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Sustainable Triacetic Acid Lactone Production from Sugarcane by Fermentation and Crystallization

Background/Objective

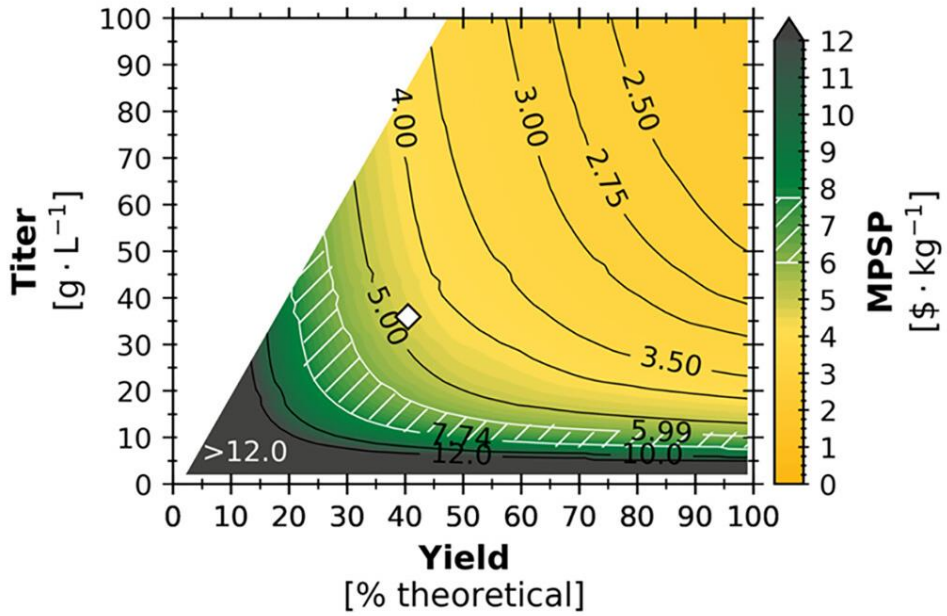
Triacetic acid lactone (TAL) has the potential to serve as a bioderived platform chemical for commercial products including sorbic acid. However, TAL currently lacks a global market as its chemical synthesis is prohibitively expensive. In this study, researchers leveraged BioSTEAM to design, simulate, and evaluate biorefineries for fermentative TAL production from sugarcane.

Approach

Researchers experimentally characterized TAL solubility, calibrated solubility models, and designed a process to separate TAL from fermentation broth via crystallization. They used BioSTEAM to design, simulate, and evaluate – using techno-economic analysis (TEA) and life cycle assessment (LCA) – TAL production from sugarcane. To drive down cost and carbon intensity (CI), they subsequently explored the theoretical fermentation space, operation scheduling and capacity expansion strategies, and potential separation improvements.

Results

The biorefinery modeled using state of the art technology could produce TAL at minimum product selling price (MPSP) of \$3.73-5.86 kg^{-1} (5^{th}-95^{th} percentiles, baseline at \$4.60 kg^{-1}) and carbon intensity (CI) of 5.31 [2.60-8.71] kg CO_2-eq·kg^{-1}. Advancements in key design and technological parameters could further reduce MPSP by 51% to \$2.26 kg^{-1} [\$1.97-2.80 kg^{-1}] and CI by 43% to 3.05 [1.91-4.15] kg CO_2-eq·kg^{-1}.



Minimum product selling prices as a function of titer and yield. White hatching indicates maximum viable TAL selling prices as a feedstock for sorbic acid production. White diamond indicates baseline yield-titer combination (40.5% theoretical and titer of 35.9g·L^{-1}).

Significance/Impacts

This work highlights the ability of agile TEA-LCA to screen promising designs, navigate sustainability trade-offs, prioritize research needs, and chart quantitative roadmaps to advance bioproducts and biofuels.

Bhagwat et al. 2025. "Sustainable Triacetic Acid Lactone Production from Sugarcane by Fermentation and Crystallization" *ACS Sustainable Chemistry & Engineering.* DOI: 10.1021/acssuschemeng.5c04797.