Increased Sugar Production from Continuous Autothermal Pyrolysis of Hemicellulose Extracted Willow

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INTRODUCTION

Shrub Willow[1]

Background & Motivation:

- **Global push for sustainable energy** is driving the need for advanced renewable fuels.
- **Autothermal pyrolysis** converts biomass into valuable intermediates, which can be upgraded into renewable fuels. Autothermal refers to the partial oxidation of pyrolysis products which provides energy to drive endothermic pyrolysis.[2]
- **Pyrolytic sugars** are derived from cellulose and a key intermediate in bio-oil which can be upgraded to renewable fuels.
- **Challenges in pyrolysis:**
  - **Alkali and Alkaline Earth Metals (AAEM)** negatively impact pyrolytic sugar production by promoting the formation of light oxygenates.[3]
  - **Thermal Instability of Xylose** at pyrolysis temperatures leads to lower yields of hemicellulosic sugars during the pyrolysis process.[4]
- **Hot Water Extraction (HWE)** extracts hemicellulosic sugars from willow as well as removing much of the AAEM from biomass making it a promising pretreatment for pyrolytic sugar recovery.[5]
  - **Hemicellulose Extracted Chips (HEC):** Cellulose and lignin rich biomass resulting from HWE

Hypothesis: Hot water extraction and subsequent autothermal pyrolysis of the HEC willow increases total sugar recovery from willow.

