Torrefied Pongamia Pod: A Coproduct of Sustainable Aviation Fuel

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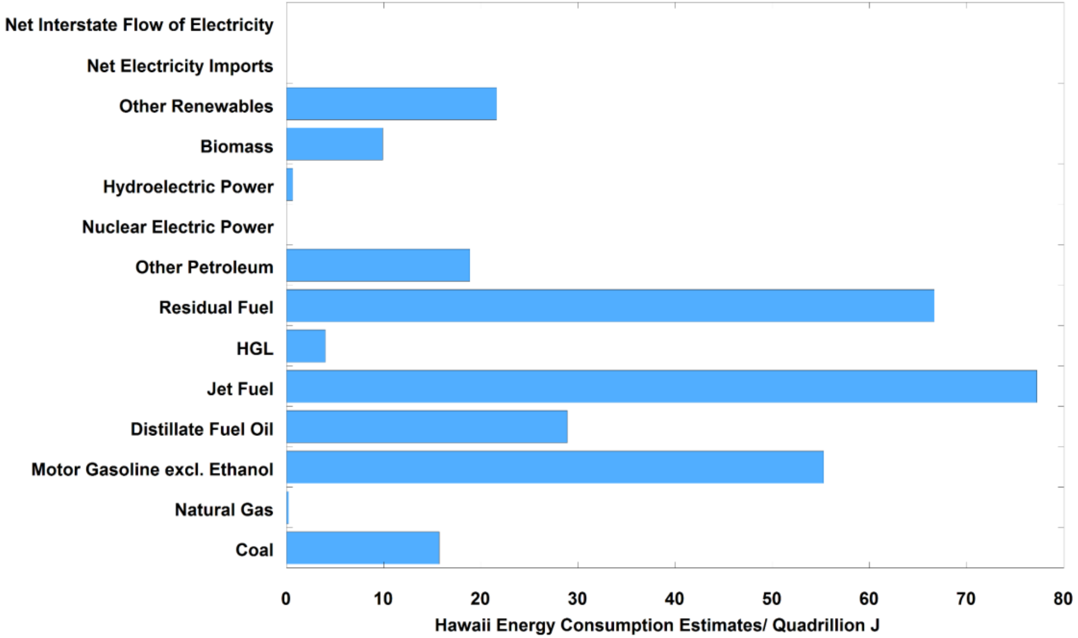
Overview: Hawaii Energy Consumption

2017 Estimates

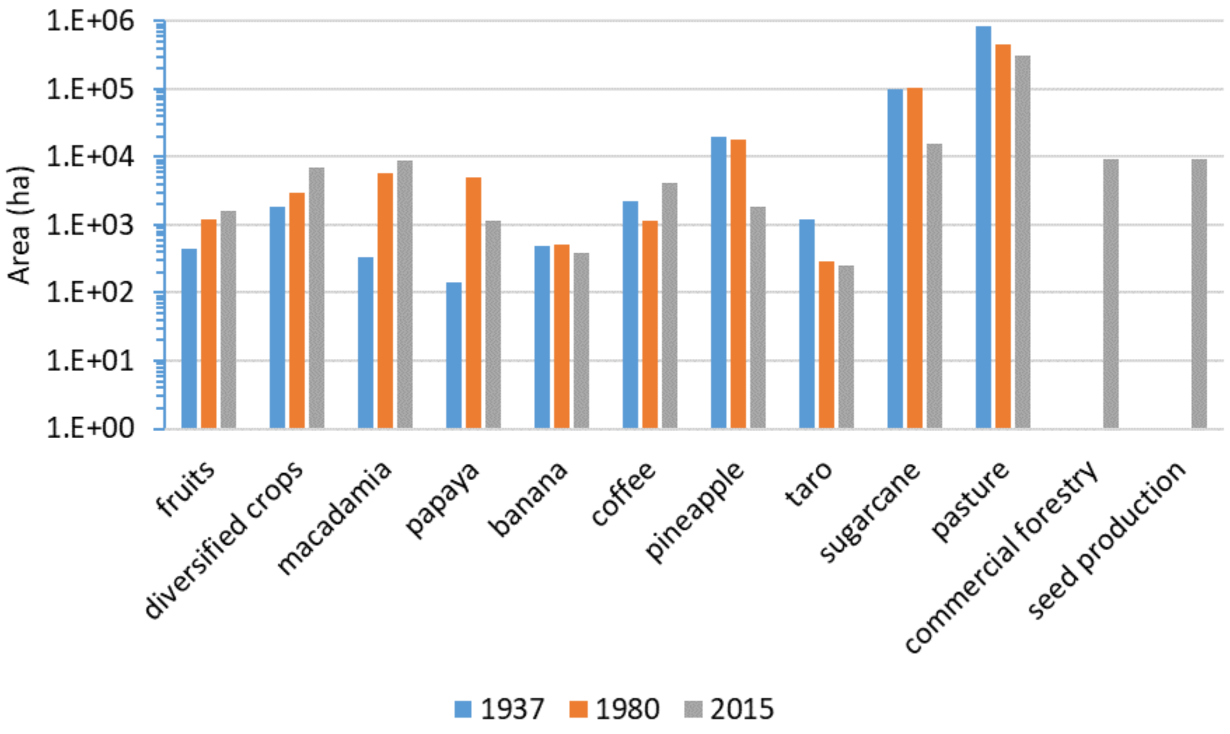


Biomass: Potential Resource for Biofuel Production

U.S. Energy Information Administration https://www.eia.gov/state/analysis.php?sid=HI

