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Process Design of a Xylitol Biorefinery with a Hybrid Optimization Approach

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Keywords: Process Synthesis, Process Design, Superstructure Optimization, Simulation-Based Optimization, Biorefinery.

Abstract

A key approach in expediting the transition towards a bio-based economy is the conceptual design and implementation of integrated second-generation biorefineries (iSGB). A conceptual design approach for these iSGBs is Superstructure Optimization (SSO), which yields an optimal candidate process topology (CPT) [1]. By following a simulation-based optimization (SBO) approach, complex models including inherent uncertainties can be employed in the search for an optimal process design [2]. We therefore propose a novel synergistic framework for the synthesis and design of iSGBs: based on a hybrid approach integrating surrogate-based superstructure optimization (SSO) with simulation-based design optimization (SBO). As a proof of concept, we apply this framework to a case study to the process synthesis and design of a xylitol biorefinery. Xylitol is a platform chemical and is used as sugar substitute in food industries. It can be produced by microbial fermentation from lignocellulosic biomass, which makes it an ideal product for an iSGB [3]. Consequently, succinic acid, another high-potential platform chemical- is selected as value-added co-product [4]. In order to meet the high energy demand of the iSGB, the lignin fraction is chosen as substrate for a combustion process. Mechanistic models for all necessary unit operations are developed and assessed by uncertainty and sensitivity analysis. Surrogate models are utilized for the composition of the superstructure. Performing SSO yields several CPTs, which are then subjected to SBO including the uncertainties in the model. The result of the application of the presented framework is then a consolidated base-case process for a xylitol biorefinery, which can be easily extended in the superstructure towards the evaluation of further products, process integration, plant-wide optimization or value chain optimization. The resulting process itself is evaluated against both criteria of being economically viable and sustainable.

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References

Chen, Q. and Grossmann, I.E. ‘Recent developments and challenges in optimization-based process synthesis’, Annual Review of Chemical and Biomolecular Engineering, Vol. 8, 2017, pp.249-283.

Al, R. et al. ‘Stochastic simulation-based superstructure optimization framework for process synthesis and design under uncertainty’, Computers & Chemical Engineering (under review).

Hernández-Pérez, F. et al. ‘Xylitol bioproduction: state-of-the-art, industrial paradigm shift, and opportunities for integrated biorefineries’, Critical Reviews in Biotechnology, Vol. 39(7), pp. 924-943.

Mancini, E. et al. ‘From second generation feed-stocks to innovative fermentation and downstream techniques for succinic acid production’, Critical Reviews in Environmental Science and Technology, 2019, pp.1-45.