Pyrolyse Olie:

Bron voor hernieuwbare grondstoffen

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Nieuwe Energiedag Oost-Nederland
26 Oktober 2023

btg biomass technology group

Your partner in bioeconomy

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CONTENT

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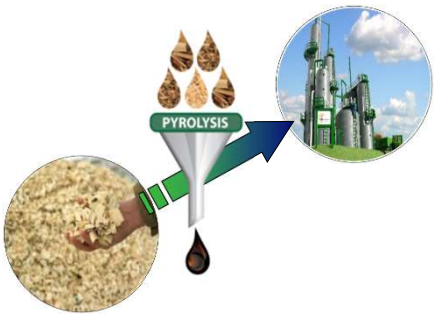
- Introduction ThermoChemical Fractionation (TCF)
- Products from pyrolysis oil fractions - *examples*:
  - Insulation foam
  - Biobased paints
  - Plywood / Cross Laminated Timber (CLT)
  - Polyols - PUR
  - Wood modification & circularity
- TCF Scaling-Up
- Summary



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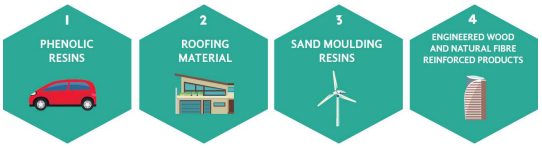
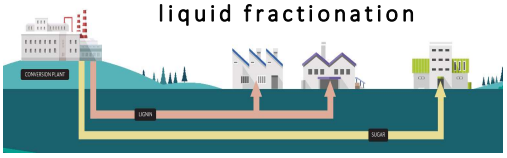
Introduction 'Thermochemical Fractionation (TCF)'

Sustainable feedstock

Bio-based products



Fast pyrolysis & liquid fractionation



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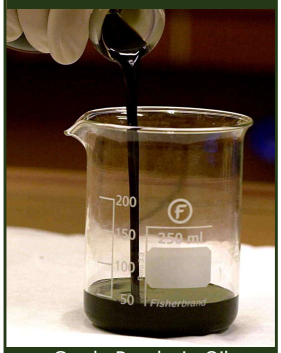
Fast Pyrolysis

- 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
- 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
MCRT	> 15	wt%



Crude Pyrolysis Oil

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Thermochemical Fractionation

Biomass		Pyrolysis Liquid		Pyrolytic fractions
Hemi-cellulose	→	Acids, Ketones, Aldehydes	→	**Pyroligneous Acid** Acetic acid, formic acid, ..
Cellulose	→	Carbohydrates - sugars	→	**Pyrolytic Sugars** Oligomers, anhydrosugars,..
Lignin	→	Pyrolytic Lignin	→	**Pyrolytic Lignin** (Partly) depolymerized lignin
Extractives	→	Extractives	→	**Extractives** (rosins, fatty acids, tannins)

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.
- No byproducts/waste: Excess fractions can be mixed back in the pyrolysis liquid for fuel application.

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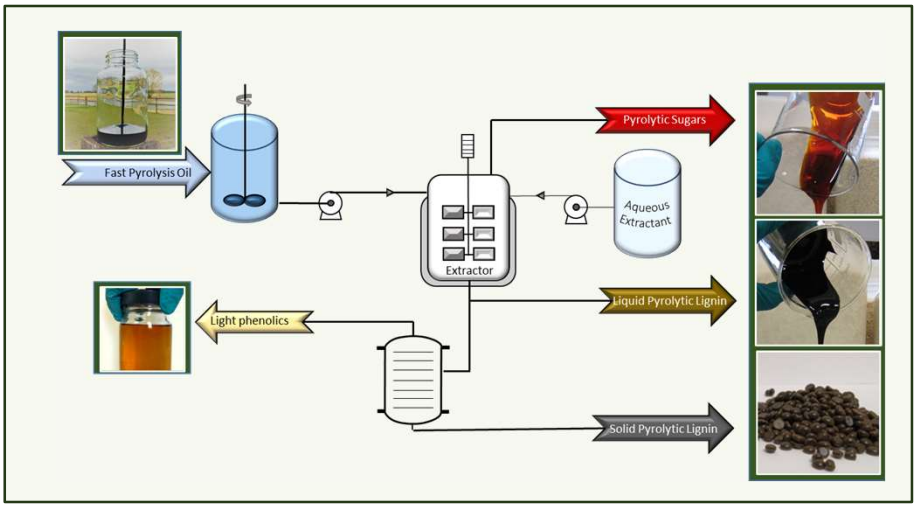
Thermochemical Fractionation



