BRC Science Highlight
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Sustainable Production of Acrylic Acid via 3-Hydroxypropionic Acid from Lignocellulosic Biomass

Background/objective

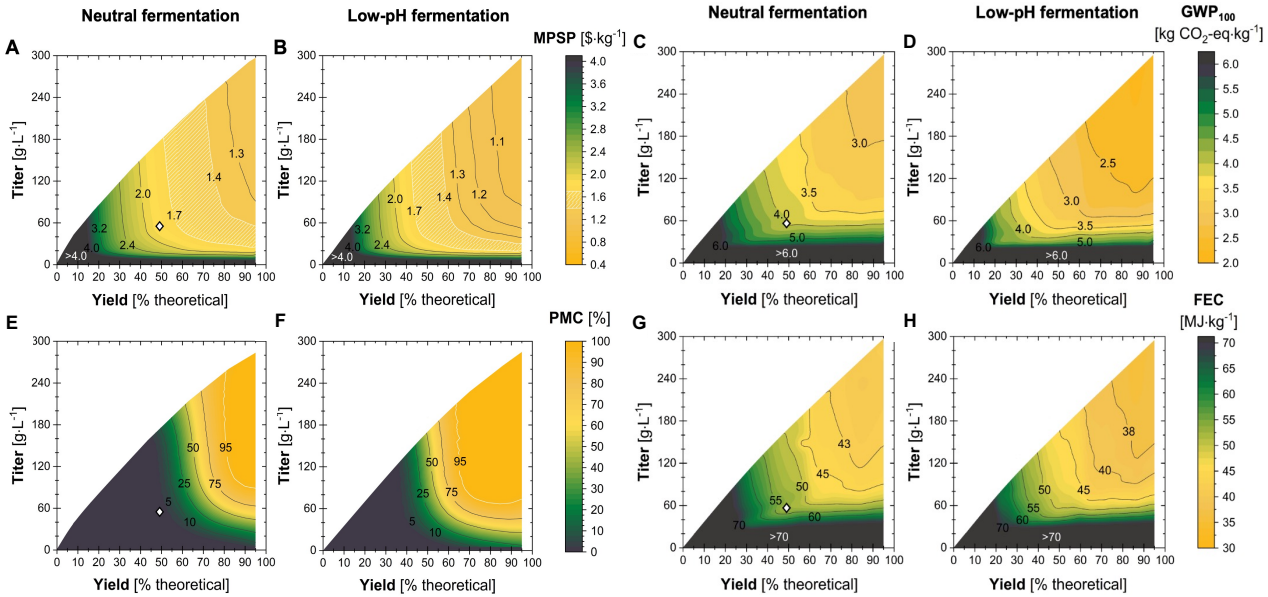
Lignocellulosic biomass is a promising renewable feedstock for sustainable production of biofuels and bioproducts. 3-hydroxypropionic acid (3-HP) is an emerging bioproduct of particular interest as a platform chemical to produce commercially significant chemicals such as acrylic acid. This study leverages the open-source BioSTEAM platform to design, simulate, and evaluate biorefineries producing acrylic acid via fermentation of sugars to 3-HP.

Approach

- Through techno-economic analysis (TEA) and life cycle assessment (LCA) under uncertainty, the minimum product selling price (MPSP), probability of market competitiveness (PMC), 100-year global warming potential (GWP_{100}), and fossil energy consumption (FEC) were estimated for current technology and across potential future improvements (e.g., to fermentation performance).
- Sensitivity analysis was performed to identify key drivers of costs and environmental impacts.

Results

- Simulations representing current technology resulted in acrylic acid MPSP above the high end of the market range — and GWP_{100} and FEC lower than those of conventional acrylic acid production.
- Targeted improvements were recommended for fermentation 3-HP yield and titer as well as solids loading during saccharifications, which would make the MPSP, PMC, GWP_{100}, and FEC highly competitive with both conventional (fossil-derived) acrylic acid and glycerol-derived acrylic acid.



***[A,B]* MPSP, *[E,F]* PMC, *[C,D]* GWP_{100}, and *[G,H]* FEC for the neutral and low-pH fermentation scenarios, respectively. Diamonds represent the current state of technology.**

Significance

This work demonstrates that agile TEA-LCA can be used to screen promising biorefinery designs, navigate sustainability trade-offs, prioritize research needs, and establish a roadmap for continued development of bioproducts and biofuels.

Bhagwat et al. 2021. "Sustainable Production of Acrylic Acid via 3-Hydroxypropionic Acid from Lignocellulosic Biomass." ACS Sustainable Chemistry & Engineering. DOI:10.1021/acssuschemeng.1c05441

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