All-weather solar-powered CO_2 utilization achieved by mimicking natural photosynthesis

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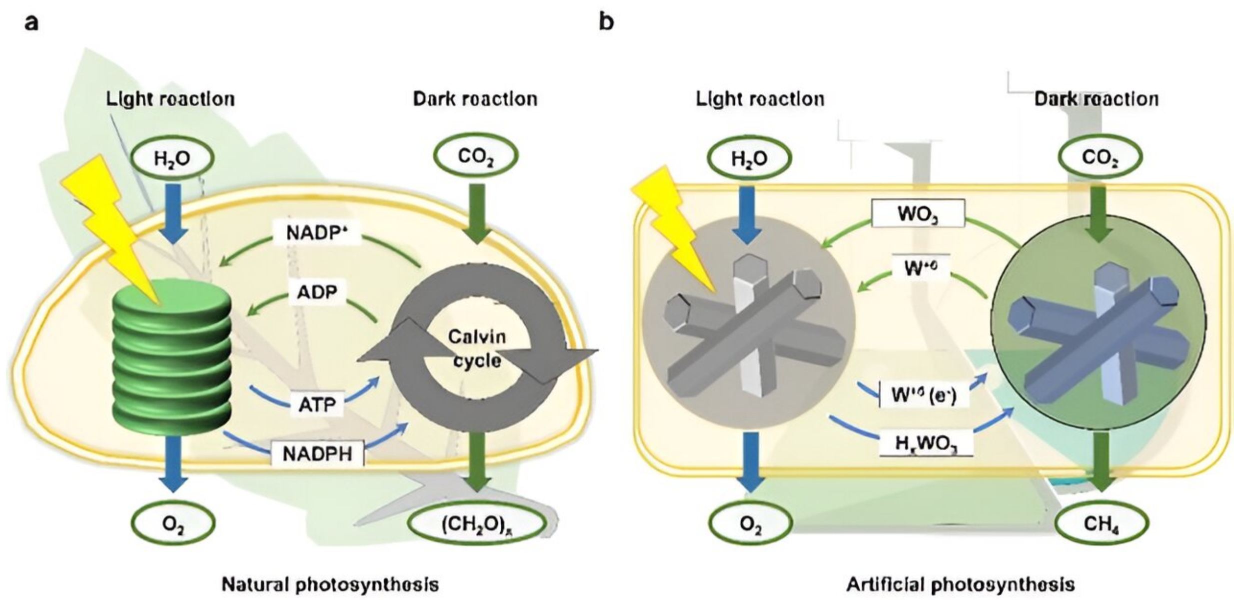


Schematic illustration of the decoupled light and dark reactions in the process of solar-driven CO_2 reduction. Credit: Shi, et al.

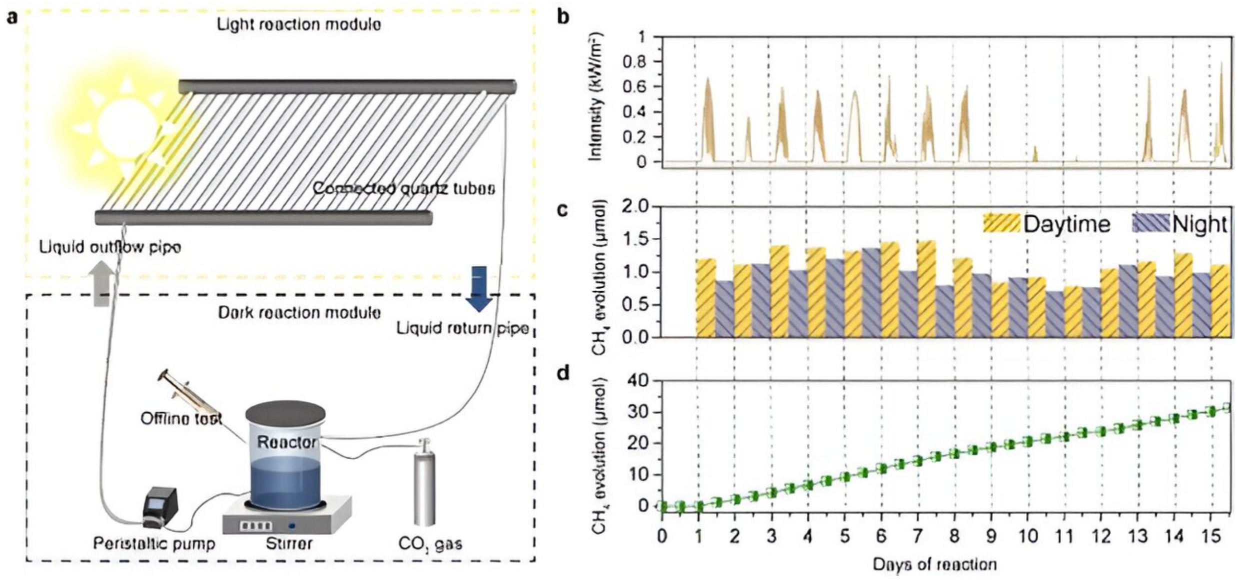
In a study published in *National Science Review*, researchers from the Institute of Earth Environment of the Chinese Academy of Sciences (CAS), together with collaborators, have used the charge storage mechanism of tungsten-based nanomaterials for all-weather carbon dioxide (CO_2) conversion.

The development of CO_2 conversion technology into valuable products is a great opportunity for the coordinated development of China's economy and ecological environment, which is a typical negentropy process that demands a substantial input of energy. However, the dependence of the solar-powered CO_2 conversion process on sunlight illumination is a limiting factor for its real-world implementation, given the intermittent availability of solar irradiance at night and on cloudy or rainy days.

In addition, there is a mismatch between the availability of solar energy and the demand for its use, influenced by variations in daylight hours and meteorological conditions. Therefore, the development of a strategy that decouples CO_2 reduction from the constraints of solar energy availability is critical to achieving continuous, all-weather CO_2 conversion.

In this study, the researchers developed a novel model material, Pt-loaded hexagonal tungsten trioxide (Pt/h-WO_3), to decouple light and dark reaction processes by mimicking natural photosynthesis.

The unique properties of the WO_3 carrier, including its ability to switch between valence states (W^{6+}/W^{5+}) and its tunnel structures, combined with Pt's ability to split water and transfer hydrogen atoms to the h-WO_3 surface, are key to achieving the decoupling of light and dark reactions for CO_2 conversion.



Demonstration of solar-driven CO_2 utilization application. Credit: Shi, et al.

When exposed to simulated sunlight for 10 minutes, the catalyst demonstrated its ability to sustain the conversion of CO_2 to methane (CH_4) even in the dark, marking the first instance of a single material achieving uninterrupted CO_2 conversion under all-condition.

Building on the properties of this material, the researchers also constructed an outdoor test facility and conducted a 15-day continuous natural light test. The data collected from the outdoor test facility showed that the CO_2 reduction process could continue at night and during rainy periods, demonstrating successful all-weather CO_2 conversion using a renewable approach.

This research approach has the potential to overcome critical technological bottlenecks in achieving continuous solar CO_2 utilization.

More information: Xianjin Shi et al, Sustainable all-weather CO2

utilization by mimicking natural photosynthesis in a single material, *National Science Review* (2023). DOI: 10.1093/nsr/nwad275

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