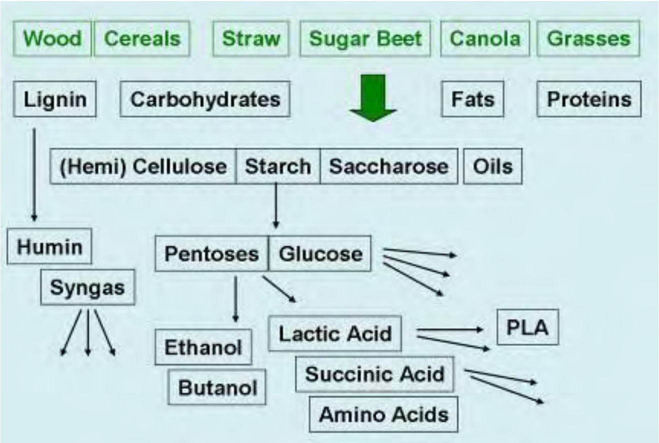
IEA Bioenergy
Task 42 Biorefining

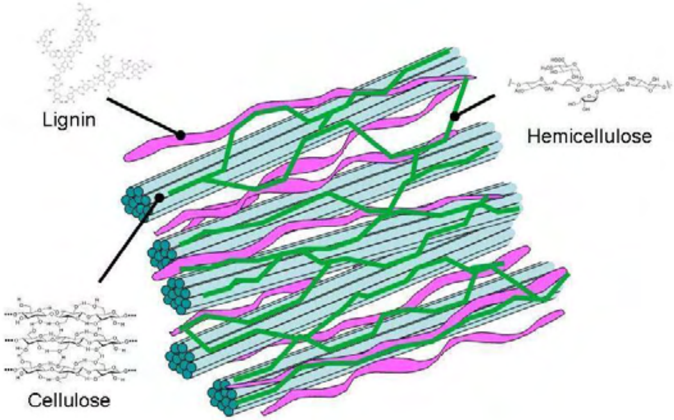
Biorefining of Wood

Perspectives for a Broad Product Portfolio

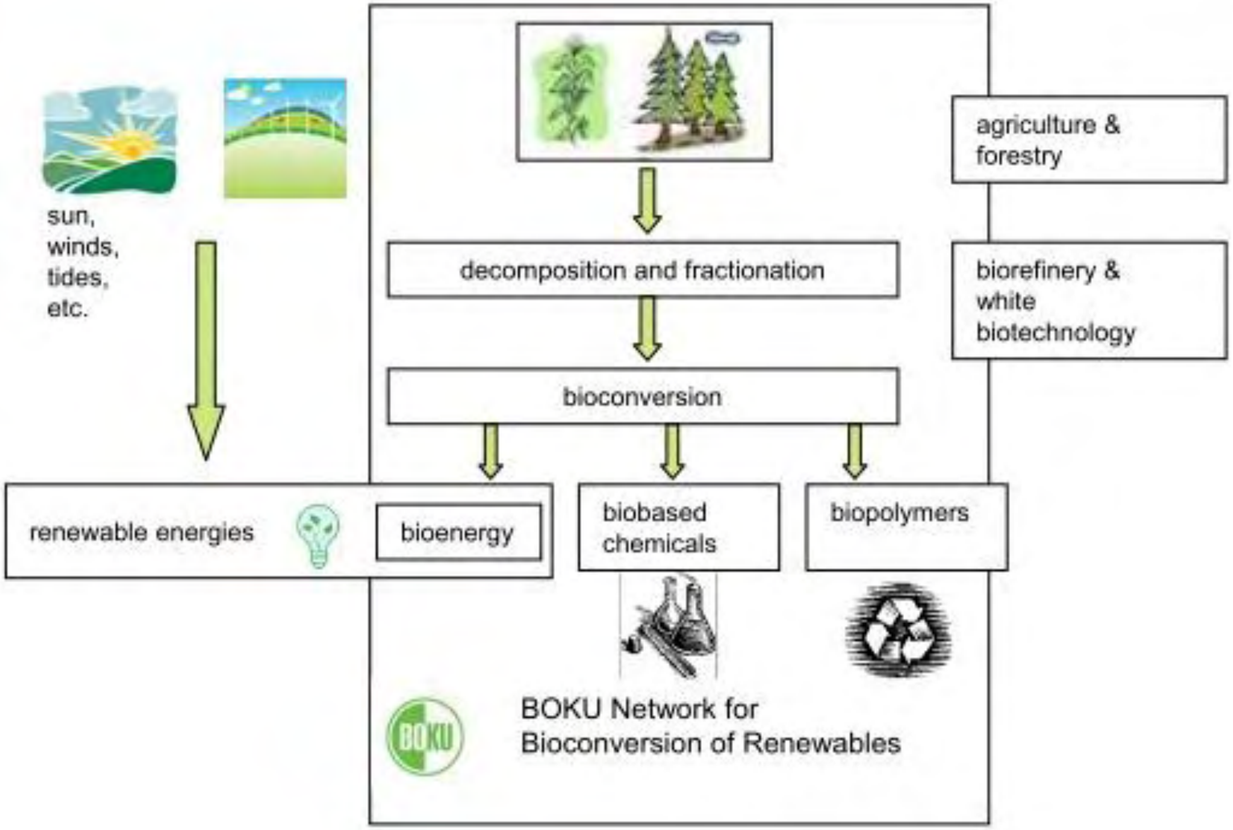
Diethard Mattanovich

Department of Biotechnology
University of Natural Resources
and Life Sciences Vienna





