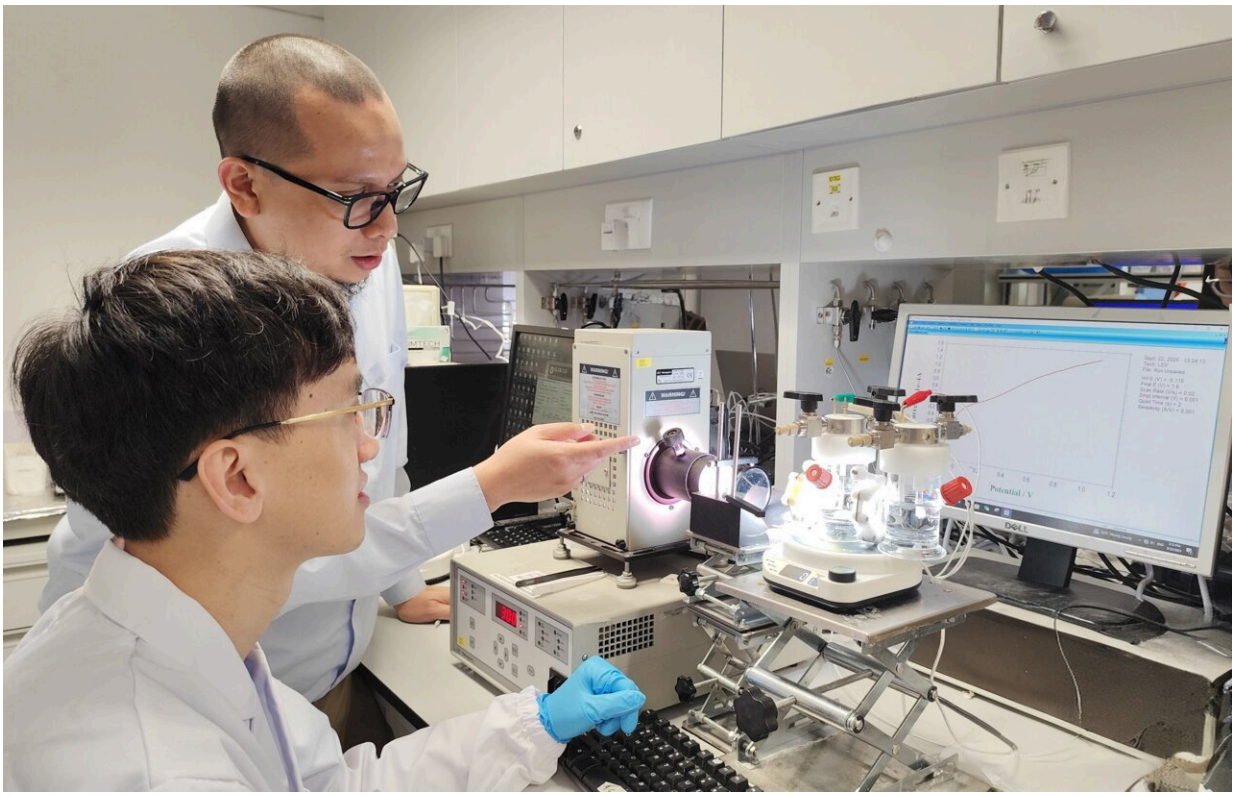
The paper offers a bold new blueprint for using sunlight not just to make clean hydrogen but to produce high-value chemicals sustainably.

The problem today is that the chemical industry relies heavily on fossil fuels and energy-intensive processes.

But this review shows how solar-powered electrolysis can do better: on one hand, instead of wasting energy making low-value oxygen, we can replace that step with reactions that generate profitable products such as bioplastic precursors or specialty chemicals.

On the other hand, rather than simply collecting hydrogen gas, we can use it immediately to turn raw materials into useful compounds.

A crucial contribution is the call to match your technology to your market. Large-scale, centralized solar farms are perfect for mass-producing affordable, high-demand chemicals.



Professor Fatwa F. Abdi (standing) and Dr. Zhu Kaijian, the first author of the paper, perform an experiment on solar-driven electrolysis coupled with valuable chemical synthesis. Credit: City University of Hong Kong

Meanwhile, smaller, flexible solar units are ideal for making expensive, low-volume specialty goods like pharmaceuticals or fine chemicals right where they're needed the most.

"What we are suggesting is a cleaner chemical industry that doesn't just cut emissions, but also stays economically viable," explains Professor Abdi, whose research centers on turning sunlight directly into chemical energy through advanced photoelectrochemical systems and next-gen catalysts.

"Big centralized single-product plants make sense for cheap, high-demand chemicals. But expensive specialty chemicals are better produced in decentralized facilities that generate multiple products," he points out.

"This isn't just about making cleaner hydrogen, but making profitable hydrogen, since when solar electrolysis is turned into a chemical reactor, the whole system can pay for itself," Professor Abdi says.

Laboratory demonstrations of these alternative reactions look promising. But scaling remains a challenge, which is why the researchers are calling for investment in pilot-scale systems and the use of advanced tools such as computer modeling and artificial intelligence to accelerate development.

They also emphasize the critical role of policy: carbon pricing, green chemistry subsidies, and tax incentives will be decisive in commercializing these technologies.

"This is the moment to align scientific innovation with market realities," Professor Abdi adds.

More information: Kaijian Zhu et al, Solar-driven electrolysis coupled with valuable chemical synthesis, *Nature Reviews Clean Technology* (2025). DOI: 10.1038/s44359-025-00089-3

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