**Effect of feedstock moisture on solvent liquefaction of biomass in non-aqueous solvents**

**INTRODUCTION**

- Energy to dry biomass to 10 wt% moisture represents about 18% of the energy content of fresh biomass [1].
- Fast pyrolysis typically requires feedstock with moisture content of less than 10 wt% to achieve necessary heating rates [2].
- Solvent liquefaction performance is relatively independent of heating rates [3].
- Since solvent liquefaction utilizes solvents other than water, excessive moisture in feedstock is expected to impact performance.
- Biomass decomposition reactions in water are expected to be different than those in non-aqueous solvents due to the unique properties of water at elevated temperatures.
- Some solvents such as tetralin are recognized to be hydrogen donors.
- Water can hydrolyze ether linkages.
- Ionic dissociation of water reaches its maximum around 280°C.
- Energy to dry biomass to 10 wt% moisture represents about 18% of the energy content of fresh biomass [1].

**METHODOLOGY**

- Experiments were performed in a modified Autoclave reactor with continuous pressure control and vapor condensation that allowed water and other low boiling point compounds to vaporize from the reactor.
- Solvent: Reagent Grade Tetralin.
- Reaction Temperature: 280°C.
- Reaction Pressure: 15 – 70 bar.
- Liquid Analyses: GC-FID, HPLC.
- Solids Analyses: FTIR, Elemental.
- Feedstock moisture was simulated by oven-drying the feedstock to <1 wt% moisture and then re-wetting with specific quantities of deionized water.

**RESULTS & DISCUSSION**

**Liquid Yields**

- Liquid yields consistently increased with increasing moisture for all 3 feedstocks.
- Increasing pressure generally improved liquid yields – most likely due to enhanced solvent penetration.
- Reduction in liquid yields resulted in very low levels of detectable products.

**Solid Yields**

- Solid yields consistently increased with increasing moisture for all 3 feedstocks.
- Increasing pressure reduced solids yields.
- Cellulose residue coagulated into a solid lump at 50 wt% moisture – below 30 wt% solids existed as a powder.
- Lignin residue agglomerated into larger particles and an acetone-insoluble sludge.

**CONCLUSIONS**

- Water had a deleterious effect on liquid yields for tetralin solvent liquefaction resulting in reduction in overall liquid yield as well as reduction in monomer yields.
- Solid yields increased at the expense of liquid yields when the feedstock moisture was increased.
- Humin formation from cellulose indicated acid behavior from water due to ionic dissociation at elevated temperatures and pressures.
- Despite only constituting up to 20 wt% of the solvent mixture, water introduced as feedstock moisture significantly reduced liquid yields and increased solid yields from the liquefaction of loblolly pine, cellulose, and lignin in tetralin.

- Some moisture was required to result in appreciable monosaccharide yields.
- At constant pressure, increasing moisture beyond 5 wt% resulted in a reduction in monosaccharides – most likely due to polymerization of monosaccharides and their derivatives in the presence of water.

**FUTURE WORK**

- Explore the effect of feedstock moisture on alternative non-aqueous solvent systems (e.g.  γ-valerolactone, phenol, etc.)
- Determine the economic impact of fully drying feedstock versus feeding wet feedstock on product yields and qualities.
- Investigate energy and economic impact of separating water from product streams.

**References:**