BOKU Joint Biorefinery – Biotechnology Concept



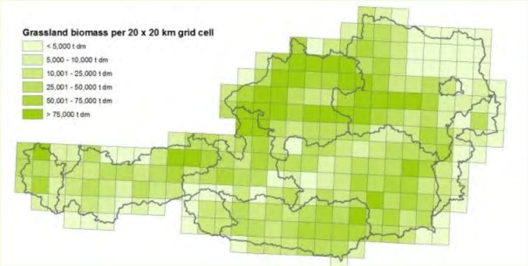
- **Joint efforts are needed:**
- **BOKU Network for Bioconversion of Renewables**

www.boku.ac.at/bioconversion.html

Spatially Explicit Supply Chain Modelling

University of Natural Resources and Life Sciences, Vienna
Institute for Sustainable Economic Development

Feedstock



Assessment of the economic biomass potential considering the competition with other sectors

Transport

Transportation costs calculated based on road network distances

Conversion

Techno-economic parameters of biorefineries

- **Investment and operation costs**
- **Product yields and prices**
- **Energy inputs and GHG-emissions**

Biorefinery Supply Chain Optimization Model

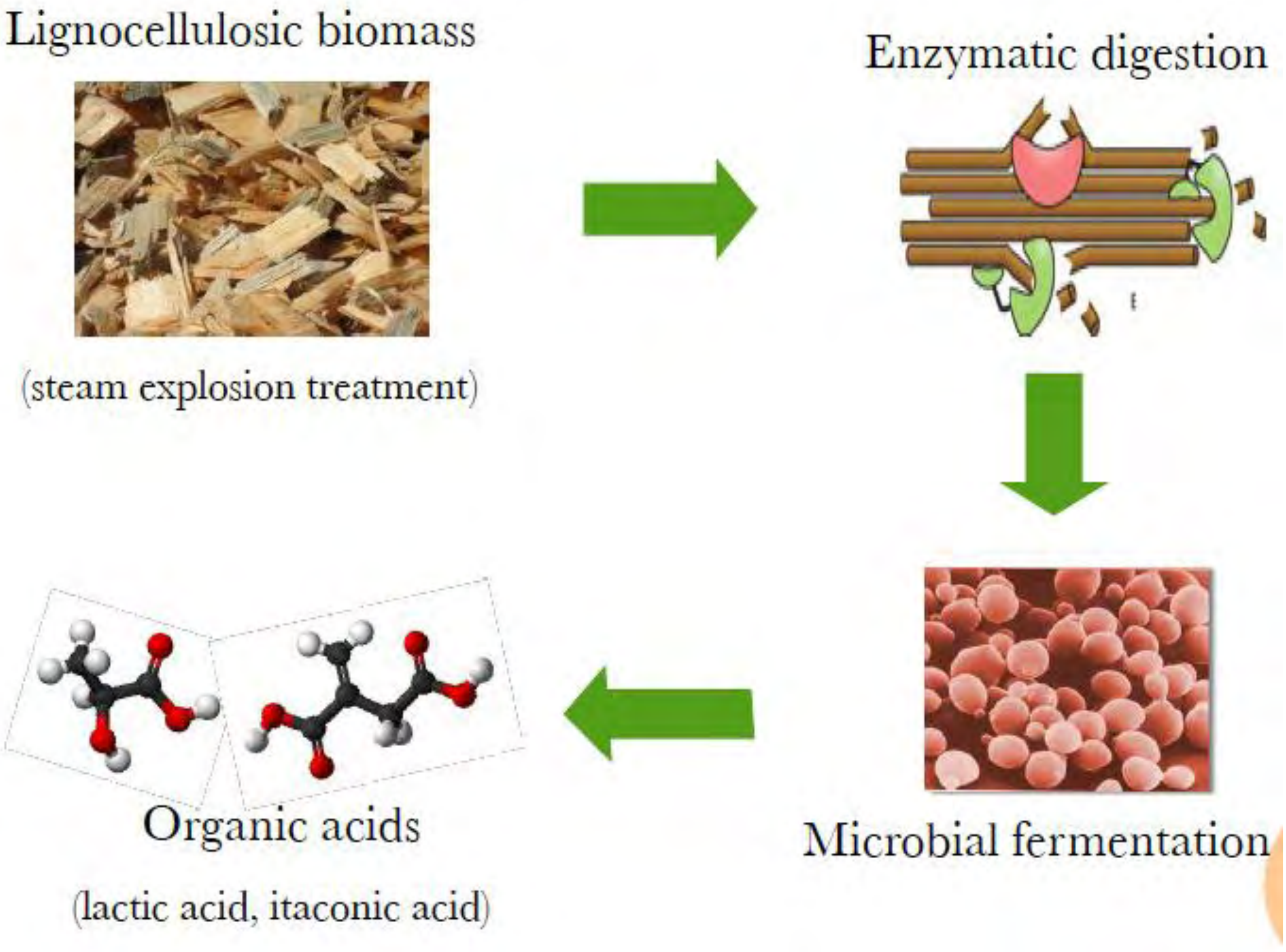
-> maximizes net revenues of full biorefinery supply chains

Results

- **Optimal locations and capacities of biorefineries**
- **Economic feasibility and sensitivity of crucial input parameters i.e. prices, costs, yields**
- **Life-cycle GHG–emissions of biorefineries and GHG-mitigation potential**
- **Policy evaluation – Assessing cost-effective policies to support environmentally friendly biorefineries**

