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Catalysis for the Production of Chemicals and Fuels from Biomass

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Abstract:

Lignocellulose is becoming an increasingly important alternative feedstock for the manufacturing of bio-based fuels, chemicals and materials. Furthermore, modern lignocellulosic biorefinery operations should produce base and fine chemicals as well as transportation fuels and materials in order to be fully competitive, making use of all the major components of lignocellulose. The required overall efficiency of future biorefineries is especially true in view of the recent developments on shale gas, which are currently occurring in the USA. Indeed, a major shift to lighter feeds, such as shale gas and tight oil, strongly impacts the overall availability of propylene, butadiene, and aromatics (BTX, i.e., benzene, toluene, and xylene) as well as the overall competitiveness of bio-refineries. In other words, on-purpose biomass-based production routes of important building blocks are the path forward and will make the chemical industry in the long run more sustainable.

In this lecture, I will discuss recent advances in making biomass-derived oxygenates (from the sugar fraction of biomass) and phenolics (starting from lignin). Lignin is a complex aromatic polymer, which holds great potential for the sustainable production of renewable aromatics and phenolics. However, the catalytic conversion of lignin is highly challenging. This is mainly due to the recalcitrance and highly heterogeneous nature of lignin. We will discuss our progress in transforming different types of lignin into mixtures of phenolics. This mixture can then be used for the manufacturing of ethylbenzene (and later on styrene via a dehydrogenation step), produced via the alkylation of benzene with bio-ethanol making use of zeolites as solid catalyst. In the case of oxygenates we will focus on levulinic acid as an interesting platform molecule for chemicals via selective hydrogenation processes. In each of these cases it is of importance to have detailed insight in the working principles of these catalyst systems as well as in their deactivation pathways. Spectroscopy plays an important role in trying to elucidate the intricacies of activation and deactivation pathways of the different solid catalysts under study.