Hydrothermal processing of food waste: a circular economy approach to improve resource recovery and minimize environmental pollution

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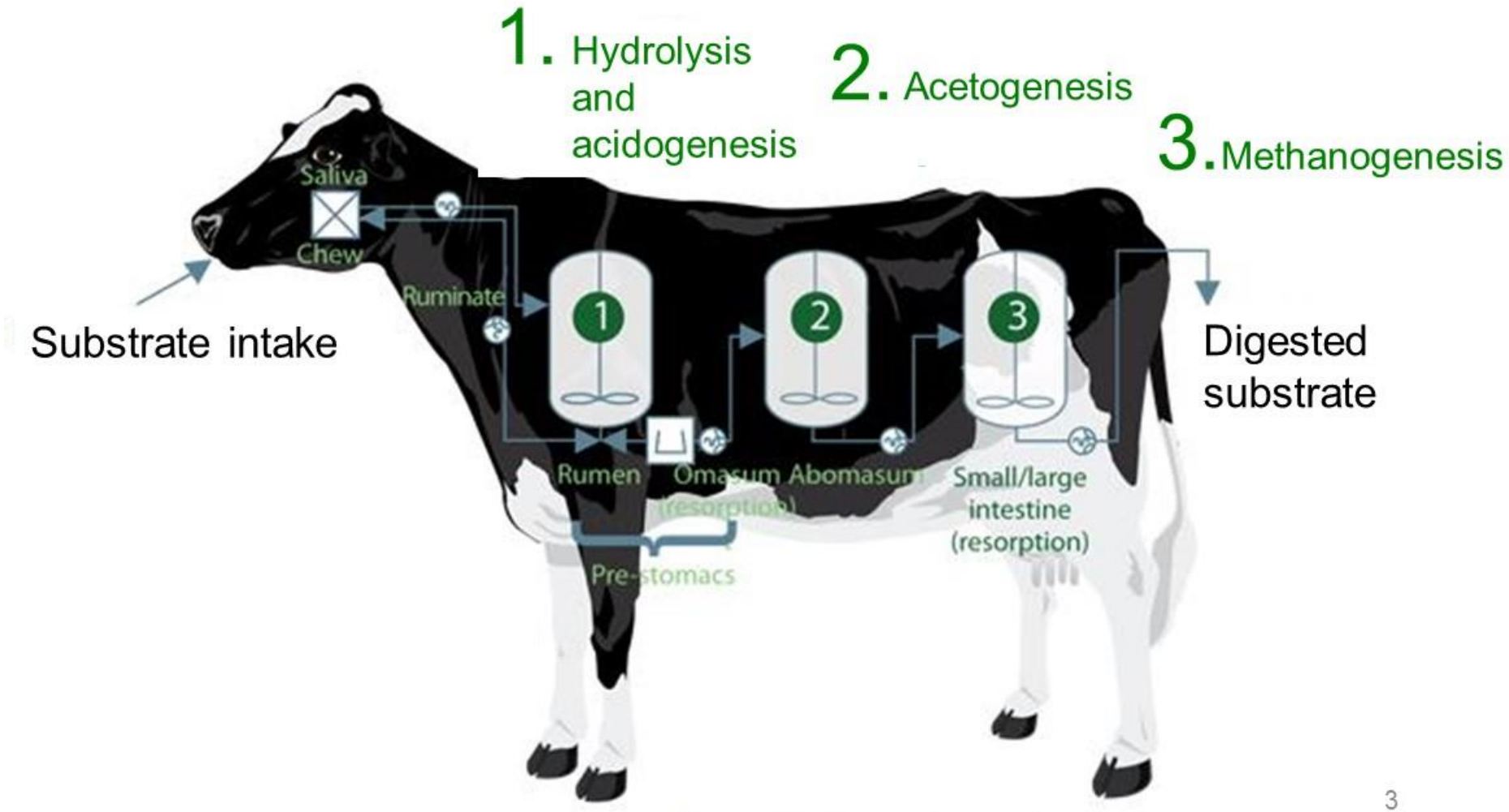
The challenge of feeding 9 billion people

Past

(Single processing)

Anaerobic digestion is widely used as a source of bioenergy



Source: http://www.solvay.com/

Insufficient return from electricity challenges anaerobic digestion implementation

Gas flare

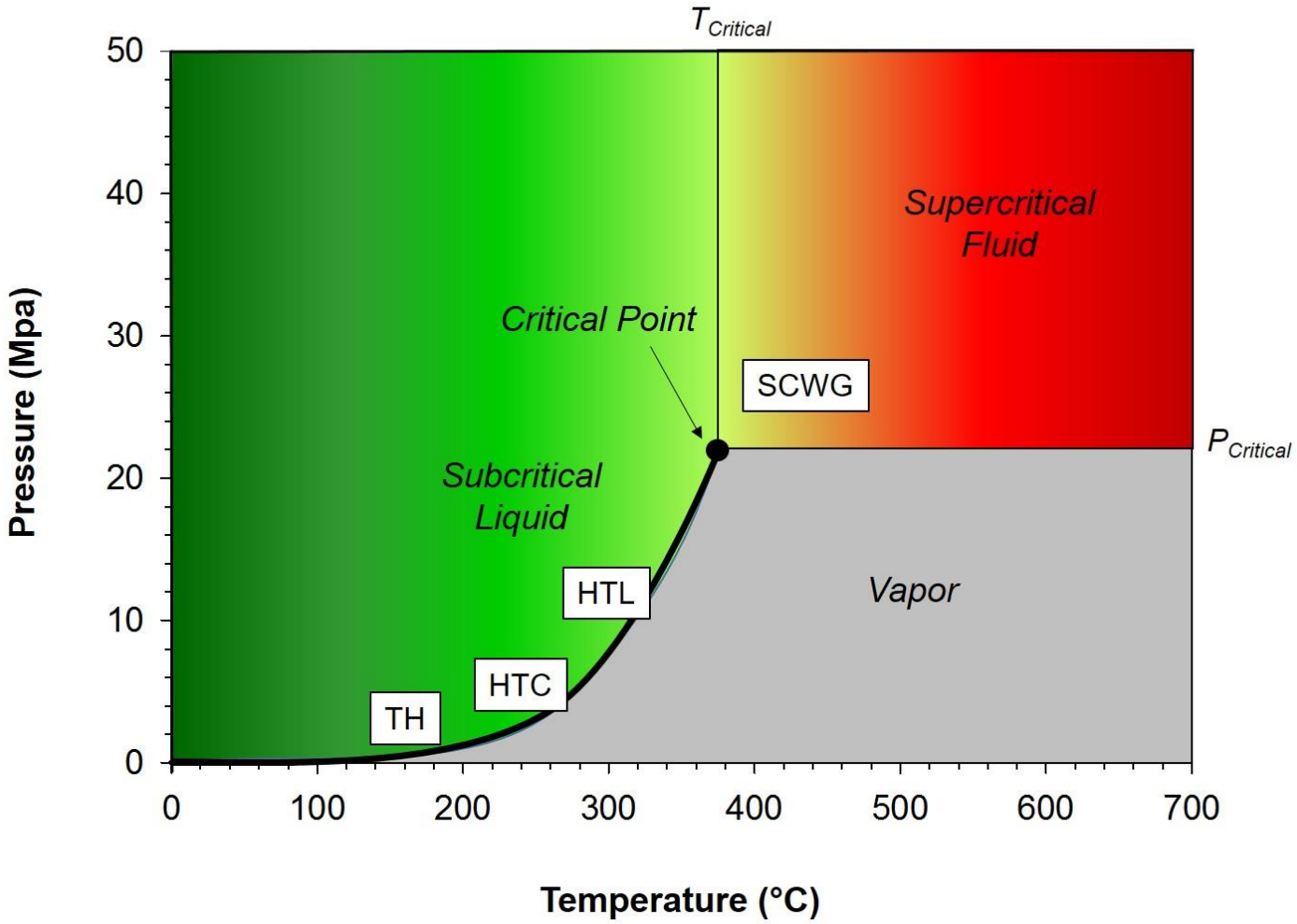
Combined heat and power (CHP)