Schematic drawing of FPBO fractionation process

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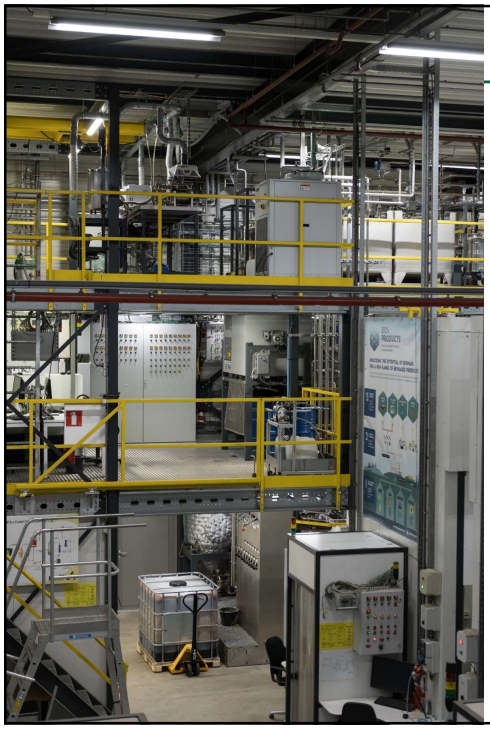


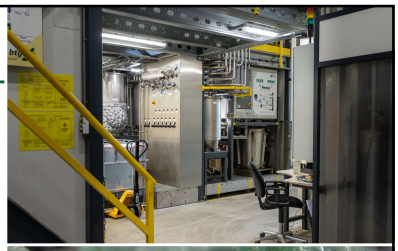
BIO4 PRODUCTS

Creating sustainable resources for process industry

- Demo-plant for FPBO fractionation is operational
- Based on liquid-liquid extraction of the whole oil
- Products are: pyrolytic lignin, pyrolytic sugars (& pyrolytic extractives)
- Proven capacity ~120 kg/h FPBO feed

- REACH registration filed for P.lignin and p.sugars (1-10 t/h)

CAS numbers	
Pyrolytic sugars:	2414605-13-1
Pyrolytic lignin:	2411004-28-7
Solid Pyrolytic Lignin:	2411004-20-9



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Biobased materials from pyrolysis oil derived fractions

- Insulation foam
- Biobased paints
- Plywood / Cross Laminated Timber (CLT)
- Polyols - PUR
- Wood modification & circularity

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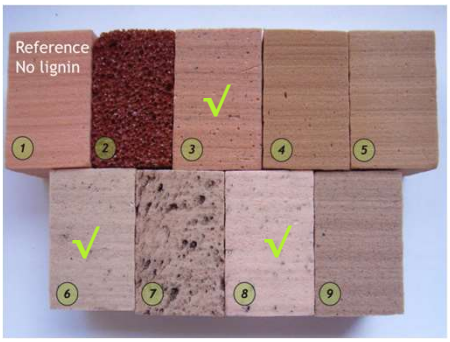
Pyrolytic lignin in insulation foam

- Traditionally, Phenol-Formaldehyde resins are used in insulation foam.
- Aim to develop resins to replace phenol by pyrolytic lignin.
- Cooperation with Bakelite (Hexion/Momentive), an industrial producer of resins. Involvement foam producers via Bakelite.

