Fast Pyrolysis

Prospects for Pyrolysis Oil as Advanced Biofuel in Shipping and Aviation

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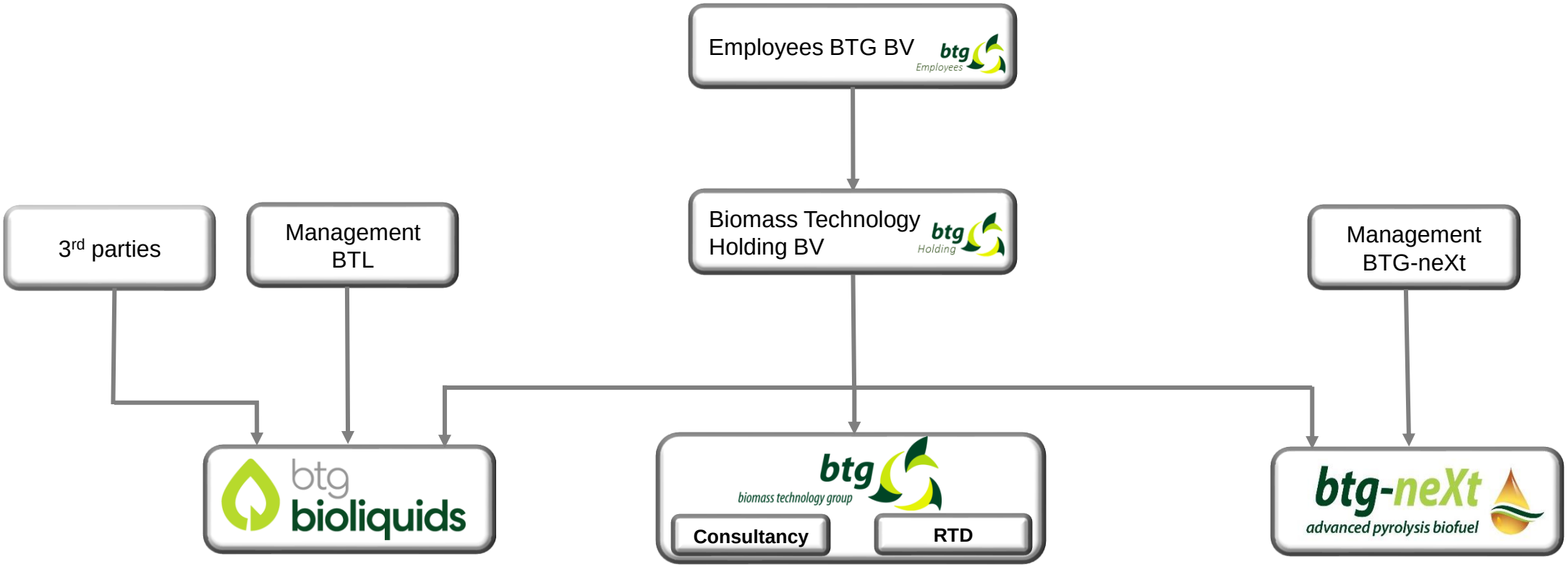
- Summary

Organisation



Commercializing FPBO production technology

Process & product development Consultancy

Commercializing FPBO upgrading technology

FPBO = **F**ast **P**yrolysis **B**io-**O**il

Company Profile

- Established in 1987
- Process & product development on thermochemical/catalytic/electrochemical biomass conversion to energy, fuels, chemicals and biobased products
- Contract research in the field of chemical process technology
- Supply of products (FPBO, upgraded FPBO, fractions (lignin, sugars))
- Value chain assessments (techno-economic, sustainability (LCA, LCC), market, logistics)
- Policies, legislation and regulation
- Project development

- Established in 2007
- Commercialization & implementation of FPBO *production* technology based on RCR;
- Owner of Patents on process and reactor;
- Acts as technology provider and supplies skid-mounted, key components of the FP-process
- Sales of FPBO (webshop)

- Established in 2019
- Commercialization of FPBO *upgrading* based on Picula™ catalyst;
- Owner of Patents on upgrading catalyst & process;

