Regional Supply Chain Analysis – Tropics

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Advisory Committee Meeting
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ASCENT
AVIATION SUSTAINABILITY CENTER

ASCENT Project 001

Construction & demolition waste regional project

University of Hawaii

Participants: Quang Vu Bach, Jinxia Fu, Scott Turn

Program Manager: Nathan Brown

Cost Share Partner: University of Hawaii, State of Hawaii

Objective:

Generate information and data needed to support regional supply chain analysis for SAF production from construction and demolition (C&D) waste feedstocks on the island of Oahu, Hawaii

Project Benefits:

Availability of physicochemical properties of C&D feedstock available to project developers

Analysis of feedstock temporal variability

Equilibrium analysis of contaminants generated from feedstocks under gasification conditions

Data on product gas contaminants to inform process design and techno-economic analysis (TEA)

Research Approach:

Conduct C&D waste sampling campaign at PVT Land Co. landfill over the course of a year

Analyze fuel sample properties relevant to thermochemical conversion technologies

Conduct analysis with FactSage™ thermochemical equilibrium software to predict contaminants and their concentrations and phases to inform gasification system design

Conduct benchscale gasification tests to determine product gas quality and yield, identify contaminants and their concentrations, identify operating difficulties

Major Accomplishments (to date):

Completed sampling campaign and sample analysis; results summarized in publication

Completed FactSage analysis, manuscript in preparation

Two benchscale gasification tests completed

Future Work / Schedule:

Complete benchscale gasification tests to produce data on gas quality, yield, and contaminants in the coming year

Begin contaminant removal work to inform process design and TEA analysis

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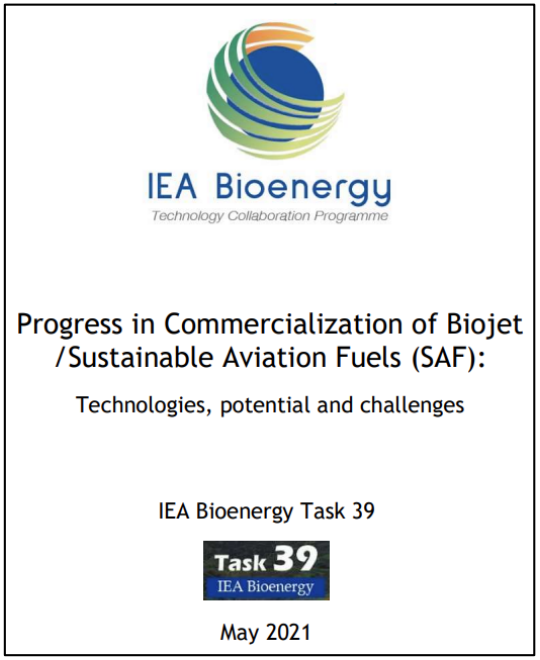
Progress in Commercialization of Biojet /Sustainable Aviation Fuels (SAF):

