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3-Hydroxypropionic Acid Recovery from Fermentation Broth Through Novel Downstream Processing: Technoeconomic Analysis

Background/Objective

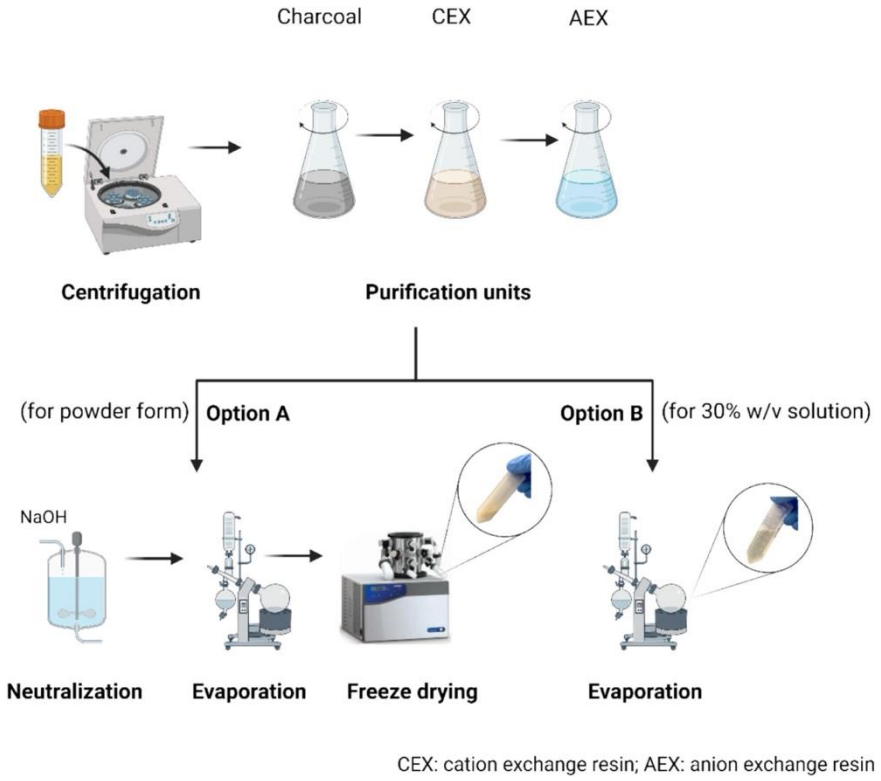
Currently, 3-hydroxypropionic acid (3-HP) is produced almost exclusively via chemical synthesis. We previously developed a more cost-effective fermentation production process by leveraging the low-pH tolerant yeast *I. orientalis* to eliminate the acidification step in downstream processing (DSP). This study validated a simplified, fully solvent-free DSP strategy for high-purity recovery of 3-HP from real fermentation broth.

Approach

First, key purification steps were optimized: Two activated carbon treatments were tested for color removal, and ion-exchange conditions (pH, temperature, resin dosage, and adsorption time) using Amberlite IRA-67 were optimized for impurity removal and minimizing 3-HP loss. Then, the DSP scheme was experimentally validated at lab scale before being adapted to an industrially relevant scale. TEA was performed to assess capital costs, operating costs, and minimum selling price (MSP).

Results

The optimized activated carbon treatment achieved 98% color removal, while Amberlite IRA-67 was operated at pH 4.5 and 30 °C to minimize product loss. At lab scale, the process achieved 77% recovery of sodium 3-HP with 83% (w/w) purity and produced a 30% (w/v) aqueous solution. TEA yielded MSP of $0.55/kg for the solution and $0.89/kg for the salt, both below target thresholds for cost-competitive bio-acrylic acid production.



Schematic of process flow diagram.

Significance/Impacts

This is the first integrated, solvent-free recovery of bio-based 3-HP as both a solid sodium salt and a concentrated aqueous solution, supported by techno-economic analysis, which demonstrates an efficient, scalable, and economically viable industrial pathway.

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