- Many different foams produced using different formulations;
- Foams 3,6,9 of lignin containing foams passing different tests, e.g.:
  - Density, burst strength, E-Modulus, heat conductivity, etc.
- Current amount of lignin in foam up to 30 %
- Flame testing, e.g.:
  - Loss after heating, popping, smoke production, flame breakthrough (5 min, burner/torch)



BAKELITE SYNTHETICS

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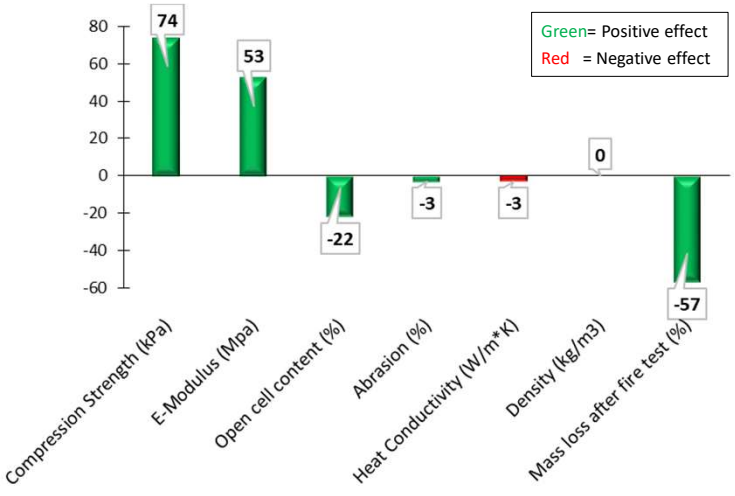
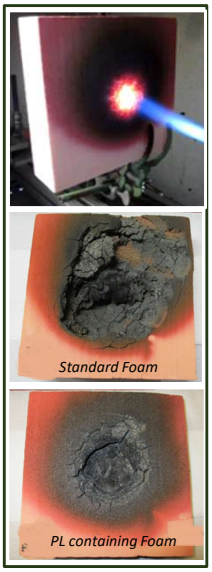
Pyrolytic lignin in insulation foam



Relative properties of PL foam compared to standard foam.



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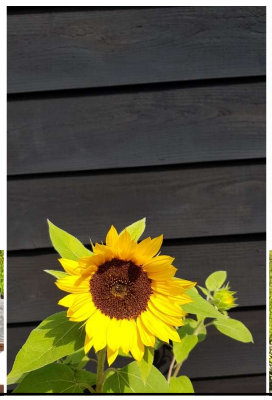
Pyrolytic lignin in Biobased Paints

- Water based as well as organic based version
- Organic solvent(s) should be biodegradable and non-VOC's emitting
- > 70 different formulations tested, up to 60 wt% of Pyrolytic Lignin achieved;
- Test for e.g.
  - Wood protection (durability) against MO's
  - Leaching
  - Drying degree/rate
  - Smell
  - Color stability
    - Water influence
    - UV influence
  - Elasticity of paint in aging (e.g. peeling of paint)
- Comparison with commercially available paints (4)
- Lacking involvement of paint producers



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Plywood – Cross Laminated Timber

- Resins ('glue') in wood products like plywood, CLT, MDF are typically based on formaldehyde combined with Phenol, Urea or Melamine.
- Aim to develop a resin on basis of pyrolytic lignin in cooperation with Foresa.
- Phenol replacement of 50 – 75%.

- Replacement of formaldehyde by HMF (Hydroxymethylfurfural), a less toxic chemical.
- Development of a process to produce HMF from pyrolytic sugar in cooperation with University of Groningen and AVA Biochem.

Plywood

university of groningen

AVA BIOCHEM

FORESA
FORESTACIÓN Y REPOBLACIÓN S.A.