Lignocellulose as Carbon Source

University of Natural Resources and Life Sciences, Vienna
Department of Biotechnology



Lignocellulose as Carbon Source

University of Natural Resources and Life Sciences, Vienna
Department of Biotechnology

Commercial products used:

- Cellic CTec 2 (Novozymes)
- Accellerase 1500 (Genencor)

Steam explosion samples
(7 types of wood)

50°C
pH not regulated (3,7-3,5)
150 rpm
10% (w dry/v)
No accessory enzyme
Up to 7 days of incubation

Project: Lignorefinery
FFG „Intelligente Produktion"

TDZ ENNSTAL

denkstatt sustainable thinking

Functional Materials from Renewable Resources: LIGNIN

Department of Chemistry

Hydrothermal pretreatment
steam explosion

Lignin extraction

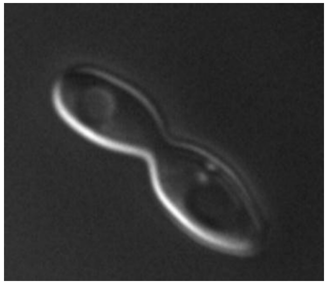
methanol/water
or dioxane

Thomas Rosenau and Falk Liebner

Candida lignohabitans: a new yeast for fermentation products

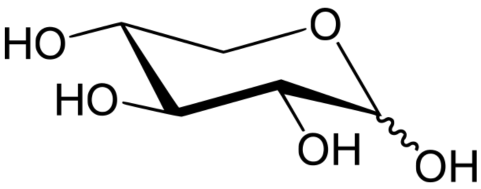
University of Natural Resources and Life Sciences, Vienna
Department of Biotechnology

- ✓ Non-conventional yeast, belonging to the *Sugiyamaella* clade



- ✓ Isolated from a decayed tree log (*Kurtzman*, 2007)

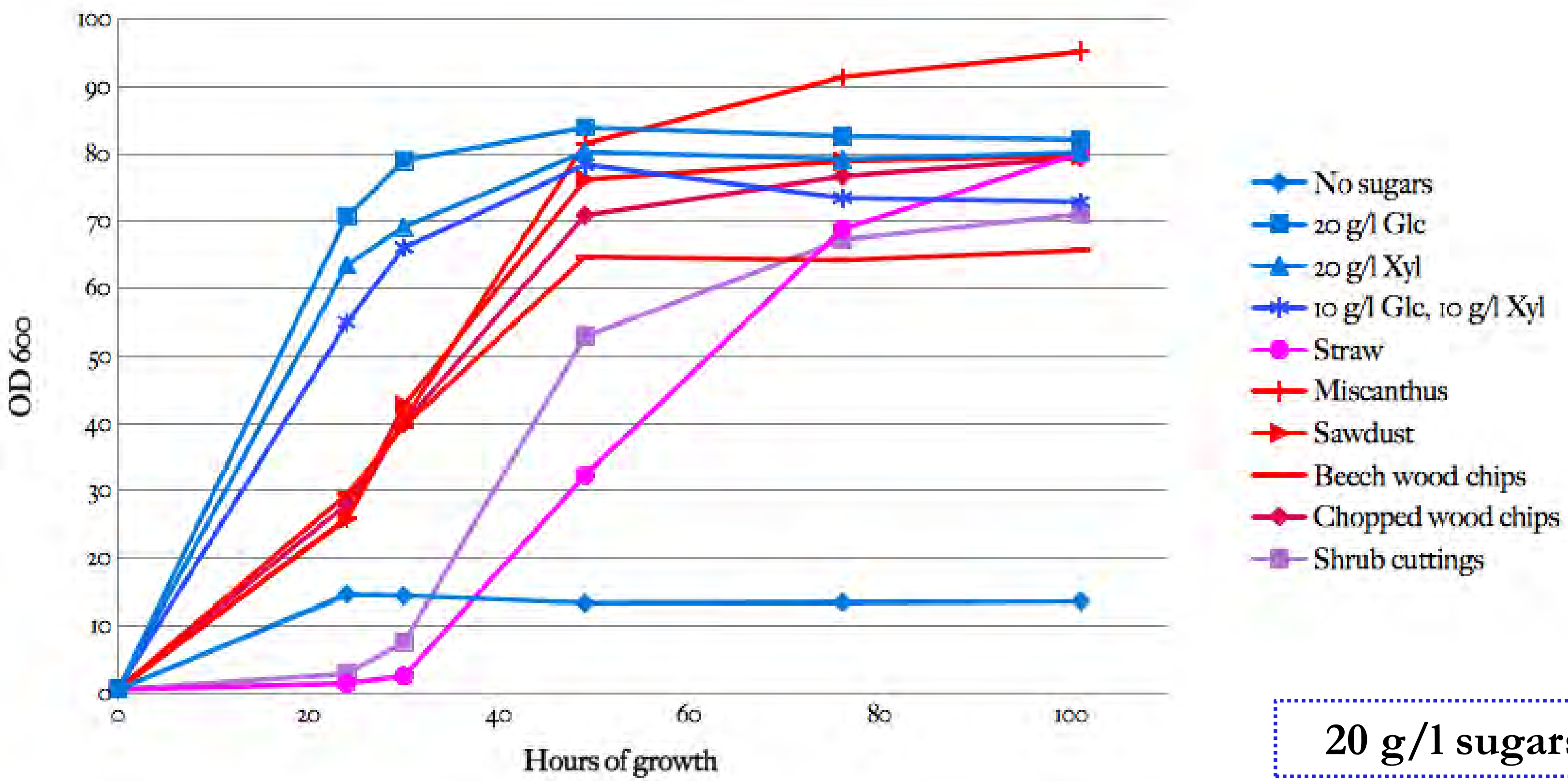
- ✓ Natural capability to ferment <u>xylose</u>



