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Characterizing the Potential for Sustainable Azelaic Acid Production from High-Oleic Vegetable Oil Using Two-Step Oxidative Cleavage

Background

Azelaic acid is a renewable monomer used in the production of lubricants, polymers, and skincare. While conventionally produced via the energy-intensive ozonolysis of oleic acid, recent advances enable its production from high-oleic vegetable oil via two-step oxidative cleavage (TSOC) process, improving process safety. This work characterizes the financial viability and environmental implications of this new process.

Approach

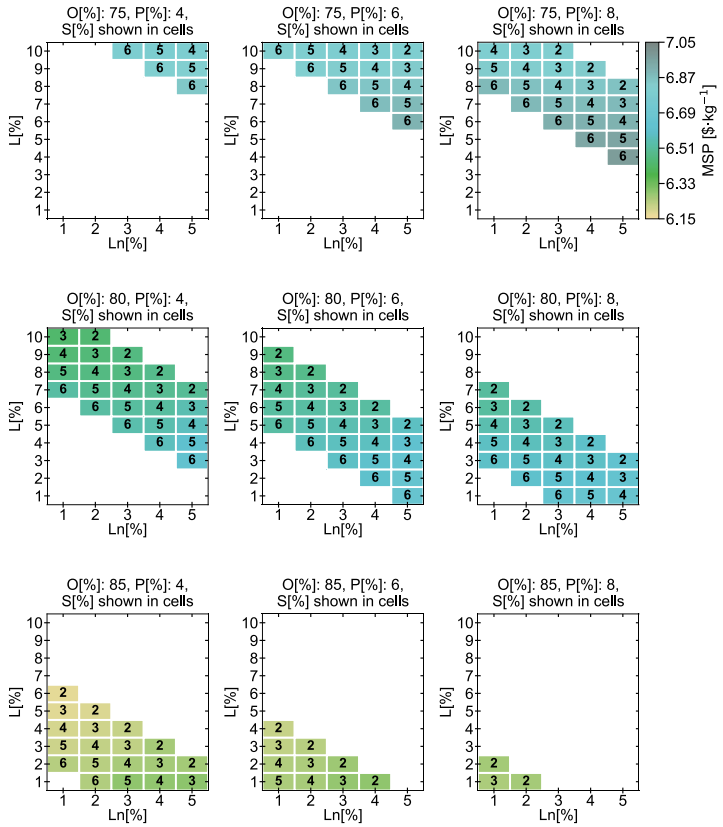
Researchers developed a biorefinery model in BioSTEAM to evaluate industrial-grade azelaic acid production from high-oleic soybean oil using the TSOC pathway. The model consists of biodiesel production, catalyst recovery and recycle, and downstream separation to produce azelaic acid and other co-products. Techno-economic analysis (TEA) and life cycle assessment (LCA) were performed under uncertainty and global sensitivity analysis was conducted to identify key drivers of minimum selling price (MSP) and carbon intensity (CI).

Results

The modeled system produced azelaic acid at a market-competitive MSP of 8.32 [4.93-13.34] \$ kg^{-1} (median, 5^{th}-95^{th} percentiles), below the minimum estimated market prices of 9.93 \$ kg^{-1}. It has the potential to approach carbon neutrality (0.0 [-5.5 to 5.6] kg CO_2-eq kg^{-1}) under displacement allocation. Improvements to dihydroxylation and oxidative cleavage conversions would reduce MSP and CI. Increasing feedstock triolein content would further lower MSP by \$0.82 kg^{-1}.

Significance

This demonstrates the potential for financially viable azelaic acid production from high-oleic soybean oil and the utility of agile TEA/LCA for evaluating and improving performance. The open-source modeling framework developed can be readily applied to assess azelaic acid production from other high-oleic vegetable oils and emerging lipid feedstocks by adjusting composition, cost, and process assumptions.



Influence of triacylglyceride (TAG) composition on azelaic acid MSP. Rows correspond to fixed triolein content (%O as wt%), columns to fixed tripalmitin content (%P as wt%). For each subplot, y-axis shows trilinolein (%L), x-axis shows trilinolenin (%Ln), and tristearin (%S) is noted in each cell.

Kudli et al. 2025. "Characterizing the Potential for Sustainable Azelaic Acid Production from High-Oleic Vegetable Oil Using Two-Step Oxidative Cleavage." *ACS ES&T Engineering*. DOI: 10.1021/acsestengg.5c00853.