Cows

Sunnyside Farm, Upstate NY

Plug flow digester

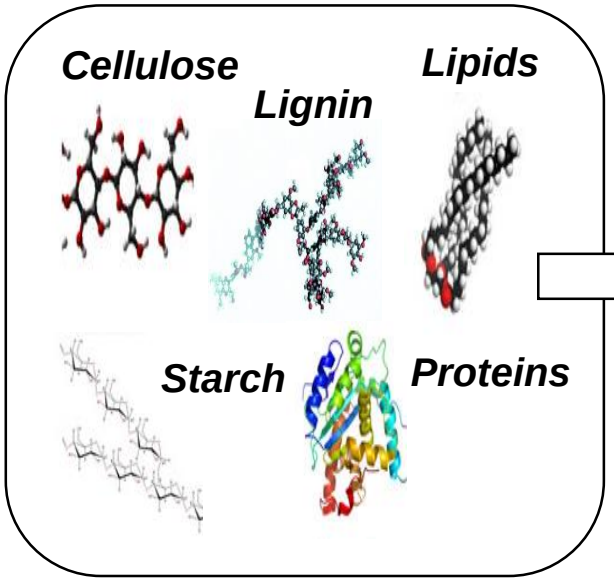
Hydrothermal biomass conversion



Angenent, L.T., Usack, J.G., Xu, J., Hafenbradl, D., Posmanik, R., Tester, J.W., 2018. Bioresour. Technol. 247, 1085–1094.

HTL allows fast conversion of organic carbon into bio-crude oil and other co-products