Diethard Mattanovich and Michael Sauer

Growth on hydrolysed lignocellulosic materials

University of Natural Resources and Life Sciences, Vienna
Department of Biotechnology



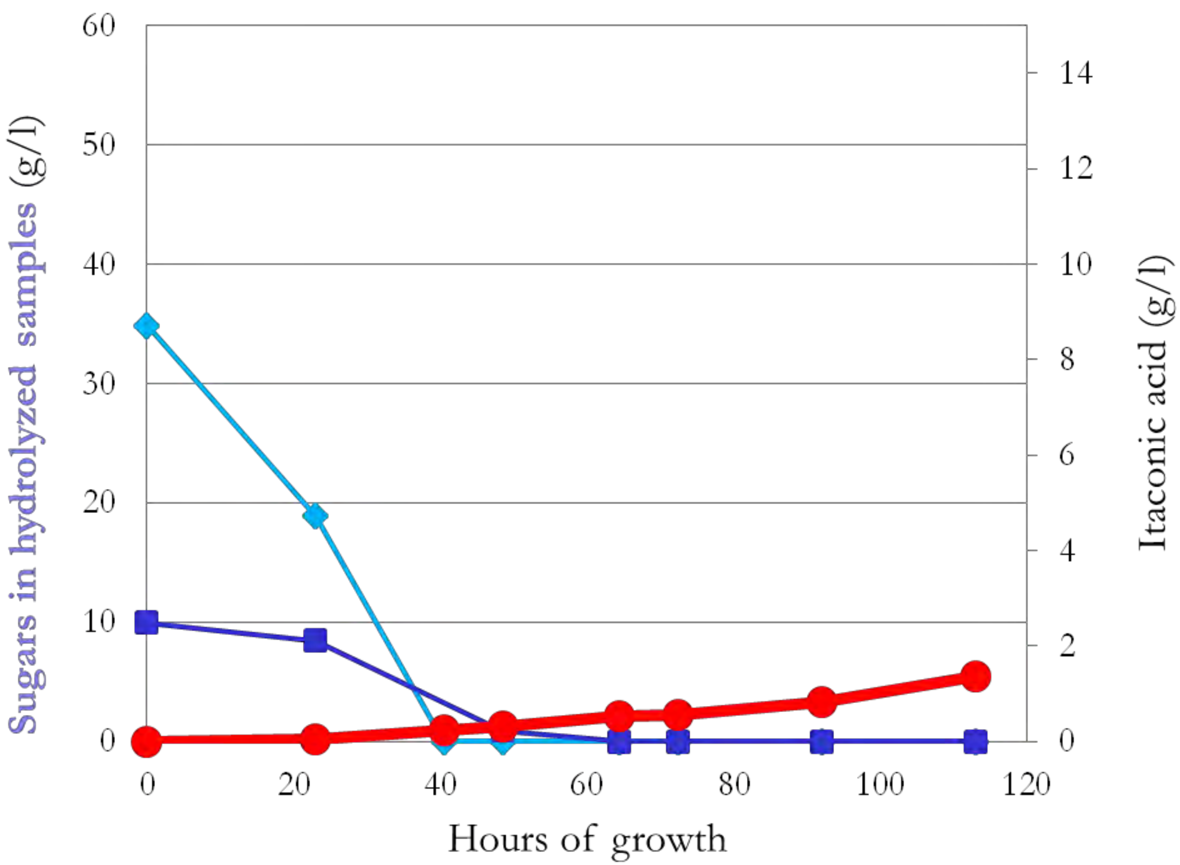
20 g/l sugars

- ✓ The strain grows on sugars present in all the types of hydrolysed lignocellulosic material

Engineered *C. lignohabitans*: Itaconic acid production on lignocellulose hydolysate

University of Natural Resources and Life Sciences, Vienna
Department of Biotechnology

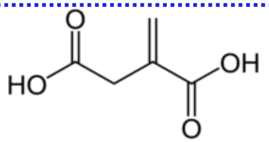
Introduction of one gene: cis-aconitate decarboxylase