- The transportation sector uses almost 2/3 of all petroleum consumed.
- Jet fuel accounts for ~1/3 of all petroleum products consumed.
- Jet fuel makes up a larger share of total petroleum consumption in Hawaii than in any other state except Alaska.
- Biomass, ~1/3 of total renewable consumption, includes ethanol blended with motor gasoline and electricity (waste-to-energy power plant).

Overview: Hawaii Agricultural Land Use

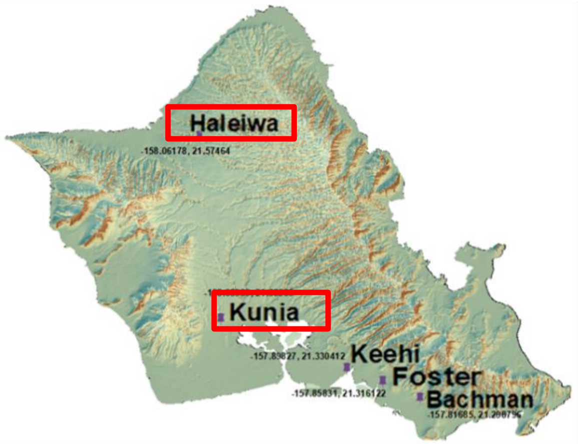


100,000 ha ≈ 250,000 acre

- Significant decrease of agricultural land use from 1980 to 2015.
- Energy crops could revitalize agricultural land use and help to reduce the reliance on petroleum based energy system.

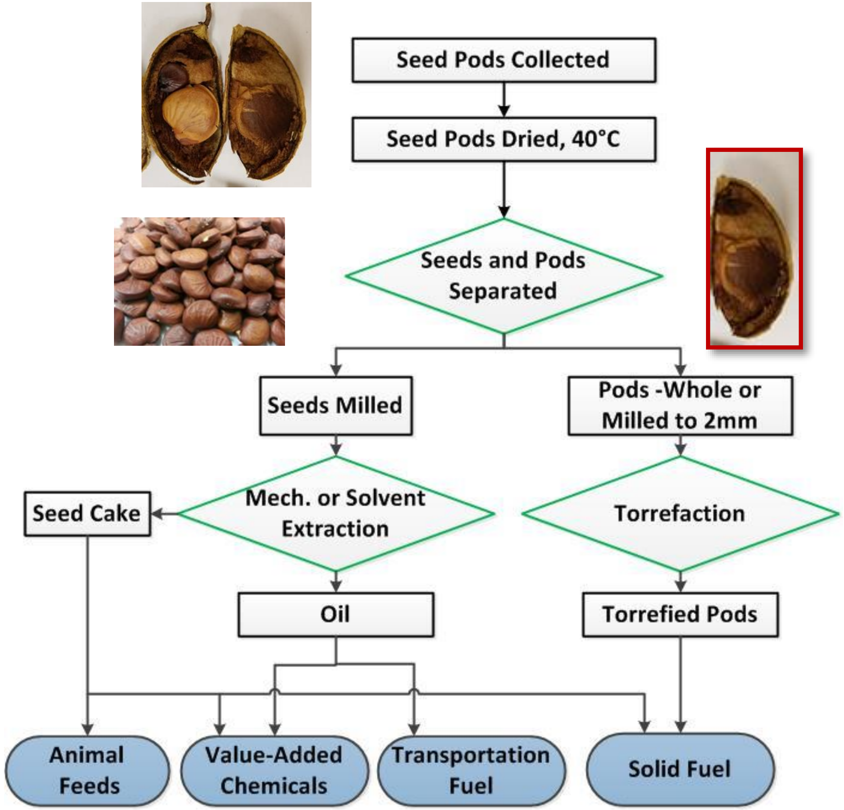
Hawaii Petroleum Dependency: > 80%

Background: Pongamia (*Milletia pinnata*)