BIOMASS



HTL

Gas

Aqueous phase

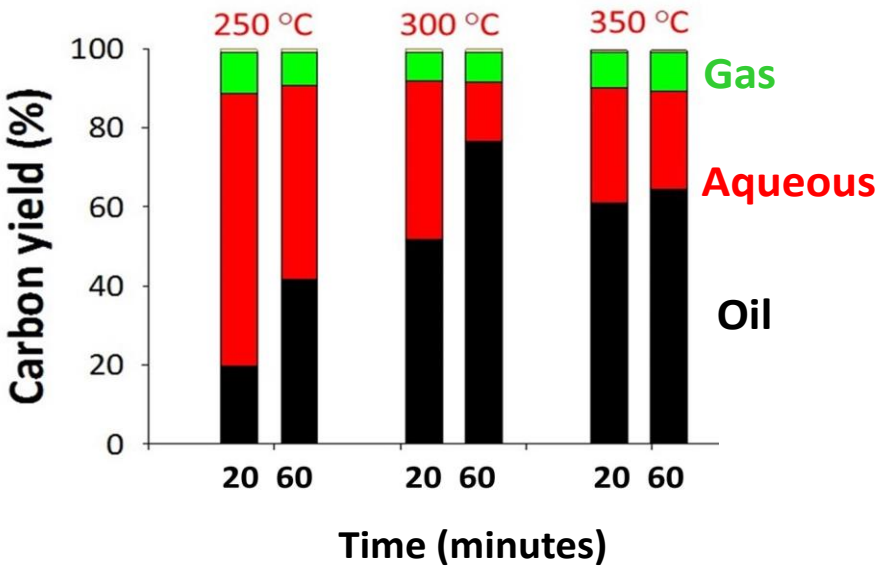
Crude oil

Hydro char

5–60 minutes
200–350 ºC
2–20 MPa

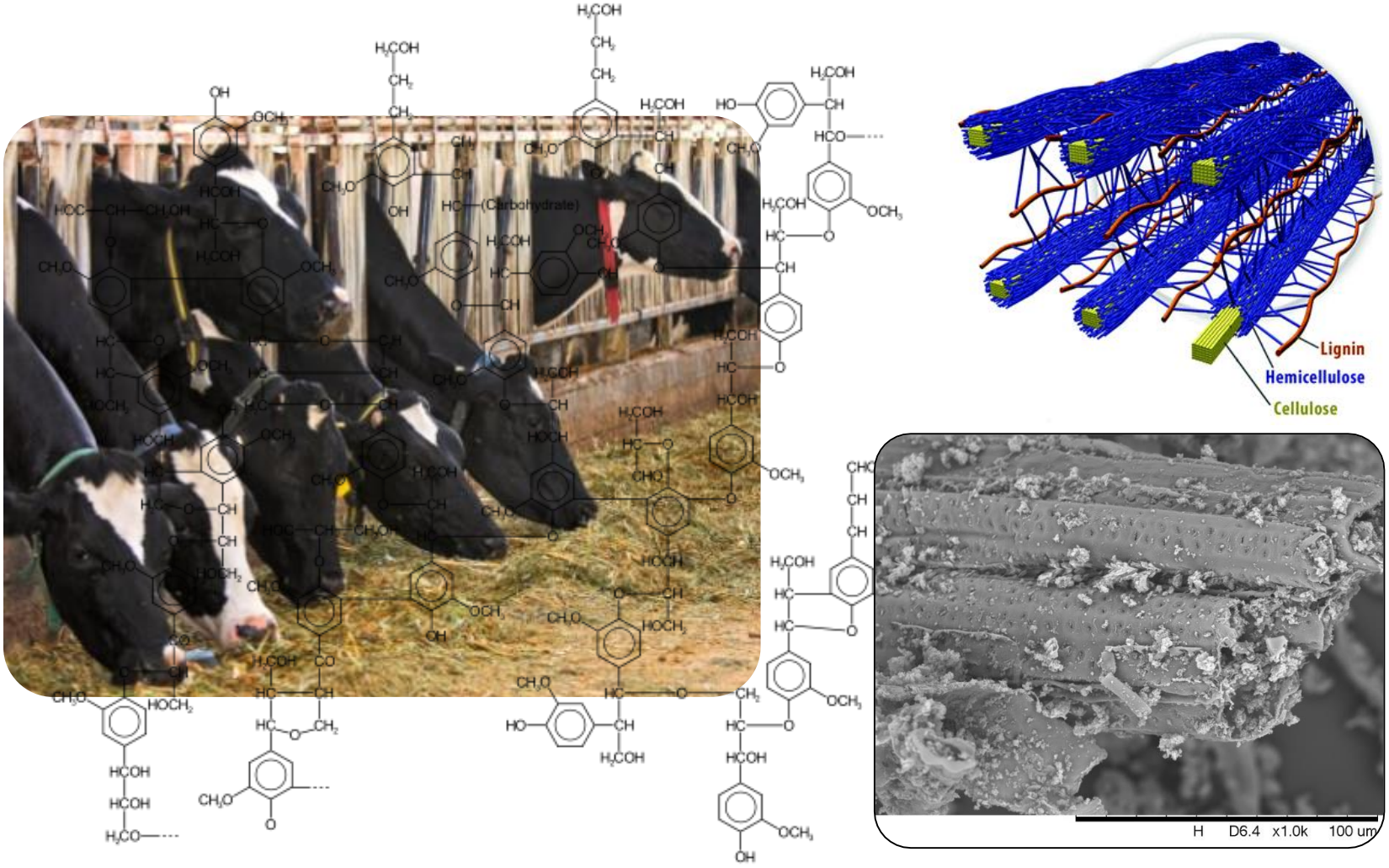
Food waste valorization as a movement into carbon neutrality

Up to 70 % of the raw carbon is converted to crude-oil via hydrothermal liquefaction

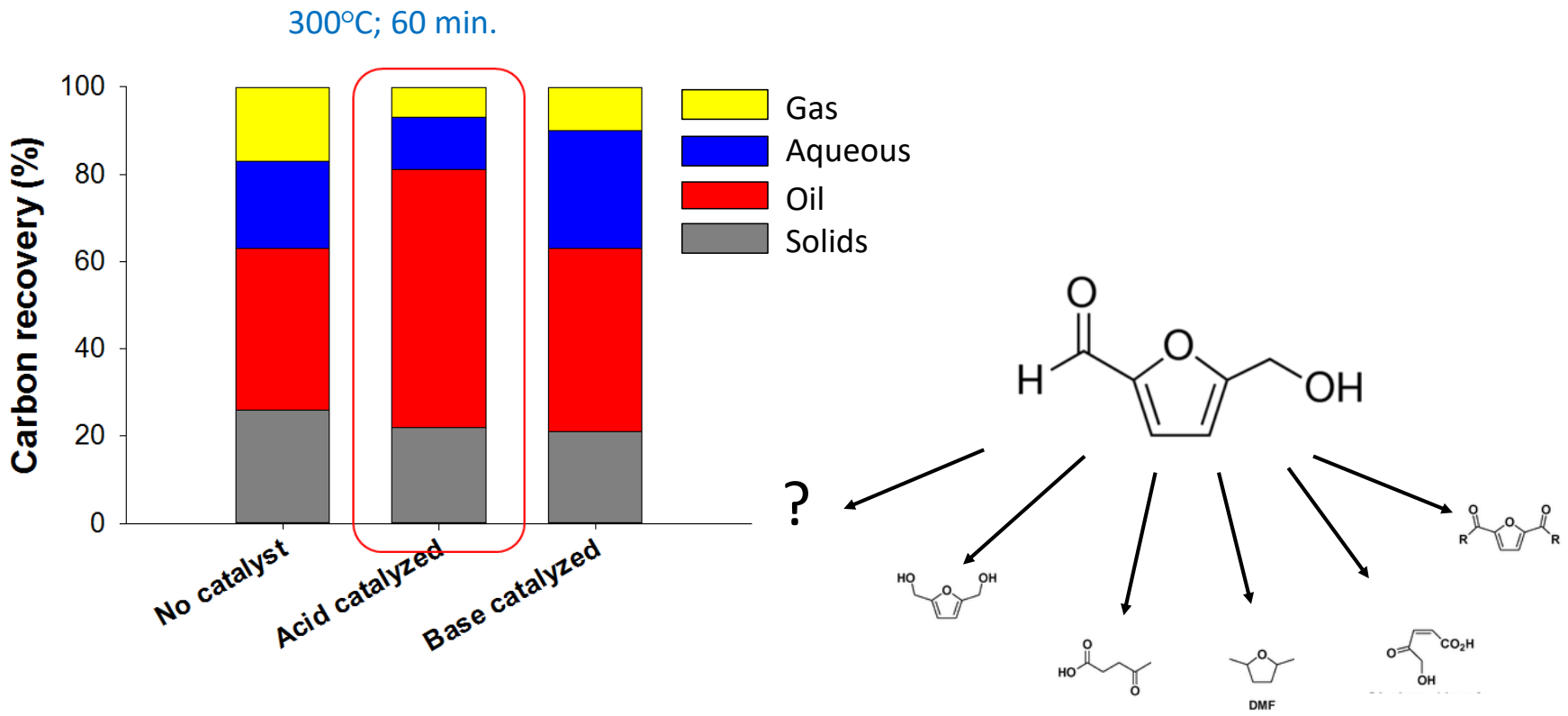


Posmanik R, Cantero DA, Malkani A, Sills DL, Tester JW. (2017) *Journal of Supercritical Fluids* 119, 26-35.

