Effects of Torrefaction on Willow

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Introduction
Torrefaction is a thermal process that involves heating biomass to temperatures between 200 and 300 °C. Torrefaction evaporates moisture, drives off various low-calorific components and alters the combustion behavior of biomass. Lignocellulosic biomass has three major components; lignin, cellulose and hemicellulose. During torrefaction, hemicellulose decomposes, forming smaller molecules. Lignin remains less modified due to its high stability to temperature. Cellulose chains lose some hygroscopic properties. Benefits of torrefaction include;
- Reduced moisture content
- Reduced O/C ratio
- Reduced grinding energy
- Enhanced energy density
- Storage and transportation benefits
- Increased resistance to biological decay. All these characteristics make torrefied biomass a more suitable bioenergy feedstock.

Objectives
This project compares the raw and torrefied properties of willow. Willow is found primarily in moist soils on cold and temperate regions of the Northern Hemisphere. The main properties of interest include;
- Mass loss
- Moisture content
- Energy density
- Ash content
- Biochemical Conversion Potential
The duration and temperature of the torrefaction process will be varied to investigate the impact of process severity on material properties.

Materials and Methods
- Preparation
Willow was ground using Munson Grinder with a 6 mm screen (Figure 1). A total of 12 samples were prepared of willow with treatment durations of 30, 60, 90 minutes and 200, 220, 240 and 260°C.

Sample Preparation
Samples were torrefied in a batch – mode reactor (50 g per sample). Test conditions consisted of:
- Elevated temperatures (200, 220, 240 and 260°C)
- Nitrogen purge (5 liters/minute)
- Atmospheric pressure
- Specific residence time (30, 60, 90 min.) during torrefaction process (Figure 2).

Results
- The Mass loss ranged from 10 – 49%.
- Moisture of torrefied willow was lower than the raw willow.

Conclusions
- Torrefaction of willow reduces mass and energy, but increases energy density.
- Moisture content is lower and more uniform for torrefied samples.
- Torrefied willow showed potential for biochemical conversion.

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