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Richard Gosselink, Stéphanie Baumberger

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Zero Waste Ligno-Cellulosic Biorefineries by Integrated Lignin and Humins Valorisation

Dr. Richard Gosselink (WFBR), Prof. Stéphanie Baumberger (INRA)

11th International Conference on Bio-based Materials, 15 - 16
May 2018, Maternushaus, Cologne



This project has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation program under grant agreement No 720303

- Pulp & Paper industry
 - Increase pulp capacity by debottlenecking recovery boiler
 - Economic feasible outlets for side streams

- Biofuel/biochemical industry
 - Cellulosic bioethanol is more expensive
 - Focus on biochemicals or advanced biofuels
 - Economic feasible outlets for side streams

- Zelcor focusses on recalcitrant side streams by an integrated solution for conversion to value added products
 - Lignins
 - Humins

Academic Excellence in:

- **Lignin** chemistry
- **Biotechnology**
- **Insect** sciences
- **Bio-Products** design

Experts of Sustainability Assessment:

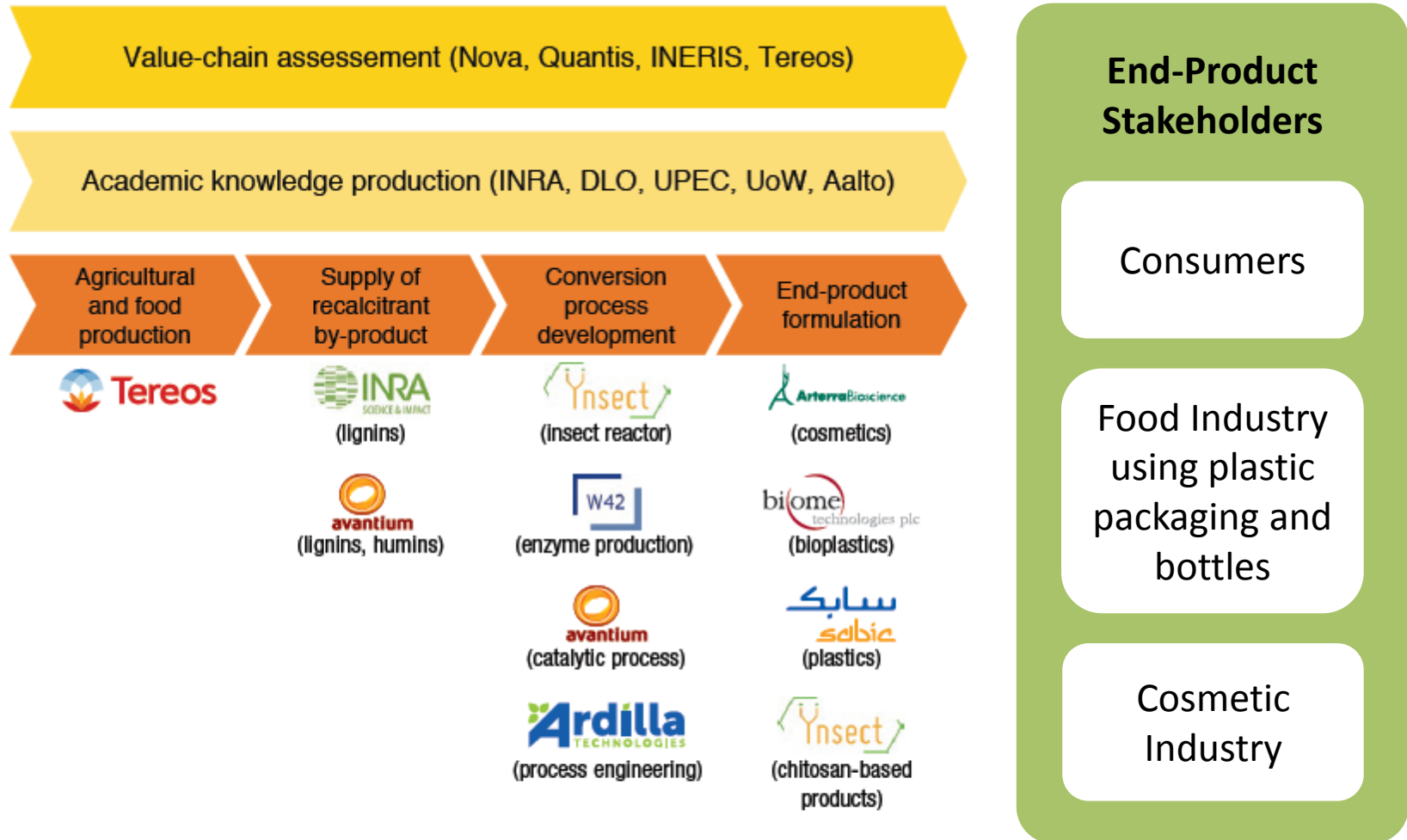
- **Environment (LCA)**
- **Safety**
- **Economy**

