Eucalyptus Gasification, Tar levels and Conversion

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Research Objectives

This research aims to accomplish two tasks; lower the amount of tar produced during gasification and improve the conversion of char to gas.

1) Lowering the Amount of Tar Produced

This will be investigated by selecting eucalyptus harvested at different ages, young samples will be studied both with the bark and with the bark removed.

2) Improving Char Conversion

The height of the fluidized bed will be increased to improve the conversion of char to syngas (H_2, CO, CO_2, CH_4).

If tar reduction is successful, syngas metrics can determine end use potential.

Background

Eucalyptus Harvesting Cycle

Woody biomass can be harvested at different ages, an advantage over herbaceous crops. Do older eucalyptus trees, having more lignin, produce more tar compounds?

Bed Height, Residence Time and Conversion

The fluidized sand provides heat transfer, longer residence time should "cook" the char more, producing more gas.

Residence Time

$$\tau = \frac{Volume\ of\ System}{Flow\ Rate\ Through\ System}$$

Bed Weight / Height

400g – 7.45 cm
300g – 5.59 cm
200g - 3.73 cm

Types of Eucalyptus, Bed Material and Tar Collection

Eucalyptus samples

Obtained from Dr. Bijay Tamang at ArborGen LLC
(2EWB) = 2 year harvest, with bark
(2EWoB) = 2 year harvest, without bark
(7EWoB) = 7 year harvest, without bark

Bed Material

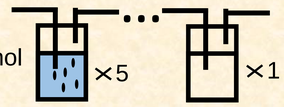
Washed and dried silicon sand from Macron Fine Chemicals.

D = ~ 0.03 cm ρ = 2.65 g cm^{-3}

Tar Samples

Collected using standard method's and analyzed using Gas Chromatography-Flame Ionization Detection (GC-FID)

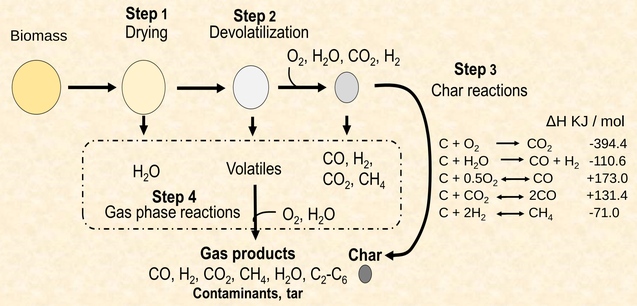
50 ml Isopropanol
0 °C, 25 °C



Analyses of Eucalyptus Samples

	2EWoB	2EWB	7EWoB
Proximate Analysis (Wt. %)			
Moisture	8.72	13.99	14.74
Volatile Combustible Mater	78.40 ± 0.19	72.10 ± 0.31	70.92 ± 0.12
Ash	0.37 ± 0.13	0.60 ± 0.09	0.78 ± 0.05
Fixed Carbon (by difference)	21.23 ± 0.07	27.31 ± 0.29	28.23 ± 0.14
Ultimate Analysis (Wt. %)			
Carbon	50.08± 0.02	51.41± 0.13	54.12± 0.08
Hydrogen	6.11± 0.07	4.34± 0.6	5.48± 0.12
Nitrogen	0.29± 0.01	0.59± 0.01	0.30± 0.00
Oxygen (by difference)	43.51± 0.07	43.65± 0.14	40.09± 0.81

A Closer Look at the Gasification Process



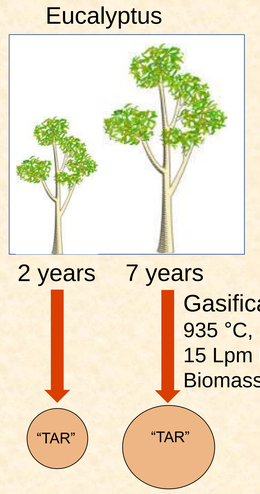
Difficulties with Tar Analysis

Unknown Compounds and High Reactivity

Many of the compounds in tar cannot be detected by GC-FID.

It is thought that some compounds might form aggregates and precipitate out of solution over time.

Older Eucalyptus Trees Produce More Tar



Gasification
935 °C, , ER = 0.25, Gasifying agent = O_2
15 Lpm Nitrogen, Bed weight = 200g
Biomass Dp < 1/16 inch

Younger trees with bark potentially produce ~ 56% less tar.

