BIO4 PRODUCTS
Creating sustainable resources for process industry

Fast pyrolysis oil fractionation

Moving towards a competitive European bioeconomy

Emerging biorefinery technologies & pathways to deployment

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February 17, 2021

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 723070.

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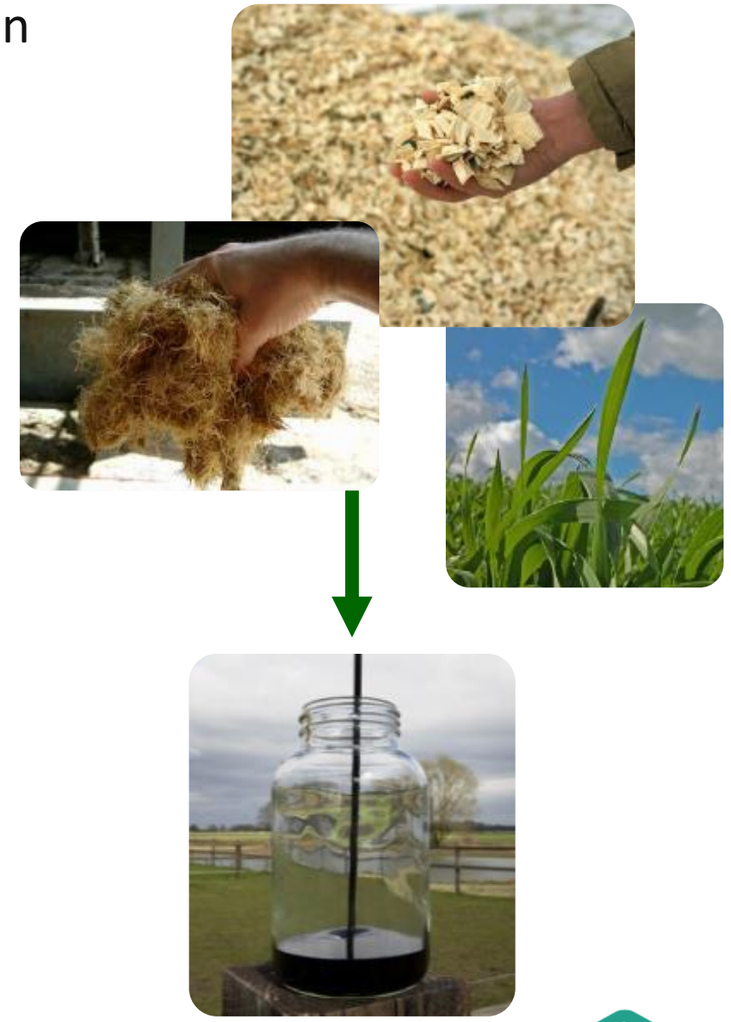
Fast Pyrolysis

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



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Pyrolysis oil

- FPBO is an acidic, polar liquid containing at least a few hundred different components;
- Heating value is comparable to biomass;
- Properties are very different from conventional oil;
- Key functionalities are preserved in FPBO (e.g. sugar, lignin & rosin fragments) making it an interesting feedstock for developing a Bioliquids Refinery;

Property	Value	Unit
Elemental		
C - carbon	44	wt%
H - hydrogen	7	wt%
O- oxygen	49	wt%
Water content	25	wt%
Density	1,170	kg/m^3
LHV	16	MJ/kg
pH	2.8	-
Acidity	70	mg KOH/g
Carbonyl content	150	mg BuO/g
MCRT	17	wt%
Viscosity (40 °C)	30	cSt