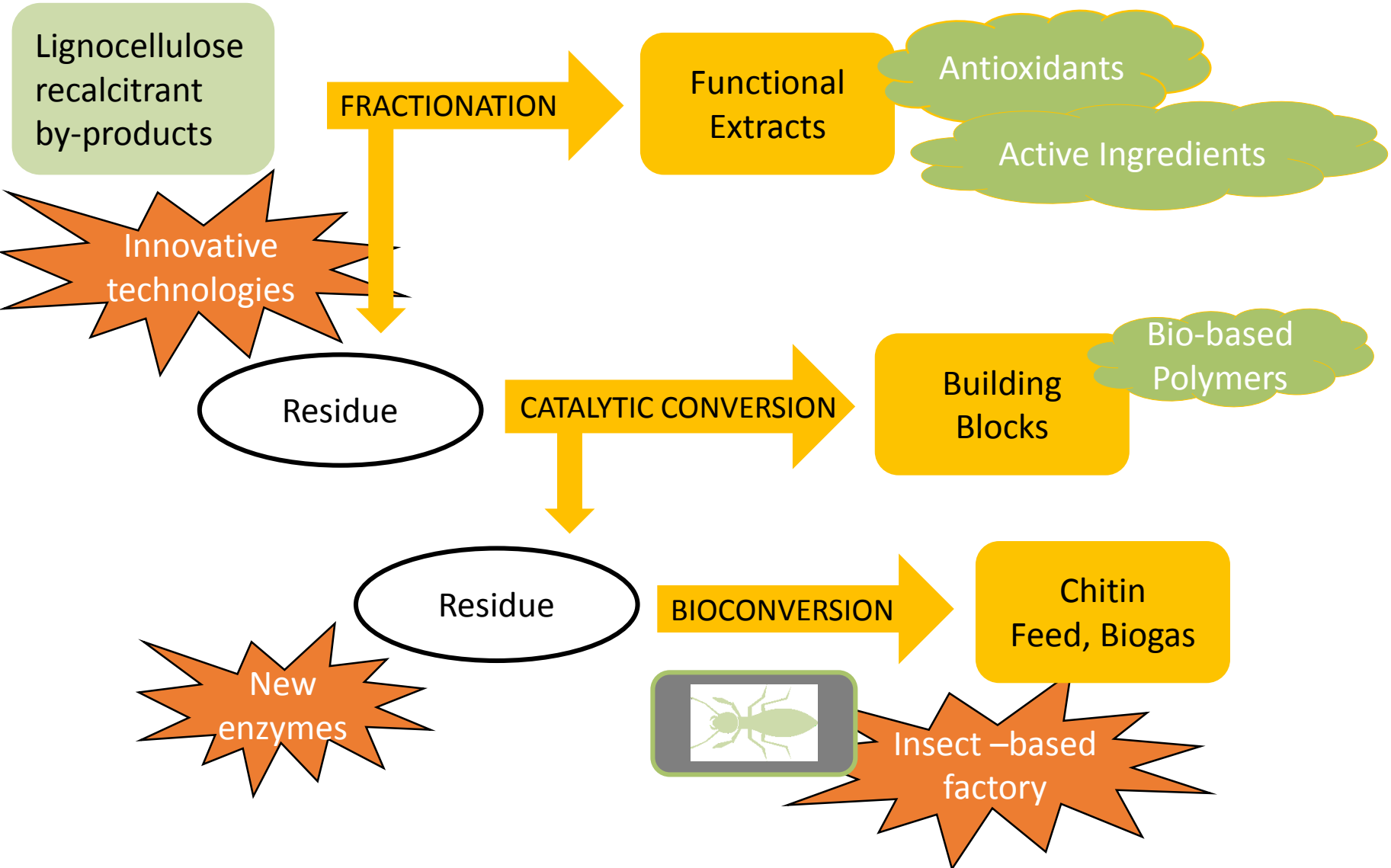


Key Industrial Actors for:

- **Lignocellulosic conversion**
- **Bioprocess engineering**
- **Enzyme production**
- **Biological activity screening**
- **Thermoplastics processing**
- **Bio-based polymers production**







- Several types of biorefinery residues representative of future industrial productions (humins, lignins, lignin-rich distillation residue)
- A common concept applied to all the substrates: zero waste and cascading processing strategy (extraction, self assembling, depolymerisation, bioconversion)