High fiber content in manure challenges its degradation

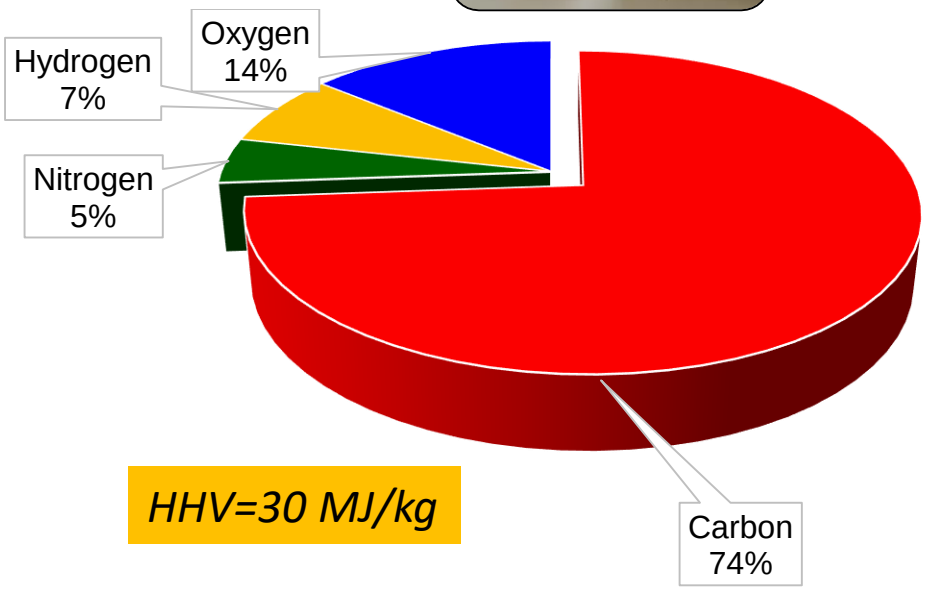


Acid-enhanced production of 5-HMF “shifts” the carbon into the oil phase

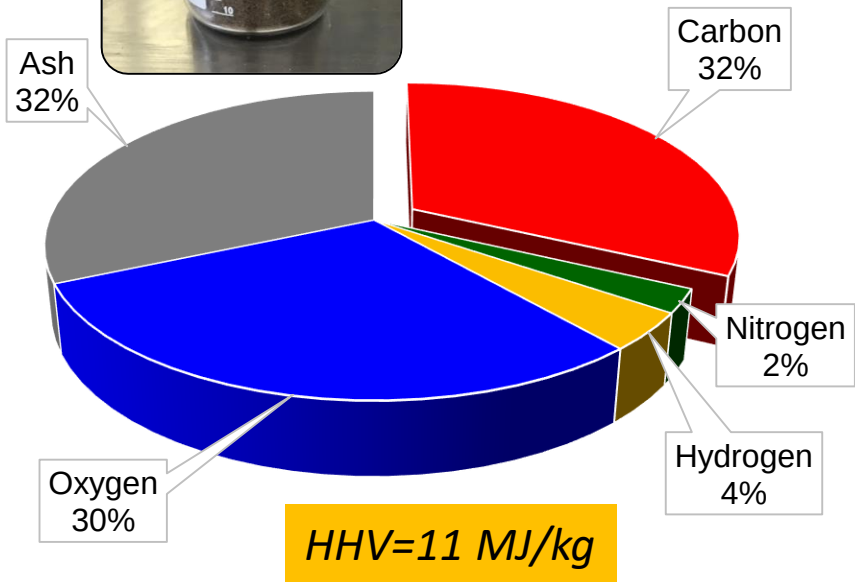


R. Posmanik, C.M. Martinez, B. Cantero-Tubilla, D.A. Cantero, D.L. Sills, M.J. Cocero, J.W. Tester (2018) *ACS Sustainable Chemistry and Engineering* 6, 2724–2732.

