

Biomass beyond biofuels- scope and perspectives at the Lodz University of Technology

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LODZ UNIVERSITY OF TECHNOLOGY



www.p.lodz.pl/en

Outline of the talk

- Lodz University of Technology (TUL) – infrastructure and perspectives
- Projects dealing with biomass research at TUL
- Research concerning valorisation of 1st generation biomass
- Research concerning valorisation of 2nd generation biomass
- Concluding remarks

University campus

TUL's unique, bustling campus covers the area of about 32 hectares. Campus is only a five to ten minute walk to all TUL faculties.



Campus A

red line – campus area in the year 1945

yellow line – campus area today

University campus

TUL's grounds include a beautiful park, a few historic villas, and revitalized factory buildings adapted to the needs of the University.



Campus B

red line – present campus area

Awards

- TUL has been awarded **ECTS Label** by the European Commission. This acknowledges highest quality standards of education and international exchange.
- TUL has been listed on the prestigious **2013 Forbes Diamonds** list as the only university in Lodz among many businesses.
- TUL is a signatory of **The Magna Charta Universitatum** that has been signed by over 750 Vice-Chancellors globally.
 - **Fourth best technical university in Poland** (Perspektywy and Rzeczpospolita university ranking)
 - **PROStudent University**
(The title was awarded by the Student Parliament of the Republic of Poland in 2011)
 - **Fourth most frequently selected university** according to Ministry of Science and Higher Education report



Signatory of The Magna Charta Universitatum



Research

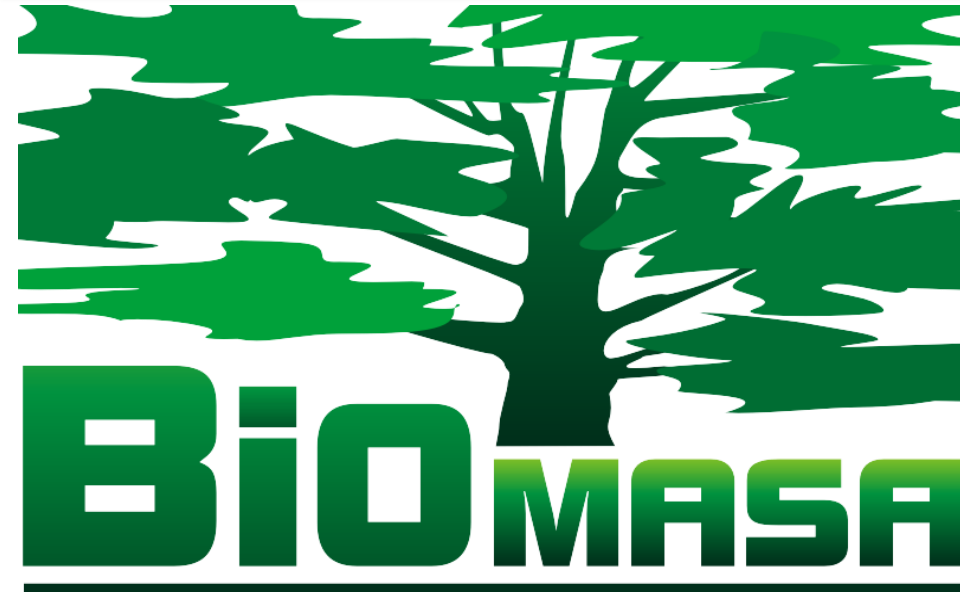
- Modern technologies for sustainable development
- Advanced material technologies
- Energy, environment and infrastructure
- IT
- Production management systems
- Industrial biotechnology
- Biomedical engineering

Student exchange and research projects are carried out in cooperation with **450 organizations** in **40 countries**.

TUL is also engaged in research projects financed with national and international grants funded by e.g. Polish-Swiss Research Program, National Science Centre and National Research and Development Centre Programs.



