

## Thermochemical Conversion of Biomass to Renewable Fuels

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Valorization of lignocellulosic biomass to renewable biofuels provides a promising solution to address growing concerns regarding energy security and environmental issues. Researchers are breaking the chemical & engineering barriers to efficiently convert lignocellulosic biomass to liquid fuels. The thermochemical deconstruction strategies can be classified into three categories: gasification, pyrolysis, and liquefaction. Pyrolysis and liquefaction are called selective thermal processing which generate liquid products via depolymerization and fragmentation of biomass feedstocks. This dissertation focuses on the pyrolysis and liquefaction of whole lignocellulosic biomass. The liquid products (called bio-oil) are inherently chemical complex, of high oxygen content, low heating values compared to commercial heavy fuels, thus need treatments towards the thermal process to enhance the bio-oil's properties. This dissertation study thoroughly examined thermochemical conversion strategies to generate high quality bio-oils as a fuel precursor. Two major aspects in this dissertation include 1) the biomass pyrolysis and 2) solvent liquefaction. Two strategies have been examined to promote the pyrolysis oils' qualities, including pretreatment and ex-situ catalysis. Two different strategies have been studied during the one-pot liquefaction including the metal chloride additive and a bi-catalyst system of Pd/C and water tolerant Lewis acid.

The major objectives in this dissertation are listed below:

- Investigated the pretreatment effect on the biomass structure and the subsequent pyrolysis oil's properties
- Optimized the auto-hydrolysis pretreatment on biomass towards the "optimal" pyrolysis oils as a fuel precursor
- Accomplished the ex-situ upgrading of the pyrolysis oils using metal oxide catalysts
- Valuate the structures of the ex-situ catalytic upgraded pyrolysis vapors from a bench-scale unit
- Examined the one-step liquefaction of biomass in solvent to produce bio-oils using metal chlorides
- Explored the bi-catalyst system performance in one-step liquefaction of biomass