FPBO = **F**ast **P**yrolysis **B**io-**O**il

Fast pyrolysis Process

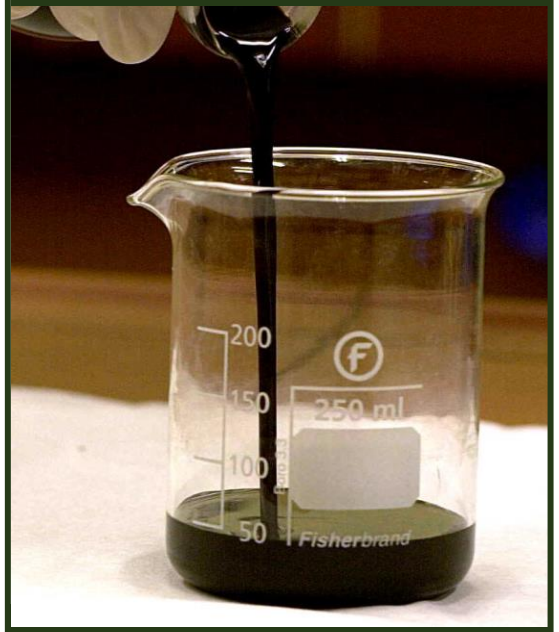
Fast Pyrolysis

- Thermal cracking of organic material in absence of oxygen
- Main product: liquid bio-oil (FPBO)
- Other products: gas and char
- Minerals recovered at low temperature
- Fast heating required to maximize liquid yield

- Typical Process conditions
  - T = 400 - 600 °C
  - P = atmospheric
  - τ_{gas} ~ seconds

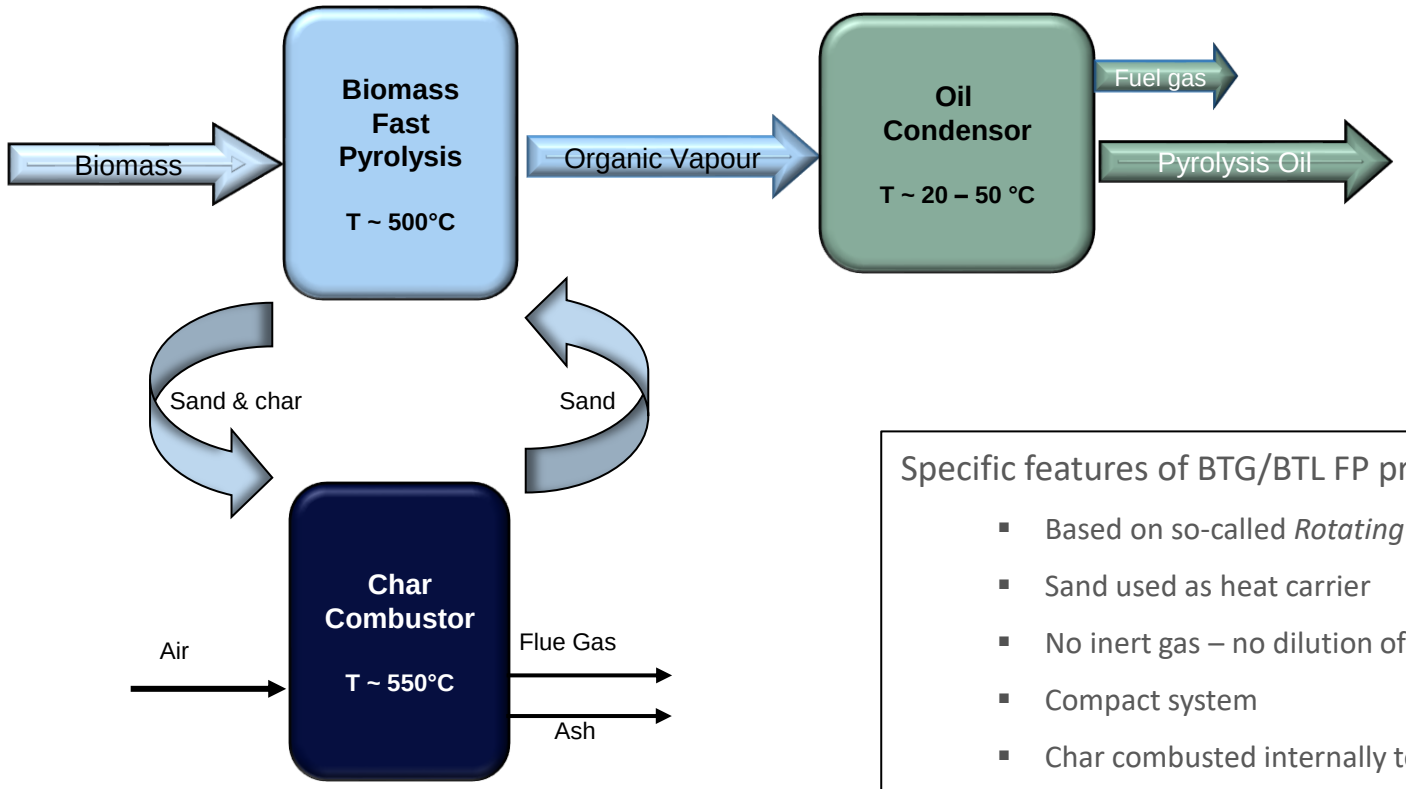
- '*Liquid Composition*': carboxylic acids, ketones, aldehydes, alcohols, carbohydrates, depolymerized lignin, extractives, water,…