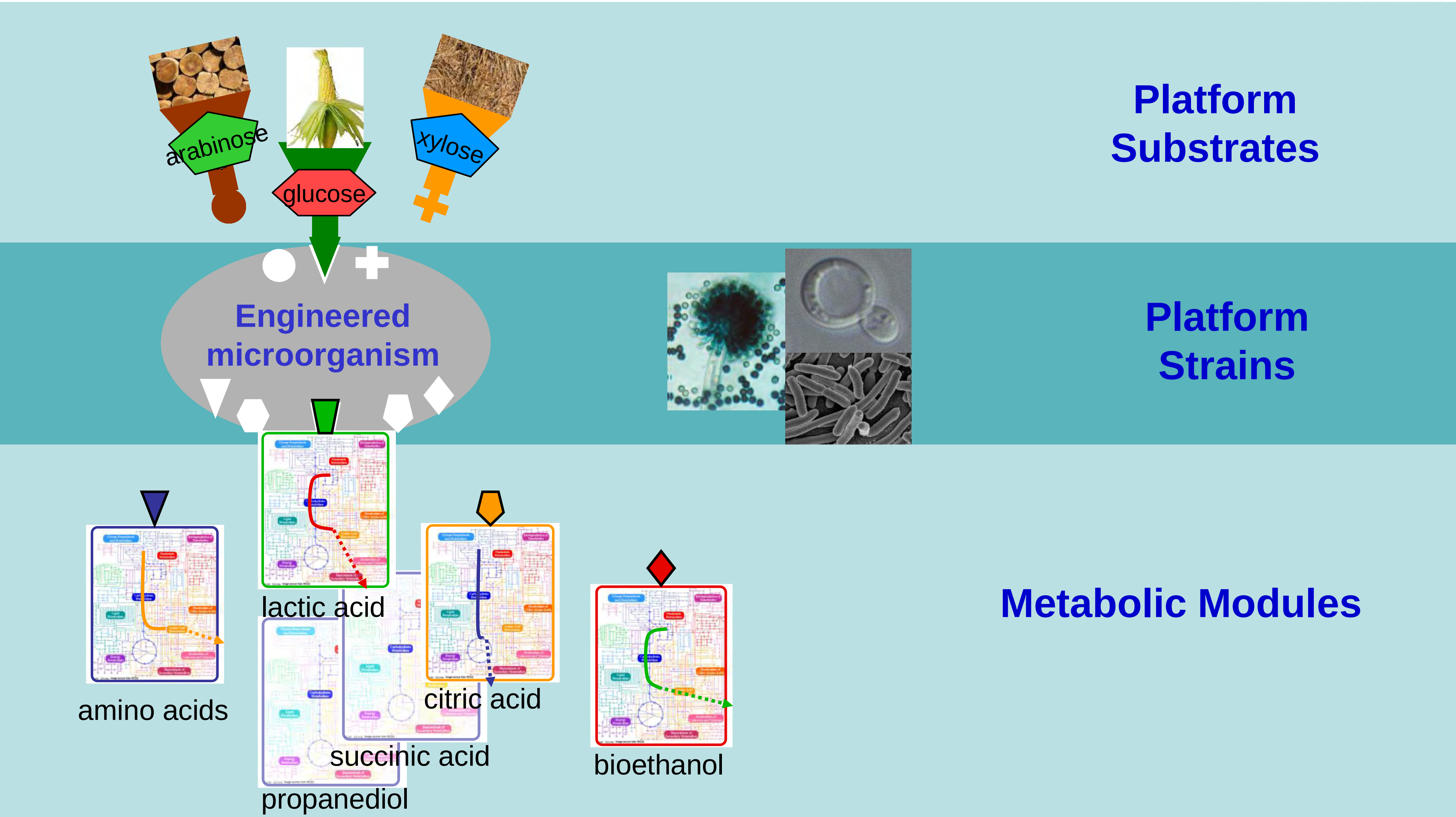
Use of itaconic acid

- polymer industry
- synthetic fiber industry
- chemical production

1.4 g/l Itaconic acid



Biotech Platform Strains and Processes



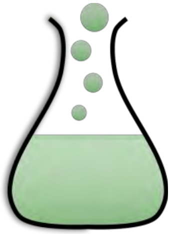
Diethard Mattanovich and Michael Sauer

Nanocellulose from Biorefinery Residues

Universität für Bodenkultur Wien
Department of Material Sciences and Process Engineering
Institute of Wood Science and Technology

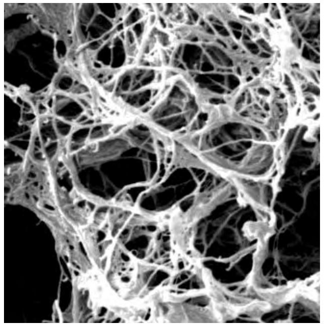
Adding value to plant biorefineries by extraction of nanocellulose from fibrous residue!

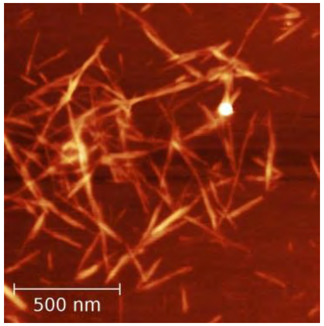
Extraction
+
Bleaching



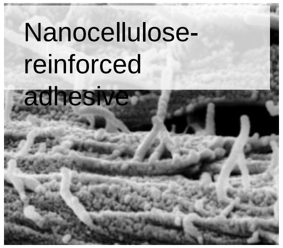
Grinding

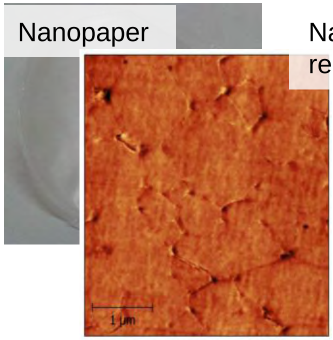
Nanocellulose: bio-based, renewable, as strong as carbon fiber





Applications: Polymer reinforcement, Coatings, Tuning Viscosity, Nanopaper, Membranes, Aerogels, and many more