Technologies, potential and challenges

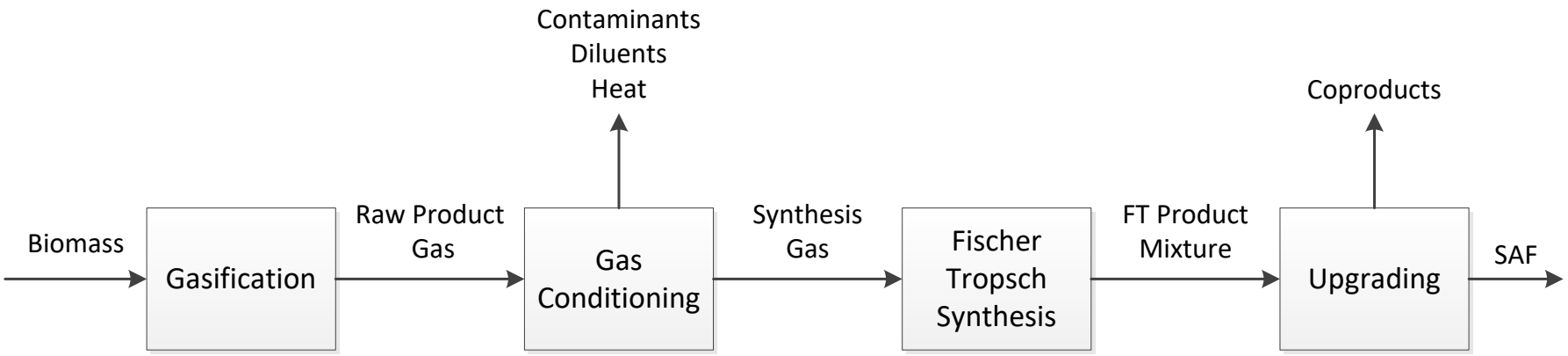


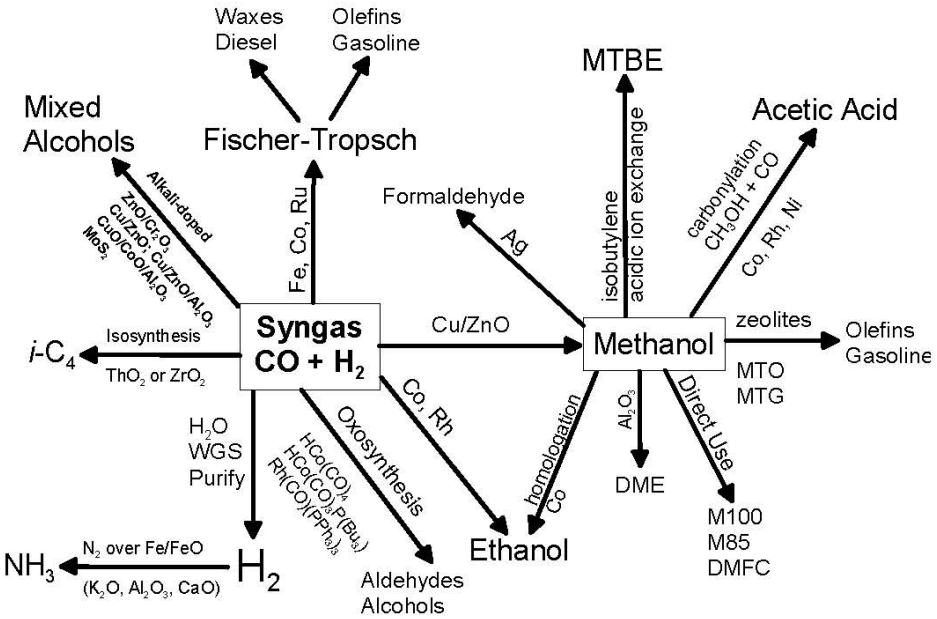
Gasification and FT Synthesis: The major challenge of gasification-based biojet production is the high investment cost that will be encountered when constructing these facilities. …..

….. **Another costly component is the need for "cleanup" of the raw syngas prior to Fischer-Tropsch synthesis. Cleanup typically involves the multiple process steps needed to remove different contaminants, with feedstock variability and different levels of contaminants increasing complexity and cost.** …..**Other areas of improvement include** the development of bifunctional catalysts that can produce a larger jet fraction (up to 70%) and **the ability to use low-cost feedstocks such as municipal solid waste (MSW).** The gasification/FT pathway is certified under ASTM D7566 for biojet production based on any type of feedstock and the Fischer-Tropsch liquids are certified for co-processing in existing refineries.

https://www.ieabioenergy.com/wp-content/uploads/2021/06/IEA-Bioenergy-Task-39-Progress-in-the-commercialisation-of-biojet-fuels-May-2021-1.pdf