Typical properties biomass derived FPBO

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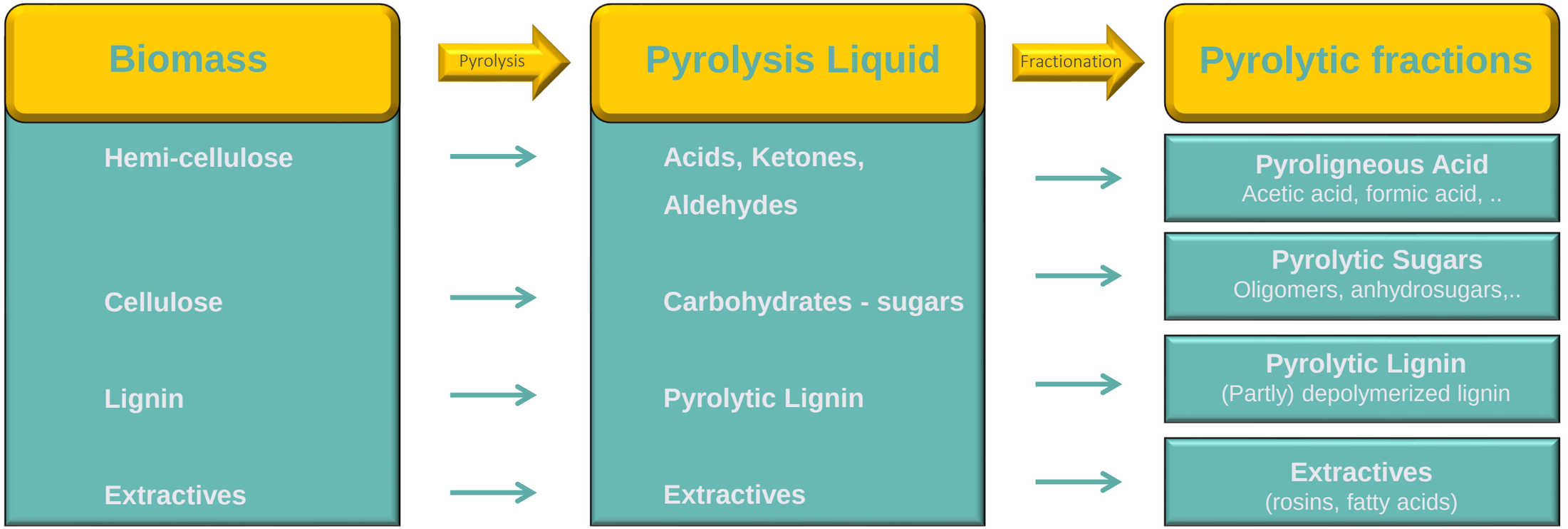
Pyrolysis oil composition



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Pyrolysis oil yields

Amount of fractions obtained from different types of biomass via fast pyrolysis and subsequent fractionation (lab & benchscale)

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Pyrolysis oil fractionation

1. **Distillation** 

2. **Fractional condensation**
   - Separation on basis of boiling point
   - Fractionation during the production process

3. **Liquid-Liquid extraction**
   - Separation on basis of functionality
   - Fractionation after production