More carbon, less oxygen



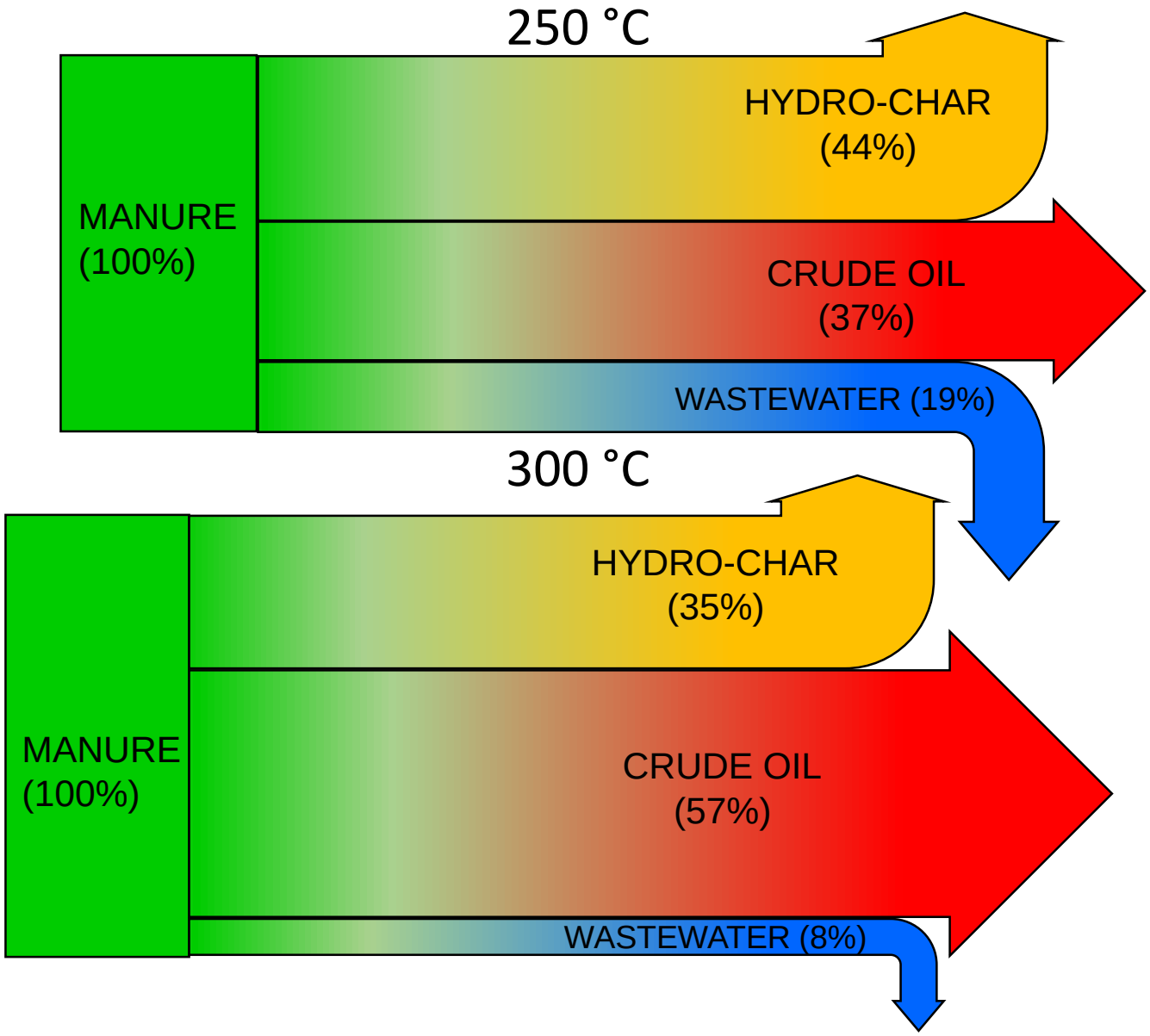
HHV=30 MJ/kg



HHV=11 MJ/kg

$$Higher\ heating\ value, HHV = 0.338 \times C + 1.428\ (H - \frac{O}{8})$$

ENERGY BALANCE

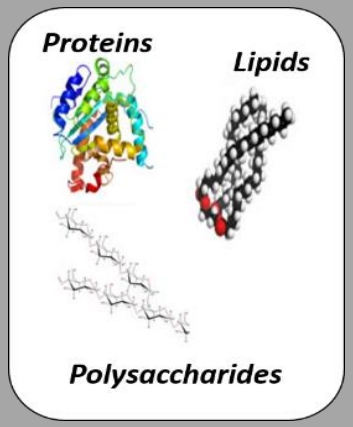


Dissolved organic carbon at hydrothermal wastewater challenges the application of HTL

Possible solutions:

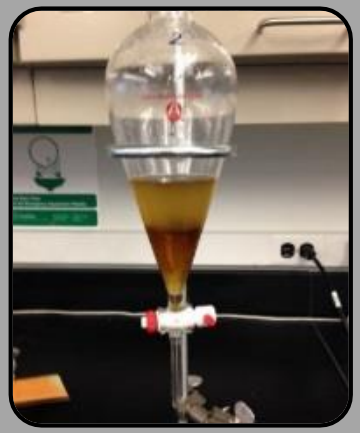
1. Anaerobic digestion (AD)
2. Catalytic hydrothermal gasification (CHG)
3. Membrane distillation

