New technique to avoid CO2 in energy conversion processes with carbon-containing fuels

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Hydrogen bubbles emerging on the catalyst and carbonate crystals precipitating from the solution. Credit: Nano-Institut / LMU

Nature knows several ways how to capture carbon dioxide (CO_2). The most prominent one is photosynthesis, where sun light is used to fix CO_2 into biomass. Nowadays, research groups around the world try hard to mimic this process and to realize artificial photosynthesis. The ultimate goal is to efficiently photo-transform CO_2 into synthetic fuels. However, nature knows also other strategies for capturing carbon dioxide, such as dissolving CO_2 as carbonate (CO_3^{2-}) in the oceans. Shellfish then make use of the dissolved carbonate and build $CaCO_3$-based solid structures for shelter, which finally end up safely in rocks around the globe.

Inspired by the way shellfishes capture carbon dioxide, LMU scientists at the Nano-Institute Munich developed the vision to transform a carbon-containing fuel into a carbon-free fuel without releasing CO_2 but capture carbon as carbonate. They chose alkaline methanol and devised a light-triggered system, which efficiently produced hydrogen and carbonate in the form of tiny stones. They introduced a novel multi-layer device to make maximum use of the incident light and the catalysts. State-of-the-art activities in hydrogen evolution rates are obtained, even much higher than benchmark systems driven by heat. Dr. Yiou Wang, who performed most of the experimental work is a Fellow of the Alexander-von-Humboldt foundation working at the Chair for Photonics and Optoelectronics led by Prof. Jochen Feldmann. He remembers: "I had two moments of great excitement: First when I saw the hydrogen bubbles emerging on the catalyst and second when I noticed the carbonate crystals precipitating from the solution." Dr. Jacek Stolarczyk, an expert in artificial photosynthesis, adds: "Light is an excellent means of triggering energy conversion reactions, more convenient to use than heat and pressure."

A possible application is the in-situ production of required hydrogen from low-cost alcohols, which avoids the risks to store and transport hydrogen before use in fuel cells. Such a carbon-neutral and light-triggered process produces hydrogen safely and efficiently, which could enable scalable fabrication and hold promise for broad and practical applications. Prof. Jochen Feldmann states: "Avoiding CO_2-emission by binding the carbon in carbonates might generally become an important concept when using carbon-containing fuels."

More information: Yiou Wang et al, A Multi-layer Device for Light-triggered Hydrogen Production from Alkaline Methanol, *Angewandte Chemie International Edition* (2021). DOI: 10.1002/anie.202109979

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