It is interesting and unexpected that samples with bark produce less tar. To try and explain this, future work will be to analyze the sugar and lignin chemical makeup of the tree samples.

Results

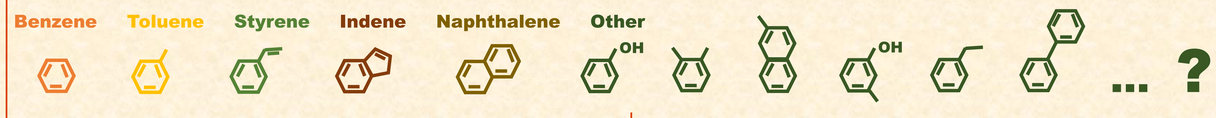
Feed Stock Selection

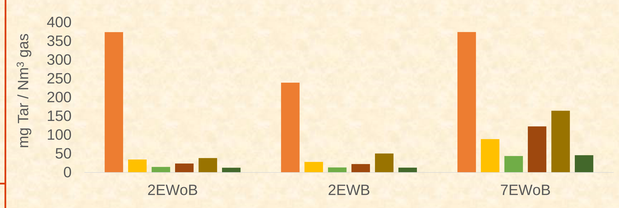
200g Bed Weight

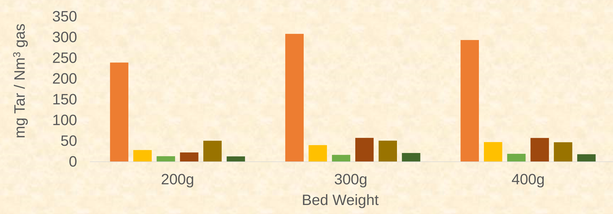
Bed Height

2 Year Eucalyptus with Bark

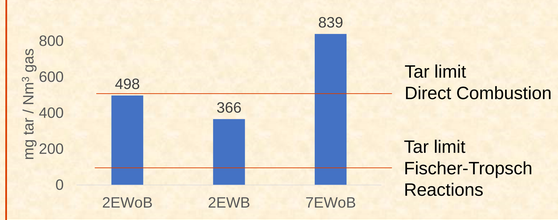
Tar Constituents

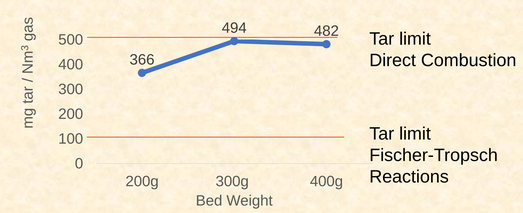




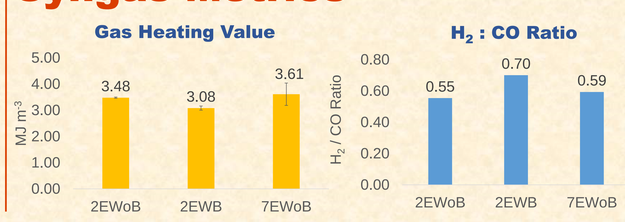


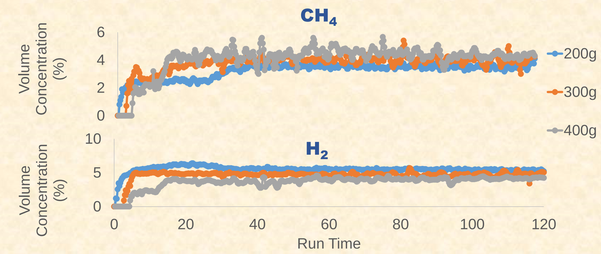
Tar Yield





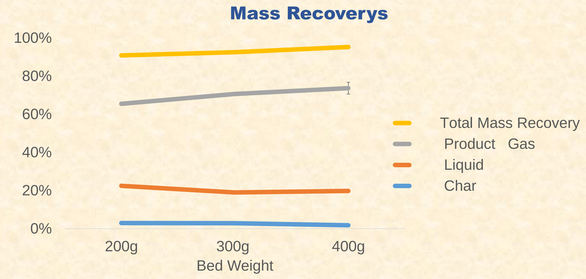
Syngas Metrics





Increasing the Bed Height Improves Char Conversion

A higher gas heating value is a result of more gas being produced, with a higher percentage of that gas being CH_4. The higher levels of CH_4 are a result of char reacting with H_2.



Thanks to

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