Projects concerning biomass on TUL



Utilisation of biomass for the preparation of environmentally friendly polymer materials

The project is being realized within the time frame 2009-2013 by nine research groups from Poland belonging to five different institutions, with the Lodz University of Technology being the leader

Coordination – prof. ANDRZEJ OKRUSZEK, ph.D.
**Lodz University of Technology, Institute
of Technical Biochemistry**



**INNOWACYJNA
GOSPODARKA**
NARODOWA STRATEGIA SPÓJNOŚCI

**UNIA EUROPEJSKA
EUROPEJSKI FUNDUSZ
ROZWOJU REGIONALNEGO**



Projects concerning biomass on TUL

The aim of the project

Utilization of various kinds of plant biomass by their transformation with biotechnological methods into fibrous polymer materials

Two ingredients of fibrous materials

1. Cellulose nanofibers
2. Co-polyesters from unsaturated fatty acid esters

Those materials can find applications in e.g. thermoplastic materials, sanitary textiles, filtration materials, geotextiles, agrotextiles and packing materials.



Projects concerning biomass on TUL

First component

High cellulose plant biomass



Mechanical work-up (grinding)

Hydrothermic work-up (boiling, steam-explosion)

Chemical work-up

Enzymatic work-up

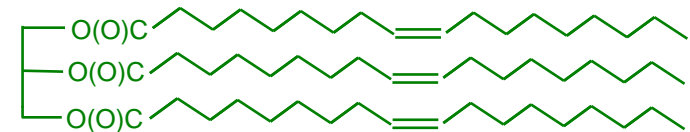
Multienzyme complex with low cellulase activity



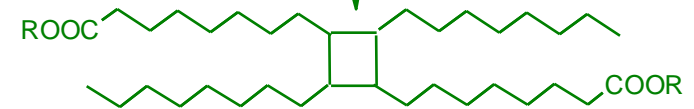
Cellulose nanofibers

Second component

OIL-PLANTS BIOMASS
(RAPESEED OIL, SUNFLOWER OIL, FLAXSEED OIL)



ENZYMATIC TREATMENT (TRANSESTERIFICATION)
CHEMICAL TREATMENT (CYCLOADDITION)



FATTY DIMER-ESTERS



CO-POLYMERIZATION INTO
BIODEGRADABLE CO-POLYESTERS



Projects concerning biomass on TUL



Institute of Soil Science and Plant Cultivation



Sida

(*Sida hermaphrodita* L.)



Rye

(*Secale cereale* L.)



Jerusalem artichoke

(*Helianthus tuberosus* L.)



Canary grass

(*Phalaris canariensis* L.)



Sorghum

(*Sorghum Moench*)