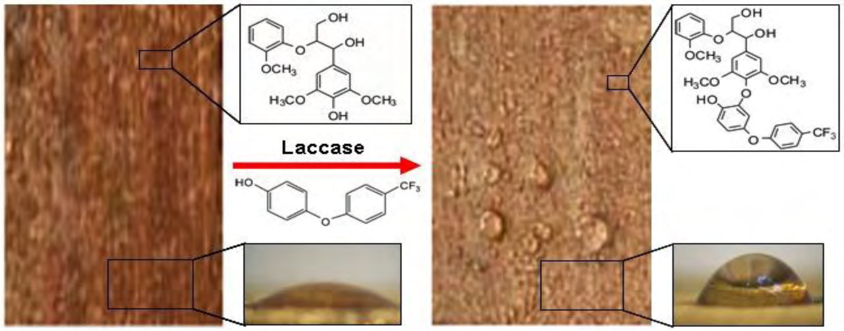
Nanocellulose-
reinforced polymer

Wolfgang Gindl-Altmutter

Hydrophobic/Antimicrobial functionalisation of lignocellulose: Mechanism

University of Natural Resources & Life Sciences Vienna
Institute for Environmental Biotechnology

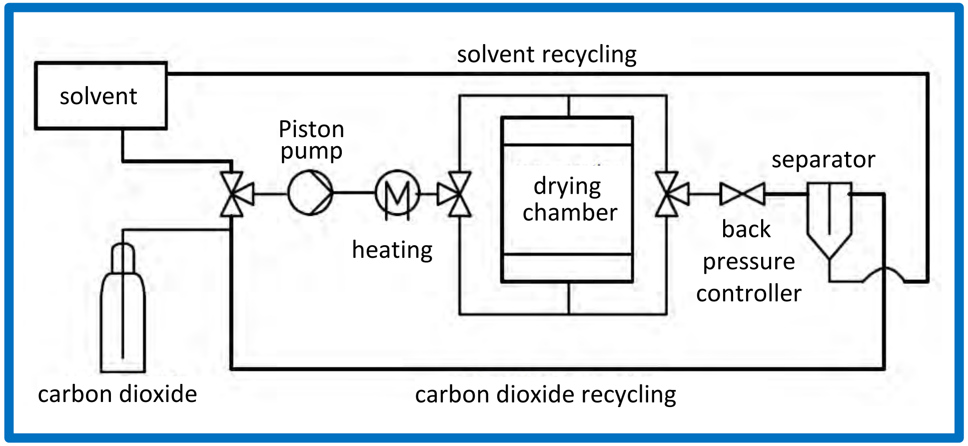
Treatment	Fluoro content %, (XPS)	Contact angle
4-(Trifluoromethoxy)phenol	**0**	**48°**
4-(Trifluoromethoxy)phenol + laccase	**3.21**	**58°**
4-(4-Fluorophenoxy)phenol	**0**	**44°**
4-(4-Fluorophenoxy)phenol + laccase	**6.39**	**88°**
4-Fluoro-2-methylphenol	**0**	**52°**
4-Fluoro-2-methylphenol + laccase	**0.26**	**58°**

