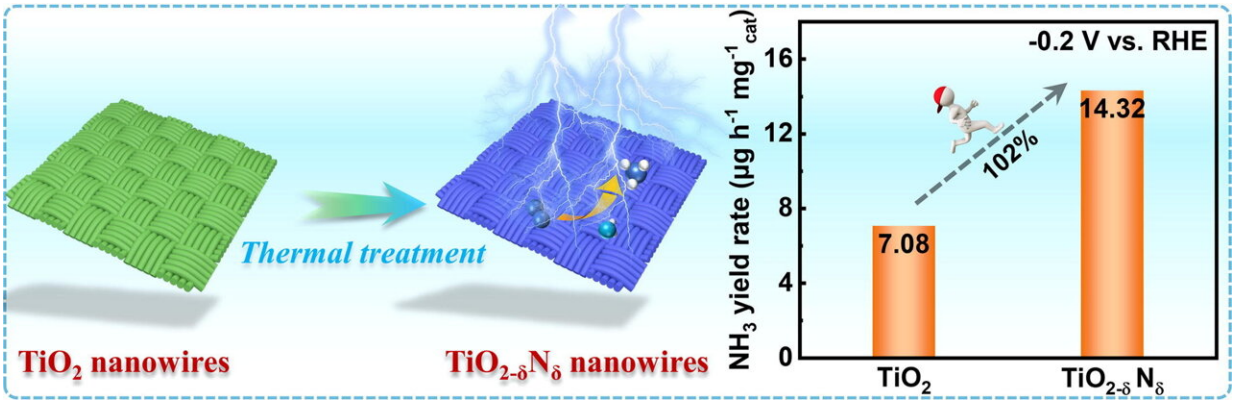
Surface defect engineering of nanowire arrays towards efficient nitrogen reduction for ammonia synthesis

September 19 2022



The catalysts based on $TiO_{2-\delta}N_{\delta}$ nanowires grown on carbon cloth feature a higher yield rate for ammonia than the electrocatalyst without N doping. Credit: *Journal of Energy Chemistry*

Ammonia is a carbon-neutral energy carrier and potential transportation fuel applied extensively in fertilizers, plastics, and explosives. Conventional ammonia synthesis methods rely primarily on the high-temperature and high-pressure Haber–Bosch process, which leads to considerable energy consumption and greenhouse gas emissions.

Therefore, developing appropriate solutions for achieving high-efficiency, low-energy, low-emission, and sustainable ammonia

production under benign environmental conditions is critical. Electrochemical ammonia synthesis, which has become a popular research topic, enables the thermodynamically non-spontaneous ammonia synthesis reaction to be realized under ambient conditions driven by electrical energy.

However, non-polar N_2 is insoluble in water, which limits its adsorption and activation on the catalyst surface, and the competitive hydrogen evolution reaction at the reduction potential substantially reduces the yield and Faradaic efficiency of N_2 reduction to ammonia. Therefore, finding novel electrocatalysts with high catalytic performance and investigating the reaction mechanism of N_2 reduction to ammonia are crucial.

Recently, Professor Luo Wenbin at Northeastern University and Li Feng at the Insititute of Metal Research published a paper titled "Boosting nitrogen electrocatalytic fixation by three-dimensional $TiO_{2-\delta}N_{\delta}$ nanowire arrays" in the *Journal of Energy Chemistry*. The first author of this paper is Mu Jianjia, a doctoral student at Northeastern University. Gao Xuanwen, who is an Associate Professor, is the co-author. The corresponding authors are Professor Luo Wenbin and Li Feng.

In this study, 3D nanowire arrays were grown on carbon cloth to form an integrated network for avoiding binder-induced side reactions, increasing the cycling lifespan. The nitrogen reduction reaction (NRR) exhibited a high ammonia yield rate (14.33 μg h^{-1} mg_{cat}^{-1}) at -0.2 V and high Faradic efficiency (9.17%) at -0.1 V in 0.1 M KOH electrolyte, outperforming the reported O_v-rich TiO_2-based electrocatalysts.

The synergistic effects of O_v and Ti^{3+} in the NRR under ambient conditions were experimentally and theoretically demonstrated, thereby presenting a novel concept for highly efficient electrocatalysts.

More information: Jianjia Mu et al, Boosting nitrogen electrocatalytic fixation by three-dimensional $TiO_{2-\delta}N_{\delta}$ nanowire arrays, *Journal of Energy Chemistry* (2022). DOI: 10.1016/j.jechem.2022.08.007

Provided by Chinese Academy of Sciences