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Compact and efficient ammonia cracker for decentralized hydrogen production

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Hydrogen is a key compound for the reduction of CO_2 emissions and the ongoing energy transition. According to current forecasts, Germany will not be able to cover its energy demand with inland production of renewable electricity. Therefore, it will be dependent on imports of energy chemically converted to hydrogen from other countries, such as Australia, Chile or Africa. However, the long-distance transport of hydrogen poses certain safety and security risks. In contrast, hydrogen carriers such as ammonia and methanol are already produced in large amounts and can be easily transported via the existing infrastructure. In this regard, ammonia with its high hydrogen content of 18 wt.% is seen as the most promising carbon-free hydrogen carrier. At the application site, ammonia must then be decomposed over catalyst to hydrogen and nitrogen, which requires compact and efficient cracking technology.
In this work, we present our reactor concept for decentralized hydrogen production from ammonia, which is based on the microstructured plate heat exchangers coated with catalyst. By applying catalytic coatings [1] instead of conventional fixed beds, the negative impact of mass transport limitations can be avoided, also allowing us to reach one of the highest catalytic activities reported in the literature [2]. Moreover, heat transport to the catalyst during endothermic ammonia cracking can be significantly improved in such microstructured reactors. This allows the ammonia cracker to be operated at lower temperatures compared to conventional technology (e.g. 650°C-700°C vs. 800-1000°C), thus also reducing the risk of material and catalyst damage. Depending on the application, the heat supply to the microstructured reactor can be achieved in different ways. For mobile applications, the hot exhaust gas from a combustion engine can be utilized for reactor heating. Alternatively, the concept of integrated catalytic heating can be applied. In this case, the hydrogen containing off-gas from hydrogen purification or fuel cells is combusted inside heat exchanger channels coated with the combustion catalyst [3]. The high energy efficiency of 90% in combination with stable and efficient catalyst formulations enable the significant size reduction of the ammonia cracker by 90% or more. The operation of the developed ammonia cracker was already demonstrated for 50 kW electric power equivalent. Further scaling up of the technology to 200 kW is currently ongoing, thus broadening the possible application areas.

References:

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