Harnessing solar energy for high-efficiency NH_3 production

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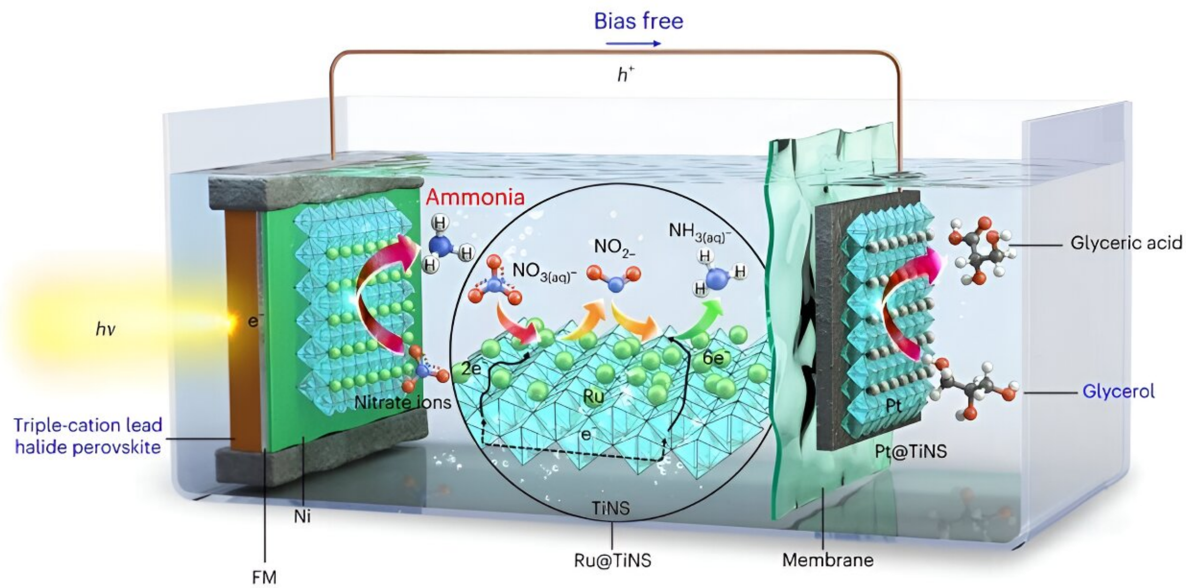

Schematic of the PEC cell used for NH_3 production. Ru@TiNS/Ni/perovskite photocathode is combined with Pt@TiNS anode to achieve a simultaneous bias-free NH_3 production and glycerol valorization. Credit: *Nature Catalysis* (2024). DOI: 10.1038/s41929-024-01133-4

A technology that harnesses solar energy to produce high-efficiency ammonia (NH_3) has been unveiled by a research team affiliated with UNIST.

Led by Professor Sung-Yeon Jang and Professor Ji-Wook Jang from the

School of Energy and Chemical Engineering at UNIST, in collaboration with Professor Thomas F. Jaramillo from Stanford University, the team has developed an eco-friendly perovskite-based photoelectrode system for NH_3 production that has surpassed the commercialization standard of the U.S. Department of Energy (DOE) by an impressive 1.7 times, setting a new world record in ammonia production efficiency.

The work is published in the journal *Nature Catalysis*.

The system operates on the principle of reducing nitrate (NO_3^-) in water to produce NH_3 using solar energy. This method not only offers a more environmentally friendly alternative to the conventional Haber-Bosch process, which heavily relies on fossil fuels, but also opens up opportunities for the synthesis of high-value compounds used in various industries such as fertilizers, food, and pharmaceuticals.

Key to the success of this technology is the development of a highly efficient photoelectrode system that combines perovskite solar cells with a ruthenium (Ru) catalyst on titanate nanosheets (TiNS). By protecting the perovskite material with Field's metal and integrating it with the catalyst for NH_3 production, the research team has achieved unparalleled performance and durability in NH_3 production.

Noteworthy is the use of glycerol as a reactant, which enables the production of NH_3 without the need for external voltage. By optimizing the oxidation reaction of glycerol with the voltage generated by the photoelectrodes, the team has demonstrated a remarkable maximum ammonia production rate of 1745 $\mu gNH_3\ cm^{-2}h^{-1}$, far surpassing the commercialization standard of the U.S. Department of Energy (DOE).

Professor Ji-Wook Jang said, "Through this study, we have demonstrated the production of NO_3^-, a main source of contamination in water, while at the same time oxidizing, glycerol, a low-value byproduct derived from biomass, to produce a higher-value glyceric acid (GA).

"This technology holds immense potential for the production of eco-friendly fuels."

Professor Sung-Yeon Jang said, "Our research represents a significant advancement in solar fuel production, surpassing commercialization standards and paving the way for a more sustainable future in ammonia production."

More information: Ahmad Tayyebi et al, Bias-free solar NH_3 production by perovskite-based photocathode coupled to valorization of glycerol, *Nature Catalysis* (2024). DOI: 10.1038/s41929-024-01133-4

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