Water content	25	wt%
Density	1,170	kg/m^3
LHV	16	MJ/kg
Acid Number	70	mg_{KOH}/g
Sulfur	< 0.05	wt%
FlashPoint	?	°C
Cetane Number	< 20	-
MCRT	> 15	wt%



Crude Pyrolysis Oil

Fast Pyrolysis Process



Simplified representation of BTG's pyrolysis process

Specific features of BTG/BTL FP process:

- Based on so-called *Rotating Cone Reactor (RCR) Technology*;
- Sand used as heat carrier
- No inert gas – no dilution of vapor stream
- Compact system
- Char combusted internally to provide heat

Patents on pyrolysis reactor, sand circulation and FPBO water control granted (a.o. United States , Indonesia, South Africa, China, Europe, Malaysia, Canada, Russia, Brazil).

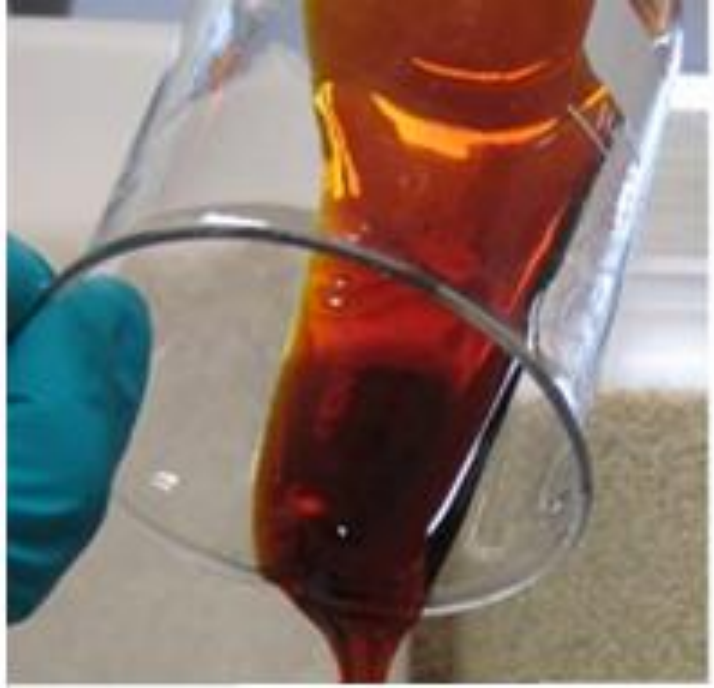
Implementation of fast pyrolysis

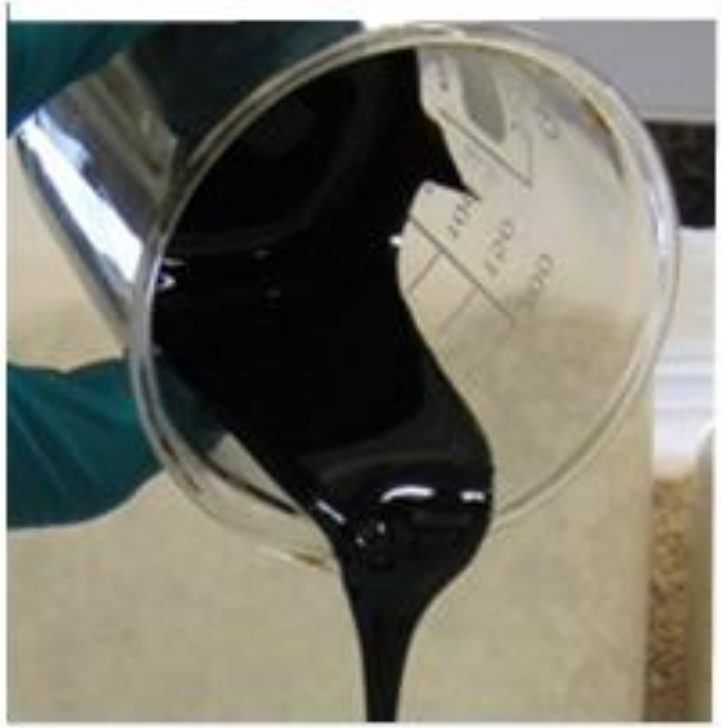
PRODUCTION

APPLICATION

Energy

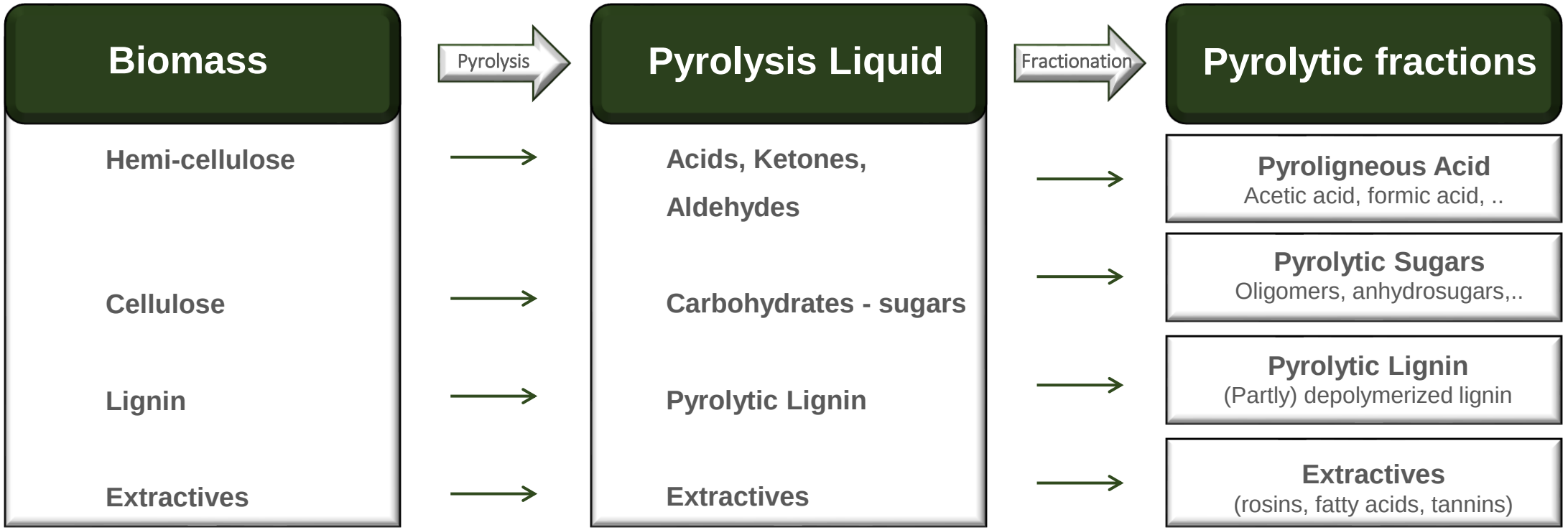
Biofuels





FPBO Fractionation

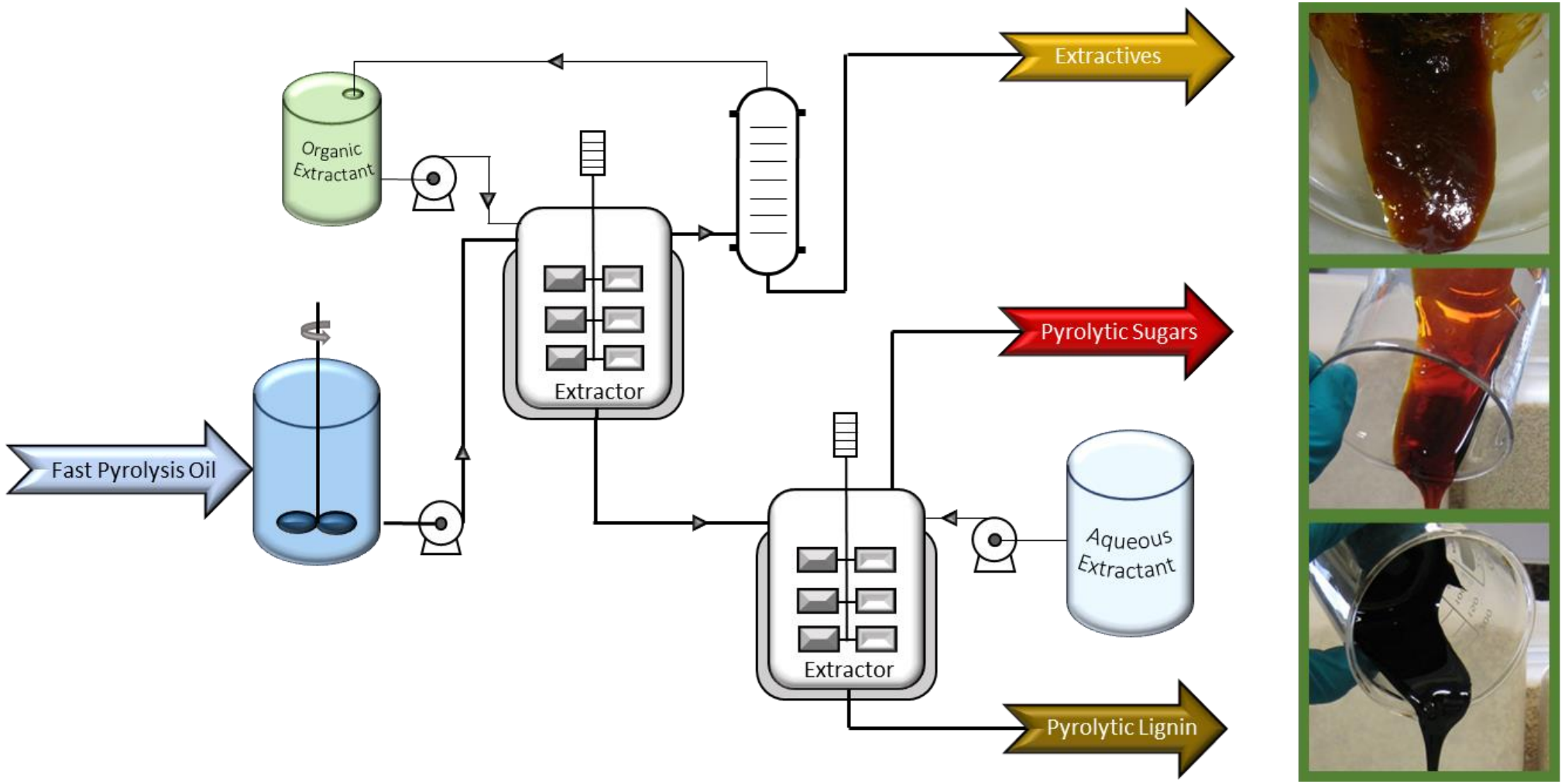
FPBO Fractionation



Thermochemical fractionation via Fast Pyrolysis:

- Key biomass functionalities retained in the pyrolytic fractions;