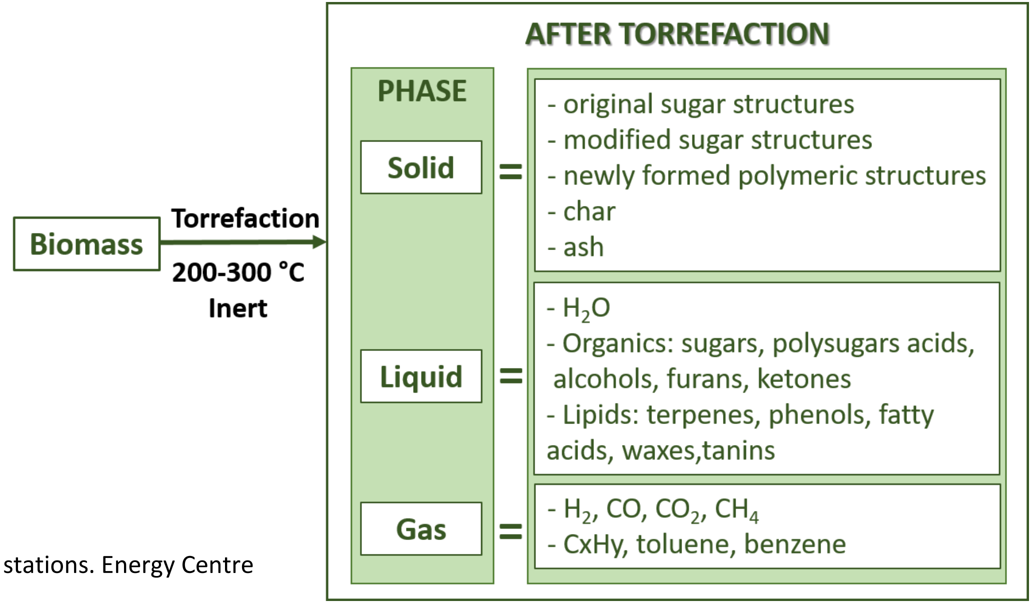


- Indigenous to the Indian subcontinent and south-east Asia
- Leguminous oil seed tree, **nitrogen-fixing**, and self-pollinating
- Current productivity estimated ~5 Mg/ha/year
- Grown in humid and subtropical environments
- Low chance of becoming an invasive species
- Robust nature: non-fertile land and **waste lands**
- Fast growing: flowering after 3-4 years, and **mature in 4-5 years**
- Production potential in **Hawaii**, Florida, Puerto Rico, US Virgin Islands

Pongamia Pod Preparation and Torrefaction



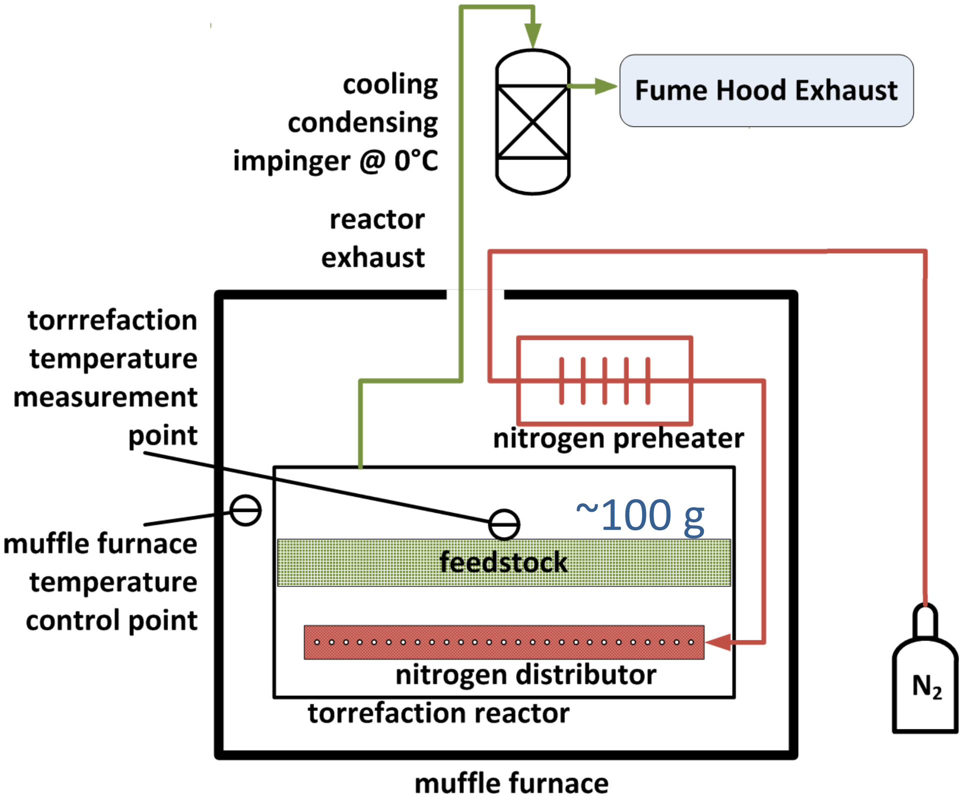
- **Torrefaction**, a moderate-temperature, thermochemical treatment process, can modify their physicochemical properties, resulting in improved solid-fuel qualities to serve as a renewable coal substitute.



Bergman PC et al. Torrefaction for biomass co-firing in existing coal-fired power stations. Energy Centre of Netherlands, Report No ECN-C-05-013; 2005.