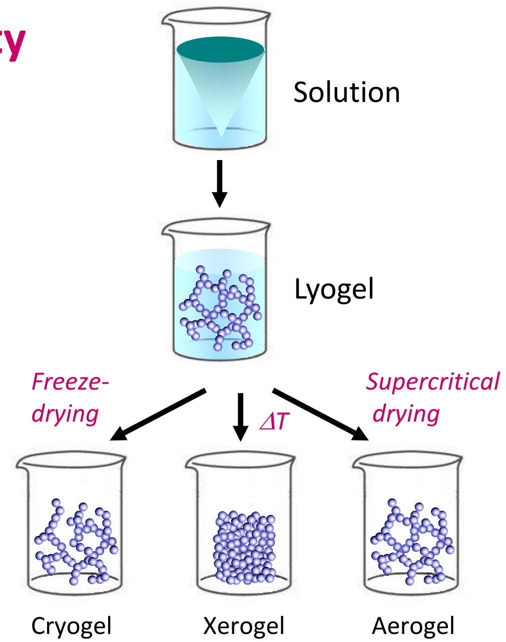


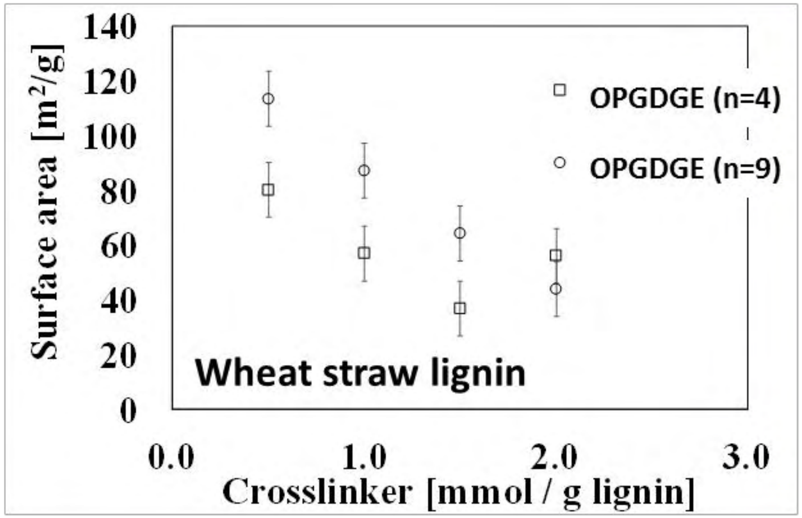
Georg Gübitz

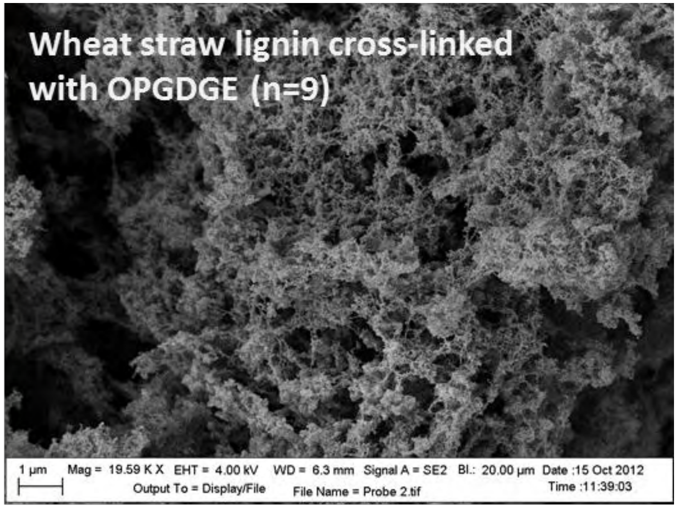
Conversion of oligo(oxyethylene) lignin hydrogels into lignin aerogels of low thermal conductivity

Department of Chemistry





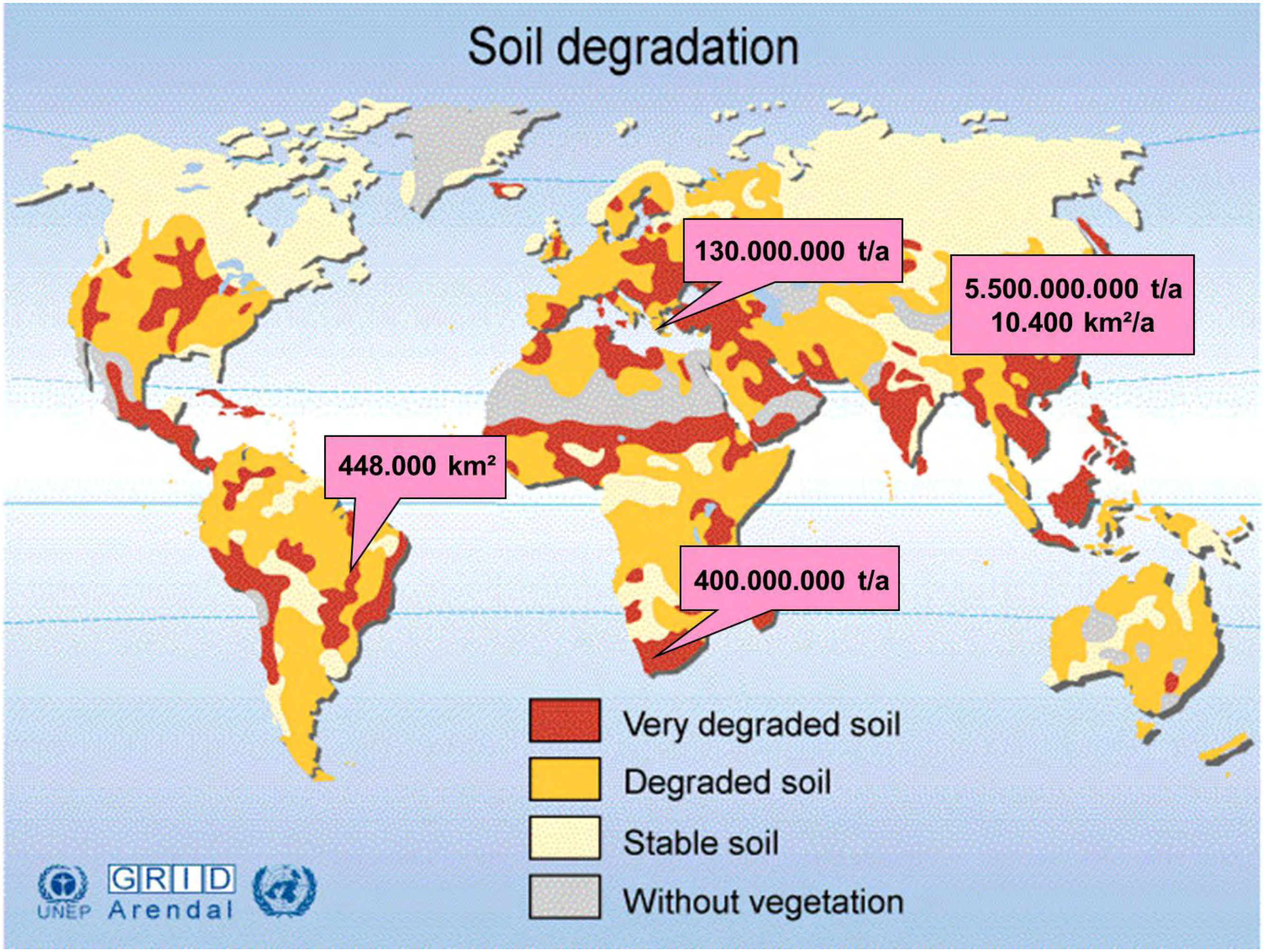




Thomas Rosenau and Falk Liebner

Conversion of Lignin into Nitrogen-rich Artificial Humic Substances for Large-Scale Recultivation of Degraded Soils

