

Thermal Conversion Of Biomass And Biomass Components To Biofuels And Bio-Chemicals

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With declining petroleum resources, increasing fuel demands and growing concerns about the effects of carbon dioxide emissions from fossil fuels, it is imperative to find sustainable resource for energy and chemicals. Biomass is a renewable resource for sustainable production of fuels and chemicals that, to date, have been made primarily from fossil resources. Lignin is a major natural aromatic polymer and a main constituent of lignocellulosic biomass; however, it has received less biorefining efforts than plant polysaccharides. For example, the US paper industry produces over 50 million tons of extracted lignin per year but only 2% is used commercially in products. The remainder is burned as a low value fuel to recover energy. Therefore, one step thermal conversion of lignin and biomass to gasoline range (molecular weight is ~ 105 g/mol) of simple petrochemicals such as benzene, toluene, xylene, phenol and catechol appears to be very pragmatic. Further upgrading process including hydrogenation of pyrolysis oils to produce total aliphatic products also provides insight into the conversion from biomass to fuels.

This thesis examined the conversions of biomass and biomass components to petrochemicals and total aliphatic gasoline like products. There are three major projects of the thesis. Since biomass is very complicated, to understand the thermal decomposition pathways of biomass, the pyrolytic behaviors of various biomass components including lignin and cellulose under different reaction were investigated in the first phase. Due to complexity and limited volatility, the thermal decomposition products from biomass bring insurmountable obstacles to the traditional analysis methods such as GC-MS, UV and FT-IR. Therefore, precise characterization of the whole portion of thermal decomposition products has significant impacts on providing insight into the pyrolysis pathways and evaluating the upgrading processes. Various NMR methods to characterize different functional groups presented in liquid and solid pyrolysis products by ^1H , ^{13}C , ^{31}P , 2D-HSQC and solid state ^{13}C -NMR were introduced in the second phase. Nevertheless, the major drawback towards commercialization of pyrolysis oils are their challenging properties including poor volatility, high oxygen content, molecular weight, acidity and viscosity, corrosiveness and cold flow problems. In situ upgrading the properties of pyrolysis oils during thermal conversion process by employing zeolites has been discussed in the third phase. The further hydrogenation of pyrolysis oils to total aliphatic gasoline like products by heterogeneous catalysis in "green medium" – water has also been examined in the third project.