Feedstock



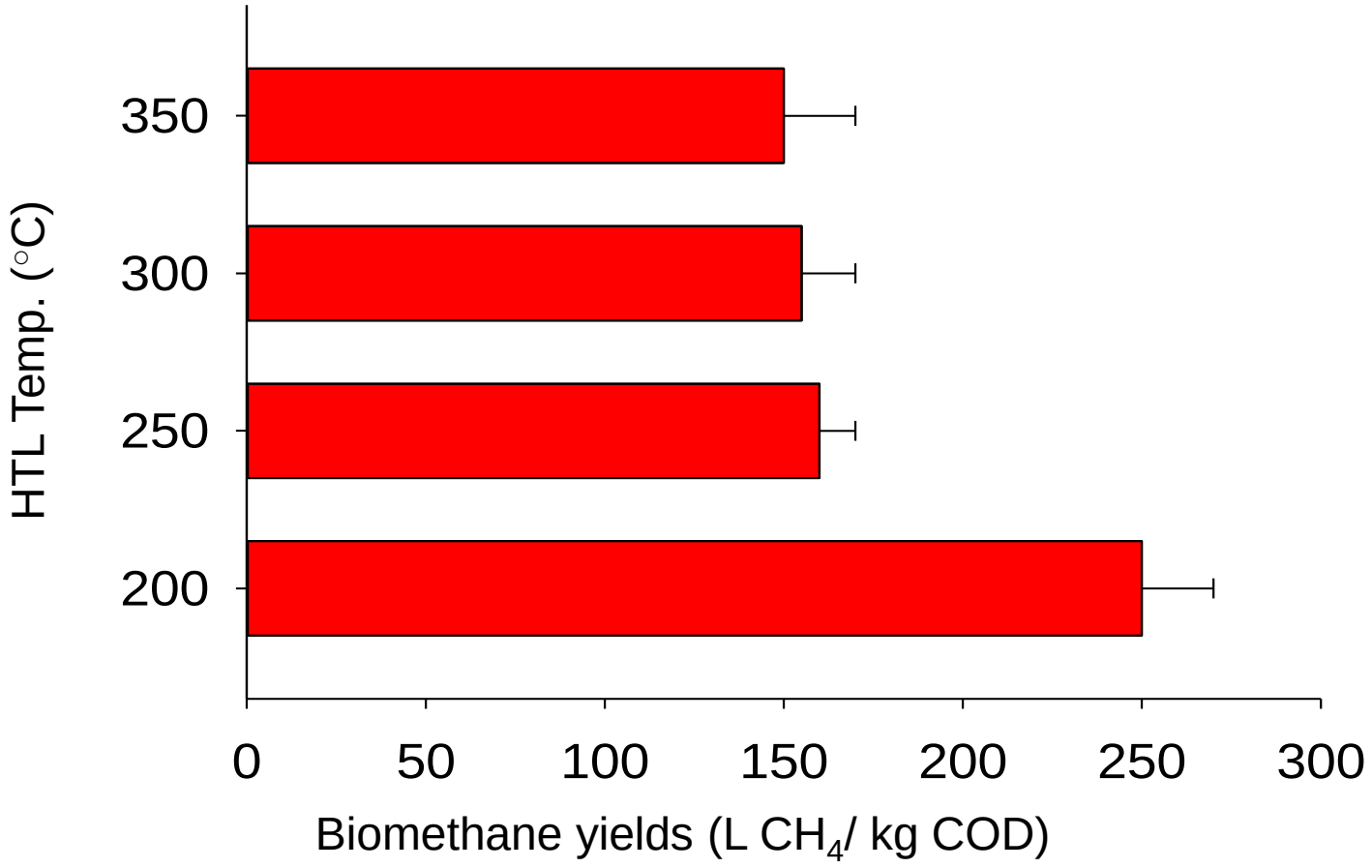
Hydrothermal processing

Separated products



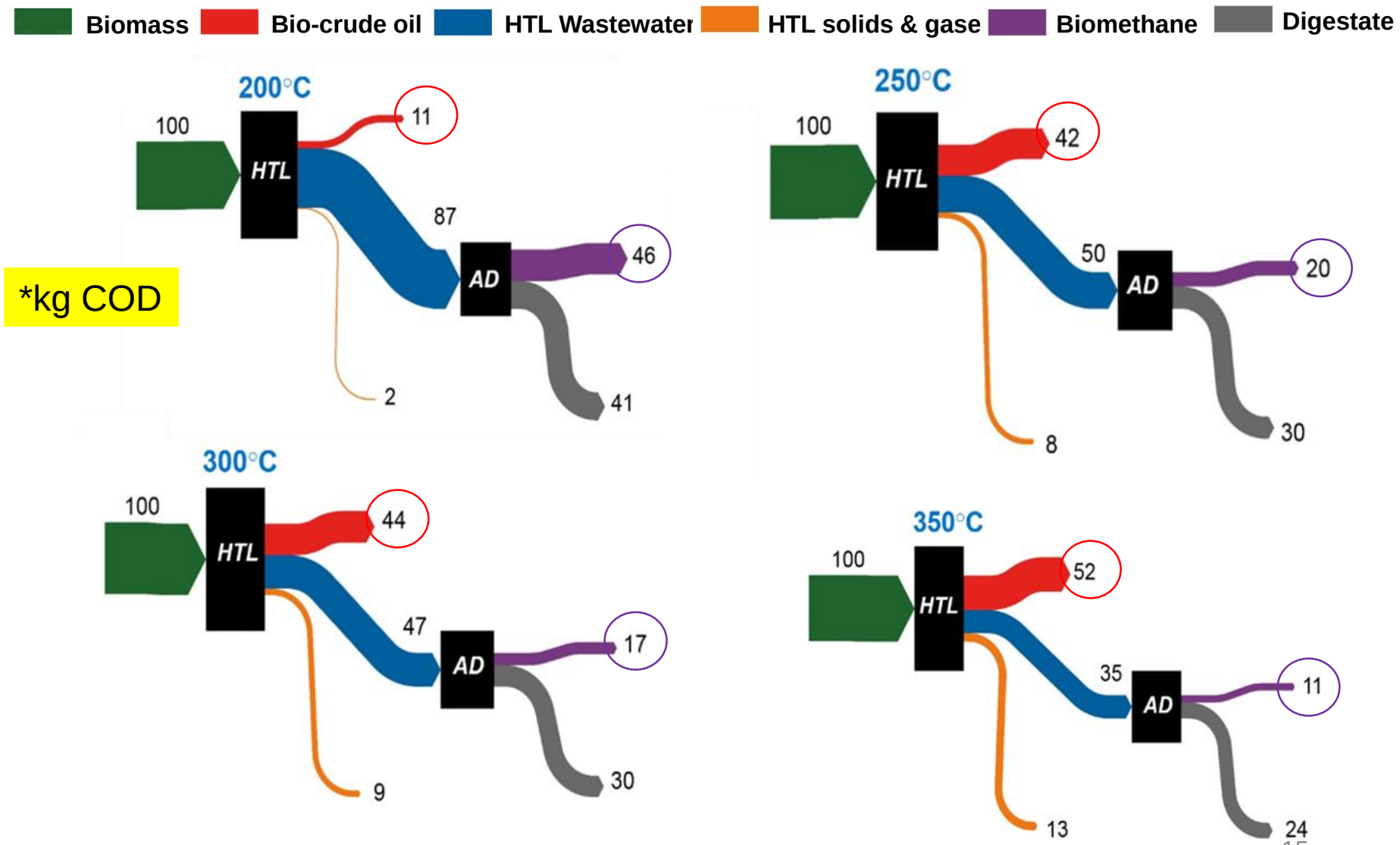
Product utilization

HTL temperature affects the biodegradability of hydrothermal wastewater



Posmanik R, Labatut RA, Kim AH, Usack JG, Tester JW, Angenent LT (2017) *Bioresource Technology* 233, 134-143.

A trade-off between bio-oil and biogas production



*kg COD

Posmanik R, Labatut RA, Kim AH, Usack JG, Tester JW, Angenent LT (2017) *Bioresource Technology* 233, 134-143.

