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Advanced Biorefinery Downstream Processing by Selective Liquid Adsorption

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PURPOSE OF THE ABSTRACT

Cost and energy efficient downstream purification of aqueous reaction and fermentation mixtures are main challenges in biorefinery processes. Liquid phase adsorption offers great potential to replace downstream processes which are energy intensive and yield undesired by-products. Here we present hypercrosslinked polymers (HCP) as versatile adsorbents showing high capacity and selectivity compared to conventional adsorbents.

Promising platform chemicals from biomass have been chosen to evaluate the potential of liquid phase adsorption. Hydroxymethylfurfural (HMF) derived from fructose showed excellent adsorption and desorption behavior in batch experiments with the HCP adsorbent.[1] The HCP's high specific surface area and small particle size seemed to play a key role. But, not only textural properties are of importance. The adsorbents' polarity was qualitatively described by water vapor physisorption experiments. HCP shows an outstanding hydrophobicity resulting in no adsorption of water in contrast to activated carbon or typical zeolites. Thus, the adsorption of less polar substances such as HMF compared to fructose is highly favored. The adsorption data was fitted to different adsorption models whereby the Langmuir model fits the best for HMF. In single as well as multiple solute adsorption experiments with equimolar concentrations, HMF was preferentially adsorbed on HCP compared to fructose. Even the adsorption of levulinic acid (rehydration product of HMF) in presence of fructose is considered to be favorable. Nevertheless, HMF and levulinic acid compete in adsorption because both show a rather high affinity for HCP. Further biogenic platform chemicals have been successfully tested in our group, i.e. itaconic acid and lactic acid derived by fermentation from glucose.[2,3] The adsorption affinity for organic acids can be influenced by the pH value. With increasing pH, the organic acid uptake on HCP decreases significantly whereas the adsorption of glucose remains almost constant. The higher polarity due to the organic acid's deprotonation enhance the repulsion forces on the hydrophobic adsorbent. With that knowledge continuous adsorption/desorption studies were conducted in a fixed-bed column setup filled with the adsorbent to confirm the technical applicability. HCP was evaluated due to its textural properties as a fine powder. The resulting high pressure drop and mass transfer limitations have to be further investigated. Organic solvents were successfully proven as eluent to recover 100 % of the organic acids. Comparing the ideal model solutions with real fermentation broth, the selectivity towards the organic acid is slightly decreased which can be explained by the presence of ions (?salting-out? effect).

In conclusion HCP exhibits a great potential regarding selective adsorptive separation technologies for future downstream processes in the utilization of renewable feedstock. Furthermore, synergistic effects related to polarity differences (pH dependency) on the adsorptive selectivity could be integrated for technical applications and require our further investigation.

FIGURES

FIGURE 1

FIGURE 2

KEYWORDS

Biomass | Separation | Adsorption | Porous Polymer

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