Recent advances in electrocatalytic ammonia synthesis

August 21 2023


NH₃ is the second largest chemical produced in the world and nearly 80% of produced NH₃ is employed in fertilizer synthesis. Meanwhile, NH₃ is an indispensable raw material for manufacturing nitric acid, which can be further employed in chemical production.
Moreover, NH₃ possesses high hydrogen capacity, making it a potential carbon-free fuel. As one of the greatest inventions, the Haber-Bosch process enables the large-scale production of value-added NH₃; however, it is against the principle of sustainable development theory due to the high operational costs and negative environmental impacts of the Haber-Bosch process.

Hence, it is imperative to explore green and sustainable approaches to produce NH₃ and simultaneously realize global environmental sustainability.

Artificial electrocatalytic NH₃ synthesis (which can couple with clean renewable electricity) is recently becoming a research hotspot, where the majority of researchers use N₂ gas as the N source. Although electrocatalytic N₂ reduction reaction (NRR) provides an eco-friendly and sustainable route for ambient NH₃ production, the conversion efficiency of N₂ reduction to NH₃ is unsatisfactory because of the high thermodynamic stability of the N₂ molecule.

Fortunately, the more active N sources (i.e., NO, NO₂⁻, NO₃⁻) have been deemed as attractive precursors to achieve effective NH₃ production, and meanwhile, the development of electrocatalytic NO reduction reaction (NORR) and NO₃⁻/NO₂⁻ (NOₓ⁻) reduction reaction (NtrRR) is also expected to control and mitigate the related environmental pollution. Although many promising studies have been done in the field of artificial electrosynthesis of NH₃, the design and development of active electrocatalysts with high selectivity and stability to achieve efficient NH₃ production remain certain challenges.

Recently, a research team led by Prof. Xuping Sun from University of Electronic Science and Technology of China introduced three
electrochemical NH$_3$ synthesis routes (NRR, NORR, and NtrRR) then summarized recent advances in electrocatalyst development for ambient NH$_3$ synthesis, mainly involving catalytic mechanisms, theoretical advances, and electrochemical performance.

The challenges and future perspectives are also proposed in the concluding remarks, aiming to provide experience and inspire more critical insights for the electrocatalytic NH$_3$ synthesis reactions. The results were published in the *Chinese Journal of Catalysis*.