CLT – Cross laminated Timber

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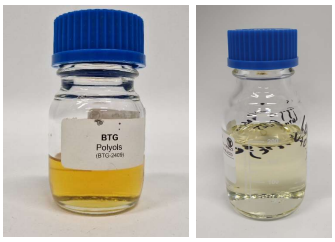
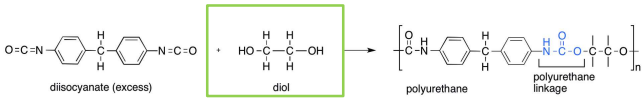
Polyurethane foam (PUR)

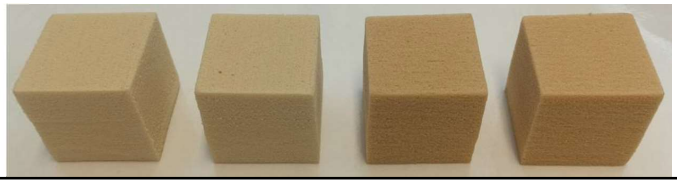
- Main components to produce a polyurethane are di- and tri-isocyanates and polyols.
- Polyols can be obtained by catalytic hydrogenation of pyrolytic sugars followed by purification (BTG).
- The sustainable polyols are used by AEP polymers to produce polyurethane foams.



Ethylene/Propylene glycol mixtures produced by hydrogenation of pyrolytic sugars (PICULA™) and subsequent purification



Polyurethane foam samples containing polyols produced from pyrolytic sugars



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Pyrolysis Oil & Pyrolytic Sugar in wood modification

- ❑ Improve wood durability by impregnation
- ❑ Two types of treatment targeted (mainly with Radiata Pine), both are based on vacuum/pressure/curing treatment
  - Envelope treatment (roundwood, poles, etc.)
  - Full cell treatment (boards, etc.)
- ❑ Modified wood samples prepared and tested
- ❑ Various tests applied and ongoing on modified wood samples, e.g.:
  - EN 113 (fungi)
  - ENV 807 (soilbox)
- ❑ Formulations based on
  - Complete pyrolysis oil (Foreco/BTG patent)
  - Pyrolytic sugars

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Pyrolysis Oil & Pyrolytic Sugar in wood modification

TFC BIOMASS BASED CHEMICALS

FORECO houtproducten

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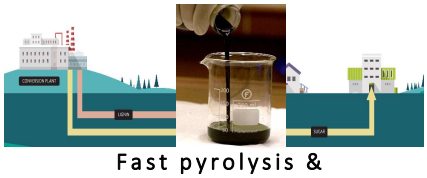
Wood modification - circularity

Sustainable feedstock

Bio-based products



Fast pyrolysis &
liquid fractionation

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ThermoChemical Fractionation - Scaling up

- Design full-scale unit in cooperation with Zeton & BTG Bioliquids.
- Guaranteed off-take required for (part of) the fractions.

Production plant (1,200 kg/h feed)

Pilot plant (120 kg/h feed)

Bench-scale unit (12 kg/h feed)

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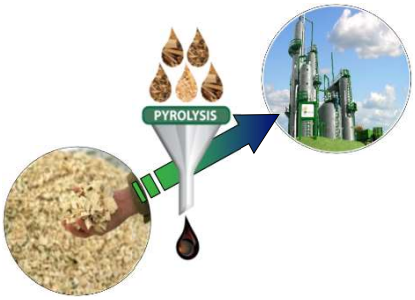
Samenvatting

- Snelle pyrolyse is een process dat geschikt is om diverse biomassa en reststromen om te zetten in een vloeistof (FPBO).
- FPBO bevat vergelijkbare chemische functionaliteiten als de oorspronkelijke biomassa en daarmee een waardevolle bron voor hernieuwbare grondstoffen.
- FPBO is een uitstekend startpunt voor de ontwikkeling van een “Bio-liquids refinery” voor de produktie van bioenergie, geavanceerde biobrandstoffen en biobased producten en chemicaliën.
- Ketensamenwerking essentieel !



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Acknowledgement

The activities described in this presentation have been obtained in a number of projects funded by the European Commission, national and regional funds. Their support is gratefully acknowledged.

Bio4Products – Grant agreement 723070 (Horizon 2020)

NewWave – Grant Agreement 101058369 (Horizon Europe)

INTERREG V A - Grünes Gold / Groen Goud (nr. 152015)

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Thanks for your attention !

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