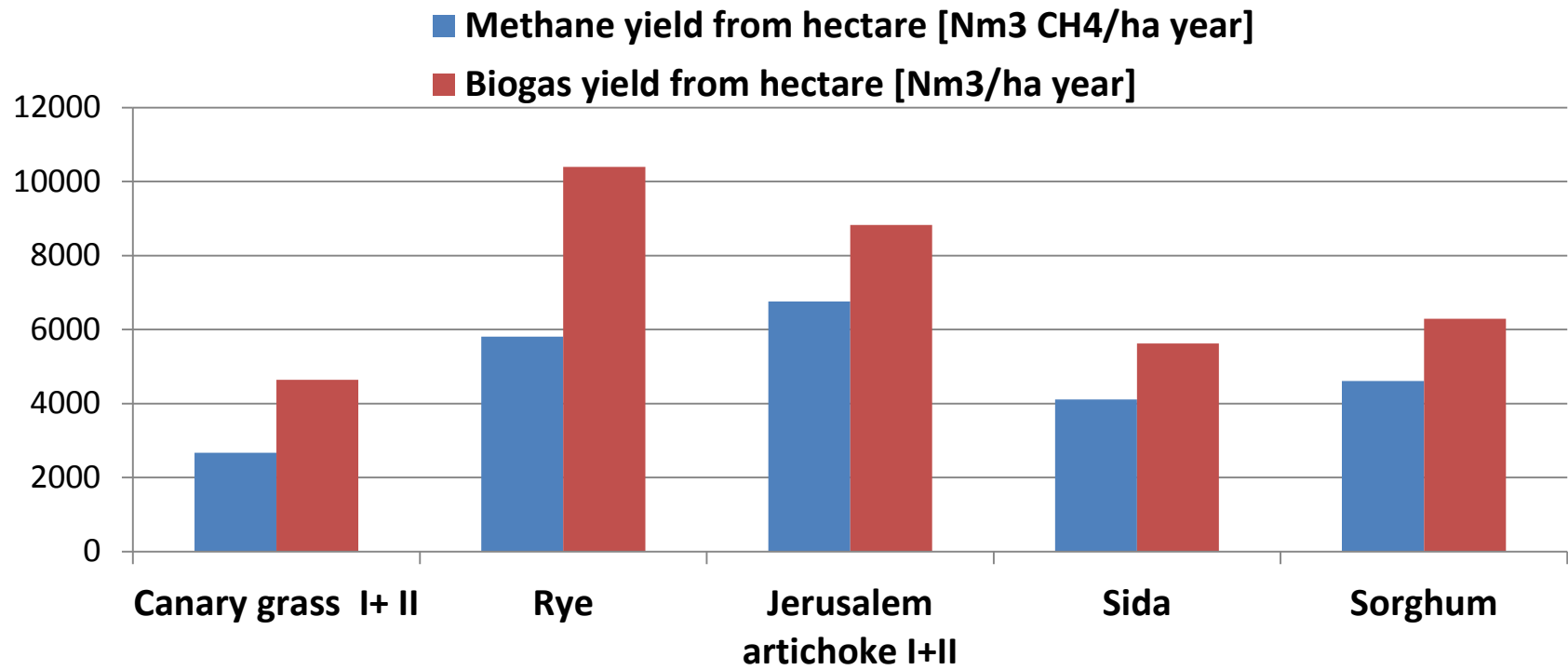
GENERAL CHARACTERISTICS AND BIOCHEMICAL METHANE POTENTIALS (BMP) OF VARIOUS ENERGY CROPS GROWN IN POLAND

Technical University of Lodz Department of Bioprocess Engineering Faculty of Process and Environmental Engineering.

Coordination – Prof. dr hab. STANISLAW LEDAKOWICZ

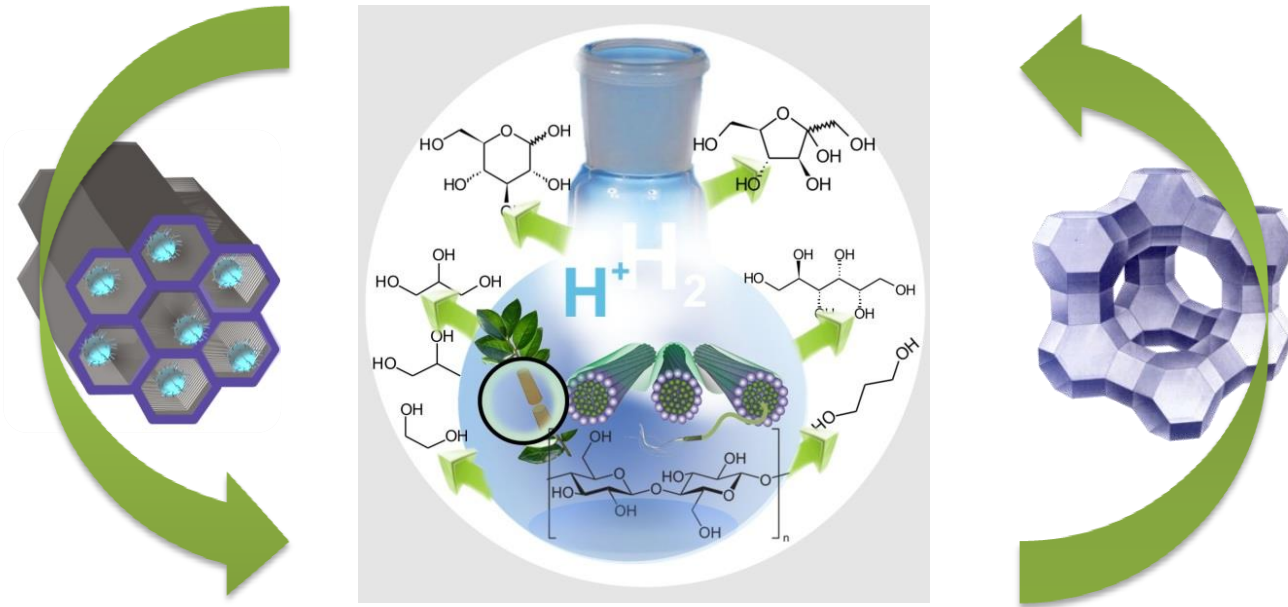
The work was supported by a grant No. PBZ-MNiSW-1/3/2006 founded by Ministry of Science & Higher Education, Poland and by EU Structural Funds in Poland founded by Ministry of Regional Development.