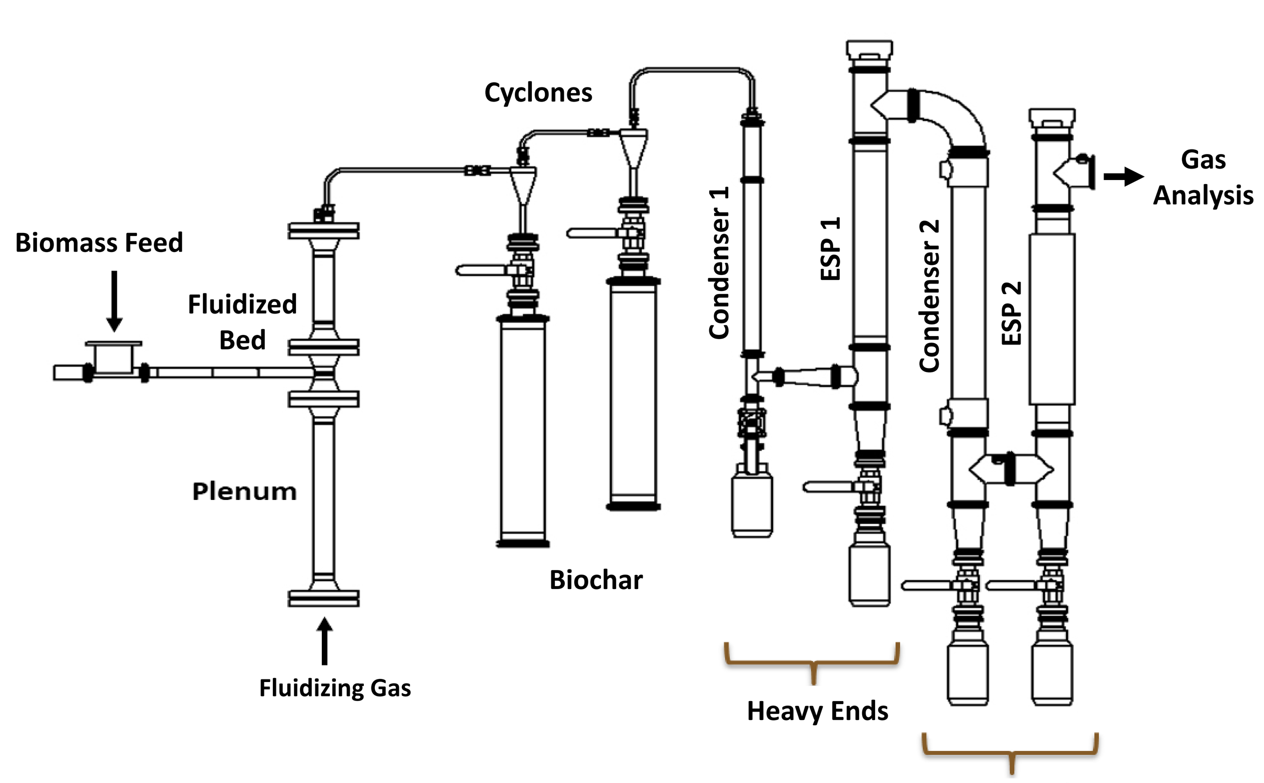
METHODS

Hot Water Extraction

- 4:1 - water : biomass
- 160°C for 120 min
- Mixing: 6 RPM
- Pressure: 15 psi

Autothermal Pyrolysis

- Feed rate ≈ 750 g/h
- Reactor Temp: 500°C
- Vapor Residence time ≈ 1 sec
- Equivalence Ratio: 6-8%