- Implementation of innovative conversion routes fitting with green chemistry principles: combination of chemistry with biotech
- A wide range of new potential products (cosmetics, bioplastics, coatings, chemistry)

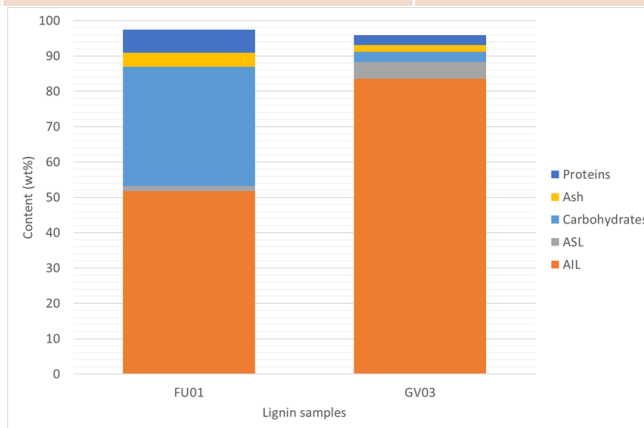
- Raw material selection
 - Variety in biomass source
 - Variety in extraction processes
 - Relevant process
- Production + distribution

Lignins	Feedstock	Process	Supplier
P1000	Wheat straw / Sarkanda grass mix	Soda	Greenvalue LLC (US)
Distillation residue	Wheat straw	Futurol	PROCETHOL 2G (FR)
Zambezi	Spruce	HCl	Avantium (NL)

