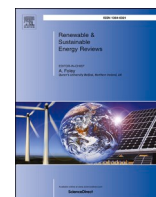




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## An efficient process for sustainable and scalable hydrogen production from green ammonia

Junyoung Cha<sup>a,b,1</sup>, Yongha Park<sup>a,1</sup>, Boris Brigljević<sup>c,1</sup>, Boreum Lee<sup>c</sup>, Dongjun Lim<sup>c</sup>,  
Taeho Lee<sup>a</sup>, Hyangsoo Jeong<sup>a</sup>, Yongmin Kim<sup>a</sup>, Hyuntae Sohn<sup>a</sup>, Hrvoje Mikulčić<sup>d,e</sup>,  
Kyung Moon Lee<sup>f</sup>, Dong Hoon Nam<sup>f</sup>, Ki Bong Lee<sup>b</sup>, Hankwon Lim<sup>c,\*\*\*</sup>, Chang Won Yoon<sup>a,g,\*\*</sup>,  
Young Suk Jo<sup>a,\*</sup>

<sup>a</sup> Center for Hydrogen and Fuel Cell Research, Korea Institute of Science and Technology (KIST), 5 Hwarang-ro 14-gil, Seongbuk-gu, Seoul, 02792, Republic of Korea

<sup>b</sup> Department of Chemical and Biological Engineering, Korea University, 145, Anam-ro, Seongbuk-gu, Seoul, 02841, Republic of Korea

<sup>c</sup> School of Energy and Chemical Engineering, Ulsan National Institute of Science and Technology, 50 UNIST-gil, Eonyang-eup, Ulju-gun, Ulsan, 44919, Republic of Korea

<sup>d</sup> Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb, Zagreb, Croatia

<sup>e</sup> MOE Key Laboratory of Thermo-Fluid Science and Engineering, Xi'an Jiaotong University, Xi'an, China

<sup>f</sup> Hydrogen Energy Business Development Team, Hyundai Motor Company, 37, Cheoldobangmulgwan-ro, Uiwang-si, Gyeonggi-do, 16082, Republic of Korea

<sup>g</sup> Department of Chemical Engineering, Pohang University of Science and Technology (POSTECH), 77 Cheongam-ro, Nam-gu, Pohang, 37673, Republic of Korea

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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–Al<sub>2</sub>O<sub>3</sub> pellet catalyst having perovskite structure showed high catalytic activity of 2827 h<sup>−1</sup> 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<sup>−1</sup> of hydrogen with state-of-the-art ammonia reforming efficiency of 83.6 %. Near-zero CO<sub>2</sub> 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<sup>−1</sup> at small modular scales to 3.98 USD kg<sup>−1</sup> 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 NH<sub>3</sub> demonstrates superior CO<sub>2</sub> reduction ranging from 78 % to 95 % in kg CO<sub>2</sub> (kg H<sub>2</sub>)<sup>−1</sup> 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 H<sub>2</sub> production from NH<sub>3</sub>.

**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.

\* Corresponding author. Center for Hydrogen and Fuel Cell Research, Korea Institute of Science and Technology (KIST), 5 Hwarang-ro 14-gil, Seongbuk-gu, Seoul, 02792, Republic of Korea.

\*\* Corresponding author. Center for Hydrogen and Fuel Cell Research, Korea Institute of Science and Technology (KIST), 5 Hwarang-ro 14-gil, Seongbuk-gu, Seoul, 02792, Republic of Korea.

\*\*\* Corresponding author. School of Energy and Chemical Engineering, Ulsan National Institute of Science and Technology, 50 UNIST-gil, Eonyang-eup, Ulju-gun, Ulsan, 44919, Republic of Korea.

E-mail addresses: [hklim@unist.ac.kr](mailto:hklim@unist.ac.kr) (H. Lim), [cwyoon@postech.ac.kr](mailto:cwyoon@postech.ac.kr) (C.W. Yoon), [yjo@kist.re.kr](mailto:yjo@kist.re.kr) (Y.S. Jo).

<sup>1</sup> These authors contributed equally.

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