Pod Torrefaction Process

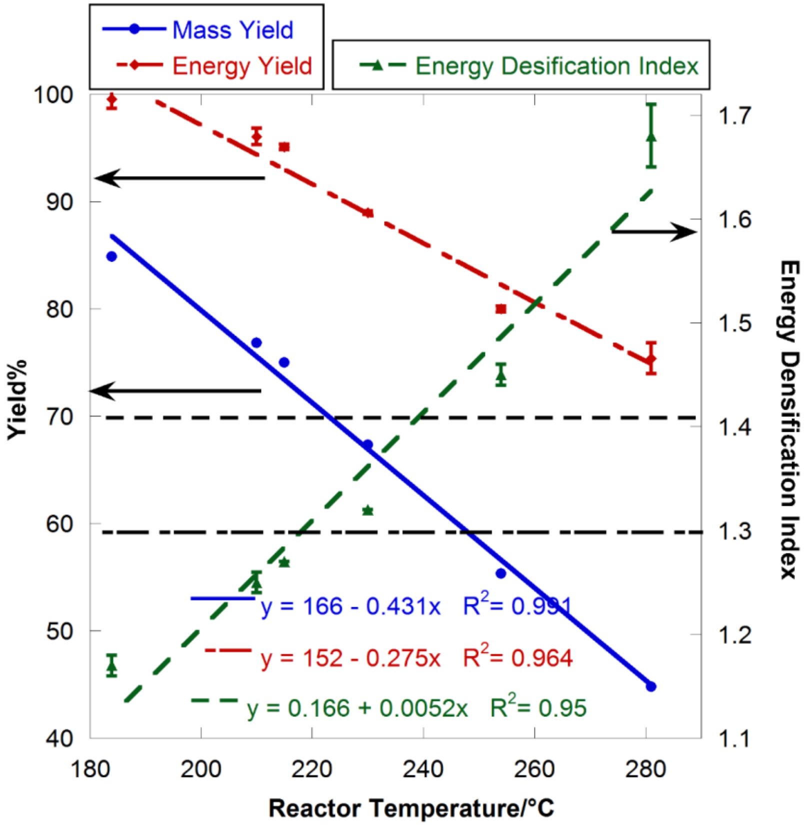
Fixed-Bed Reactor

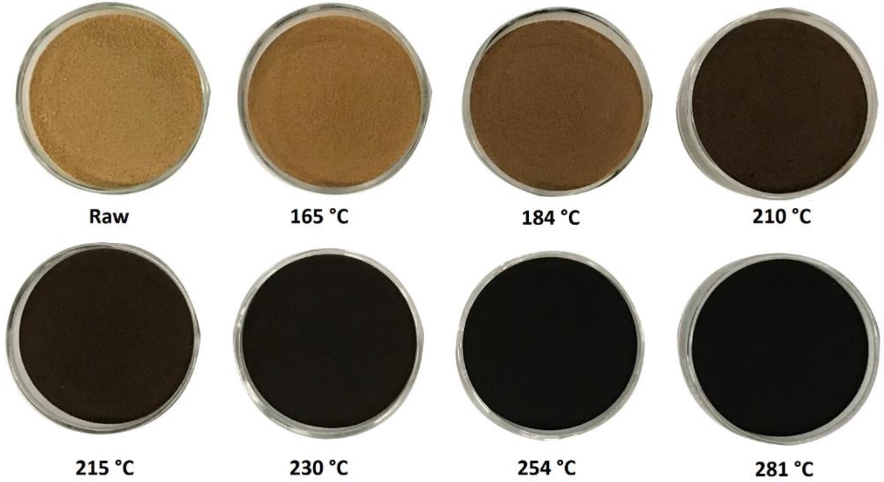


Macro-TGA

~5 g sample per crucible,
~95 g sample loading capacity
Capable of monitoring mass change