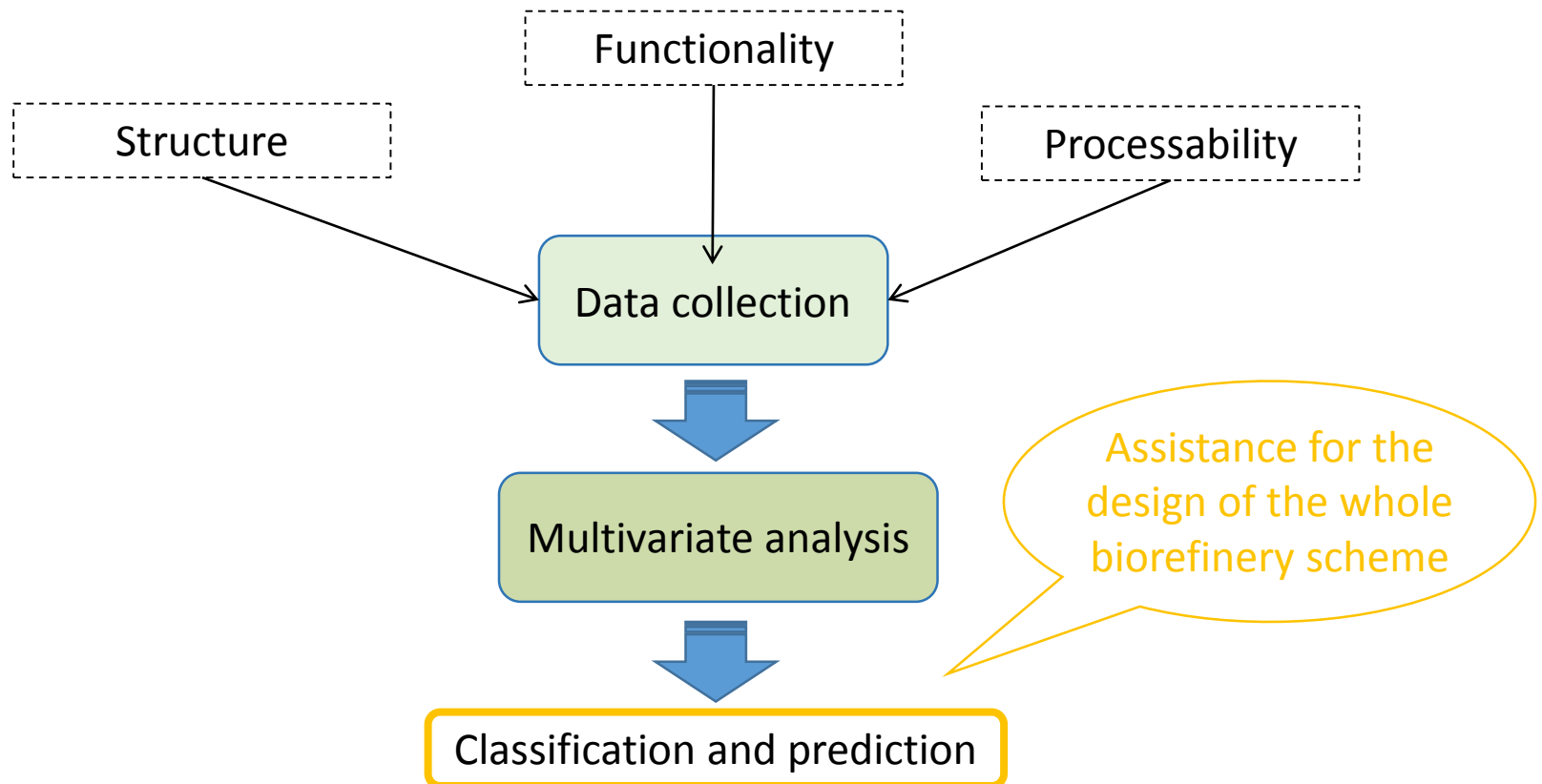
Humins	Feedstock	Process	Producer
Liquid humins	Sugars	YXY	Synvina (NL)

➤ *Lignins and humins were extensively characterised for composition, properties, functional groups etc.*

	HCl (Zambezi)	Soda (P1000)	Residue (Futurol)	Humins (YXY)
Dissolved during isolation	No	Yes	No	Yes
Soluble at RT	No	Yes, alkaline and some organic solvents	No	Yes, organic solvents
Non phenolic compounds	Sugars	Proteins, sugars	Sugars, proteins	Monomers, sugars
Mw	Unknown	Low	Unknown	Low
Ash content	Low	Low	High	Low



- Variability of the raw material = botanical origin, production process, stability over time
- Impact of variability on the downstream conversion processes



- To assess **target functionalities** for end-users and industrials
- To develop methods to **screen new functionalities** according to the products specifications
- To formulate the biomolecules, nanoparticles or preparations at laboratory scale to assess technical feasibility
- To identify the candidates for **demonstration**
- To build and implement the strategy to improve of the conversion process and provide biomolecules and nanoparticles of interest for further demonstration
- To provide data for the **safety assessment** of ZELCOR bio-based intermediates

