Catalytic Conversion of Carbohydrates

Modern civilization is dependent on oil to supply energy for power, heating and transportation and carbon for the production of the plethora of chemicals needed. Oil is however a limited resource and alternatives need to be identified before we freeze in the dark [1]. This thesis deals with the production of commodity chemicals from the most abundantly available renewable source of carbon, carbohydrates. The production of alkyl lactates by the Lewis acid catalyzed conversion of hexoses is an interesting alternative to current fermentation based processes. A range of stannosilicates were investigated for this reaction; Sn-BEA, a zeolitic Lewis acid, displays a remarkably high activity for this reaction due to the presence of a uniquely strong acid site, a site which is not observed in other stannosilicates and is therefore likely related to the silicate structure. The tin site in Sn-BEA was studied using DFT calculations, which indicate that the strongest, and most stable, acid site is formed through the introduction of a silicon vacancy adjacent to the tin site.

Aromatics are an important class of compounds. In particular benzene, toluene and p-xylene finds use in a wide range of industries. The synthesis of these by the cycloaddition of ethylene to furanic compounds, followed by dehydrative aromatization, was demonstrated in good yields, using a strong Brønsted acidic catalyst, WOx/ZrO2. As both ethylene and furanics can be derived from carbohydrates by known processes, this constitutes a renewable route to aromatics. The conversion of biomass by high temperature processes is a desirable prospect due to the high volumetric production rates which can be achieved, and the ability of these types of processes to convert a wide range of substrates. Current processes however typically have rather low selectivity towards any particular compound, which can be problematic for chemicals production. In the current work, a process for converting monosaccharides by high temperature thermolysis was investigated. A wide range of substrates could be converted with a high selectivity towards C1- to C3-oxygenates through thermal retro-aldol condensations. One compound, glycolaldehyde, could be prepared in yields of over 60% by this method; as this compound can potentially be used as a starting point for producing a wide range of chemicals, such as ethylene glycol or acetic acid, this process could prove to be an efficient initial conversion step in the utilization of biomass for chemicals production. The shift from an oil based chemical industry to one based on renewable resources is bound to happen sooner or later, however the environmental problems associated with the burning of fossil resources means that it is desirable to accelerate the process. To this end, processes for efficiently converting biomass to commodity chemicals are needed, and the above mentioned processes are a small step towards this goal.