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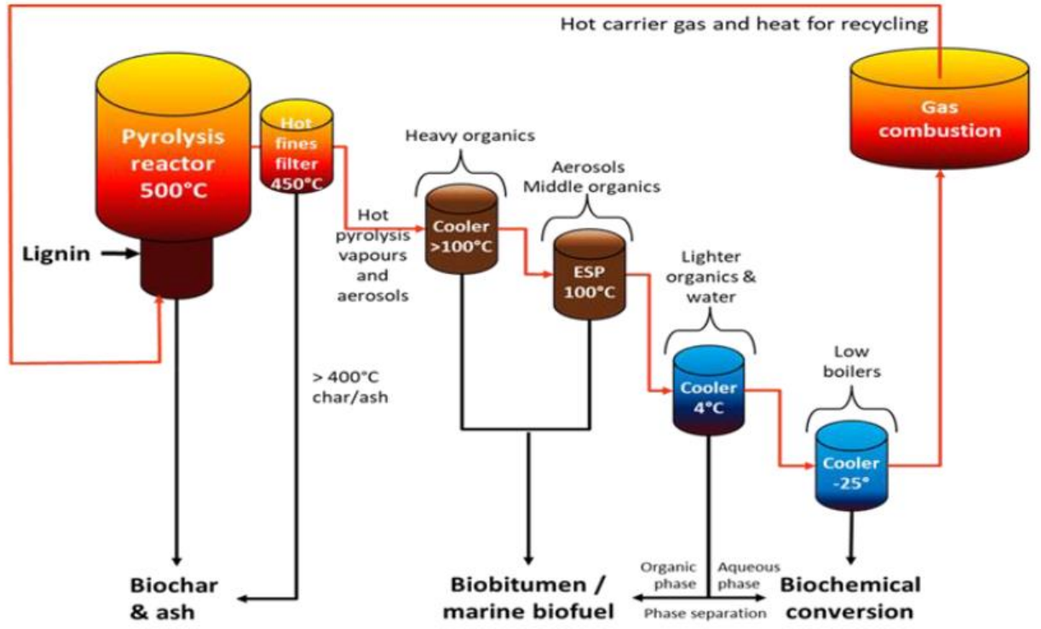
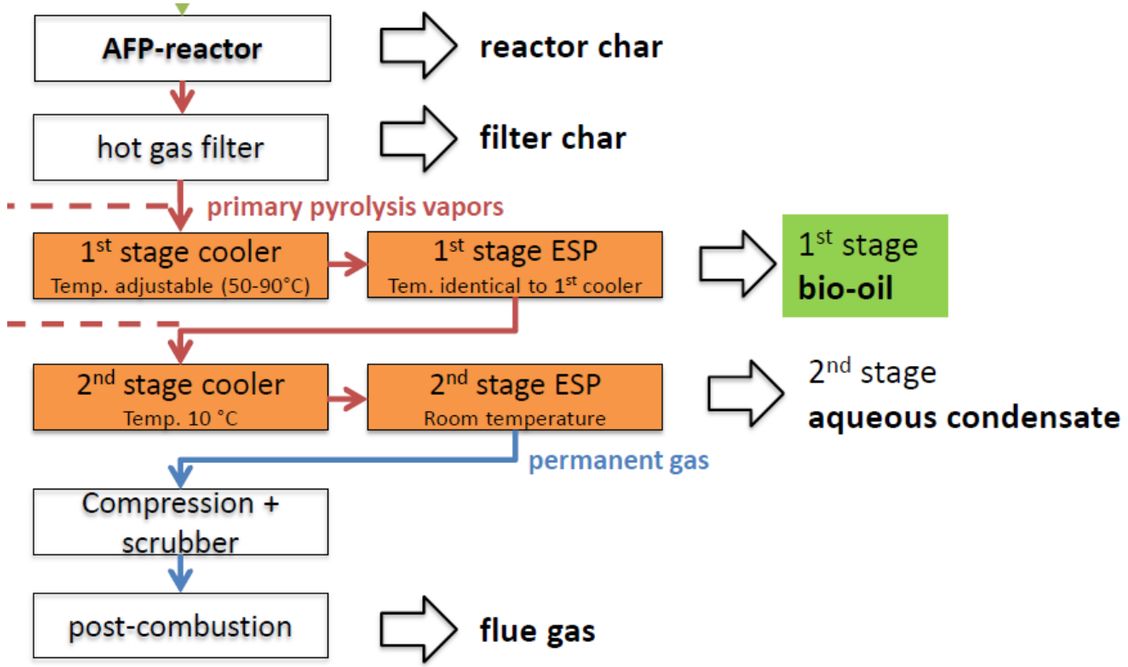
Fractional condensation

- Produce different fractions in the condensation train – multiple condensors operating at different temperatures
- RTD ongoing at several places around the world (e.g. Avello, VTT, UMSICHT, TNO-ECN)