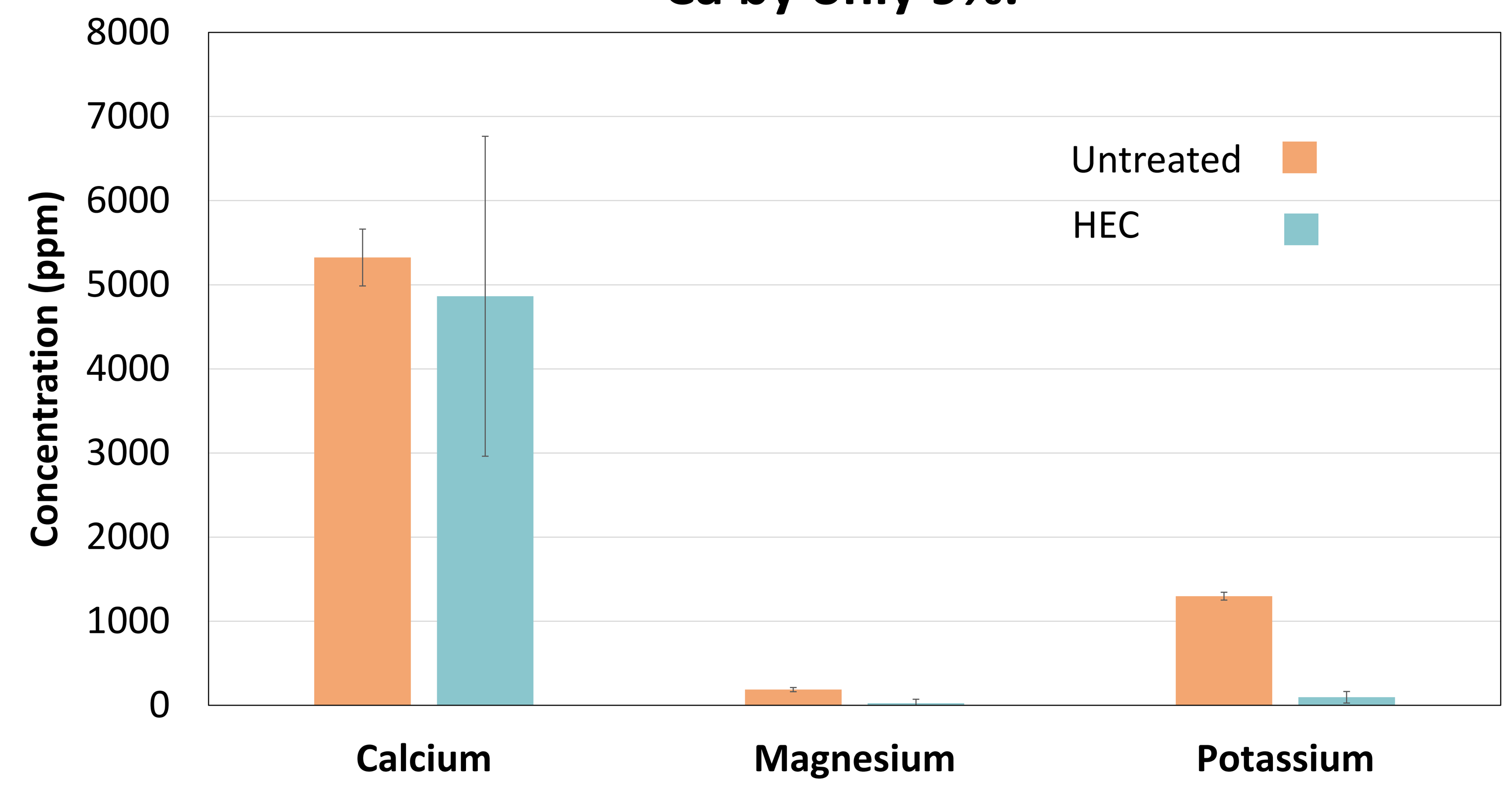


Fluidized bed reactor and stage-fractionation system

Heavy Ends: sugars and phenolics **Light Ends**: light oxygenates **ESP**: electrostatic precipitator

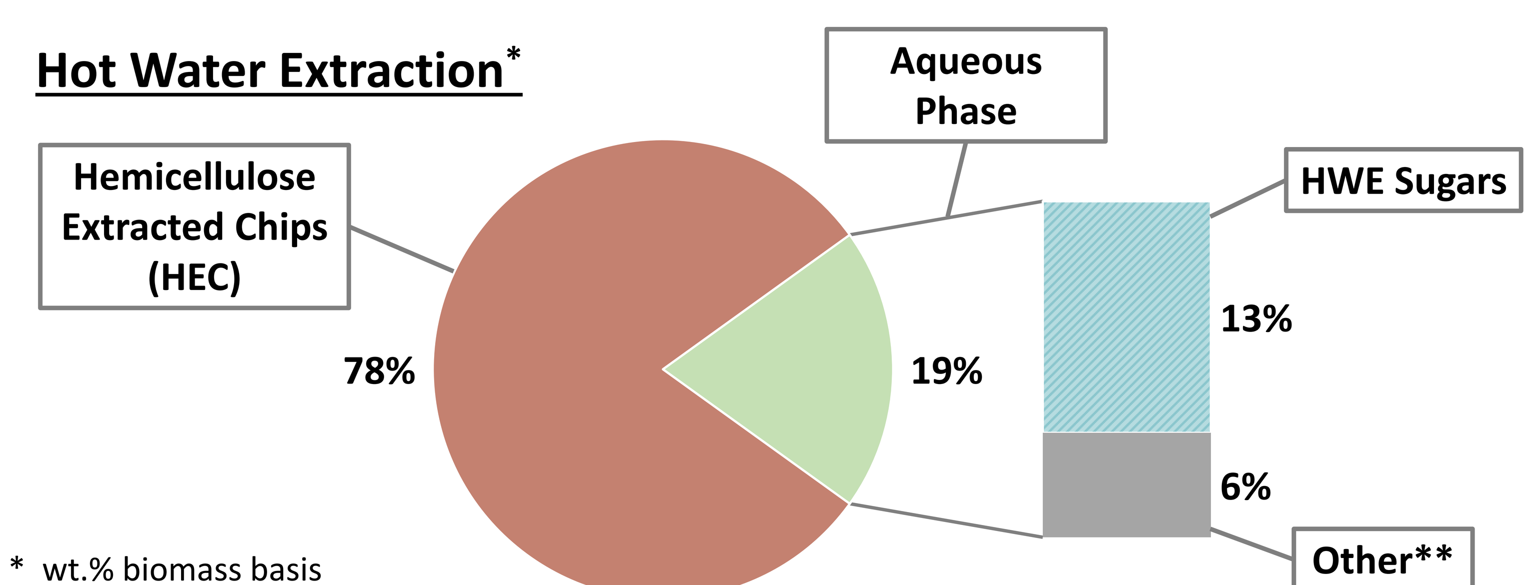
AAEM REMOVAL

HWE reduces K + Mg by 92% but Ca by only 9%.



