Hawai‘i Natural Energy Institute Research Highlights

Alternative Fuels

Investigation of Waste-Based Feedstocks for Sustainable Aviation Fuel Production

OBJECTIVE AND SIGNIFICANCE: The aviation industry (civilian and military) faces significant challenges due to dependence on petroleum jet fuels and limited opportunity for electrification. Sustainable aviation fuels (SAF) from renewable resources provide alternatives to petroleum fuels and have added environmental benefits. This research investigates the behavior of urban solid waste under possible gasification environments defined by temperature, pressure, and reactive environment. Results of the project can be used to inform participants in the urban solid waste to sustainable aviation fuel value chain; fuel suppliers, technology providers, gasification system operators, and research and development funding agencies. Project success will support the production, adoption, and use of sustainable bio-based aviation fuel, a much needed alternative to petroleum legacy fuels.

BACKGROUND: The aviation industry (civilian and military) faces significant challenges due to dependence on petroleum jet fuels and limited opportunity for electrification. Sustainable aviation fuels (SAF) from renewable resources provide alternatives to petroleum fuels and have added environmental benefits. Feedstocks for SAF production include fiber, sugar, starch, and oil available from the forestry and agricultural sectors, and from urban solid wastes (USW). The fiber fraction of USW can be used to feed any of the downstream technology pathways leading to SAF products. EPA data shows that more than 100 million tons of combustible material are landfilled in the U.S. annually[1]. An estimation also reported that ~8.5 billion tons of waste materials could be mined from the existing U.S. landfills[2].

Although the use of USW for SAF feedstock shows high potential, it is not without challenges. USW may include municipal solid waste (MSW) and construction and demolition waste (CDW) that are heterogeneous in composition. A recent sampling program at a CDW landfill in Nānākuli, Hawai‘i showed that CDW samples may contain ash approaching 10 wt% of fuel and ~25 elements of interest. In comparison, the ash in clean wood accounts for less than 1 wt% of fuel and contains ~12 elements of interest.

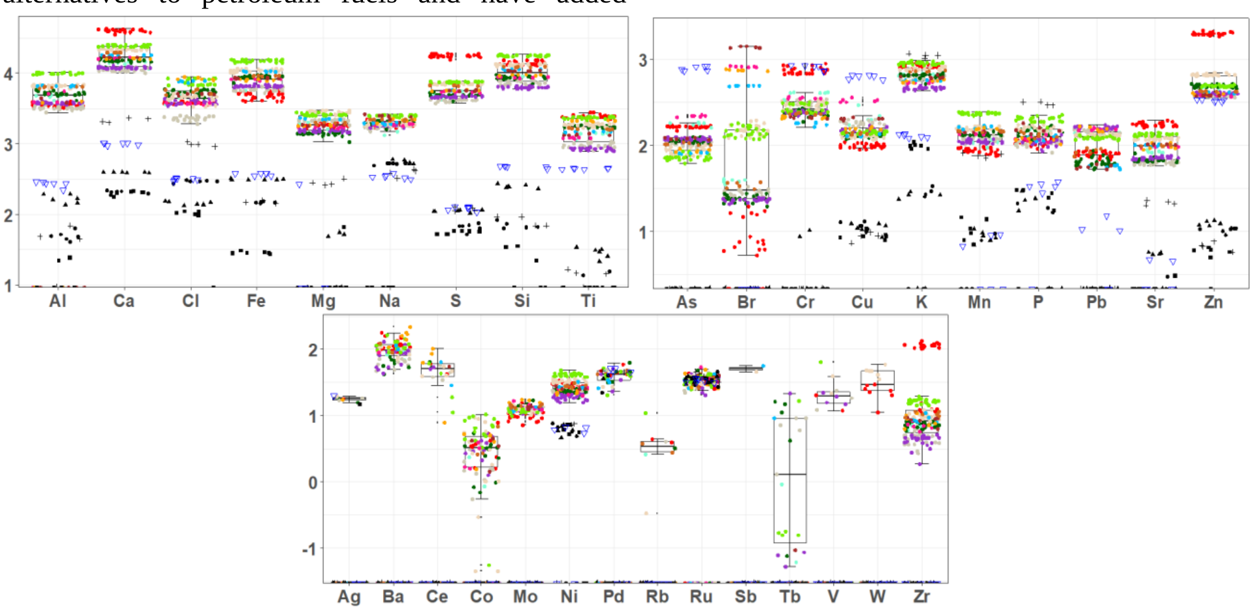

Figure 1. Element concentrations (log10 of ppm) in 12 CDW samples and five reference material samples.

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[1] EPA. (2022) National overview: Facts and figures on materials, wastes and recycling. https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/national-overview-facts-and-figures-materials.

[2] Powell, J.T., J.C. Pons, and M. Chertow (2016) Waste Informatics: Establishing characteristics of contemporary U.S. landfill quantities and practices. *Environmental Science & Technology* 50, pp 10877-10884.

Gasification and gas cleanup of urban solid waste can be modeled as a series of thermochemical and phase equilibria steps defined by the thermodynamic state points of unit operations. Results can identify opportunities to improve gasification system performance by 1) managing urban solid waste components entering the gasification process, 2) guiding selection of reactor materials, and 3) avoiding operating conditions that result in ash deformation or pollutant formation. Under gasification conditions, ash present in the fuel may deform to produce vapors or liquid slags. The latter causes operating difficulties in the reactor, agglomerating bed material, and reducing fluid bed performance. The former may deposit on heat exchange surfaces, deactivate downstream catalysts, or contribute to pollutant formation. Understanding the behavior of ash elements under gasification conditions can provide information to further reactor design, process optimization, and strategies to mitigate the negative impacts of ash elements.

