1. Cellulose and hemicellulose randomly crack into anhydro-oligomers during thermal deconstruction (high temperature solid or liquid phase decomposition)  
2. Competition between further cracking and end-chain unzipping and/or thermohydrolysis determine the pyrolytic yield of the anhydro-monomosaccharide levoglucosan, which is usually less than 60 wt%  
3. We hypothesize that rapidly quenching thermal deconstruction products before end-chain unzipping/thermohydrolysis produces anhydro-oligosaccharides that can be substantially acid hydrolyzed to glucose

**Goal:** Use thermal deconstruction as a biomass pretreatment to make cellulose susceptible to acid hydrolysis for the production of fermentable monosaccharides

**Methodology**

**Thermal Deconstruction as Biomass Pretreatment**
- Performed in free fall reactor  
  - 1 kg/hr  
  - Vapor products condensed in two stage fractions  
  - Solid products quenched by liquid nitrogen  
- Thermal Deconstruction conditions  
  1. Cellulose, 450 °C, 5 SLPM, 5.2 s residence time  
  2. Red oak, 450 °C, 5 SLPM, 1.22 s residence time  
  3. Red oak, 550 °C, 5 SLPM, 1.24 s residence time

**Acid Hydrolysis Experiments (after thermal pretreatment)**
- Thermally pretreated biomass hydrolyzed in sulfuric acid at five concentrations in the range of 200 – 1000 mM heated by an oil bath to 90, 110, or 130 °C  
- Reaction times from 0 – 6 hours (one hour increments)  
- Response surface methodology used to evaluate the effects of temperature, acid concentration, and reaction time  
  - Used SAS JMP 11 to design and analyze a 27 point screening design  
  - Three center points were used to calculate 95% confidence intervals  
- Glucose and xylose concentration determined by HPLC with RI detector

**Summary of Results**

**Cellulose**
- Thermal deconstruction of biomass increases susceptibility to hydrolysis  
- Water-soluble anhydro-oligosaccharides readily hydrolyze to glucose  
- Experiments in progress to determine whether water-insoluble anhydro-oligosaccharides can readily hydrolyze

**Red Oak**
- Optimal conditions for maximizing glucose yield were not found within this RSM  
- Xylose partially decomposes under these hydrolysis conditions  
- Excessive thermal pretreatment reduced glucose yields

**Conclusions**
- High monosaccharide yields are easily obtainable through thermal deconstruction and subsequent hydrolysis  
- Harsher thermal deconstruction conditions resulted in lower hydrolyzed monosaccharides and slightly higher vaporized monosaccharide yield but not enough to justify the harsher thermal conditions  
- With the current hydrolysis apparatus, maximum yields cannot be realized due to the temperature limitations  
- Hemicellulose readily hydrolyzes to xylose significantly faster than cellulose converts to glucose  
- Xylose decomposition indicates a semi-batch or continuous hydrolysis system would significantly increase total monosaccharide yields

**References**

This work was supported by the National Science Foundation (NSF EAGER Award:Abstract 1630404) 
Experimental assistance by Joshua Ohn 
Residence time approximations from Juan Aviles