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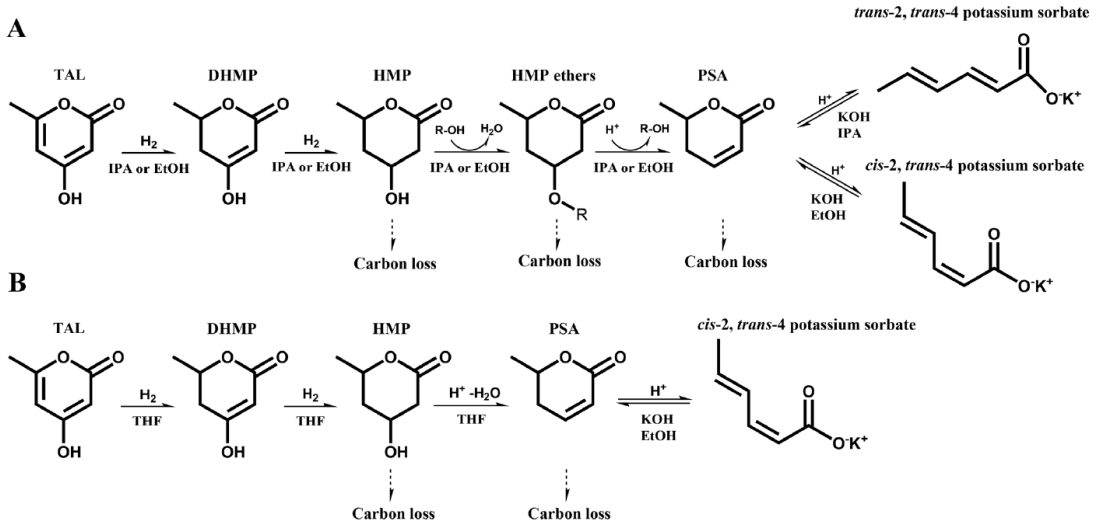
Sustainable Potassium Sorbate Production from Triacetic Acid Lactone in Food-Grade Solvents

Background/Objective

Potassium sorbate (KS) is a food preservative, which has historically been chemically derived from petroleum. However, there is growing demand for bio-based alternatives to petroleum-based products. Prior work described the production of KS from triacetic acid lactone, a bio-derived platform chemical, in tetrahydrofuran (THF) solvent. This work improves upon that process by producing KS in the food-safe solvents ethanol (EtOH) and isopropanol (ISP).

Approach

This study used a catalytic approach to converting TAL to KS in food-grade EtOH and ISP solvents. The three main steps were hydrogenation, etherification and hydrolysis, and ring-opening hydrolysis. Subsequent technoeconomic analysis (TEA) and life cycle assessment (LCA) modeled key economic and environmental metrics associated with scale-up of this process using sugarcane as an initial feedstock.



Reaction pathways for producing TAL-derived KS in (A) EtOH and ISP and (B) THF and EtOH.

Results

KS production in IPA led to higher yield and reduced reaction time compared to EtOH. Reaction time in IPA was 35.7 h compared to 42.1 h in the previous study using THF, while achieving a KS yield of 84% from TAL. TEA and LCA estimated full-scale production of KS from sugarcane via the new IPA process could achieve a minimum product selling price (MPSP) of $8.27/kg [$7.06-10.16/kg, 5th-95th percentiles] and carbon intensity (CI) of 13.7 kg [9.6-18.6] CO_2-eq/kg. Both metrics were improvements over the previous THF-based method (MPSP of $9.68/kg [$8.47-11.45/kg], CI of 16.2 kg [12.0-21.2] CO_2-eq/kg).

Significance/Impacts

This work provides a new approach for the synthesis of bio-based KS in a food-safe solvent. Future improvements in titer and yield of biological TAL production, catalyst turnover frequency, and reduced reaction temperature would improve the process and its sustainability metrics.

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