Waste-to-Energy: Hydrothermal Liquefaction

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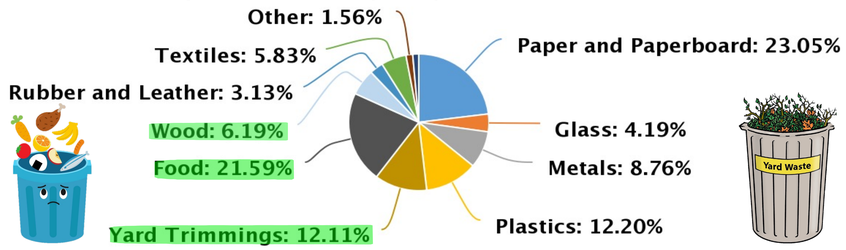
Introduction & Motivation

Engineering for People and the Planet
WPI Research Experiences for Teaching Integrated STEM

7 AFFORDABLE AND CLEAN ENERGY — SUSTAINABLE DEVELOPMENT GOALS — 12 RESPONSIBLE CONSUMPTION AND PRODUCTION

Municipal Solid Waste (MSW) in 2018 = 292.4 Million Tons

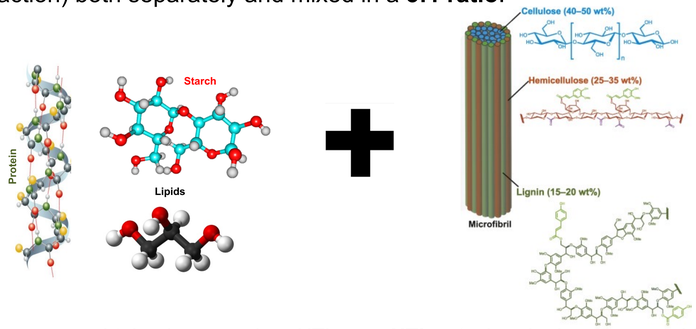


Hydrothermal Liquefaction:

- HTL is more **sustainable**, and **economically viable** thermochemical technology, compared to competing mechanisms such as: pyrolysis, torrefaction, etc.
- The HTL process: water-aided reaction at **elevated temperatures** (250-400°C) **and pressures** (above 400psi)
- HTL converts **waste** feedstocks **into** an energy-dense **bio-crude**
- The project aims to evaluate best conditions to maximize yield and quality

HTL Operational Dynamics

Food waste and **green waste** are used as a **feedstock for HTL** (Hydrothermal Liquefaction) both separately and mixed in a **3:1 ratio**.



Samples were obtained comparing HTL vs. **HTL+** (using hydrogen peroxide as a promoter can alter partitioning, lowering char formation and increasing oil yield):

- Reaction times of 20min & 60min
- Different combinations of feedstocks
- Temperatures of 275°C & 300°C

} Evaluated to achieve an **optimal system**

Transformation of Energy

1. Grind & Sieve Green Waste

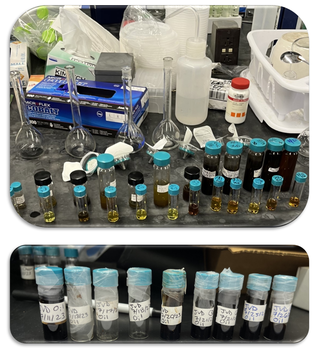
2. Prepare Food Waste

3. Heat & React

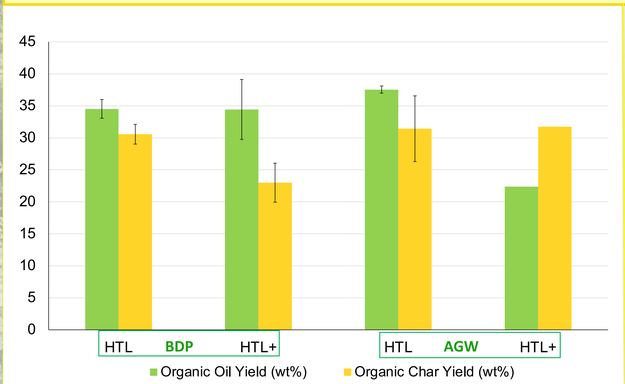
4. Vacuum Filtration x2

5. Rotary Evaporator: Oil Extraction

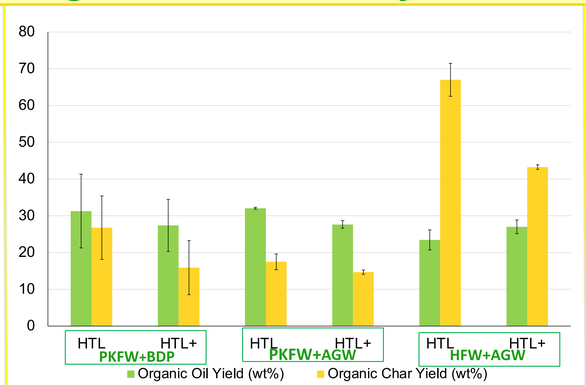
6. Analysis After Extraction:
- Total Organic Carbon (TOC)
- Gas Chromatography-Mass Spectrometry(GC/MS)
- Elemental analysis of Char & Oil



Increasing Oil Yield & Quality



- The figure above illustrates the organic yield (%) of the **green waste** (BDP vs AGW) reactions at **275°C** and **20min**, comparing of effects of **HTL vs HTL+** in char and oil (bio-crude).
- HTL+ decreased the amount of char for BDP, but there wasn't any impact on the oil. For AGW it was the opposite, the oil yield decreased with HTL+, but significant change in the char.



- The figure above shows the organic yield (%) for different types of **food waste** combined with **green waste** in a **3:1** ratio, all **60 min** reactions at **300°C**, contrasting the impacts of HTL vs HTL+ on the production of char and oil (bio-crude).
- HTL+ had no substantial effect on the oil yield, it only noticeably impacted the char produced.

Reactions GW 275°C 20min	HTL	HTL+
AGW	48.0%	-
BDP	53.4%	66.8%

- This table portrays the **bio-crude** (oil) **carbon percentage** for green waste (BDP vs AGW) reactions (at **275°C** and **20min**).
- Results for AGW HTL+ still pending, but in the BDP the percentage increased distinctively.

Reactions FW:GW (3:1) 300°C 60min	HTL	HTL+
PKFW+BDP	66.9%	67.1%
PKFW+AGW	65.2%	68.5%

- The table above indicates the **bio-crude** (oil) **carbon percentage** for the combinations of **food and green waste** reactions (**3:1** ratio, **60min**, **300°C).**
- HTL+ increased its quality, but not by much.

Future Work

Lab Experience = Lesson Plans

High School Chemistry Standards - **PS1. Matter and Its Interactions:**

- HS-PS1-4. **Bond energies**
- HS-PS1-11(MA). Identifying and and separating the components of a mixture

Continuous research to achieve the most efficient system

References

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