Gasification Fischer-Tropsch SAF

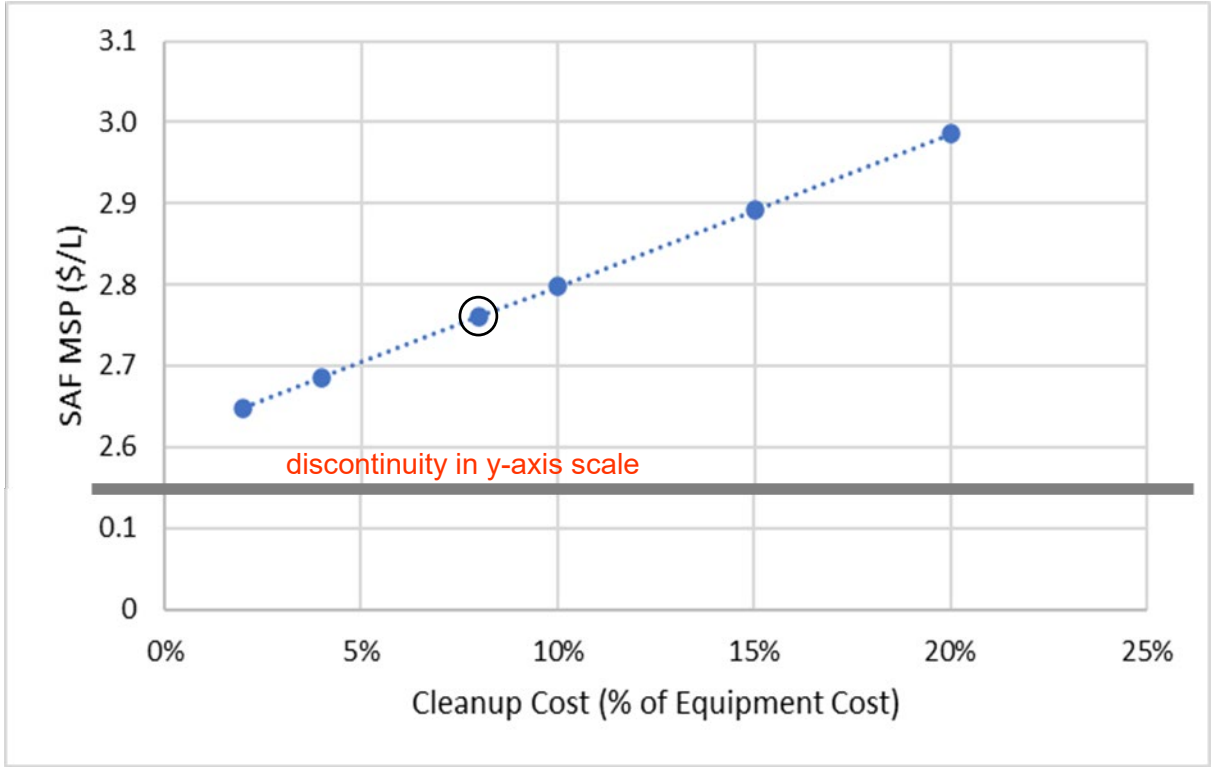




Spath, P.L. and D.C. Dayton. 2003. Preliminary Screening – Technical and Economic Assessment of Synthesis Gas to Fuels and Chemicals with Emphasis on the Potential for Biomass-Derived Syngas; NREL/TP-510-34929. http://www.nrel.gov/docs/fy04osti/34929.pdf

Experimental Data Supporting TEA

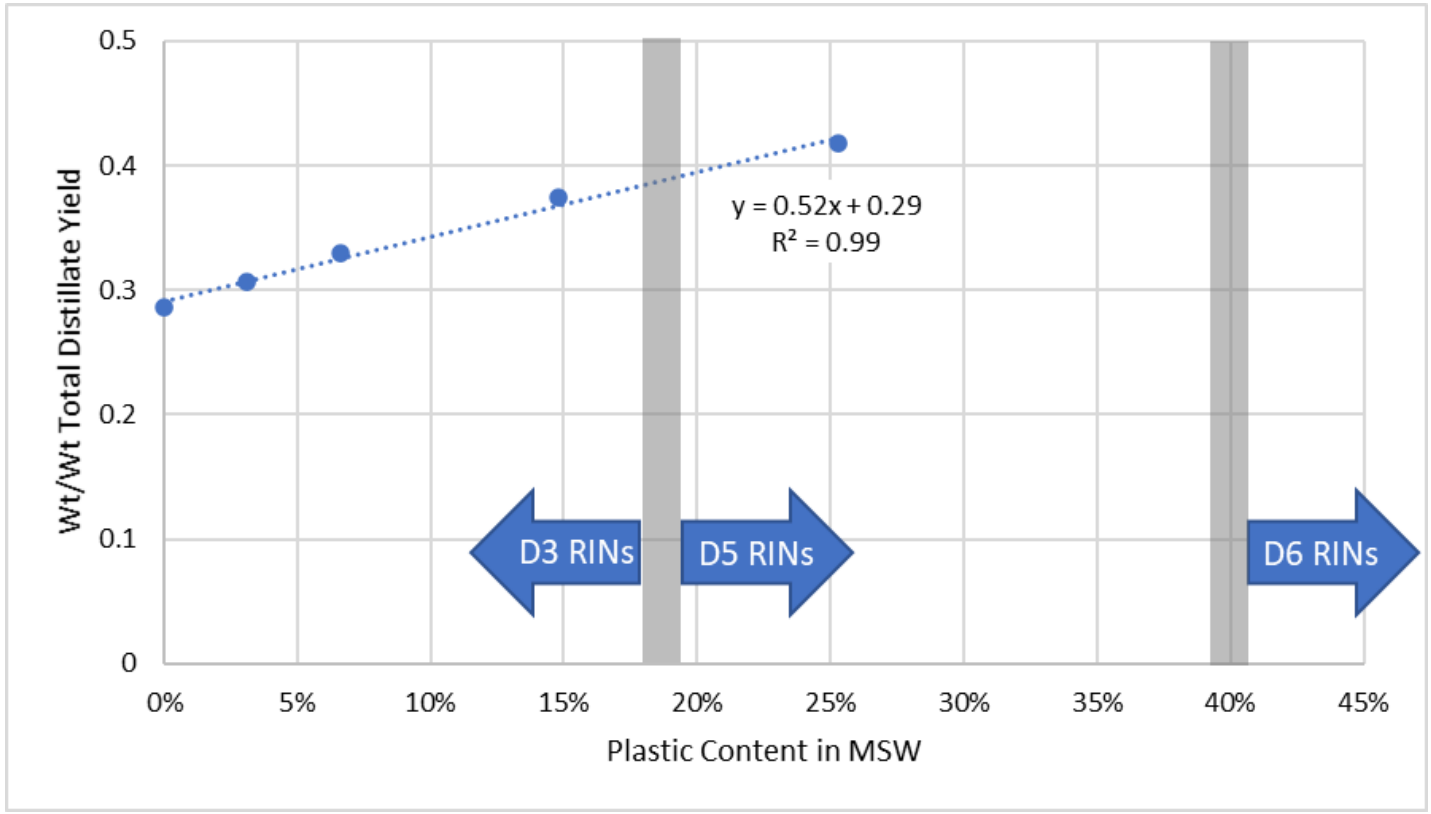
- Syngas Composition Data Control:
  - Need for equipment to cleanup the raw syngas
  - Type and scale of cleanup equipment (currently 8% of total equipment costs)
  - Fuel distillate yield that dictates scale of all downstream equipment and therefore equipment costs



Slide from Brandt, K., Wolcott, M. et al. at WSU

Techno-Economic Analysis Support

- Correlates waste composition with product gas yield
  - Sets scale of equipment for downstream syngas cleanup
  - Allows producers to maximize revenue by balancing non-biogenic and biogenic carbon input -- increased yield vs. increased policy support from lower CI scores.