- Fractionation process based on liquid-liquid extraction enabling separation on basis of functionality
- Each fraction is used directly as raw material in bio-based products or a starting point for further dedicated (electro)-chemical, catalytic or biotechnological conversion.

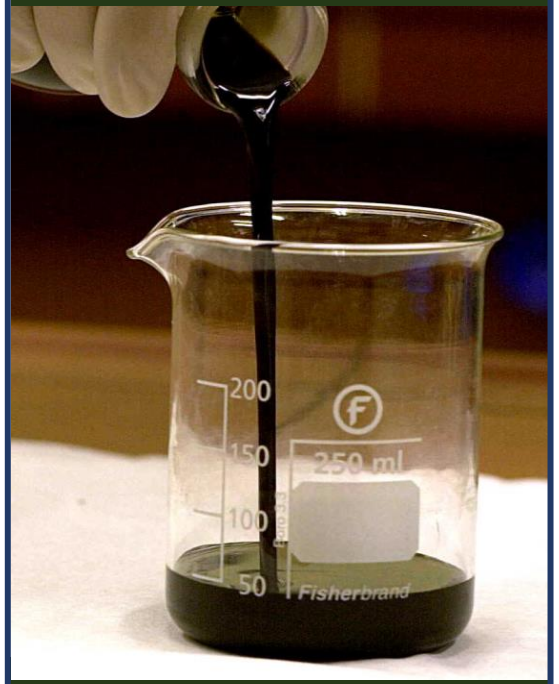
Fractionation Process



Pyrolysis oil fractionation by liquid-liquid extraction

Properties

Water content	25	wt%
LHV	16	MJ/kg
Acid Number	70	mg_{KOH}/g
C	45	wt%
H	7	wt%
O	48	wt%
MCRT	17	wt%



