Advanced Biofuels from Refinery Processing of Fast Pyrolysis Bio-Oil

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1. About BTG Bioliquids and Fast Pyrolysis
2. Refinery Processing of Fast Pyrolysis Bio-Oil
3. Summary and Conclusions
As a technology provider and product leader we are committed to the commercial deployment of our fast pyrolysis technology.

Fast Pyrolysis Bio-Oil is explicitly made from biomass residues and is known as second generation (2G) or advanced biofuel. It does not compete with the food chain.
Our company history & milestones

1987
BTG starts as a spin-off from the University of Twente

2008
BTG Bioliquids is established by BTG

2015
Start up of Empyro in the Netherlands

2016
Cooperation agreement with TechnipFMC

2020
Start up of GFN plant in Finland

2021
Start up of Pyrocell plant in Sweden
Fast pyrolysis technology

- **Thermochemical decomposition** of biomass residues through rapid heating (450-600 °C) in absence of oxygen.

- Different types of lignocellulosic biomass residues are converted into one homogeneous energy carrier: **Fast Pyrolysis Bio Oil (FPBO)**.

- By products are **heat** (steam) and **power** (electricity).
Our process from biomass to FPBO

Wood residue 5 dry ton/hr

FPBO 65 wt% / 56 E-%

Heat + Power 32 E-%
Technology deployment: Empyro and more

- Empyro, Hengelo, The Netherlands - 2015
  - Sold to Twence Jan 2019

- Green Fuel Nordic, Lieksa, Finland - 2020
  - Start up Dec 2020

- Pyrocell Setra, Gävle, Sweden - 2021
  - Start up Sep 2021
Pyrocell (Sweden) from sawdust to tank

- Joint Venture of Setra and Preem
- FPBO from sawdust – started up in 2021
- Turn-key EPC delivery by TechnipEnergies
- FPBO production: 24,000 tonnes/year
- GHG reduction of 80-90%
- Preem Lysekil refinery will co-process FPBO to produce advanced biofuels
- In compliance with EU REDII-Annex 9, etc.
Refinery Processing of FPBO to produce advanced biofuels
The FPBO supply chain

Biomass conversion
- Local processing of biomass residue
- Returning minerals to the soil

FPBO transportation
- Biomass liquified
- 10x denser than solid biomass

FPBO (co-)processing
- Centralized location
- Make use of existing infrastructure

Advanced biofuels from FPBO – Oct 2021
Lignocellulosic: sawdust, forestry / agro residues, etc.

- Water content: 20 – 30 wt-%
- Oxygen content: 45 – 50 wt-%
- Density: 1.1 – 1.2 kg/L
- Viscosity (40 °C): 10 – 30 cSt
- Energy content (LHV): 16 – 17 MJ/kg
- Ash and solids contents: < 0.1 wt-%
- Sulfur content: < 0.01 wt-%
- (Earth) Alkali’s content (Na+K+Ca+Mg): 50 – 70 ppm

FPBO is “an emulsion of lignin fragments in a sugar syrup”.

It is a dark liquid... ... but not a typical refinery feedstock!
**Routes from FPBO to transport fuels**

Co-processing uses existing infrastructure:
- Low CAPEX
- Short time-to-market
- Fast GHG reduction

FPBO: fast pyrolysis bio-oil
SPO: stabilised pyrolysis oil
MTF: mixed transportation fuels

Advanced biofuels from FPBO – Oct 2021
Fluid Catalytic Cracker (FCC)

FCC unit: the FPBO gateway into a refinery:
- Can deal with water, oxygenates, coking
- Many possible outlets for FCC products
- Challenge: how to track green content?
Co-FCC of FPBO
how does it work?

- FPBO fed by separate injection line & nozzles
- Biomolecules cracked together with regular feed
- Acidity disappears upon contact with hot catalyst
- Green content distributed across the products
- Commercial FCC operability proven for 5 % FPBO
- Pilot scale operability proven for 10 % FPBO
FPBO impact on FCC product yields

- Co-processing 5 wt-% FPBO has little impact on the overall FCC product yields
- Gasoline yield increased
- LPG yield the same
- Dry gas, LCO, fuel oil and coke decreased slightly
- Oxygen in FPBO is turned into CO, CO$_2$ and water

FCC “bio-yields” from FPBO shown; calculated from overall yield shifts when co-processing

Observed "Bio-yields" for 5 wt-% FPBO co-processing in FCC

Bio-product yields calculated from FCC yield shifts reported by Petrobras (Pinho et al.)
Other refinery pathways

Hydrotreating (standalone)
- 1st step: FPBO stabilisation
- 2nd step: ‘regular’ hydrotreatment
- BTG neXt develops demoplant for marine biofuel (1 kta, 2023)

Hydrotreating + co-FCC
- FCC co-processing of stabilised FPBO possible at > 10 wt-%
- Provides higher bio-carbon yield (Fang et al., 2018)

Gasification
- DME, methanol, Fischer-Tropsch fuels
- 2002: entrained flow gasifier (Shell)
- 2012: black liquor gasifier (ETC)

Hydrocracking
- Fixed bed requires FPBO upgrading
- 20% FPBO co-processing in slurry hydrocracker pilot plant (RISE) (Bergvall et al., 2020)
Summary and Conclusions

- Fast Pyrolysis Bio-Oil production reached commercial maturity
- Advanced biofuels from FPBO co-processing has high potential
  - Low CAPEX
  - Short time-to-market
  - Fast GHG emissions reduction
- Feasibility of FPBO co-processing in FCC is proven up to 5 wt-%
  - Operability was demonstrated at commercial scale
  - FCC products show a favourable gasoline yield
  - Exact yields depend on unit, feedstock and process conditions
- Other refinery pathways of FPBO at various stages of maturity
  - Hydrotreating, Hydrocracking, Gasification (Fischer-Tropsch)
Thank you

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