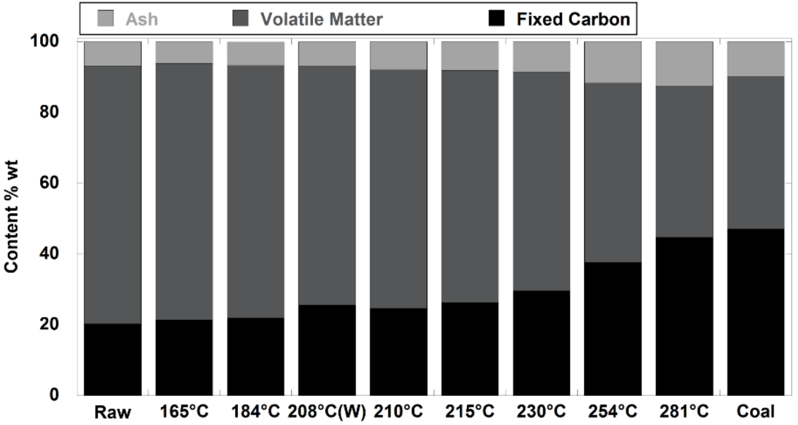
Torrefaction: Fixed-Bed Reactor

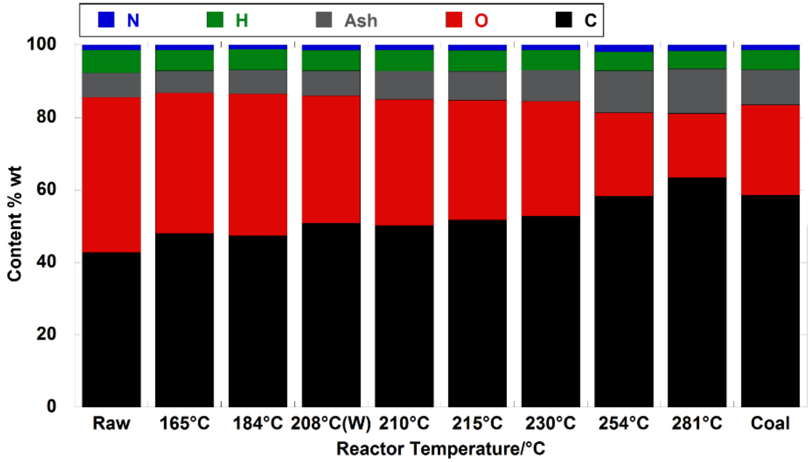


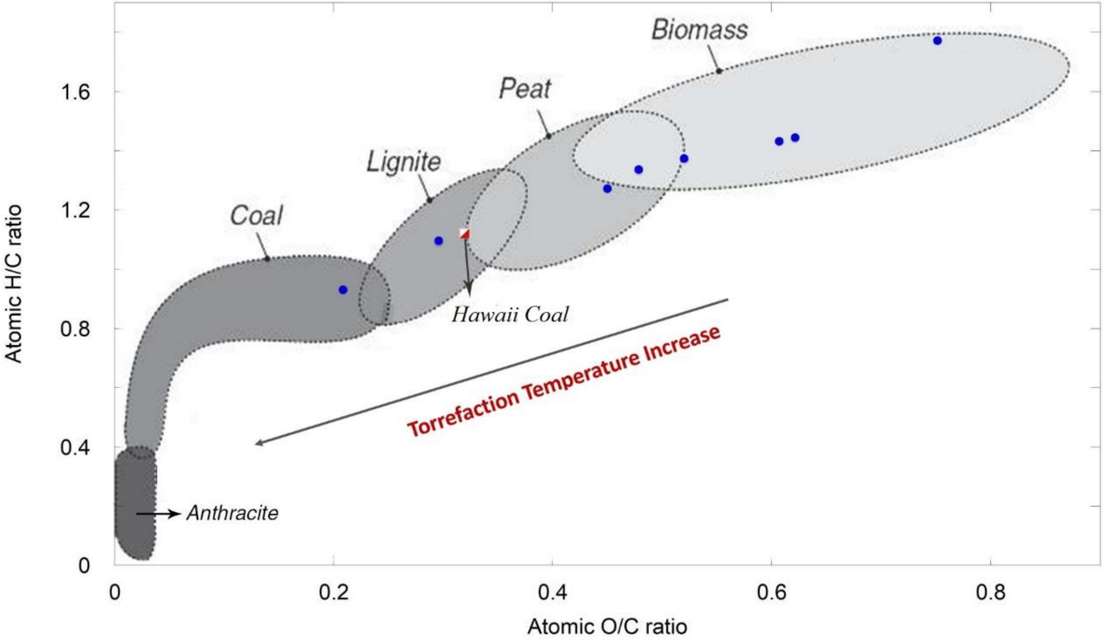


- The mass yield reached the targeted value, 70 %, when T = ~ 225° C.
- Torrefaction of whole pods is not energy or mass transport limited for the reactor conditions employed.
- The grinding process may be eliminated.

