Chemical Engineering Doctoral Defense

Separations of Biofuels and Bioproducts via Magnetic Mesoporous Carbons

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abstract

The aims of this project are to demonstrate the design and implementation of separations modalities for 1) in situ product recovery and 2) upstream pretreatment of toxic feedstocks. Many value-added bioproducts such as alcohols (ethanol and butanol) developed for the transportation sector are known to be integral to a sustainable future. Likewise, bioproduced aromatic building blocks for sustainable manufacturing such as phenol will be equally important. The production of these compounds is often limited by product toxicity at 2- 20 g/L, whereas it may desirable to produce 20-200 g/L for economically feasible scale up. While low-cost feedstocks are desirable for economical production, they contain highly cytotoxic value-added byproducts such as furfural. It is therefore desirable to design facile detoxification methods for lignocellulose-derived feedstocks to isolate and recover furfural preceding ethanol fermentation by Escherichia coli. Correspondingly it is desirable to design efficient facile in situ recovery modalities for bioalcohols and phenolic bioproducts. Accordingly, in-situ removal modalities were designed for simultaneous acetone, butanol, and ethanol recovery. Additionally, a furfural removal modality from lignocellulosic hydrolysates was designed for upstream pretreatment. Solid-liquid adsorption was found to serve well each of the recovery modalities characterized here. More hydrophobic compounds such as butanol and furfural are readily recovered from aqueous solutions via adsorption. The primary operational drawback to adsorption is adsorbent recovery and subsequent desorption of the product. Novel magnetically separable mesoporous carbon powders (MMCPs) were characterized and found to be rapidly separable from solutions at 91% recovery by mass. Thermal desorption of value added products was found efficient for recovery of butanol and furfural. Fufural was desorbed from the MMCPs up to 57% by mass with repeated adsorption/thermal desorption cycles. Butanol was recovered from MMCPs up to an average 93% by mass via thermal desorption. As another valuable renewable fermentation product, phenol was also collected via in-situ adsorption onto Dowex Optipore L-493 resin. Phenol recovery from the resins was efficiently accomplished with tert-butyl methyl ether up to 77% after 3 washes.

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