TOWARDS FULL CARBON RECOVERY IN A DUAL FLUIDIZED BED STEAM CRACKER FOR THERMOCHEMICAL RECYCLING OF PLASTIC WASTE

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Abstract

Dual fluidized bed steam crackers (DFB-SC) are emerging as a promising pathway for chemical recycling and offer a route to decarbonize plastic production [1]. However, processing heterogeneous or low-grade feedstocks reduces conversion efficiency, increases CO_2 emissions, and raises feedstock demand per unit of product. In this work, we propose a novel process concept combining a DFB-SC with Fischer-Tropsch (FT) for full carbon recovery, to maximize the conversion of plastic waste into building blocks, such as olefins and BTX. A process model was developed in Aspen Plus, including advanced gas cleaning (MEA absorption towers + WGS), reforming section (SMR–POX), hydrogen production (SOEC), and carbon conversion through FT synthesis. Two feedstocks were evaluated: pure polyethylene (PE) and heterogeneous municipal plastic waste (MPW), to assess the effect of composition on system complexity, energy demand, and carbon recovery. Following previous work done by Thunman et al. [2], different carbon recovery scenarios were assessed from no to full carbon recovery, including CO_2 and CH_4 capture and utilization. The results show that up to 92% of carbon can be converted into products when adding external hydrogen, however, requiring up to 6.1 MWh of energy per ton product, and an additional 56% more if the feedstock is MPW. PE yields 37% more products with lower system complexity, while MPW increases process intensity but allows for partial biogenic carbon claims and feedstock flexibility. Nevertheless, the system can decrease its hydrogen dependence by converting less carbon to products (84% and 79%, for PE and MPW respectively), and requiring 2 and 4 MWh/ton feedstock, respectively (where 47% is for hydrogen production). This work highlights a fundamental trade-off: maximizing carbon recovery and emissions reduction leads to higher energy demand and system complexity.

References

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