Crude Pyrolysis Oil

Water content	5
LHV	18
Acid Number	58
C	49
H	7
O	44
MCRT	22

Pyrolytic Sugar

Water content	12
LHV	21.3
Acid Number	26
C	54
H	7
O	39
MCRT	30

Pyrolytic Lignin

Water content	< 1
LHV	35
Acid Number	60
C	76
H	10
O	14
MCRT	2

Extractives

Indicative values

Advanced Biofuels from FPBO

bioliquids refinery

Biomass | Primary process | Secondary process | Products | Applications



BIOMASS



MINERALS

PYROLYSIS PROCESS

PYROLYSIS LIQUID

FRACTIONATION

EXTRACTION

RESINS
PHENOLS
ORGANIC ACIDS
OXYGENATES

(BIO-)CHEMICAL PROCESSING

CHEMICALS
SPECIALTIES

ELECTROCHEMICAL PROCESSING

CHEMICALS
BIOFUELS

HYDROTREATMENT

BIOFUELS
FEEDSTOCK REFINERIES

CO-REFINING

GASIFICATION

BULK CHEMICALS
HYDROGEN

COMBUSTION

HEAT & POWER



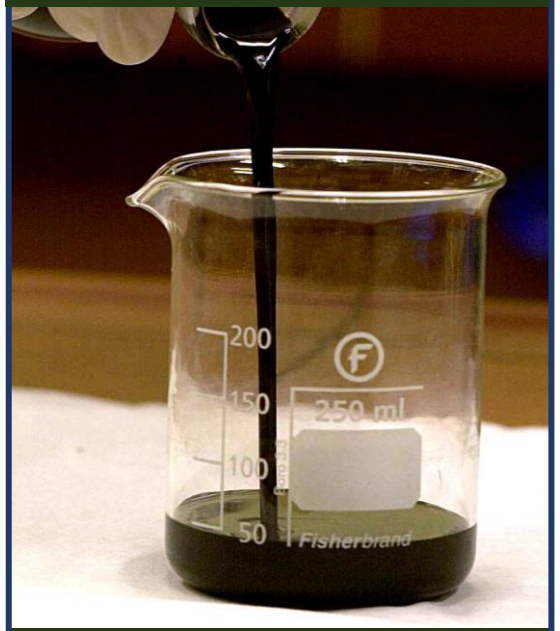




btg

Fuel Properties

Water content	25	wt%
Density	1,170	kg/m^3
LHV	16	MJ/kg
Acid Number	70	mg$_{KOH}$/g
Sulfur	< 500	ppm
FlashPoint	?	°C
Cetane Number	< 20	-
MCRT	> 15	wt%



Fast Pyrolysis Oil - **FPBO**

Water content	0.5	wt%
Density	< 991	kg/m^3
LHV	~39	MJ/kg
Acid Number	< 2.5	mg$_{KOH}$/g
Sulfur		ppm
FlashPoint	> 60	°C
CCAI	< 870	-
MCRT	< 18	wt%

Residual Marine Fuel – **RMG380**

Water content		wt%
Density	< 890	kg/m^3
LHV	~42	MJ/kg
Acid Number	< 0.5	mg$_{KOH}$/g
Sulfur	< 1,000	ppm
FlashPoint	> 60	°C
Cetane Number	> 40	-
MCRT	< 0.3	wt%

Distillate Marine Fuel - **DMA**

Water content	< 0.008	wt%
Density	< 840	kg/m^3
LHV	> 42.8	MJ/kg
Acid Number	< 0.015	mg$_{KOH}$/g
Sulfur	< 15	ppm
FlashPoint	> 38	°C
Cetane Number	> 35	-
MCRT	<< 1	wt%