System under development by TNO-ECN



System under development by UMSICHT

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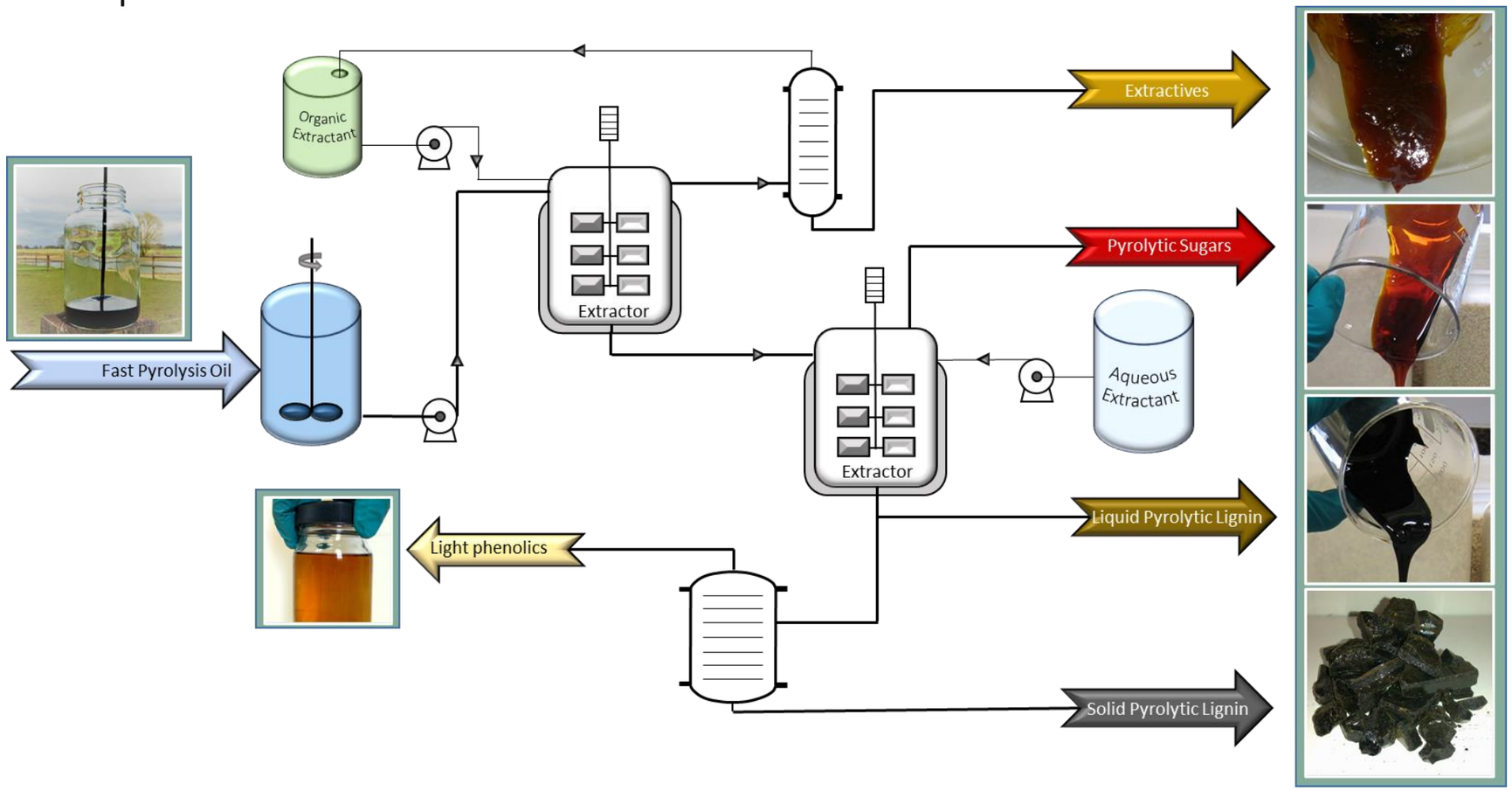
Liquid-liquid extraction

- Produce different fractions -after production- by liquid-liquid extraction using organic and aqueous solvents



Schematic process flow diagram of multiple, liquid-liquid extraction of FPBO

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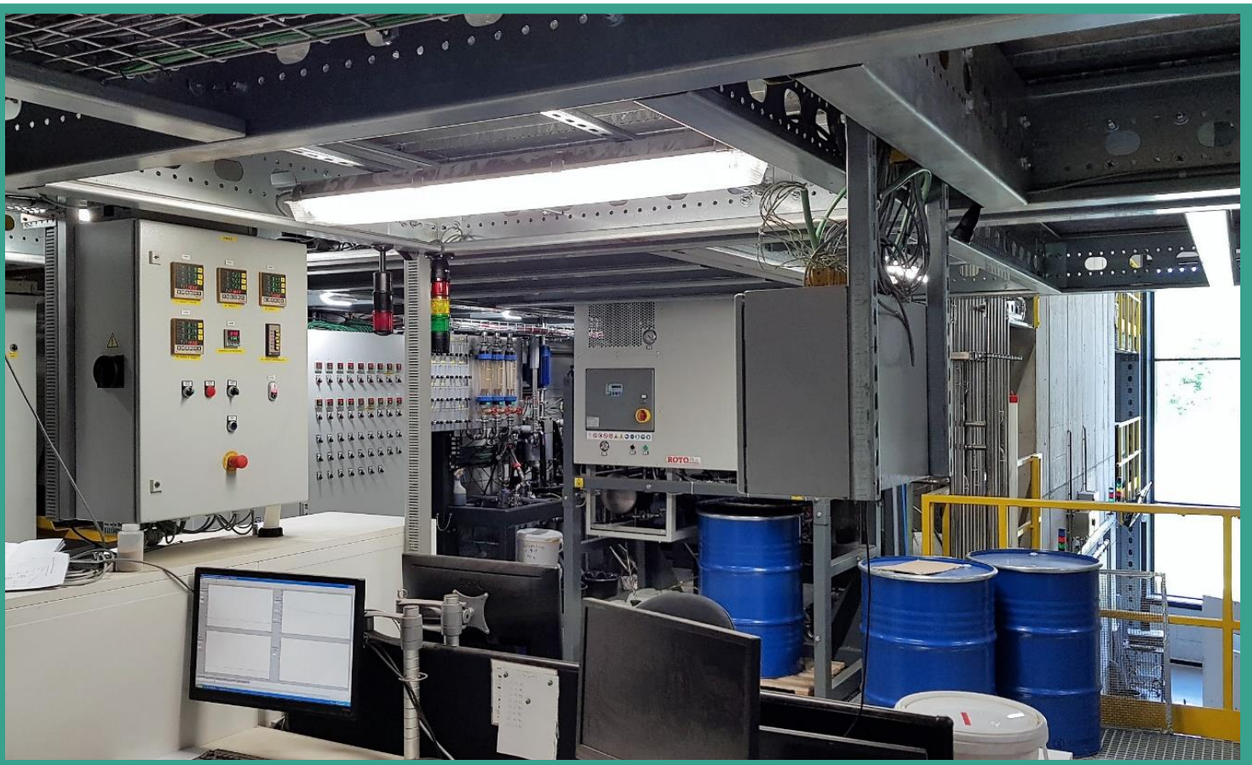
Pilot scale demonstration Liquid-liquid extraction