PROJECT STATUS/RESULTS: A literature review was conducted to identify the typical ranges for the elemental compositions of available waste-based fuels.

A sampling and characterization campaign determined the detailed composition of CDW materials mined from the PVT Land Company landfill over a period of time[3]. These data were used as input to FactSage for thermochemical equilibrium calculations to investigate:

- The fate of ash from CDW fuels under gasification at different temperatures, pressures, and in different reactive environments (oxygen, steam, and oxygen-steam);
- Possible interaction between ash elements and common fluidized bed materials or oxygen carriers in chemical looping systems;
- Possible interaction and/or deactivation of ash element and common catalysts.
- Strategies to control and/or remove gas phase inorganic species (e.g. As) from product gas using sorbents.

A number of these FactSage calculations at different gasification conditions are plotted on the following page (Figure 2).

Funding Source: DLA Energy.

Contact: Scott Turn, sturn@hawaii.edu

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[3] Bach Q-V, Fu J, and Turn S (2021) Construction and Demolition Waste-Derived Feedstock: Fuel Characterization of a Potential Resource for Sustainable Aviation Fuels Production. *Frontiers in Energy Research* 9:711808.

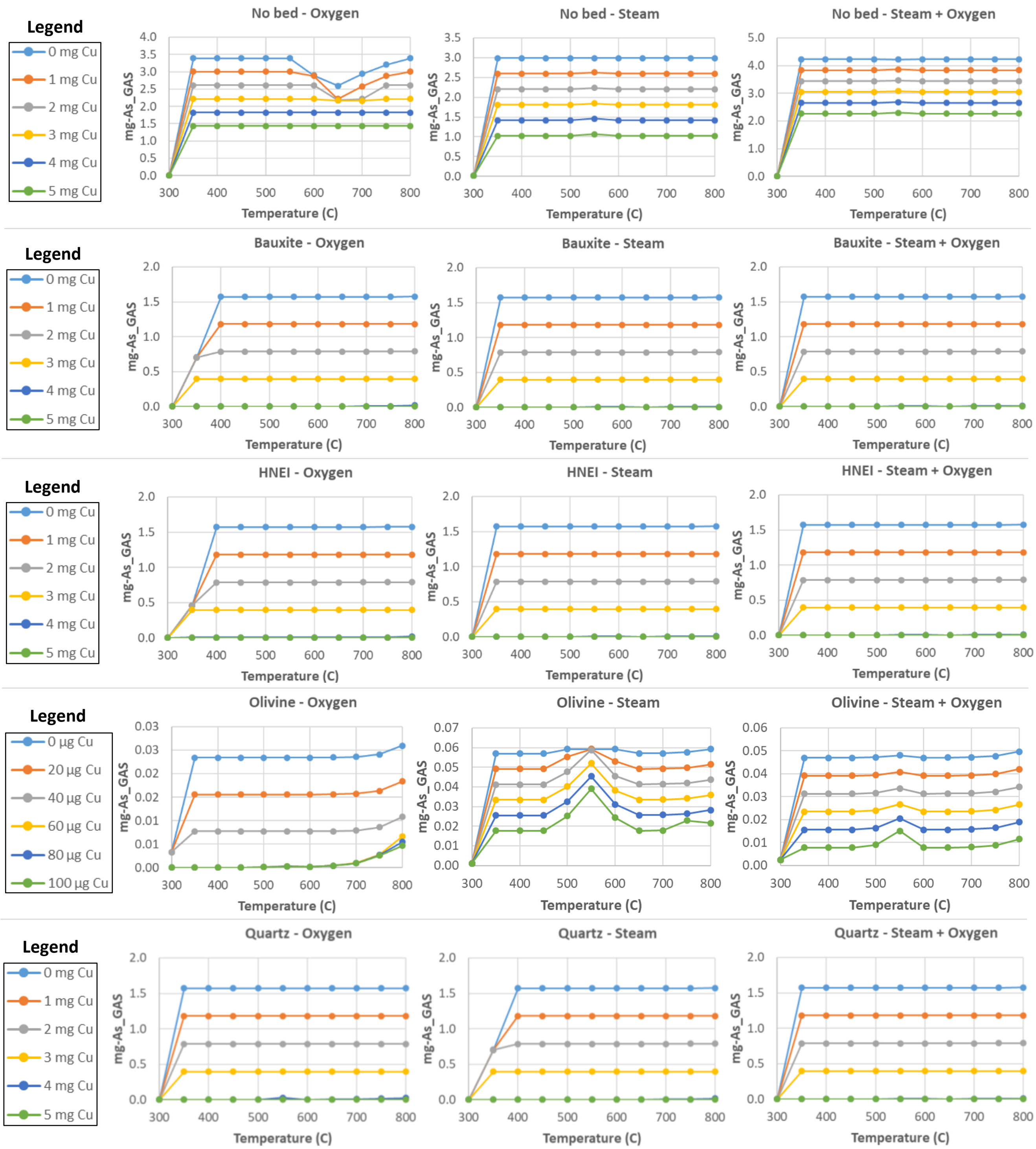

Figure 2. Masses (in milligram) of arsenic in gas phase from the FactSage calculations at different gasification conditions (bed materials: No-Bed, Bauxite, HNEI, Olivine, Quartz; and oxidizer: Oxygen, Steam, and Steam+Oxygen) and sorbent conditions. Copper masses are (µg Cu in sorbent per 100 g of fuel) for Olivine bed and (mg Cu in sorbent per 100 g of fuel) for other bed materials.