The key role that co-processing will play in the production of drop-in biofuels

Why?, How?, Impacts and challenges

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International Energy Agency Bioenergy Task 39 (Liquid biofuels)
‘DROP-IN’ BIOFUELS: The key role that co-processing will play in its production

Review

Potential synergies of drop-in biofuel production with further co-processing at oil refineries

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Abstract: Drop-in biofuels have been defined as functionally equivalent to petroleum-based transportation fuels and are fully compatible with the existing petroleum infrastructure. They will be essential in sectors such as aviation if we are to achieve emission reduction and climate mitigation goals. Currently, however, the use of drop-in biofuels is limited by the high cost of producing the feedstock biomass via traditional means.
Assessment of likely Technology Maturation pathways used to produce biojet from forest residues - (The ATM project)
BC SMART ROADMAP:

A decarbonisation strategy for British Columbia’s (BC’s) Marine, Aviation, Rail and Truck (MART) Sectors

Establishing the BC SMART Fuels Consortium

Roadmap centered around advancing drop-in biofuel production through co-processing

Jack Saddler, Don O’Connor, Susan van Dyk, Mahmood Ebadian

Forest Products Biotechnology/Bioenergy at UBC
Drop-in biofuels and current / conventional biofuels

- Drop-in biofuels: are “liquid bio-hydrocarbons that are:
  - functionally equivalent to petroleum fuels and fully compatible with existing petroleum infrastructure”

- Conventional biofuels (ethanol and biodiesel) still have high oxygen levels
WHY co-process?

- Regulatory compliance - meeting carbon intensity targets (which you can’t meet through blending conventional biofuels)
- Desire to reduce climate impact
- Policy incentives - financial rewards
- Niche products and niche markets e.g. aviation

*Biofuels for Aviation. An IRENA Technology brief*

FEBRUARY, 2017

Susan van Dyk & Jack Saddler
Co-processing as a key strategy to expand drop-in biofuel production?

- Build stand-alone infrastructure
- Co-location (hydrogen)
- Repurpose existing infrastructure (e.g. World Energy (AltAir) in California, ENI Italy, Total La Mede, France)
- Co-processing of biobased intermediates in existing refineries to produce fossil fuels with renewable content (lower carbon intensity)
HOW? of co-processing

Potential insertion points of biobased intermediates
1. Atmospheric distillation - highest risk of contamination
2. Processing/finishing steps - FCC, hydrotreater/hydrocracker
3. Blending stage - Lowest risk
Where and how you insert depends on
(1) nature of feedstock &
(2) risk to refinery operations

- Oxygen
  - ~11%-40%
  - Lipids < biocrudes
- Acidity/TAN
  - Fast pyrolysis biocrude > hydrothermal liquefaction biocrude
- Alkali metals
  - Magnesium
  - Phosphorus e.g. canola oil
- Miscibility
- Viscosity

**Development of STANDARDS for intermediates are critical**
The ATM project
Comparison of biocrudes

<table>
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<tr>
<th>Parameter</th>
<th>1</th>
<th>2</th>
<th>3</th>
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<tr>
<td>Heating Value, MJ/Litre (HHV)</td>
<td>21.52</td>
<td>32.3</td>
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<td>Density, g/litre</td>
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<td>Aromaticity, %</td>
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<td>pH</td>
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<tr>
<td>Pour point, °C</td>
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<tr>
<td>TAN, mg KOH/g</td>
<td>125</td>
<td>82.6</td>
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<tr>
<td>Water content, wt %</td>
<td>25.7</td>
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</table>
Progression of feedstock refinery integration

Short-term
Lipids

Longer-term strategy
Biocrudes

Refinery integration at
- FCC
- Hydrotreater

Light gases
Naphtha
Jet
Diesel
Heavy fuel oil
Impacts of co-processing - FCC

Carbon is lost! Yield reduced

Products

CO₂, CO, H₂O

Biobased feed → Coke

Fossil feed

Coke

Biobased feed

Fossil feed

Carbon is lost!

Yield reduced

Products
Impacts of co-processing - hydrotreater

- Biobased feed
- Fossil feed

Oxygen mostly removed through H₂O!
Higher carbon yield
Impacts of co-processing

- **Product** - yields, product characteristics, product quality & compliance with specs
  - Jet fuel and ASTM certification

- **Refinery** - New and modified infrastructure
  - Pretreatment e.g. removal of alkali metals
  - Small-scale stabilizing hydrotreatment step
  - Separate feed into FCC

- Increased Hydrogen demand
- Increased Wastewater
Tracking renewable content during co-processing

- Policy incentives linked to renewable content in liquid products
- C14 isotopic method
- Potential mass balance approach
  - Total mass balance method
  - Mass balance based on observed yields
  - Carbon mass balance method

(CARB, 2017)
Co-Processing Experiments
• Two pine-derived pyrolysis oils
• Up to 20 wt% pyrolysis oil in FCC feed

- Up to 10 wt% of FP bio-oils can be co-fed with VGO with 2-3 wt% biogenic carbon captured in produced gasoline
- Feeding bio-oils at > 10 wt% negatively impacted both process and product
- TEA of the Petrobras results showed that:
  - **FCC co-processing can reduce the overall costs of biofuels production**
  - **Bio-oil producers and petroleum refiners have opportunities to realize shared profitability**
Key challenges

- Limited DATA on co-processing
- Understanding interactions of co-processing different feedstocks
- Understanding impact on products and quality
- Ideal blend % for different feedstocks
- Specific impact on refinery, cost and managing of risk
- Defining standards for biobased intermediates
- Method for determining renewable content