Ammonia as Chemical Energy Carrier: Electro-Catalytic Synthesis and Decomposition

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The talk focuses on alternative electro- and thermo-catalytic pathways for the production and decomposition of ammonia related to the use of NH_3 as carrier of renewable energy. Recent advances in electrocatalytic ammonia synthesis in proton-conducting ceramic cells (PCCs) are discussed with a focus on iron-based electrodes [1]. The effects of temperature, gas flow, voltage, and electrolyte thickness on electrochemical ammonia synthesis are investigated. To differentiate the various effects and mechanisms contributing to the electrocatalytic formation of NH_3, different gas flow configurations are studied. The experimental results demonstrate that NH_3 formation is primarily governed by the applied cell voltage, while the current density plays only a minor role. A strong interaction between electro- and thermo-catalytic reactions occurs. Co-feeding H_2 at the cathode proved advantageous for optimizing reaction conditions and increasing ammonia synthesis rates to values of 3×10^{-8} mol s^{-1} cm^{-2} using a PCC with an iron based electrode of an active area of 12.57 cm^2. Also, decomposition of NH_3 to H_2 can be conducted in PCC. In all cases both electro- and thermos-catalytic processes have to be understood [2]. The combination of thermo-catalytic and electrochemically supported ammonia synthesis and decomposition opens new pathways for the electrification of NH_3 production using the rather inexpensive material iron and the use of NH_3 as hydrogen carrier.

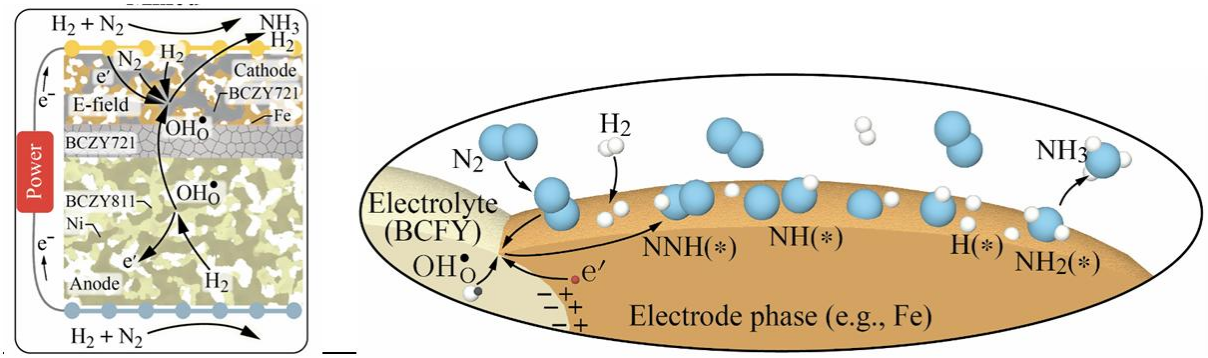

Figure 1: Schematic representation of reactions occurring at a proton-conducting ceramic cell that either contribute to NH_3 synthesis or compete with it. The reactions take place simultaneously; adapted from [1].

[1] P. Blanck, E.P. Martin, D. Schmider, J. Dailly, R.J. Kee, O. Deutschmann. Electrochemical Ammonia Synthesis in a Proton-conducting Ceramic Cell: A Parameter Study of an Iron-based Electrode. J. Electrochem. Soc. (2025) DOI: 10.1149/1945-7111/adfc9e.

[2] S. Davari, R. Chacko, T. Bastek, P. Lott, J. Dailly, S. Angeli, O. Deutschmann. Experimental and Microkinetic Investigation of Thermo-Catalytic Ammonia Decomposition over a Ba-promoted Ru/Ni BCZY Catalyst for Use in Ammonia-fed Protonic Ceramic Cells. Appl. Catal. A. 708 (2025) 120571. DOI:10.1016/j.apcata.2025.120571