Striking Solvent Effect on Continuous Catalytic Hydrogenation of High-Concentration HMF to THFDM for Bio-lubricant Production

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Abstract

Lubricants play a vital role in machinery by reducing friction between moving components, thereby enhancing operational efficiency, prolonging equipment lifespan, saving energy, and lowering greenhouse gas emissions. Based on the outstanding properties of being biodegradable and renewable, bio-lubricants have gained significant attention as sustainable alternatives to conventional lubricants. Our work highlighted the potential of bio-based esters synthesized from 2,5-tetrahydrofurandimethanol (THFDM) and fatty acids as promising lubricant candidates. THFDM, a diol containing a tetrahydrofuran ring, is a high-value platform chemical derived from the catalytic hydrogenation of 5-hydroxymethylfurfural (HMF), a key biomass-derived intermediate. However, the instability of HMF, especially at high concentrations, has posed challenges for scalable THFDM production. To address this, we developed a continuous-flow hydrogenation process using a high-concentrated HMF (25 wt.%) as a feedstock. By optimizing solvent conditions, the process achieved high THFDM yield and selectivity even at elevated WHSV (h-1), while maintaining excellent catalyst stability over time. This work not only demonstrates a viable and scalable route for green THFDM production but also paves the way for its application in the formulation of renewable ester-based lubricants, supporting the transition to a carbon-neutral future.

Keywords

HMF hydrogenation, Bio-lubricant, Continuous flow system.