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C&D Waste Regional Project

C&D Waste mined from landfill or truck intake

~50 kg feedstock sample

C&D Sampling

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Construction and Demolition Waste-Derived Feedstock: Fuel Characterization of a Potential Resource for Sustainable Aviation Fuels Production

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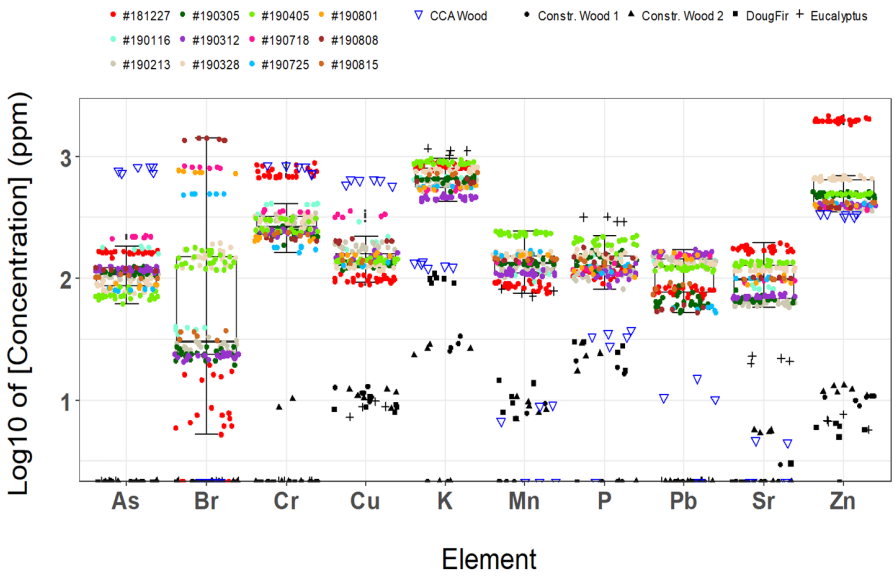
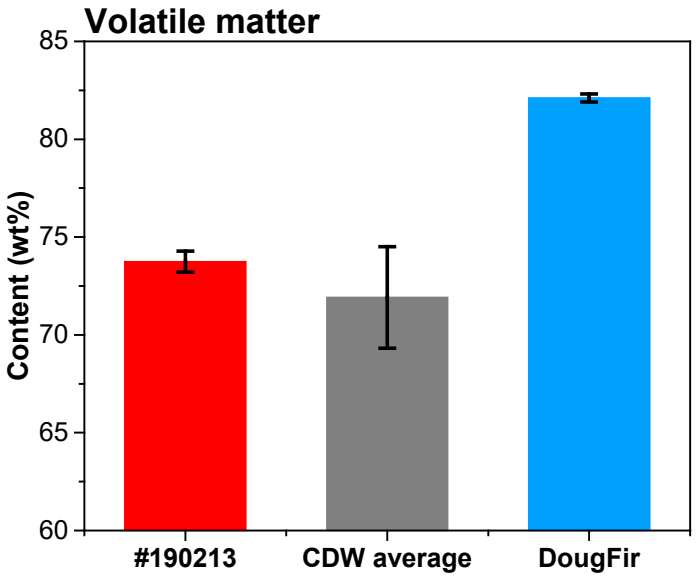
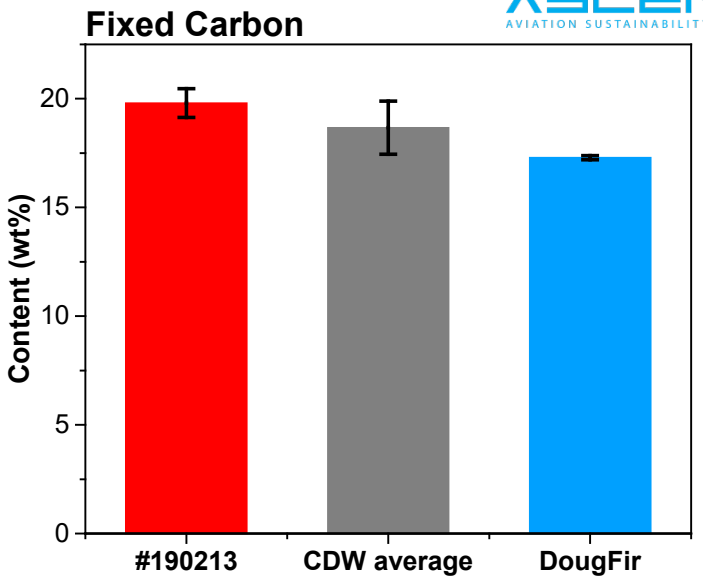
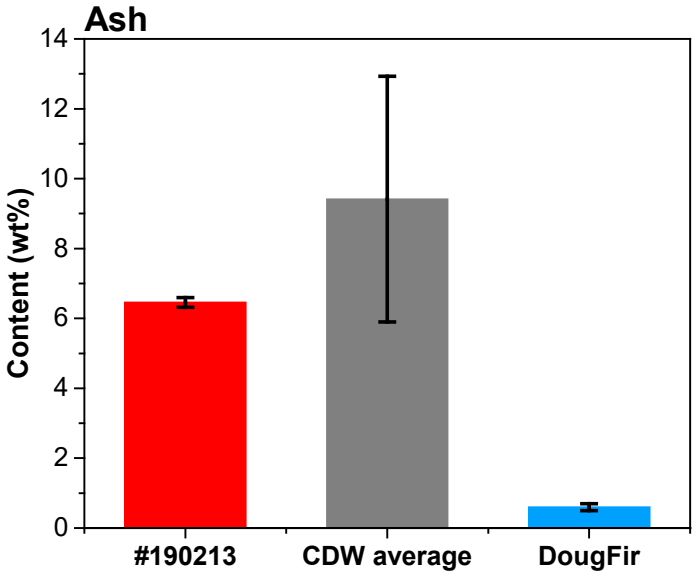


