Integrating hydrothermal liquefaction and anaerobic digestion for sustainable energy generation from food waste

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“Finding ways to achieve global food security without expanding land-use and without increasing greenhouse gas emissions”.

In the U.S., 40% of the food produced never reaches the consumer… (Gunders, 2012)

**Anaerobic digestion** is probably the most environmentally-sustainable and cost-effective technology to address this problem.

- **Low efficiency**
- **Electricity Pay-off:** $0.035-0.10/ kWh
- **Nutrient recovery**
Hydrothermal biomass conversion is an attractive treatment for wet biomass

**Temperatures**
150-700°C

**Pressures**
$P_{vap}$ or $P_{critical}$

**Residence times**
seconds to minutes

**Feedstocks**
wastes, energy crops, algae, grains, etc.

Critical point for water:
$T_c = 374$ C
$P_c = 22.1$ MPa
Hydrothermal liquefaction (HTL) allows fast (< 60 min) conversion of carbon components into bio-crude oil.

1-5% feedstock (polysaccharides, proteins, lipids)
Temperature: 250-350 °C
Pressure: 5-20 Mpa
Residence time: 10-60 minutes.
Hydrothermal conversion of food waste

Temperature: 250-350 °C; Pressure: 5-20 Mpa
Time: 20, 60 min

Posmanik et al, in preparation

Reduction of the oxygen content from 50% to 10% due to dehydration reactions at subcritical water.
Adding ethanol to the reaction increases the oil yield

Temp = 300 °C; Time = 10min + 10min

Glucose + Ethanol
- Gas: 13%
- Oil: 32%
- Aqueous: 41%
- Char: 14%
- pH: 2.9

Glucose + Ethanol + NaOH
- Gas: 11%
- Oil: 61%
- Aqueous: 27%
- Char: 1%
- Final pH: 6.6
High organic carbon at the aqueous phase challenges the application of the technology.

Possible solutions:
1) Catalytic gasification
2) Membrane separation
3) Fast anaerobic digestion

Biochemical methane potential (BMP) shows highest anaerobic biodegradability of the HTL-aqueous phase at 250-300 °C.
So far...

• Food waste can be a suitable substrate for hydrothermal treatment.
• Addition of ethanol under alkaline conditions disfavors char and shifts the carbon at the aqueous phase to the oil phase.
• Condensation reactions between long chain (from lipids) and short chain (from sugars) are catalyzed under alkaline conditions (contributed by degradation of proteins).
• The residual carbon at the aqueous phase is a suitable substrate for fast anaerobic digestion.
Implementation
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