lignins

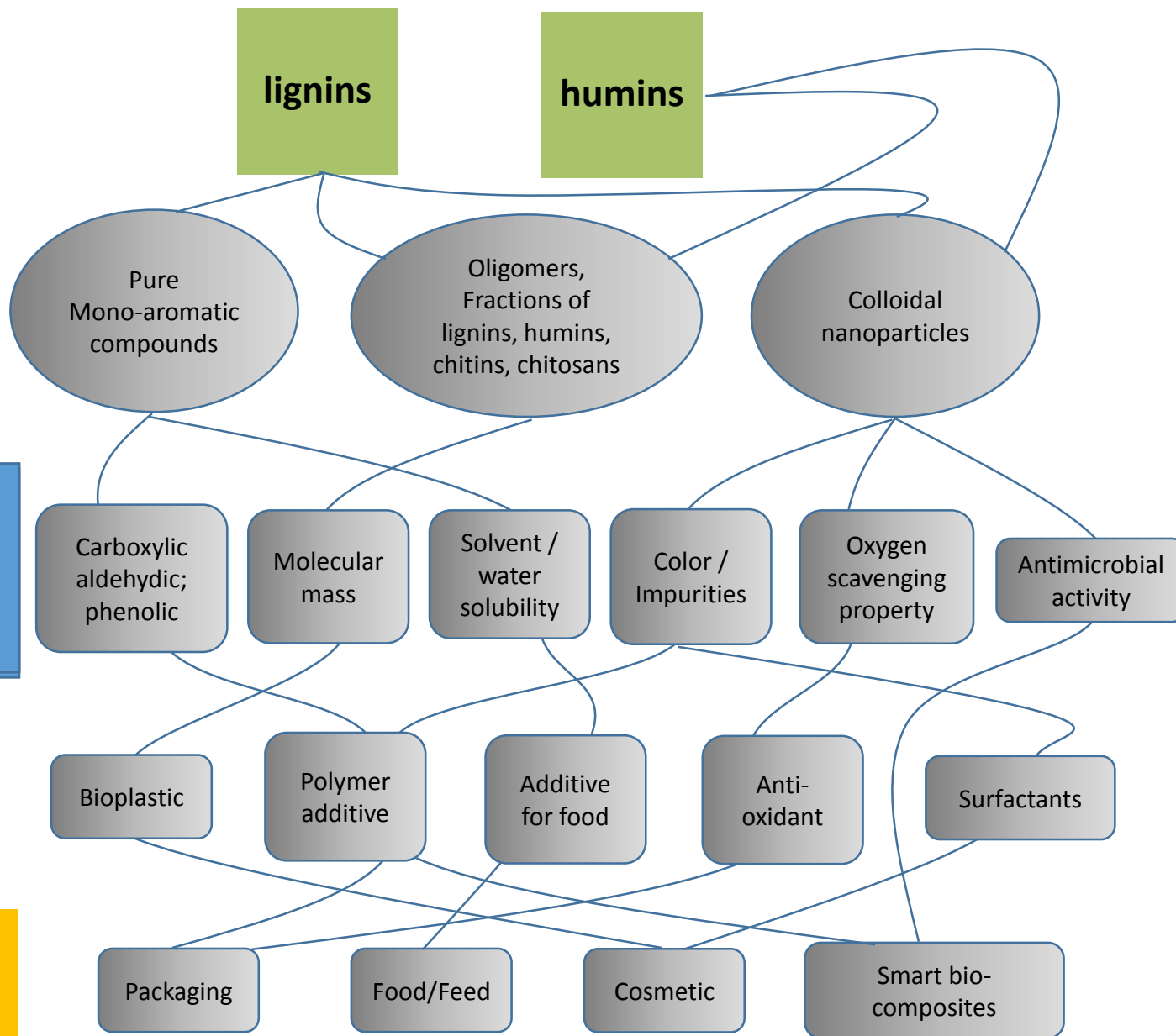
humins

Intermediate products

Functional groups and Characteristics

Application products

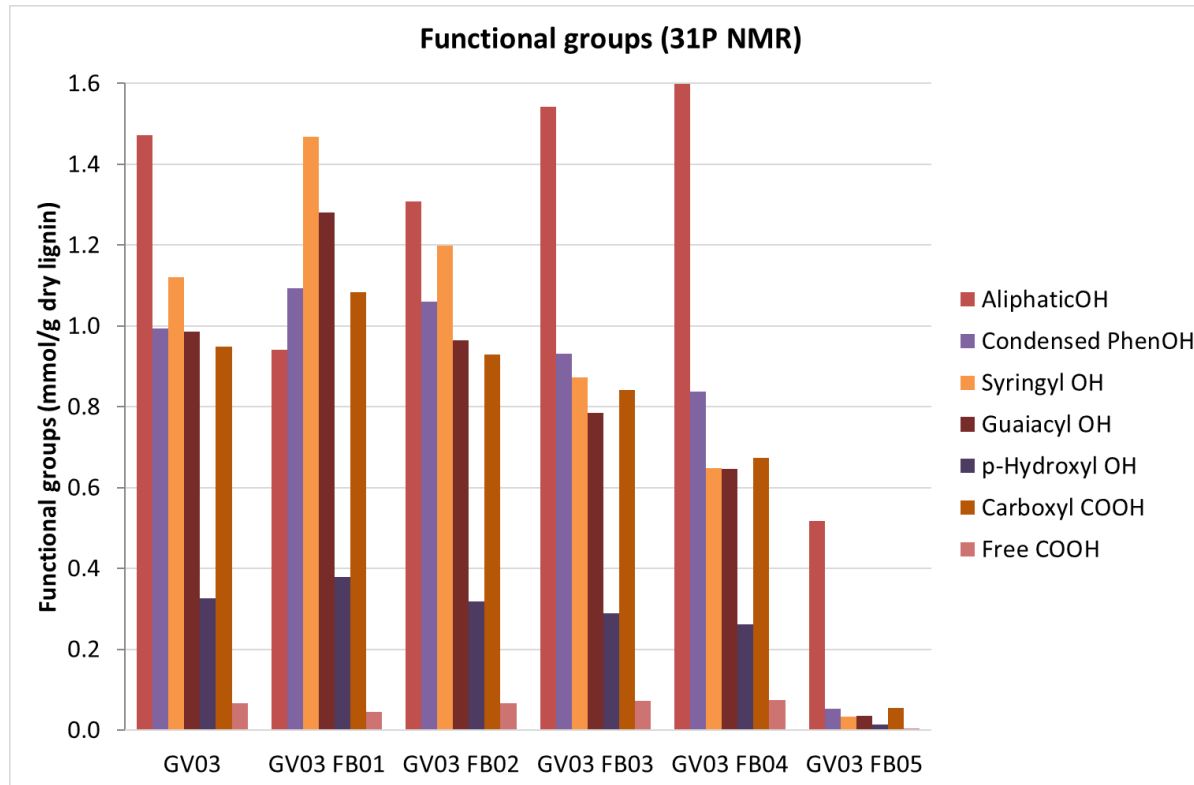
End usages



Note: routes are shown for illustration only

Identified key properties of the molecules and materials targeted for the valorisation of lignins, humins and chitins / chitosans





- In FB01 fraction higher aromatic OH and lower aliphatic OH
- Reversed tendency with the other fractions
- FB05 residue has a low solubility

What method to determine functionalities and screen new ones?

Products with adequate properties

Virtual platform of relevant and validated methods



- 4 raw material selected (industrial plant / pilots) all available at >50 kg scale: ready for process development
- 3 value chains identified for sustainability assessment
- 1 termite species (/16) selected : ready for bioreactor design
- 2 recombinant enzymes expressed in yeast: ready for immobilization and test on substrates in bioreactors
- 1 analytical platform settled gathering 30 methods: ready for the optimisation of intermediate products functionalities
- 4 main properties proved with quality criteria identified (biological activity, reactivity towards depolymerisation, antioxidant properties, self assembling into particules)

- Demonstration of the interest of the cascading approach
- Multi-functionality of the lignin fractions soluble in ethanol or ethyl acetate
- Reactivity of the non-soluble fractions towards treatments by ionic liquid



Imidazolium-Based Ionic Liquids as Efficient Reagents for the C–O Bond Cleavage of Lignin

Marina Thierry,^[a] Amel Majira,^[a] Bruce Pégot,^[b] Laurent Cezard,^[a] Flavien Bourdreux,^[b] Gilles Clément,^[a] François Perreau,^[a] Stéphanie Boutet-Mercey,^[a] Patrick Diter,^[b] Giang Vo-Thanh,^[c] Catherine Lapierre,^[a] Paul-Henri Ducrot,^[a] Emmanuel Magnier,^[b] Stéphanie Baumberger,^[a] and Betty Cottyn^{*[a]}

