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Hydrophobic Zeolites for Applications in Adsorption and Catalysis

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ABSTRACT

Lewis acidic zeolites such as Sn-Beta are commonly studied for use as selective catalysts for glucose isomerization to fructose in liquid water. Glucose to fructose isomerization is a critical reaction for lignocellulosic biomass upgrading, which converts abundant and renewable feedstocks into commercially desirable fuels and chemicals.

Industrial applications require catalysts that maintain optimal reactivity over long time scales, yet at typical reaction temperatures, Lewis acidic Beta zeolites are known to deactivate in liquid water through poorly understood mechanisms. Recent work in our group has shown that interactions between water and Sn-Beta zeolites can cause leaching of active Sn sites from the zeolite framework, and can also hydrolyze siloxane linkages to form silanol groups that also lower catalytic isomerization rates. This study investigates how water exposure and treatment affects the structure of Sn-Beta, by systematically changing the water contact time and analyzing the resulting glucose isomerization rates, in order to determine the catalysts and treatments to maintain optimal reactivity. Functionalization procedures were performed on Sn-Beta using hydrophobic alkylsilane precursors to form an external hydrophobic shell and minimize water diffusion into the zeolite pores. Limiting water contact may slow the deactivation rates caused by active Sn site leaching or silanol group formation.

Functionalized zeolites showed a substantial decrease in initial glucose isomerization rates compared to that of untreated zeolites, however, reaction rates remain constant for longer time scales after functionalization, suggesting that silylation treatments may improve time-on-stream stability of Sn-Beta catalysts in liquid water.

KEYWORDS

Glucose isomerization, Lewis acidic zeolites, Silylation, Biomass upgrading