Sunlight-driven photocatalytic water splitting for hydrogen production at scale

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Panoramic view of the hydrogen production photocatalytic panel reaction system. Credit: Adapted from Nishiyama, H., Yamada, T., Nakabayashi, M. et al.

Large-scale solar hydrogen production through water splitting using a powder photocatalyst is considered one of the most promising methods of producing sustainable fuels in the future. In 2018, this research group demonstrated that water-splitting photocatalytic panel reactor can be

scaled up to 1 meter squared in size without compromising the solar water splitting activity of the photocatalyst. However, large-scale separation and collection of solar hydrogen beyond the laboratory scale had never been realized. It was necessary to review the design of the photocatalytic panel reactor and develop a system to safely separate the gas mixture of hydrogen and oxygen in an outdoor environment.

The joint research project involving NEDO, ARPChem, The University of Tokyo, Fujifilm, TOTO, Mitsubishi Chemical, Meiji University and Shinshu University (who was responsible for the photocatalytic water-splitting technology) demonstrated that in a large-scale outdoor area of $100m^2$ it is possible to split water using a powder photocatalyst and solar rays to retrieve solar hydrogen from the generated hydrogen-oxygen gas. More rigorous safety tests are still needed, but if a properly designed system is used, the highly explosive hydrogen-oxygen gas can be safely handled for long periods. Therefore, a system for producing a large amount of solar hydrogen at low costs through the improvement of the visible light responsive photocatalyst, the photocatalyst panel, and the gas separation module is within reach.

Achieving this feat required a lot of technological advancement and collaboration of experts from various fields. The development and demonstration of stable hydrogen separation of the moist hydrogen oxygen mixed gas regardless of the weather and sunshine conditions is an unprecedented breakthrough technology that is currently under patent review. Shinshu University's Associate Professor Takashi Hisatomi of the Research Initiative for Supra-Materials who is an expert on photocatalysis for water-splitting and hydrogen production states that "by demonstrating the entire process from hydrogen generation to separation on the world's largest scale, the realization of a solar hydrogen production system based on water splitting reaction using powdered photocatalysts has become more realistic and will be better understood by the general public."

The photocatalyst in this study uses ultraviolet light. A highly efficient visible light-responsive photocatalyst with a practicality level of 5% or higher solar energy conversion efficiency will need to be realized for real-world implementation. The group is also working to lower the cost and expand the scale of the photocatalyst panel. The current panel reactor is robust, but it is necessary to develop an inexpensive reactor that can be mass-produced while maintaining durability and safety. The separation performance and energy efficiency of the gas separation process needs improvement because the separation membrane used was ready-made and not designed for this gas separation module. The separation performance of hydrogen from hydrogen-oxygen mixed gas was not sufficient. The separation process has no precedent, so there is no comparative example which means there is still room for improvement.

More information: Hiroshi Nishiyama et al, Photocatalytic solar hydrogen production from water on a 100 m^2-scale, *Nature* (2021). DOI: 10.1038/s41586-021-03907-3

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