PROCESS YIELDS

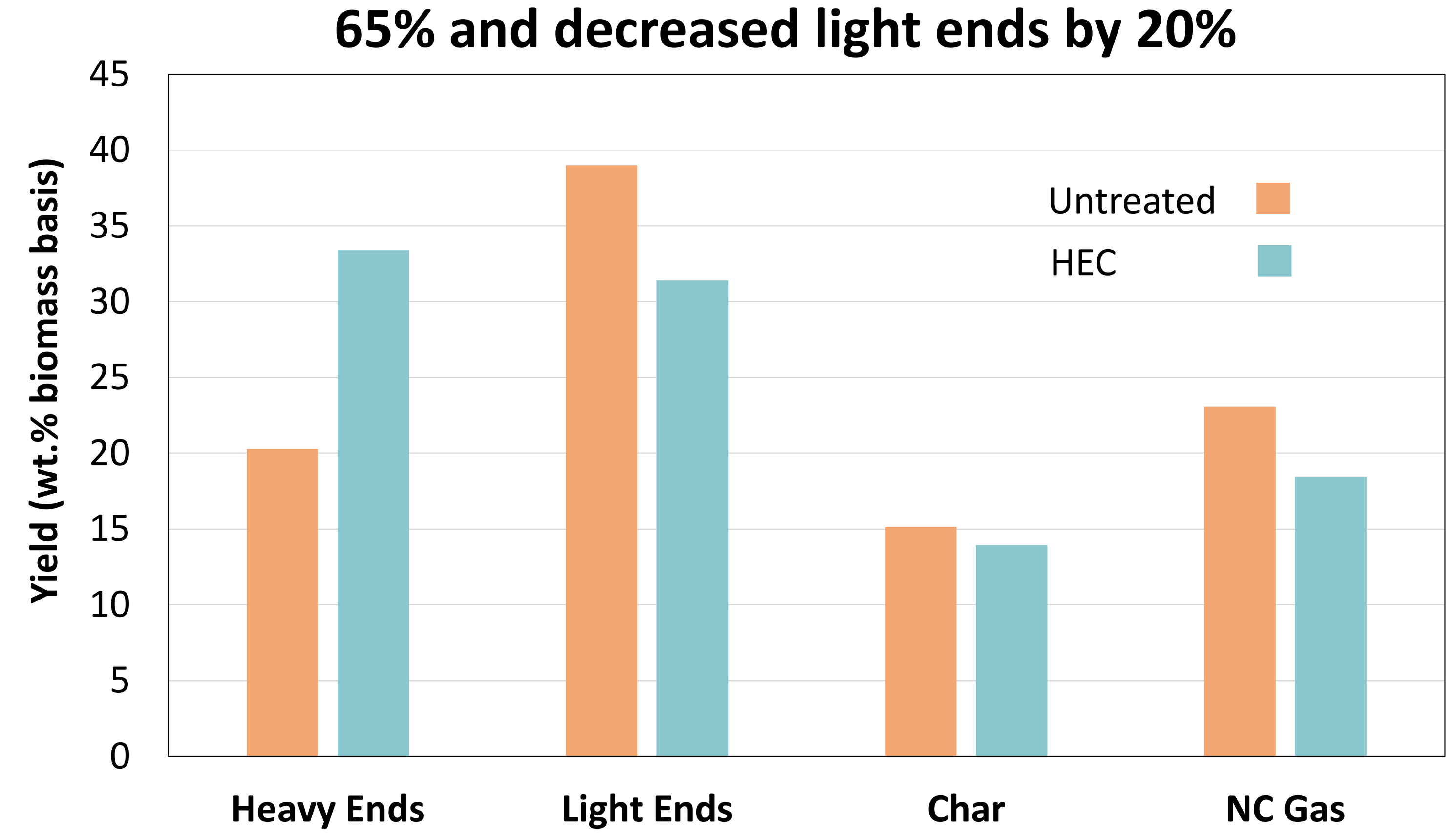
Hot Water Extraction*



* wt.% biomass basis
**acetates, furans, ash, etc.[5]

