Chemical Engineering Doctoral Defense

Engineering Synthetic Coculture Systems for Enhanced Bioproduction Applications

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Abstract

Bioconversion of lignocellulosic sugars is often suboptimal due to global regulatory mechanisms such as carbon catabolite repression and incomplete/inefficient metabolic pathways. While conventional bioprocessing strategies for metabolic engineering have predominantly focused on a single engineered strain, the alternative development of synthetic microbial communities facilitates the execution of complex metabolic tasks by exploiting unique community features (i.e., modularity, division of labor, and facile tunability). In this dissertation, these features are leveraged to develop a suite of generalizable strategies and transformative technologies for engineering Escherichia coli coculture systems to more efficiently utilize lignocellulosic sugar mixtures. This was achieved by rationally pairing and systematically engineering catabolically-orthogonal Escherichia coli sugar specialists. As demonstrated in Chapters 2 and 3, coculture systems were systematically engineered, as derived from either wild-type Escherichia coli W, ethanologenic LY180 or lactogenic TG114. Net catabolic activities were then readily balanced by simple tuning of the inoculum ratio between sugar specialists, ultimately enabling improved co-utilization (98% of 100 g L-1 total sugars) of glucose-xylose mixtures (2:1 by mass) under simple batch fermentation conditions. Meanwhile, in Chapter 4 we extend this strategy to a coculture-coproduction system capable of capturing and fixing CO2 evolved during biofuel production through inter-strain metabolic cooperation; thereby increasing overall carbon conservation efficiency. Lastly, in Chapter 5 we discuss the development of a novel apparatus and analytical platform that serves as a transformative tool for studying metabolic interactions occurring between strains. Holistically, this work contributes to an improved understanding of the dynamic behavior of synthetic microbial consortia as enhanced bioproduction platforms and carbon conservation strategy for renewable fuels and chemicals from non-food carbohydrates

April 16, 2021; 9 AM;
Zoom Link: https://asu.zoom.us/j/89180899011