JET - A

Advanced biofuels from fast pyrolysis oil

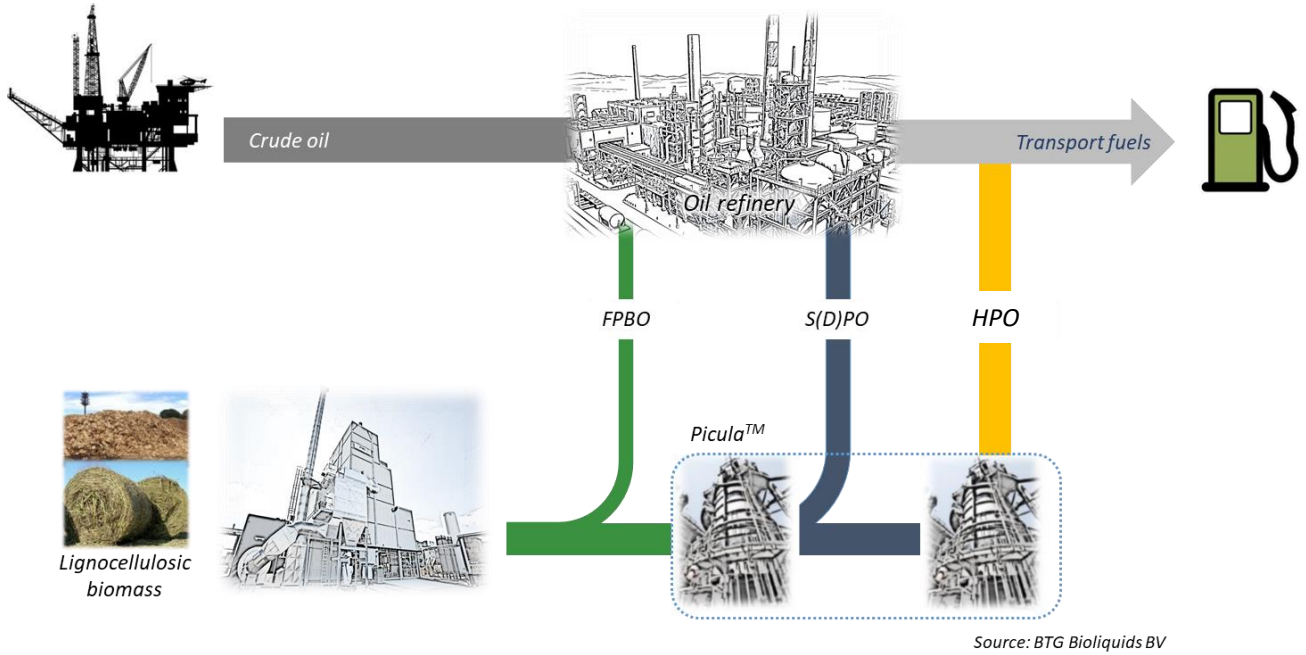
Options to produce a drop-in fuel

1. Co-feed of FPBO with VGO in existing FCC unit
- Extensive testing by Petrobras
- Demonstrated full-scale by Preem (2022)
- Max co-feed around 5-10 wt%

2. Co-feed of SPO with VGO in existing FCC unit
- Lab- and pilot testing
- Higher co-feed ratio's possible (20-30 wt%)
- Less impact on product slate compared to crude FPBO

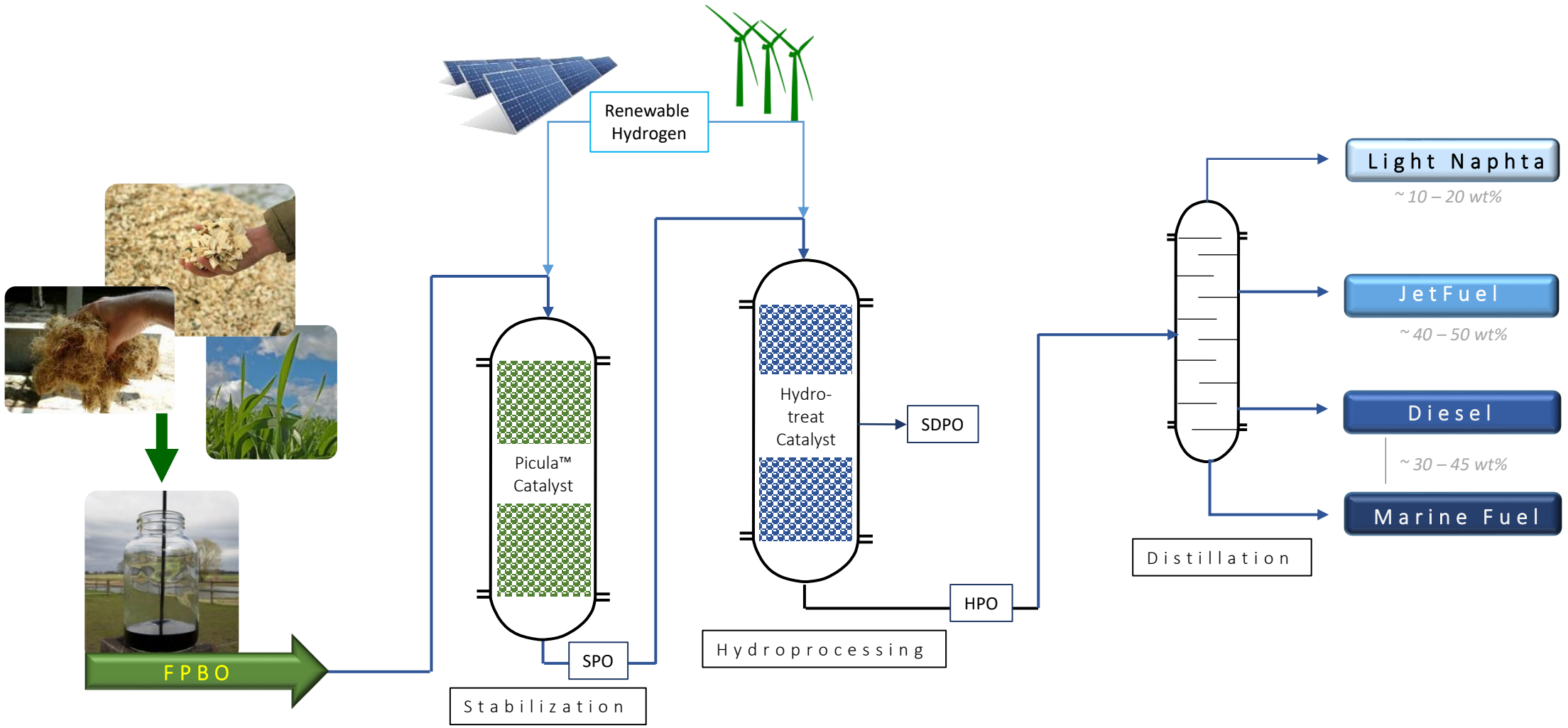
3. Stand-alone upgrading of FPBO to drop-in
- Lab- and pilot testing
- Multi-step hydrotreating process
- Product (HPO) is fully miscible with fossil fuels