ChemSusChem 2018, 11, 439 – 448

Colloidal Lignin Particles for Biomaterial Applications

Majja-Liisa Mattinen¹, Guillaume Rivière¹, Monika Österberg¹,
Véronique Aguié-Béghin², Bernard Kurek¹, Stéphanie Baumberger²

¹AALTO University, Finland
²INRA, France

INRA

Tekes

Bio-based Industries Consortium

European Union funding for Research & Innovation


This project has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation program under grant agreement No 770401.

- Process development and design of purification and conversion of lignins and humins are ongoing
- Structure-property relationships will be established
- First application tests in packaging, cosmetics and particles in coatings are currently performed by industrial parties

- More information can be found:
 - www.bbi-europe.eu/projects/zelcor
 - www.zelcor.eu

- This project has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No 720303
- All Zelcor partners are kindly acknowledged for their contribution

- Zero waste biorefineries
- **September 2-6 2018 in NL**
- Focus on recalcitrant sidestreams
 - Lignin & Humins
- Specialised lecturers
- State-of-the-art
- Scientific knowledge
- Techno-economic evaluation
- LCA methodologies
- Case studies
- Biorefinery visit
- www.vlaggraduateschool.nl/en/courses/course/ZELCOR18.htm



ZELCOR
SUMMER SCHOOL



2 – 6 September 2018
Wageningen International Congress Centre (WICC)
Wageningen, The Netherlands

Zero waste biorefineries: technical advances and sustainability assessment

The 1st Summer School on waste biorefineries in the context of bioeconomy, with a focus on valorization of recalcitrant side streams. A panel of specialists in the biorefinery field will provide an up-to-date state-of-the-art overview based on the latest advances in terms of scientific knowledge, techno-economical developments and life cycle assessment methodologies.

10/2016 - 09/2020 www.zelcor.eu

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 **Bio-based Industries Consortium**  Horizon 2020 European Union Funding for Research & Innovation

Exploring Lignocellulosic Biomass 2018 Challenges and Opportunities for Bioeconomy

26-29 June 2018

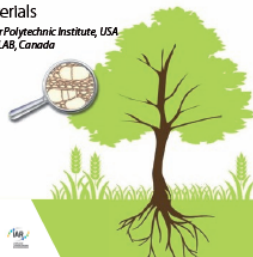
Reims
France

Abstract submission opened

6 sessions covering all aspects of lignocellulosic biomass:

- Bioeconomy of biorefinery**
Anne-Christine Ritschkoff - VTT, Finland
Antoine Missemmer - CNRS, France
- Structural and chemical complexity**
Art Ragauskas - University of Tennessee Knoxville, USA
Peter Ciesielski - NREL Golden, USA
- Physical and biological deconstruction**
Anne S. Meyer - Technical University of Denmark, Denmark
- Source of organic matters in soils**
Claire Chenu - AgroParisTech, France
Petr Baldrian - Czech Academy of Sciences, Czech Republic
- Source of biomolecules**
Ed de Jong - Avantium, The Netherlands
Warwick Raverty - CIRCA, Australia
- Source of biomaterials**
Richard Gross - Rensselaer Polytechnic Institute, USA
Armand Langlois - ENERLAB, Canada

@ELB_2018
 ELB-2018@inra.fr
 <https://colloque.inra.fr/explorebiomass/>



The grid contains 14 speaker cards, each featuring a photo, name, affiliation, session title, and date. The sessions are: 'Exploring lignocellulosic biomass: Challenges and opportunities for bioeconomy' and 'Exploring lignocellulosic biomass: Structural and chemical complexity of lignocellulose'. Keynote speakers include Anne-Christine Ritschkoff, Antoine Missemmer, Arthur Ragauskas, Peter Ciesielski, Anne S. Meyer, Claire Chenu, Ed de Jong, Richard Gross, and Armand Langlois. Invited speakers include Thomas Farmer, Anne S. Meyer, Petr Baldrian, and Warwick Raverty.