Proximate & Ultimate Analysis



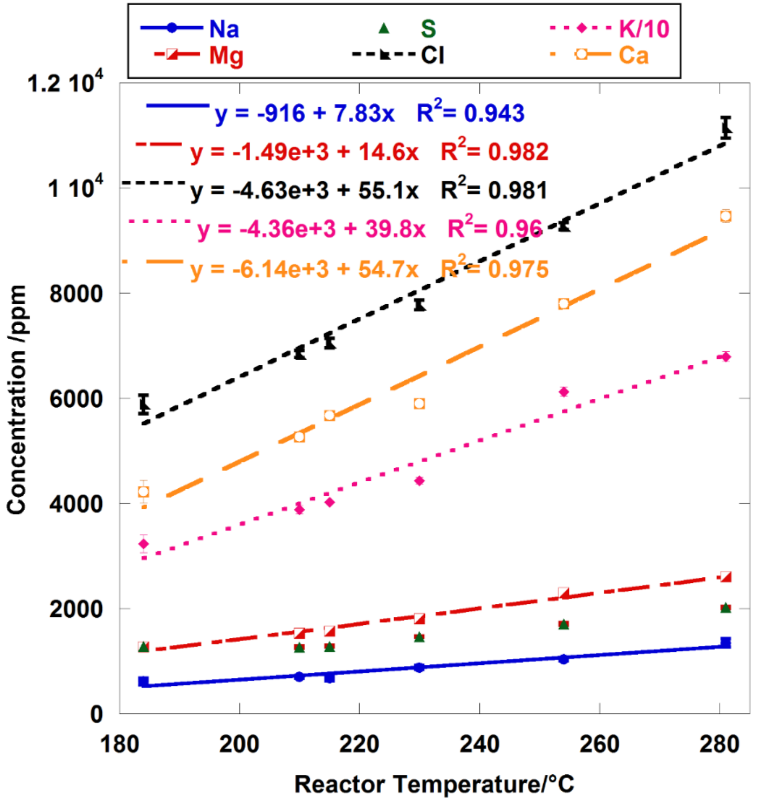


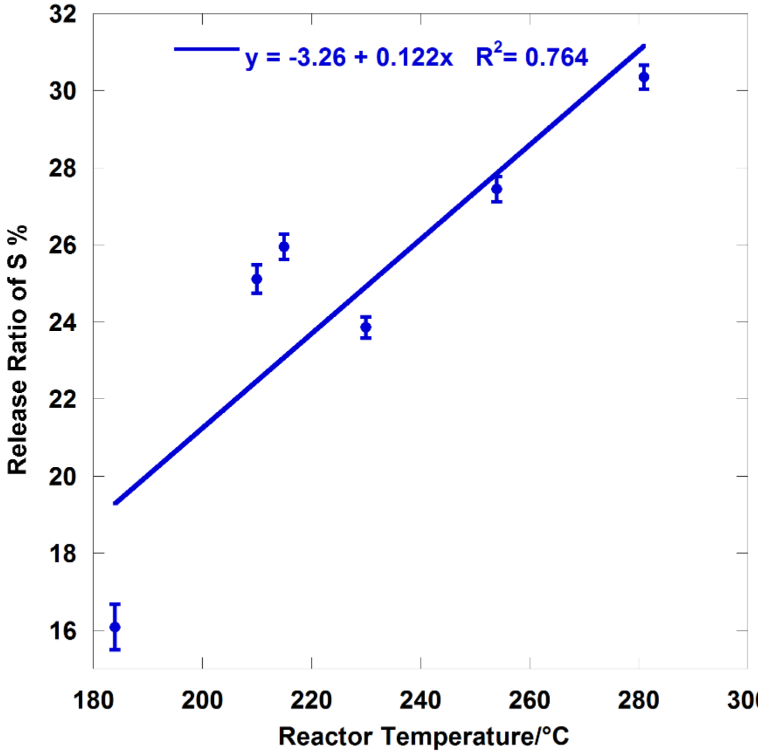


- ➢ The torrefied pod is expected to have similar fuel qualities as subbituminous coal when the torrefaction temperature is 281 ° C.

W = whole pod; Coal from Hawaii power plant

XRF Analysis: Element Composition

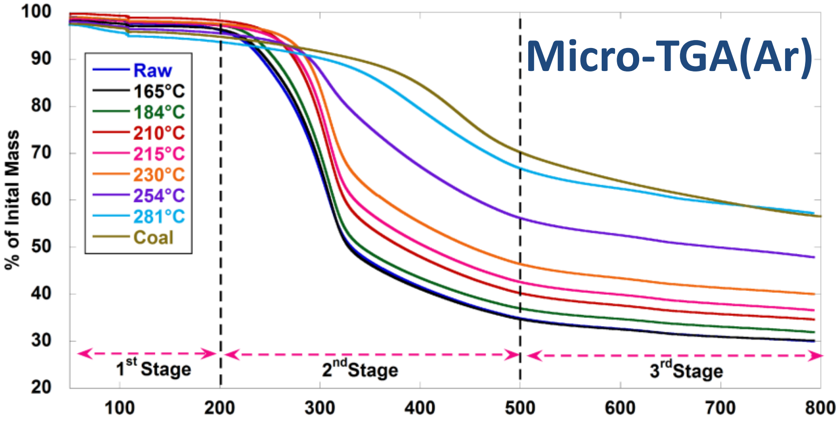


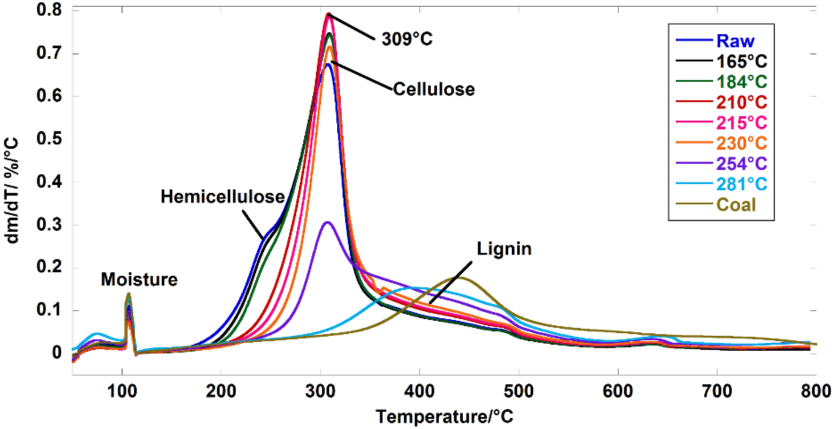


- As alkali metals, no release of K from the pod was observed after torrefaction.
- The fraction of sulfur released from the pods was found to increase with torrefaction temperature.