***FPBO** = Fast Pyrolysis Bio-Oil*
***S(D)PO** = Stabilized (Deoxygenated) Pyrolysis Oil*
***HPO**= Hydrotreated Pyrolysis Oil*



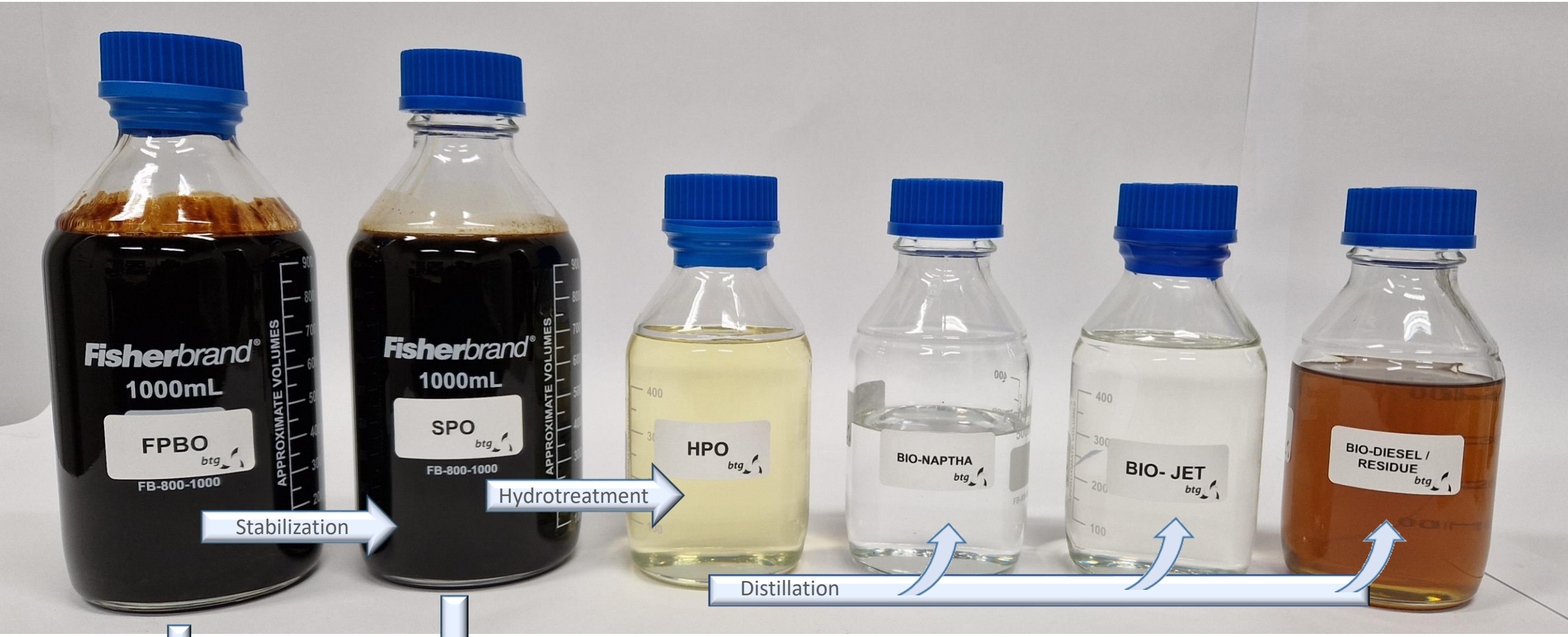
Source: BTG Bioliquids BV

Fast pyrolysis oil upgrading



FPBO = Fast Pyrolysis Bio-Oil **SPO** = Stabilized Fast Pyrolysis Oil **SDPO** = Stabilized Deoxygenated Pyrolysis Oil **HPO** = Hydrotreated Pyrolysis Oil

Products from fast pyrolysis oil upgrading



Summary

- Fast pyrolysis is getting mature.
- Industrial scale plants have been implemented in Europe & North America (TRL9 for woody biomass).
- For application in marine or aviation sector the FPBO needs upgrading to comply with specifications.
- Co-feeding FPBO in conventional oil refineries is demonstrated on full scale (TRL8).
- Stand-alone upgrading of FPBO in pilot/demonstration phase (~TRL5-6).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Thanks for your attention !