Department of Chemistry

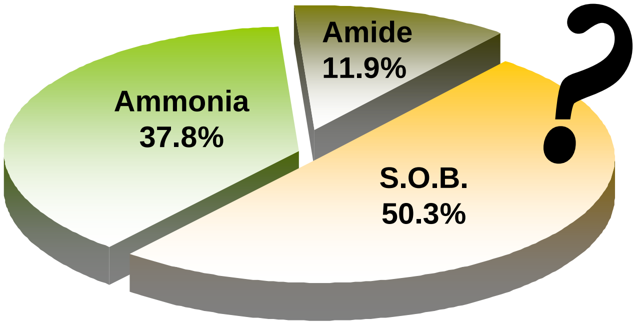


Thomas Rosenau and Falk Liebner

Conversion of Lignin into Nitrogen-rich Artificial Humic Substances for Large-Scale Recultivation of Degraded Soils

Besides the humus-type structure, *N*-modified lignins contain different *N*-binding forms that mineralise in soil at different rates (slow nitrogen release)

- **NH_4-N** (short-term plant-available)
- **Amide-N** (mid-term plant-available)
- **Strong organically bound nitrogen** (long-term plant-available)



Advantages:

- prevents plants and soil from over-fertilization
- optimizes the efficiency of fertilization (economic aspects)
- avoids nitrogen leeching by seepage water (sandy soils)

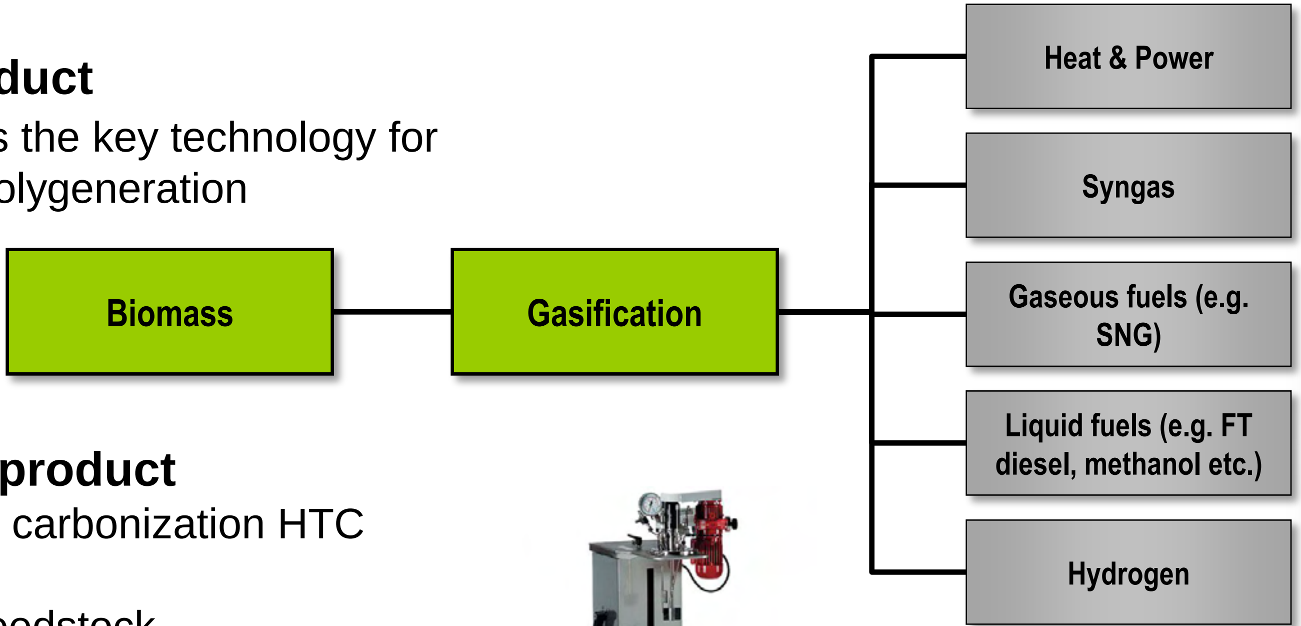
Thomas Rosenau and Falk Liebner

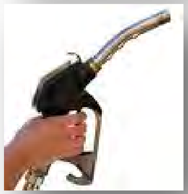
Focus on thermo-chemical biomass conversion

Universität für Bodenkultur Wien
Department of Material Sciences and Process Engineering
Institute of Chemical and Energy Engineering

Gas as product

Gasification is the key technology for multi-use & polygeneration





Biocoal as product

Hydrothermal carbonization HTC

Solid, liquid feedstock
Main products: coal suspension,
coal granulate

Univ.Prof. Dr. Christoph Pfeifer
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Summary and Acknowledgements

Research field	BOKU Department	Key Contact
Biomass availablility and transport logistics	Economics and Social Sciences	Erwin Schmid
Pretreatment, lignocellulose chemistry	Chemistry	Thomas Rosenau, Falk Liebner
Hydrolysis and Fermentation to value added chemicals	Biotechnology	Diethard Mattanovich, Michael Sauer
Nanocellulose	Material Sciences and Process Engineering	Wolfgang Gindl-Altmutter
Enzymatic functionalisation of cellulose and lignin	Agrobiotechnology	Georg Gübitz
Lignin upgrading	Chemistry	Thomas Rosenau, Falk Liebner
Thermo-chemical conversion of residues	Material Sciences and Process Engineering	Christoph Pfeifer

www.boku.ac.at/bioconversion.html