- Design capacity = 3 t FPBO/d (10-fold scale-up);
- Production of ***extractives, pyrolytic lignin (Solid/Liquid), pyrolytic sugars (aqueous/concentrated syrup)***
- Commissioned late 2018;
- Pyrolysis oil feedstock produced in pilot plant or obtained from Empyro plant;
- Proven input capacity ~ Organic extractant – 75 kg/h (~60% of design)
  Aqueous extractant - 120 kg/h (~ 96 % of design);
- Product properties & yields (lignin & sugars) similar to bench-scale testing;



Bio4Products concept

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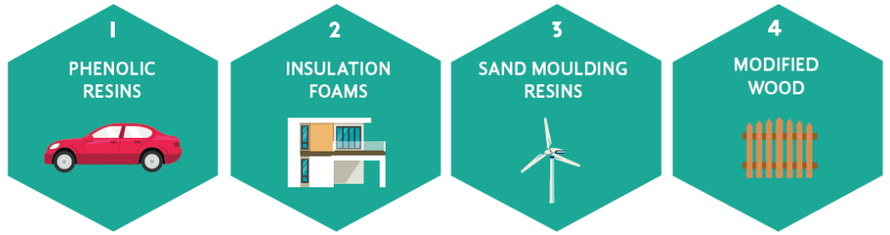
Sustainable feedstock

Bio-based products



Fast pyrolysis & liquid fractionation

- Mono-phenolics
- Ethylene & Propylene glycol
- Sorbitol
- Biobased paints
- Cyclo-hexanes
- Fatty acids/rosins (‘pine chemicals’)
- ……

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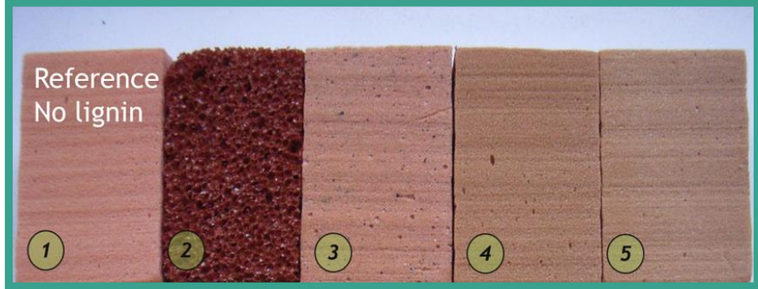
Summary

- Fast pyrolysis bio-oil can be produced from a variety of ligno-cellulosic biomass.
- Key functionalities of biomass are preserved in FPBO making it an interesting feedstock for developing a *Bioliquids Refinery*.
- Liquid-liquid extraction with organic and aqueous extractants is a suitable method to fractionate FPBO.
- Each fraction can be used directly as raw material for bio-based products or a feedstock for dedicated (electro)-chemical, catalytic or biotechnological conversion into sustainable chemicals & materials.



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Acknowledgement

The Bio4Products project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No. 723037

Sustainable Process Industry through Resource and Energy Efficiency

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