<u>Assessment of likely Technology Maturation pathways</u> used to produce biojet from forest residues (The ATM project)













UBC Bioenergy/Forest

Green Aviation Research & Development Network

Drop-in biofuels reports (2014 & 2019) www.Task39.org



James D. McMillan, IEA Bioenergy Task 39 and National Renewable Energy Laboratory, Denver, Colorado Jack Saddler, IEA Bioenergy Task 39 and Forest Products Biotechnology/Bioenergy Group, University of British Columbia, Vancouver, BC, Canada

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Main challenges of different technologies identified in 2014 report

Oleochemical

- Feedstock cost, availability, sustainability
- Pyrolysis & HTL (direct thermochemical liquefaction)
 - Hydrogen demand
 - Hydrotreating catalyst cost and lifespan
- Gasification
 - Capital / scale
 - Syngas conditioning
- Biochemical
 - Low productivity
 - Valuable intermediates

ATM Project -Assessing the potential of direct thermochemical liquefaction technologies for biojet production

- Source biocrude from different technology providers (3)
- Upgrading of biocrudes (biogenic feedstocks/bio-oils?)
- Characterization of biojet & other fractions
- Feedstock supply chain logistics and feasibility;
- Life cycle assessment;
- Biocrude production process performance and technoeconomics;
- Demonstration plant concept and design
- Policy environment and recommendations

Biocrude Upgrading approaches

CanmetEnergy-Ottawa

CanmetENERGY Leadership in ecoInnovation

- Co-processing strategy blending biocrude (18%) with furnace fuel oil before hydrotreating (C14 analysis used)
- Proprietary MoS₂ dispersed catalyst
- Pacific Northwest National Laboratory
 - "Dedicated" hydrotreating of biocrudes one or two-stage upgrading
- Pacific Northwest NATIONAL LABORATORY

Commercial Ni-Mo sulfide based hydrotreating catalyst

⁶ UBC Bioenergy/Forest Products Biotechnology Group

Sources of biocrudes

Fast pyrolysis bio-oil/biocrude Challenges: High oxygen, high TAN, unstable BTG, Netherlands (small commercial & optimized) Catalytic pyrolysis biocrude Lower oxygen & stable but low yields VTT, Finland (pilot, not optimized) Hydrothermal liquefaction biocrude Lower oxygen, stable & wet feedstock Supercritical (<10% O₂) vs subcritical (>10% O₂) • Aarhus University, Denmark (pilot, not optimized)





Key components of ATM Project

- Integrated analysis of technical, techno-economic and life cycle factors, within the current policy framework in British Columbia.
- Note:Most projects consider only technical or technical & economic viability



POLICY

Simple flow diagram of the project



Composition and Source of HTL biocrude: Aarhus University, using Subcritical conditions

Heating Value, MJ/Litre (HHV)	35.87
Density, g/litre	1,120
Carbon fraction %	78.2
Sulphur fraction %	0
Hydrogen fraction %	7.2
Oxygen fraction %	14.5
Aromaticity, %	60.9
Ash Content, wt %	0.61
pH	4.53
Pour point, °C	33
Solids, wt%	0.5
TAN, mg KOH/g	28.6
Water content, wt %	5.6

^{*} UBC Bioenergy/Forest Products Biotechnology Gro

Composition of biocrudes

Parameter	Fast pyrolysis	Catalytic pyrolysis	HTL
Heating Value, MJ/Litre (HHV)	21.52	32.3	35.87
Density, g/litre	1,197	1,168	1,120
Aromaticity, %	42.9	63.9	60.9
рН	2.66	3	4.53
Pour point, °C	-36	-6	33
TAN, mg KOH/g	125	82.6	28.6
Water content, wt %	25.7	7.6	5.6

Upgrading of HTL biocrude

- Upgrading of HTL biocrude was demonstrated to be technically feasible, resulting in a "biocrude" with low oxygen levels and from which multiple fuel products were obtained (naphtha, jet fuel, diesel, heavy fuel oil)
- A significant jet fraction was produced (29.8% Canmet and 22.9% PNNL)
- The fuel fractions were analysed with a specific focus on the jet fraction.
- The quality of the jet fractions met most of the general ASTM D7566 specifications. With further optimization very likely that all standards could be met

NB - Yield results from Canmet coprocessing upgrading were based on biogenic fraction only

Life cycle analysis (GHGenius)

- PNNL upgrade: -51% (optimized -71.3% based on demo design)
- Canmet upgrade: -5.4%
- Further optimization of the HTL pathway with dedicated hydrotreating, based on a possible demonstration facility of 200 bbl/day, could deliver emission reductions of 71.3%.
- Key factors influencing potential emission reductions are:
 - co-products and
 - hydrogen consumption.



Hypothetical Supply chain for ATM Project

Biomass availability was assessed based on the current volumes within a 100 km radius of the proposed biocrude facility in BC.

Sufficient feedstock was available at an average cost of \$80CAN per oven dry tonne delivered to the biorefinery gate.



Engineering flow sheets (Class 5) of HTL pathway

Biocrude production assumed near to feedstock supply and transported to upgrading facility



Waste water treatment adds significantly to CAPEX

Hydrotreatment co-located with refinery



ATM/HTL biocrude upgrading - Key conclusions (full report at www.Task39.org)

- Biojet fuel successfully produced from HTL biocrude via the two upgrading pathways
- The Biojet fraction meets the majority of general ASTM specifications
- Possible emission reductions of up to 71.3% are possible
- Techno-economic assessment was reasonable compared to other potential biojet fuel pathways (e.g. alcohol to jet, HEFA biojet, FT biojet, sugar to biojet)
- HTL biocrudes were more stable, less corrosive, had a higher energy density and were "conducive" to one stage hydroprocessing
- However, "Nature" of the feedstock needs further study

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