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Zeolites and related catalysts for the conversion of biomass

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Biomass derived molecules are expected to play an increasingly more important role in the chemical and petrochemical industries. Acid catalyzed steps are key in many of the value chains starting from biomass, and thus zeolites and related catalysts can advantageously be used for such conversions. The presentation will highlight the importance of such catalytic steps by several illustrative examples.

Copper nanoparticles incorporated in ordered mesoporous moderately acidic □-alumina were found to be highly active catalysts for the direct synthesis of dimethylether from biomass-derived synthesis gas. This catalyst integrates both the functionality for methanol production from syngas and for the ether formation, and it surprisingly does not require the Zn-compound normally needed for syngas conversion to methanol.

The thermochemical route via syngas can basically use any biomass as starting material. Other pathways are more specific: Biodiesel production from oils and fats results in glycerol formation as byproduct. The glycerol can be dehydrated to acrolein over acid catalysts and thus a link to conventional value chains of the chemical industry can be established. In a systematic study of zeolites for this process, guidelines for an optimal catalyst have been established: well performing catalysts should have a high concentration of acid sites and consist of small particles, to minimize mass transfer limitations. Another interesting route starting from glycerol is the synthesis of solketal, a potential fuel additive. Some zeolites are suitable for this reaction, but it has been found that tailored porous acidic polymers, obtained by hard templating, are the best catalyst systems for solketal synthesis.

Other value chains start from cellulose or lignocellulose. The first challenge is the depolymerization of this highly recalcitrant biopolymer. A mechanically assisted acid catalyzed process has been developed which allows quantitative depolymerization to fully water soluble oligomers in short times. The resulting sugars can then be further converted, either by acid catalysis to different platform molecules, or via fermentation routes to ethanol. Ethanol can then be used directly as fuel, or can be transformed further to value-added products. Acetic acid is often synthesized by biochemical pathways from ethanol. Alternatively, various porous, platinum modified catalysts can be used for the aerobic oxidation of ethanol to acetic acid with high selectivity and yield, the best catalysts being porous polymers modified with platinum particles.