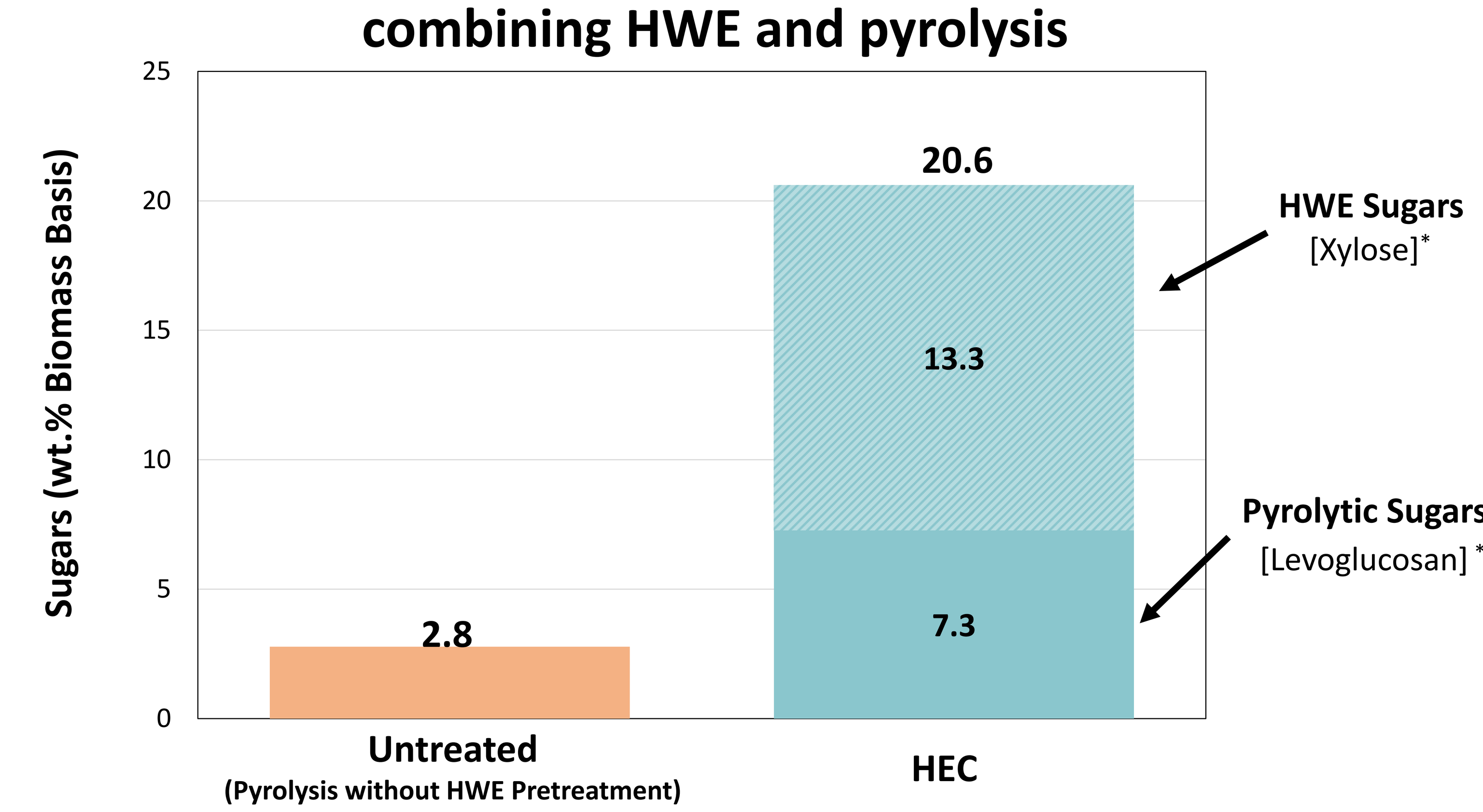
Autothermal Pyrolysis

HWE increased heavy end yield by 65% and decreased light ends by 20%



SUGARS

Total sugar recovery increased 635% by combining HWE and pyrolysis



*Predominantly, but not exclusively

CONCLUSIONS

- Effective Removal of AAEM
- Improved Bio-Oil Yield Distribution
- Enhanced Sugar Recovery

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