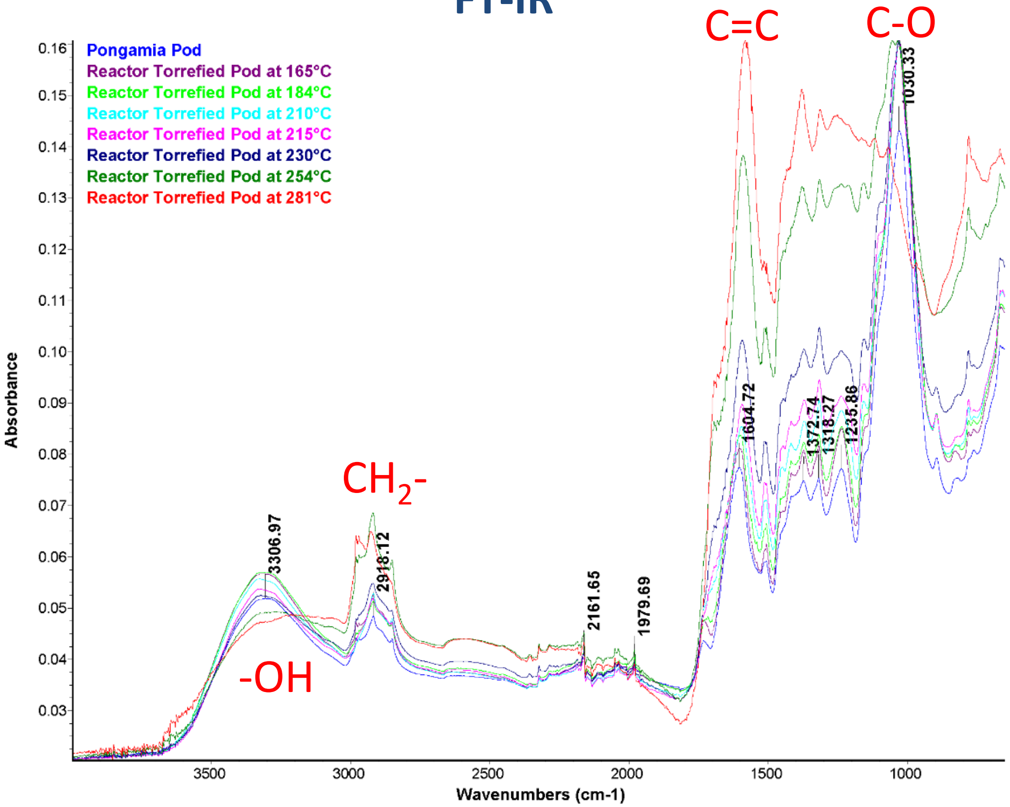
Thermal Decomposition & Chemical Structure