Future

(Circular economy)

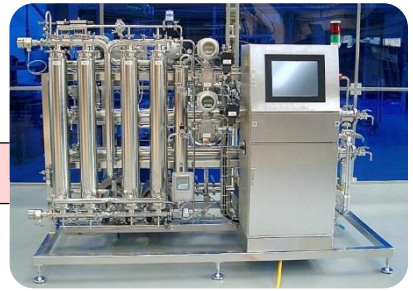
Manure and waste from the dairy industry

Biogas
for renewable energy applications

HEAT

Bio-oil
for renewable energy applications

HEAT



Nutrients
Clean water

Feed-to-Food project in Newe Ya'ar model farm

FIELD

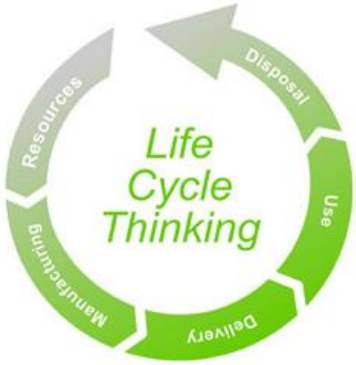
- New crops and byproducts for cattle feed
- Recycling organic soil additives

FEEDLOT

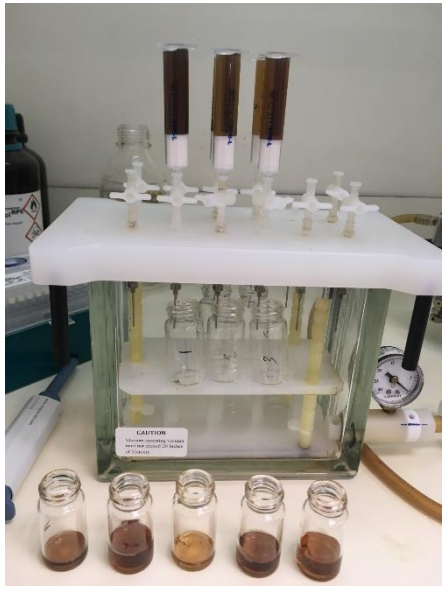
- High feed efficiency
- Improved product quality
- Low morbidity
- Odorant control

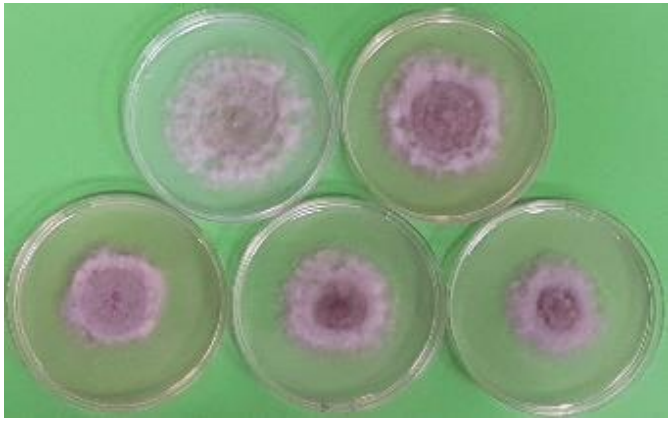
WASTE MANAGEMENT

- Process integration
- Waste stabilization
- Resource recovery
- Renewable energy generation



