Hydrogen Production from Low-Grade Wastes: Integrated Drying, Gasification, Chemical Looping, and Haber-Bosch Process

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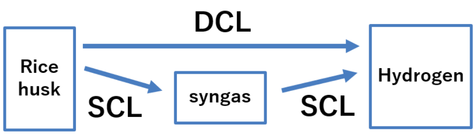
Hydrogen is considered as a promising candidate to replace fossil fuels in the future because of its high efficiency, carbon-free characteristics, high flexibility in its production and utilization. Among many sources to produce hydrogen, biomass is receiving high attention due to its advantages, including carbon neutral characteristics, large energy potential, and low cost. As one of biomass, rice husk also has high energy potential. Thus, from both economic and environmental points of view, it is necessary to develop an efficient conversion system of hydrogen from rice husks.

Chemical Looping Hydrogen Production

Previous research focused on electricity generation from rice husks. However, it lacked consideration of storage of electricity. This research aims to store energy in form of hydrogen.
Previous hydrogen production method (gasification, water-gas shift reaction and CO2 separation) had disadvantages such as low efficiency and system complexity. To overcome these disadvantages, we focus on chemical looping technology.
Chemical looping technology has advantages such as high efficiency due to the point that hydrogen and CO2 can be generated separately. However, currently there's still a lack of study in this field and inadequate consideration of energy recovery.



There are two types of chemical looping, direct chemical looping (DCL) and syngas chemical looping (SCL). DCL converts solid fuel directly into hydrogen, so you could achieve more simple system. SCL first converts solid fuel into syngas and then to hydrogen, so ash and char is removed in advance.

Chemical looping hydrogen production method consists of three reactors: reducer, oxidizer and combustor. Oxygen carrier (OC) is circulated around these three reactors.

Reducer:

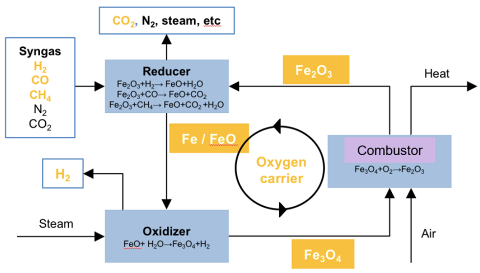
- $Fe_2O_3 + CO \rightarrow 2FeO\ (Fe) + CO_2$
- $Fe_2O_3 + H_2 \rightarrow 2FeO\ (Fe) + H_2O$
- $4Fe_2O_3 + 3CH_4 \rightarrow 8Fe + 3CO_2 + 6H_2O$

Oxidizer:

- $3FeO + H_2O \rightarrow Fe_3O_4 + H_2$

Combustor:

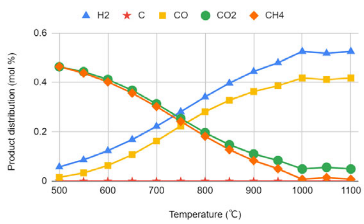
- $4Fe_3O_4 + O_2(air) \rightarrow 6Fe_2O_3\ (+ N_2)$



This research integrates both agricultural products processing and hydrogen production. The novelty of this study includes the adoption of chemical looping technology and hydrogen to ammonia conversion.

Expected Results and Future Prospects

- The system can achieve around 50% hydrogen efficiency and 40% ammonia efficiency.
- DCL had higher efficiency compared to SCL.
- The system requires electricity input to run the system.



Produced ammonia could be used to produce fertilizer or used as fuel to realize a circular economy in the existing agriculture.
In addition, produced hydrogen could be converted into electricity to cover the electricity shortage.