ASCENT
AVIATION SUSTAINABILITY CENTER

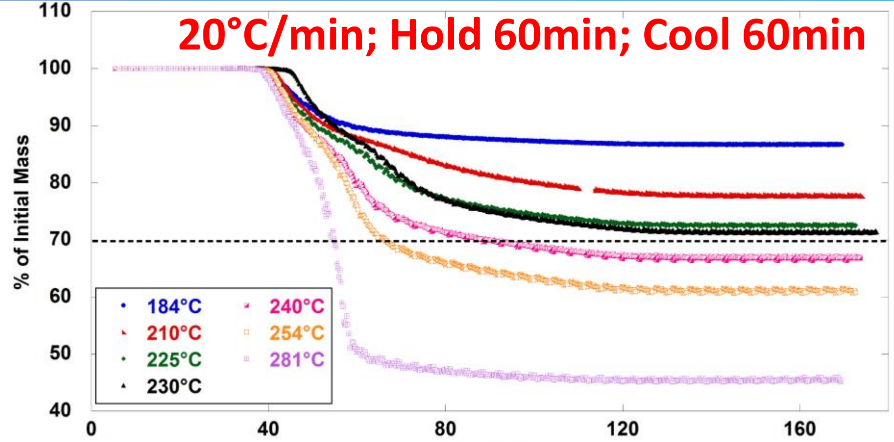


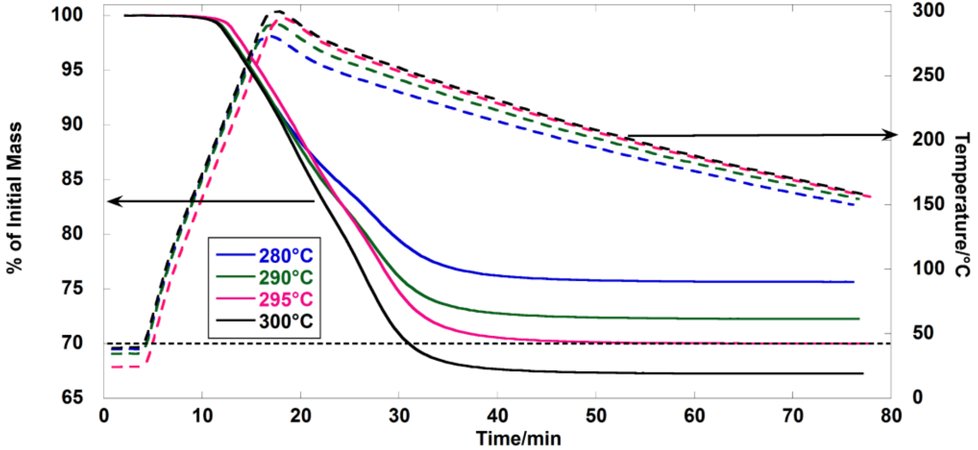


FT-IR



Macro-TGA Torrefaction

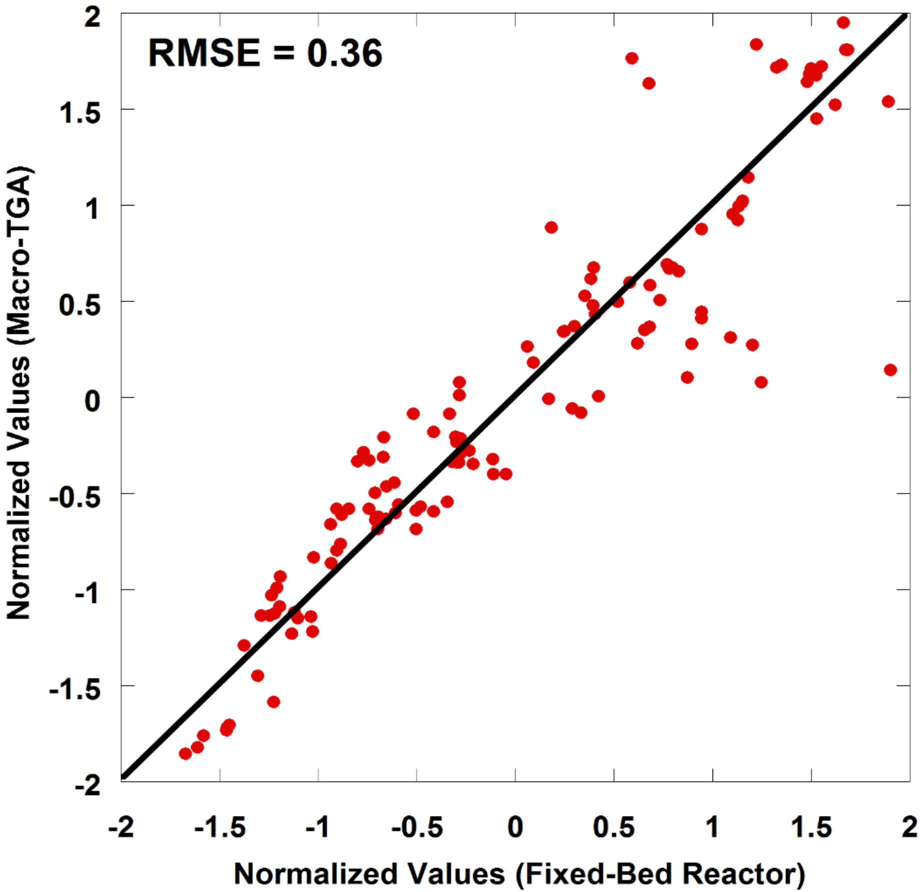




- ➢ Macro-TGA is capable of loading similar amount of sample as the fixed-bed reactor.
- ➢ The mass yield approaches to targeted values, 70%, when the torrefaction temperature is approximately 230°C
- ➢ The mass yield at 281° C can reach 70% when the residence time is ~5 min.
- ➢ The mass yield reaches 70% at 295 °C, with no hold time, and 60 min cooling.

20°C/min; No Hold; Cool 60min

Fixed Bed Reactor vs. Macro-TGA



Macro-TGA advantages

- Simplified sample loading and unloading
- Easier to operate
- Capable of semi-continuously monitoring the mass loss

- The torrefied pods generated by macro-TGA possess similar fuel properties as that from the fixed-bed reactor.

- The disadvantage of macro-TGA is that the product gases are not swept from the covered crucibles during the torrefaction process as would be the case at larger scales.

Summary

- The mass and energy yield, and energy densification index of the torrefaction process for pongamia pods reach the **targeted values**, i.e. 70%, 90% and 1.30, respectively, when torrefaction temperature is **220 -230 °C**.
- A small fraction of **sulfur** can be **released** from the pod during torrefaction, but the torrefied pods still possesses increased level of sulfur in comparison with the raw materials.
- The **release** of **chlorine** was not observed during torrefaction, and the further **increased potassium** and **chlorine** content of the torrefied pods will **require management** to avoid **deposition and fouling** when utilized for combustion and gasification.
- The macro-TGA is capable of similar loading capacity, ~100g, as the fixed-bed reactor, and torrefied pods generated by macro-TGA possess **similar fuel properties** as that from the fixed-bed reactor.
- The macro-TGA is demonstrated as a **fast screening tool** to generate torrefaction samples under varied process parameters of temperature, heating rate, and hold time.

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Questions?