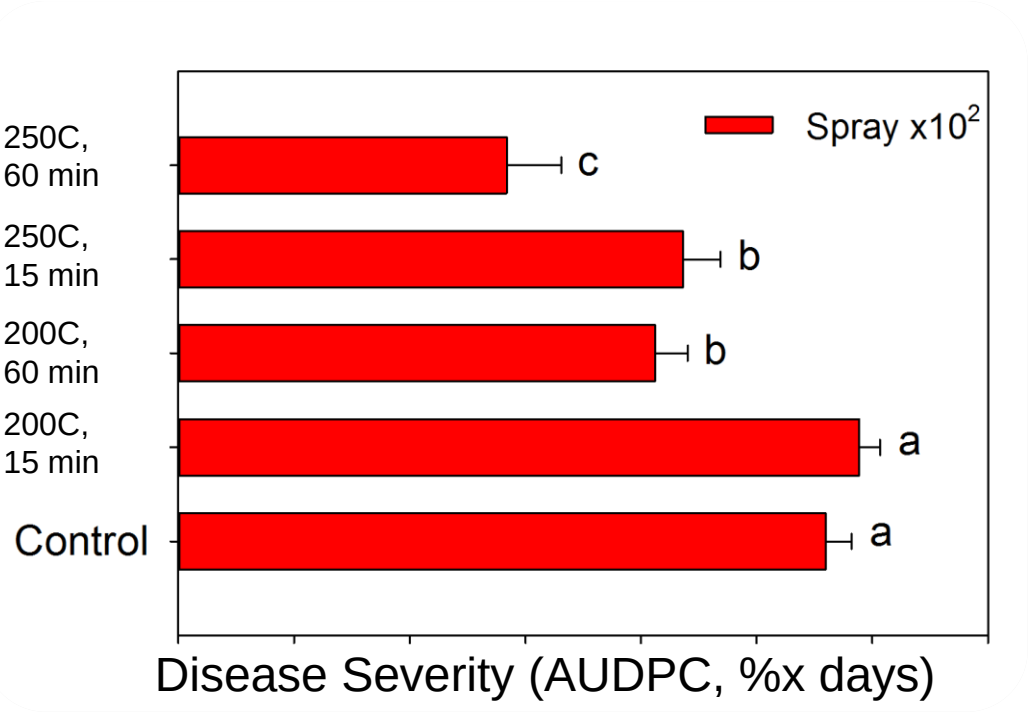
Seeking for new opportunities





** Plant protection ability of biomass thermally processed liquids with Prof. Y. Elad and Dr. E. Graber, ARO*

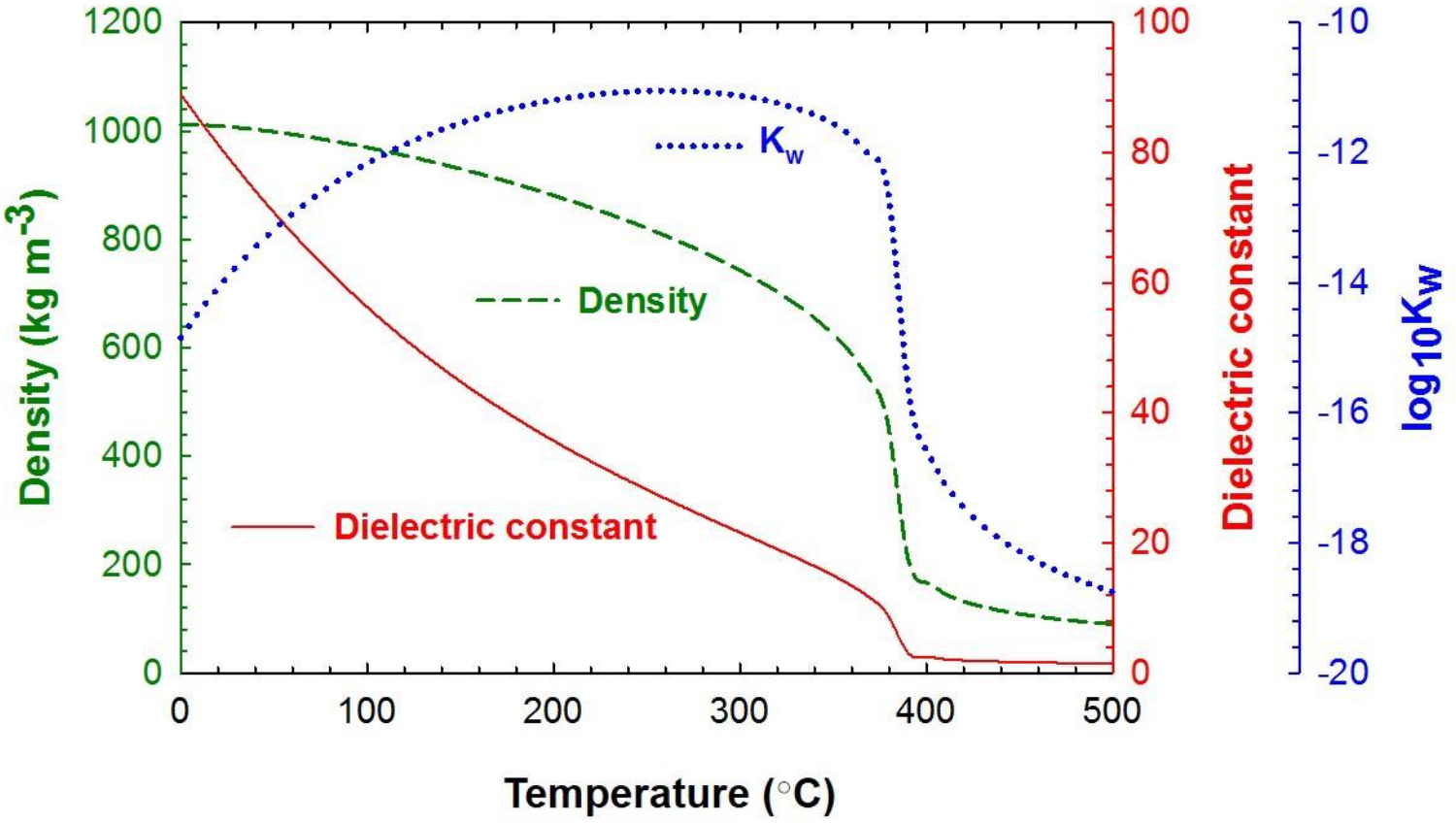
Induced resistance to pathogenic fungi



** Plant protection ability of biomass thermally processed liquids with Prof. Y. Elad and Dr. E. Graber, ARO*

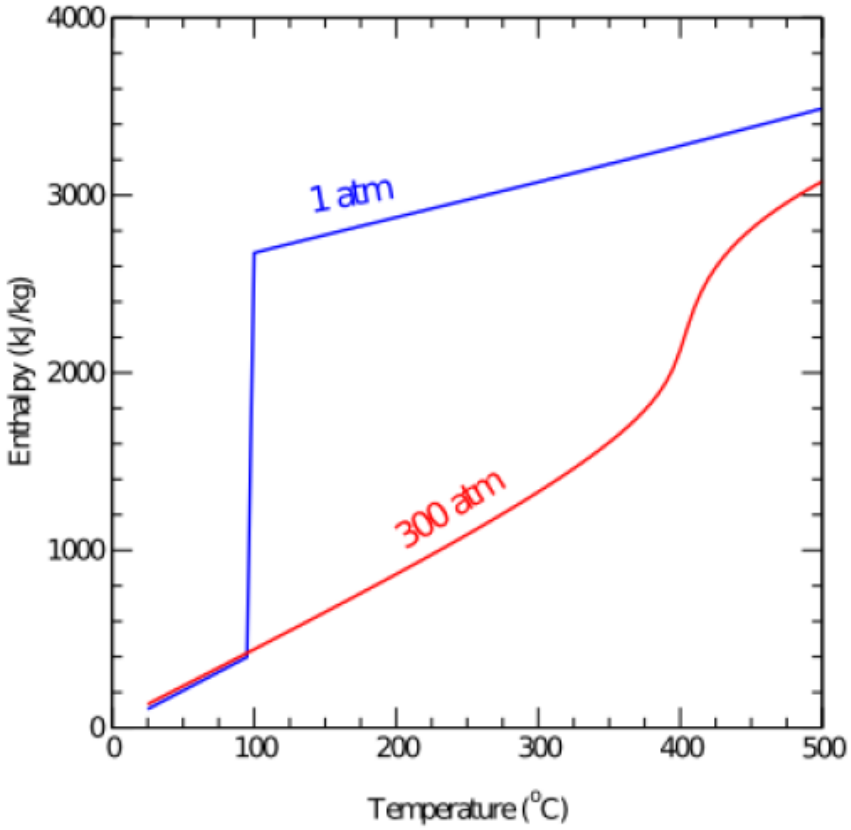
Thank you!

We are currently recruiting graduate students and postdocs
Please visit: www.posmaniklab.com



- Drastic drop in **dielectric constant** and **water density** with the increase of the **ionic product** near critical conditions.
- A good alternative to dissolve, hydrolyze and fractionate biomass.

Enthalpy of water vs. Temp. at 1 and 300 atm



Available thermal energy expressed by the change in enthalpy (ΔH) that can potentially be recovered by cooling water from reaction to room temperature.

Temperature (°C)	ΔH (kJ/kg)
175	627
200	739
225	852
250	970
275	1094
300	1229
325	1379
350	1557

Energy out= $30 \frac{MJ}{kg\ oil} \times 0.7 \frac{kg\ oil}{kg\ biomass}$

= 21MJ/kg biomass

Environmental and economic sustainability

Techno-economic Analysis

Life-Cycle Assessment