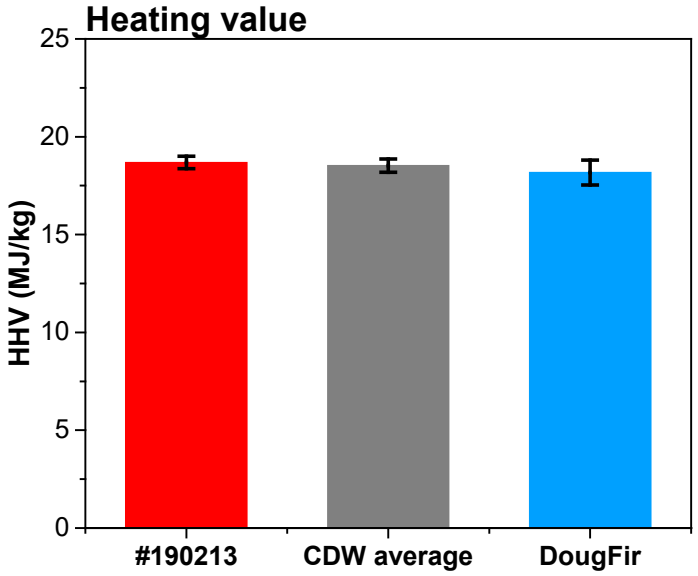
Feedstock Analysis

Fuel Properties









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ORIGINAL RESEARCH
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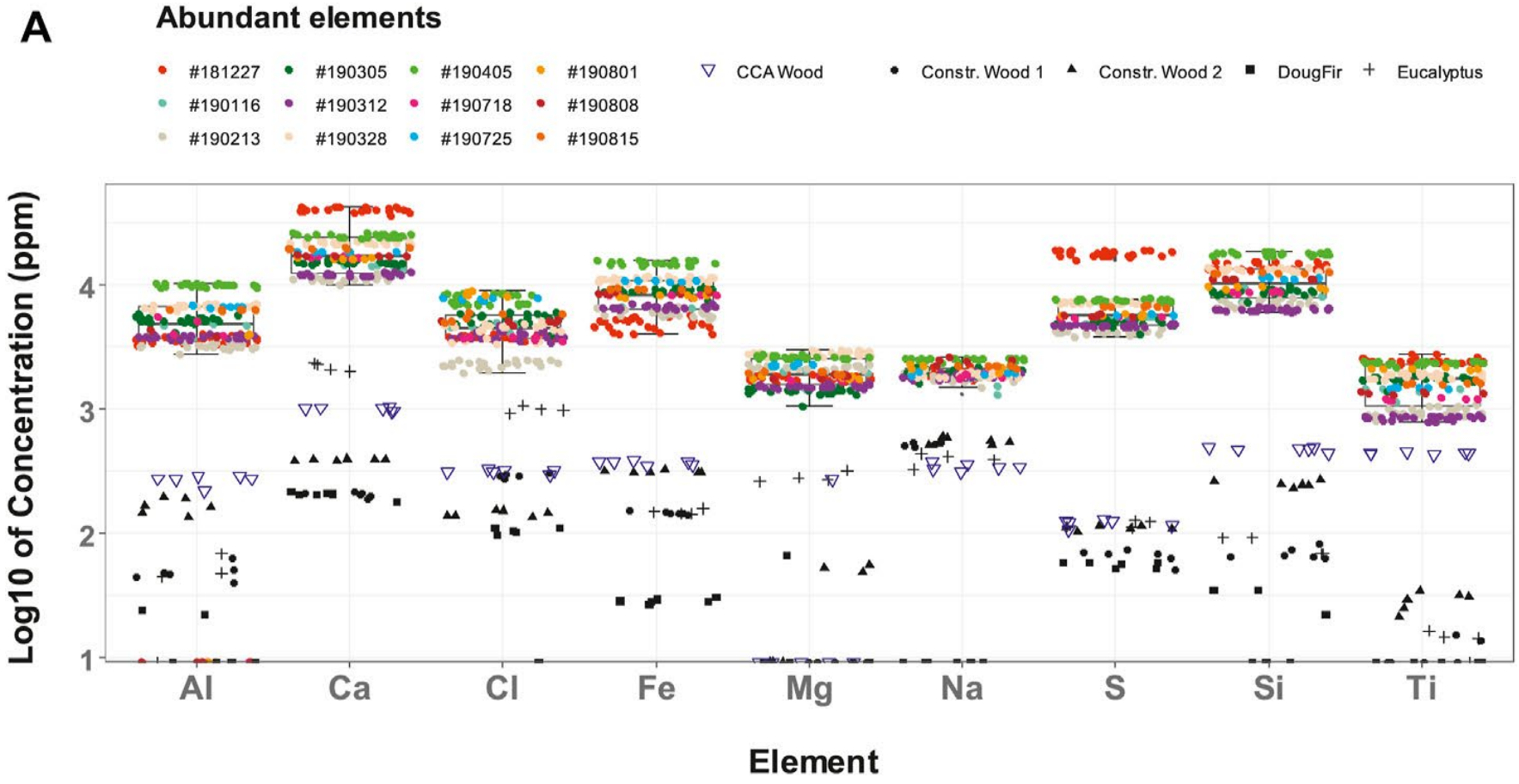

