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An optimization model for assessment of membrane-based post-combustion gas upcycling into hydrogen or syngas

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Abstract

In this work, we present an optimization model and techno-economic analysis aimed at assessing the viability of employing membrane technology to recover value-added compounds from post-combustion gases of the process industry. In particular, the tail gas generated in carbon black manufacturing process is targeted. The content of hydrogen (H_2) and carbon monoxide (CO) in this waste gas stream is relatively high, thus the possibility of increasing the sustainability of the process by recovering either H_2 or both compounds simultaneously (syngas) is addressed. A comparison is performed between the optimal process designs for each recovery scenario based on the separation characteristics provided by state-of-the-art and prospective membrane materials. To that end, a two-stage membrane separation process using hollow-fiber membranes is implemented in the General Algebraic Modeling System (GAMS) as a nonlinear programming model (NLP). The optimal process design for each recovery scenario is found determining the feed pressure, membrane area, power consumption and composition of all process streams that meet the specified H_2 recovery and