Investigation of autothermal operation of a fluidized bed pyrolyzer

**Introduction & Motivation**

- Pyrolysis is an inherently endothermic process which requires heat to convert biomass into higher value bio-oil, biochar, and non-condensable gases.
- Traditional pyrolysis depends on complex thermal or mechanical arrangements to facilitate heat transfer from an external energy source.
- Biomass throughput is limited by heat transfer considerations.

**Materials & Methods**

**Fluidized Bed Reactor System**

Pyrolysis Process Development Unit (PPDU) located at the ISU BioCentury Research Farm.

- Fractional recovery system collects bio-oil from six stage fractions (SF1-6) over a temperature gradient.
- Biochar and Bio-oil measured by mass difference at the beginning of each test to account for differences in insulation and ambient conditions.

**Autothermal Operation**

- The reactor heat loss baseline is established at the beginning of each test to account for differences in insulation and ambient conditions.
- These heat losses are then balanced using electrical heaters (active insulation) in order to simulate the adiabatic conditions prevalent in large scale reactors.

**Product Characterization**

- Ultimate analysis of solid and liquid products using Elemental Analyzer.
- Moisture content determined by Karl Fischer Titration.
- Bio-Oil Sugar Identification & Quantification.
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- Molecular Weight distribution analyzed with Gel Permeation Chromatography (GPC) in conjunction with Refractive Index (RI) and UV-Vis detectors.

- MW distribution of SF1 bio-oil was not adversely affected by AT or AT/HF operation.
- SF2 bio-oil generally contained more compounds (100 ≤ MW ≤ 1,000) during AT and AT/HF operation using RI detection; these compounds appear to be phenolic oils determined using UV-Vis @ 254nm.

**Results & Discussion**

- Differences in product distribution between N2 and Autothermal pyrolysis at 5 kg.hr are minimal; however, less carbon is retained in heavy end organic content in favor of non-condensable gas under autothermal conditions.
- Autothermal operation under high feed rate conditions increased the organic and carbon content in bio-oil heavy ends over that of N2 pyrolysis. Additionally, both biochar and non-condensable gas yields decrease slightly with increased feed rate indicating these products could be preferentially consumed in the combustion reactions.

- As expected, autothermal operation resulted in increased CO2 concentration in non-condensable gases compared to traditional pyrolysis arising from products of combustion.
- Light, flammable NCG’s concentrations decreased during autothermal operation; it is hypothesized that these gases are preferentially consumed for heat production within the reactor.
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**Conclusions**

- Autothermal operation overcomes heat transfer limitations encountered with traditional pyrolysis systems by internally providing heat for pyrolysis.
- Autothermal pyrolysis provides process intensification by allowing increased biomass feed rates through a similarly sized conventional pyrolysis reactor.
- Autothermal pyrolysis under high feed conditions doubled the overall yields of pyrolytic sugars from biomass.
- Autothermal pyrolysis increased pyrolytic sugar in bio-oil heavy ends.
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**Acknowledgements**

The authors would like to thank Patrick Hall, Patrick Johnston, & Marge Rover for their assistance characterizing the bio-oil.