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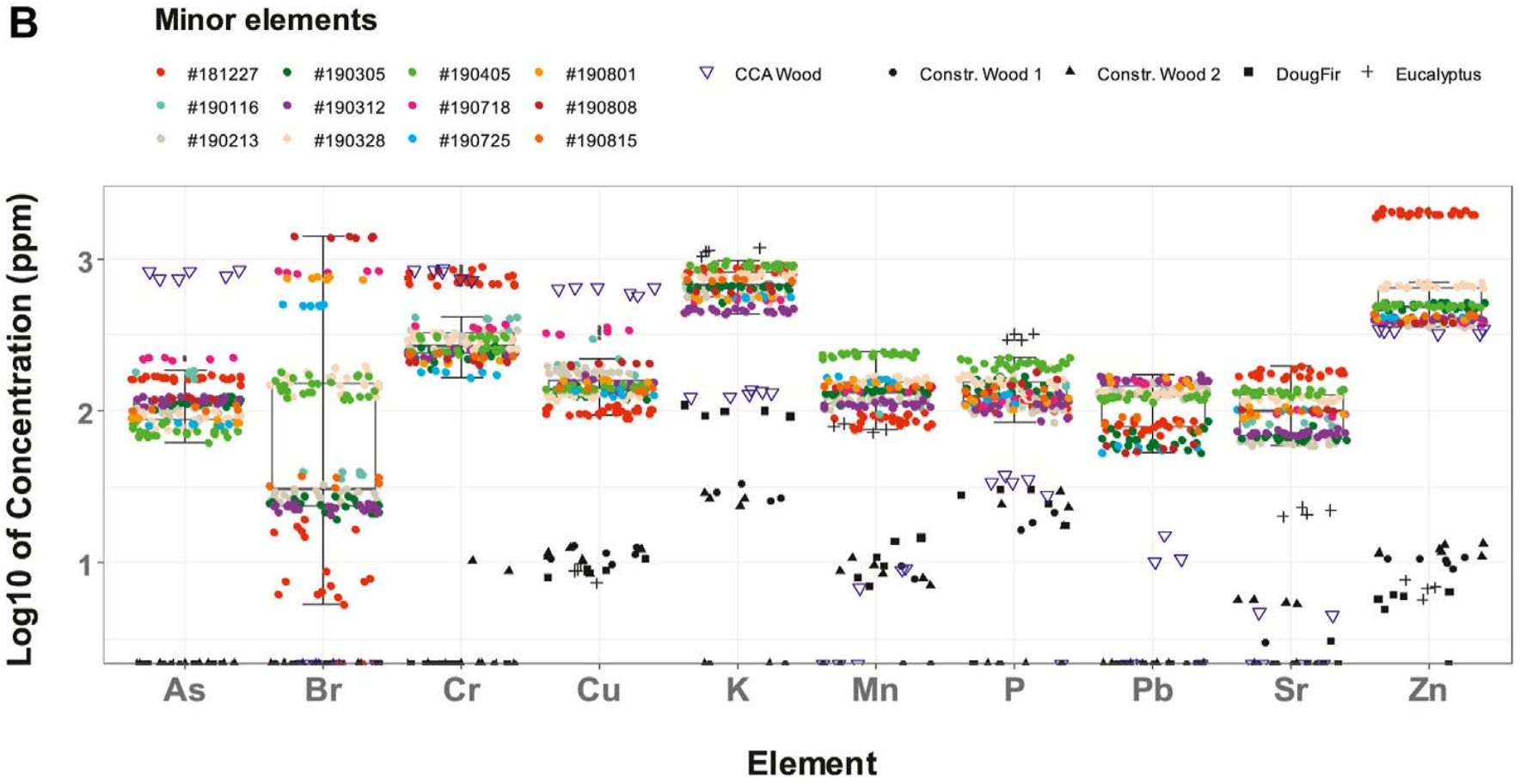
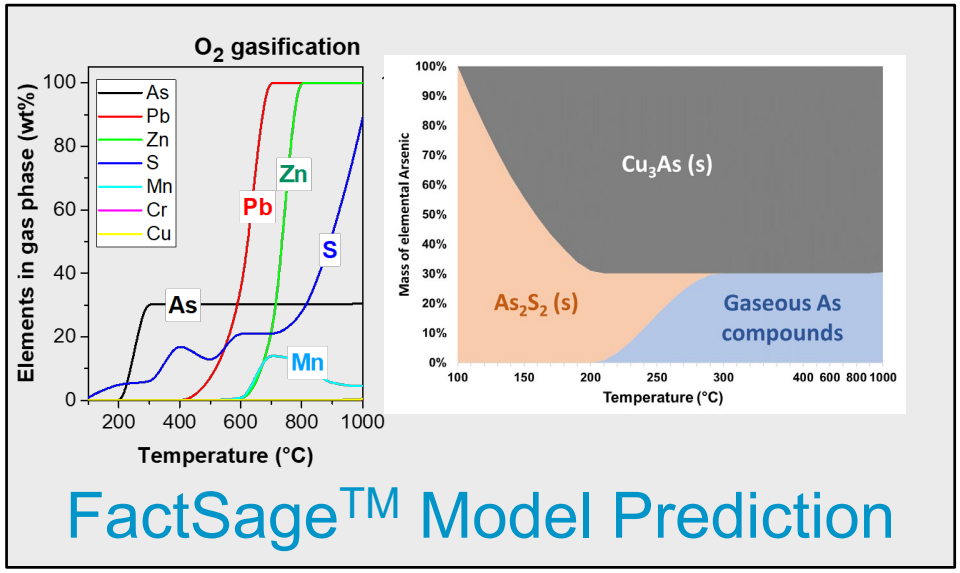


