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Decentralized Ammonia Cracking in a Resistively Heated Reactor

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This work addresses the research question of how decentralized ammonia cracking technologies can enable flexible, low-emission hydrogen and energy provision within a sustainable ammonia-based energy system. The objective is to develop and evaluate efficient NH_3 cracking concepts for small to medium-scale applications that are supplied by renewable electricity and integrated into local energy infrastructures, while only briefly considering upstream ammonia synthesis and downstream energy use. Within the lighthouse project AmmonVektor a pioneering initiative aimed at establishing ammonia as a cornerstone in the transition to sustainable energy systems is made.
Methods for the ammonia cracking combine catalyst and reactor development. Resistively heated fixed-bed reactors are investigated using nickel-, and cobalt-based catalysts on tailored supports, targeting high conversion at moderate temperatures. Membrane-assisted reactors are evaluated for in situ hydrogen separation, with a focus on hydrogen purity, ammonia slip, and integration into hydrogen supply systems. In addition, process simulations and techno-economic assessments are performed within AmmonVektor to compare decentralized cracking with alternative hydrogen supply options, considering efficiency, specific costs, and greenhouse gas emissions are targeted within the project. Safety aspects related to localized ammonia storage and handling are analyzed to derive design and operational guidelines. The focus of the presentation is the reactor and catalyst design and development for the ammonia cracking.
Initial results show that optimized catalysts in resistively heated reactors achieve near-complete ammonia conversion and high hydrogen yields at reduced operating temperatures, while maintaining stable performance under repeated start–stop cycles and load changes. Membrane-assisted configurations further increase hydrogen purity and can reduce the need for downstream gas cleaning, at the expense of higher system complexity and cost. System analyses indicate that decentralized cracking supplied by regionally produced or imported ammonia can be competitive with compressed or liquefied hydrogen distribution in selected industrial and mobility applications, particularly where waste heat utilization and high full-load hours are feasible. Within the broader framework of developing a sustainable ammonia economy, these findings underline the central role of efficient cracking technologies and highlight remaining challenges in catalyst durability, system integration and regulatory acceptance that must be addressed to enable widespread deployment.