Electrochemical Ammonia Synthesis Under Ambient Conditions

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Electrochemical ammonia synthesis under ambient conditions offers a decentralized, low-carbon alternative to the conventional Haber-Bosch process, which is responsible for over 1% of global CO_2 emissions[1]. Among various approaches, lithium-mediated nitrogen reduction reaction (Li-NRR)—pioneered by Tsuneto *et al.* in the 1990s [2] and regained the spotlight by Andersen *et al.* in 2019 [3]—has emerged as one of the most promising. It has demonstrated commercially relevant ammonia production rates and high Faradaic efficiencies [4]. The Li-NRR mechanism is generally accepted to involve three key steps: (1) electrodeposition of lithium metal onto the cathode surface, (2) activation of molecular nitrogen via reaction with lithium to form lithium nitride species (LiN_xH_y), and (3) protonation of these intermediates by a proton source (e.g., ethanol) within the electrolyte, yielding ammonia and regenerating Li^+. Despite recent advances, challenges persist in controlling and understanding the complex interfacial phenomena that govern ammonia synthesis selectivity/performance.

This presentation will share the latest insights into these interfacial processes, drawing on collaborative research between the University of Osaka (JP) and Imperial College London (UK). We will demonstrate how comprehensive characterization of the electrolyte–electrode interface can provide new levers to modulate proton transfer and solid electrolyte interphase (SEI) formation, ultimately enhancing both the activity and stability of the Li-NRR system.

Acknowledgments

A part of this study was supported by "R&D Program for Promoting Innovative Clean Energy Technologies Through International Collaboration(JPNP20005)" of the New Energy and Industrial Technology Development Organization (NEDO), Japan.

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