Current Status

- Modeling:
  - Draft manuscript: Bach, Q.V. and S. Turn. Fate of arsenic and other inorganic elements during gasification of construction and demolition wastes: Thermochemical equilibrium calculation. UH internal review and experimental data for comparison.



- Benchscale gasification tests
  - ThermoChem Recovery International (TRI) – technology provider for the Fulcrum BioEnergy DPA project in Reno, Nevada.

Gasification Tests at Thermochem Recovery International

- Gasification system
  - Bubbling fluidized bed reactor equipped with external heaters for start up and temperature control
  - Metered fuel delivery system (~2 kg/h)
  - Controlled reactive gas delivery – steam, O_2, trace gas
  - Heated downstream filter with temperature control

Energy Fuels **2010**, *24*, 1222–1233 · DOI:10.1021/ef9010109

Outcomes

- Quantify product stream (gas, solid, liquid) flows and composition
- Conduct mass and element balances

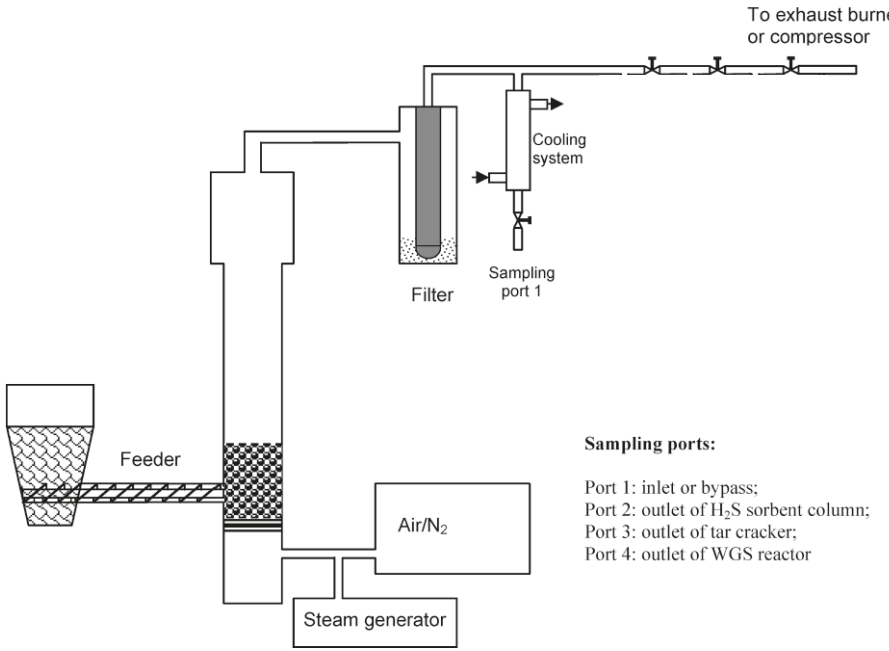


Figure 1. Schematic diagram of the bench-scale fluidized-bed biomass gasifier system.

