Thermodynamic and Techno-Economic Assessments of Green Methanol Production Through Direct Chemical Looping

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Innovative methanol production routes from biomass through direct chemical looping processes (CLP) contribute to a sustainable and carbon-neutral society. However, there are very limited studies regarding biomass to green methanol production in the light of direct CLP. Two methanol production routes based on biomass direct CLP are proposed and compared in terms of thermodynamic and techno-economic performances.

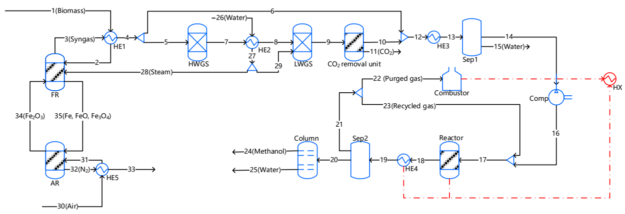
Methanol Synthesis Routes Based on Direct CLP

Methanol is regarded as one of the most promising energy carriers because of its high bulk energy density, ease of transport and storage with already built infrastructure, and versatile applications as a raw material.

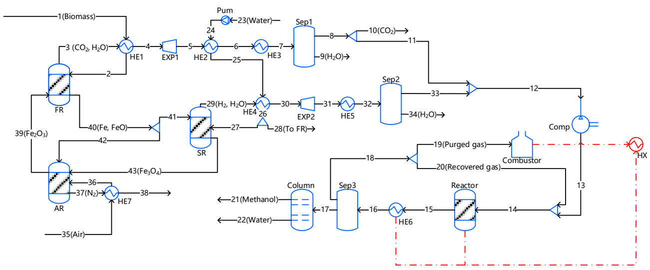
Traditional methanol synthesis uses fossil energy as the feedstock and consumes considerable energy in air separation unit (ASU) and surplus CO_2 capture.

Methanol production from biomass direct CLP is a promising alternative for green and sustainable methanol production.

The first methanol production route (configuration 1) is based on biomass chemical looping gasification (B-CLG). The primary difference from that of the conventional methanol synthesis system is that the ASU is replaced by CLG, as shown in the following figure:



The second methanol production route (configuration 2) is based on biomass chemical looping hydrogen production (B-CLHP). Configuration 1 still has a water gas shift reaction unit and CO_2 removal unit despite the elimination of the ASU. However, in configuration 2, the above two components were substituted as well, as shown in the following figure:



Comparative thermodynamic and techno-economic analyses were conducted to observe the thermodynamic (in energy and exergy efficiencies) and economic (in levelized cost of methanol (LCOM), net present value (NPV), internal rate of return (IRR), and dynamic payback period (DPP)) performances of the two routes.

Expected Results and Future Prospects

Process simulation is adopted to design and analysis the system. It is found that both configurations have similar thermodynamic performances, but configuration 2 has favorable techno-economic performances. This finding provides some guidance for practical application of direct CLP based methanol production both technologically and economically.