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Design of base catalysts for the catalytic deoxygenation of bio-oil by aldol condensation

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The development of cost-efficient pathways to deoxygenate crude bio-oil will contribute greatly to the sustainable production of biomass-derived fuels, as established methods, such as catalytic cracking or hydrodeoxygenation, suffer from low carbon yield and excessive hydrogen consumption, respectively. A cascade combination of three catalytic transformations combining pyrolysis, intermediate deoxygenation, and a subsequent hydrodeoxygenation step could address both issues simultaneously. Among different deoxygenation strategies, we are investigating the development of efficient base catalysts to exploit the intrinsic reactivity of aldehydes for deoxygenation via aldol condensations. Three different catalytic systems are considered: alkali metal-doped high-silica zeolites, supported MgO catalysts, and hydroxyapatites. The optimization of the concentration and strength of basic sites is shown to be the key to attain catalysts combining excellent activity and stability with a high selectivity in the self-condensation of propanal, which is studied as a model reaction. To evaluate the deoxygenation performance of the optimized catalysts under more realistic conditions, the complexity of the reaction mixture is increased stepwise by co-feeding water and acetic acid as representative components in bio-oil. Preliminary results for acetic acid-propanal mixtures (5-95%v/v) have revealed that the alkali metal-doped high-silica zeolites and supported MgO catalysts retain their stable and selective character, whereas the activity decreases (by ca. 50%) in all cases. The catalytic insights obtained with realistic mixtures are expected to be the key to rationalize the performance obtained with real bio-oil.

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