Analytical for test solids

- Feedstock characterization for fuel properties (ultimate, proximate, heating value) and elemental analysis
- Bed media characterization pre-test and post-test – elemental analysis, microscopy as needed
- Other bed materials post-test
- Hot filter contents post test -- characterization for fuel properties (ultimate, proximate, heating value) and elemental analysis

Analytical gases/liquids

- Permanent gas species
  - Online gas chromatograph – H_2, N_2, O_2, CO, CO_2, CH_4, higher HCs
  - Offline speciation of sulfur and nitrogen permanent gases
  - Gas yield (m^3 per Mg feedstock)
- Trapping methods
  - HCl, NH_3, and HCN
  - Trace element analysis via ICP
- Condensates

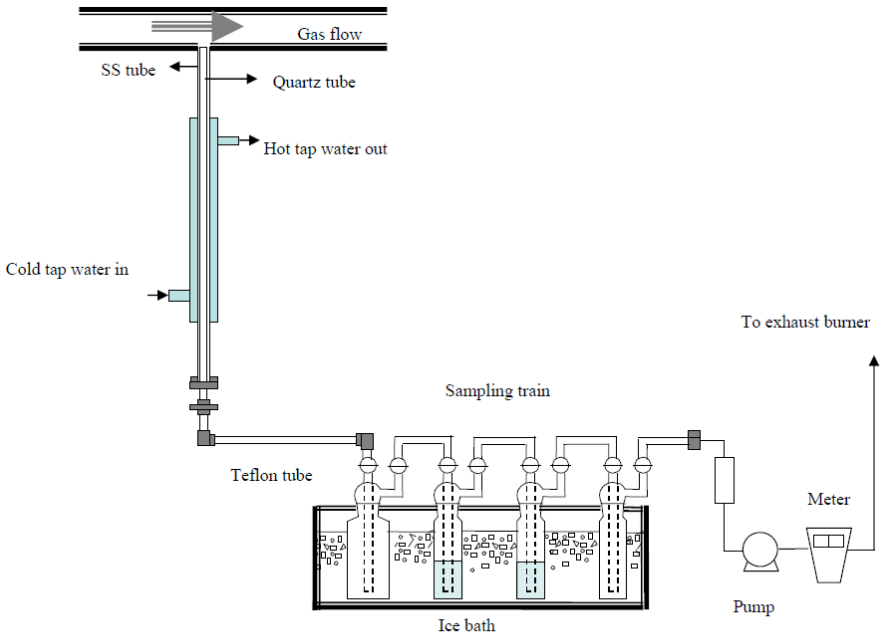
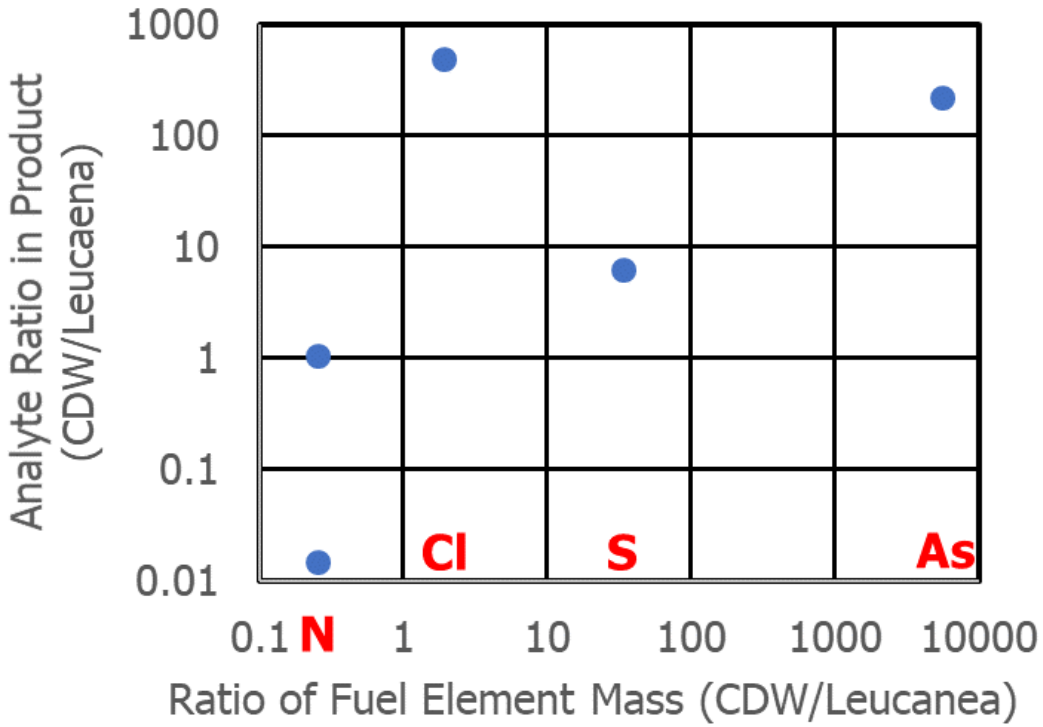


Fig. 1. Gas sampling system for trace element collection from gasifier product gas.

Gasification Test Summary

- Tests conducted at ThermoChem Recovery International (TRI) facility
- Four fuels
  - Test #1 – *Leuceana leucocephela* – clean wood fuel (Nov. 2021)
  - Test #2 – Synthetic construction demolition waste (Dec. 2021)
  - Test #3 – TBD
  - Test #4 – TBD
- Preliminary results



University of Hawaii participants

- Jinxia Fu
- Quang Vu Bach
- Seren Weber
- Lloyd Paredes

Questions?