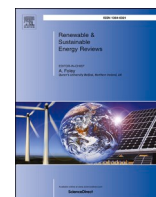




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An efficient process for sustainable and scalable hydrogen production from green ammonia

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ABSTRACT

This study comprehensively investigates hydrogen production from green ammonia reforming, including synthesis of catalysts, reactor development, process integration, and techno-economic analysis. In-house developed Ru/La–Al₂O₃ pellet catalyst having perovskite structure showed high catalytic activity of 2827 h^{−1} at 450 °C and stability over 6700 h at 550 °C, exceeding the performance of the majority of powder catalysts reported in the literature. A scalable 12-faceted reactor adopting the as-produced catalyst was designed to enhance heat transfer, producing over 66 L min^{−1} of hydrogen with state-of-the-art ammonia reforming efficiency of 83.6 %. Near-zero CO₂ emission of hydrogen extraction from green ammonia was demonstrated by-product gas recirculation as a combustion heat source. A techno-economic assessment was conducted for system scales from 10 kW to 10 MW, demonstrating the effect of reduced minimum hydrogen selling prices from 7.03 USD kg^{−1} at small modular scales to 3.98 USD kg^{−1} at larger industrial scales. Sensitivity analyses indicate that hydrogen selling prices may reduce even further (up to 50 %). The suggested hydrogen production route from green NH₃ demonstrates superior CO₂ reduction ranging from 78 % to 95 % in kg CO₂ (kg H₂)^{−1} compared to biomass gasification and steam methane reforming. These findings can be used as a basis for following economic and policy studies to further validate the effectiveness of the suggested system and process for H₂ production from NH₃.

Abbreviations: Abs, Adsorber; CAPEX, Capital expense; CE, Costing exponent; CNT, Carbon nanotube; FFR, Fuel flow rate; GHSV, Gas hourly space velocity; HX, Heat exchanger; LHV, Lower heating value; MHSP, Minimum hydrogen selling price; NCF, Non-discounted cash flow; NPV, Net present value; OPEX, Operating expenses; PEMFC, Polymer electrolyte membrane fuel cell; PFD, Process flow diagram; PSA, Pressure swing adsorption; REF, Reformer; SC, Storage cost; SMR, Steam methane reforming; STP, Standard temperature and pressure; TCI, Total capital investment; TEA, Techno-economic assessment; TEM, Transmission electron microscopy; TIC, Total installation cost; TOF, Turnover frequency.

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