Projects concerning biomass on TUL



- Energy crops are very suitable for anaerobic digestion.
- Specific methane yield varied from 32 to 119 Ndm³CH₄/kg wet weight.
- The highest yield of methane production from hectare was obtained from **maize** and **rye**, **6147** and **5807 Nm³CH₄/ha year**, respectively.

Catalytic transformation of biomass



Evolving ideas in biomass transformations

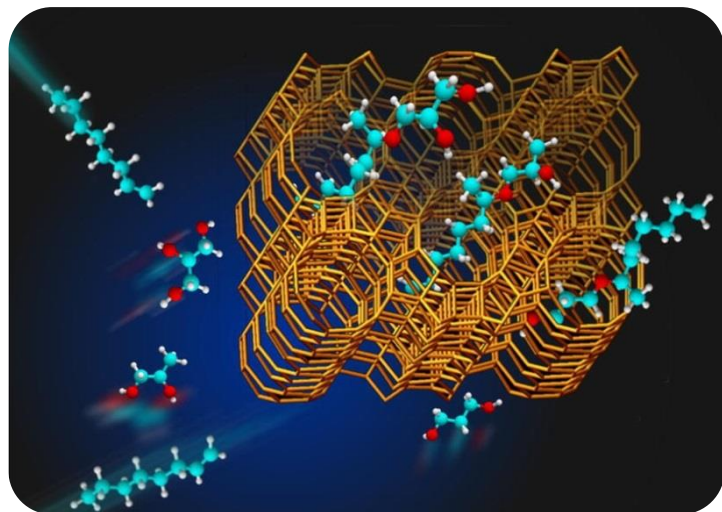


I generation

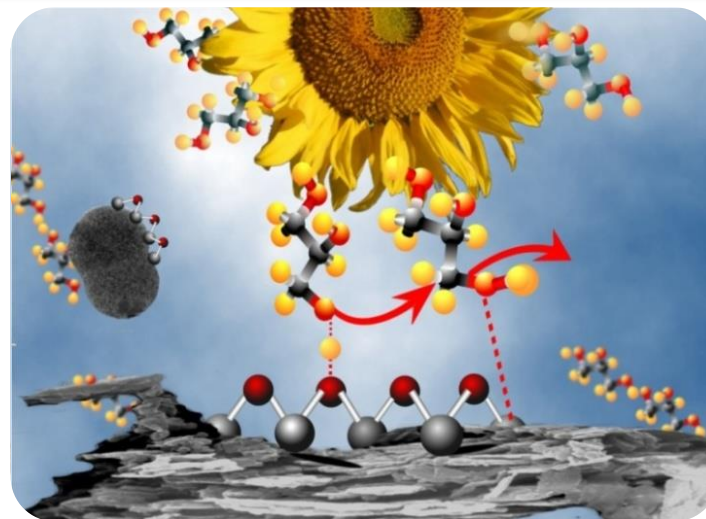
II generation

III generation

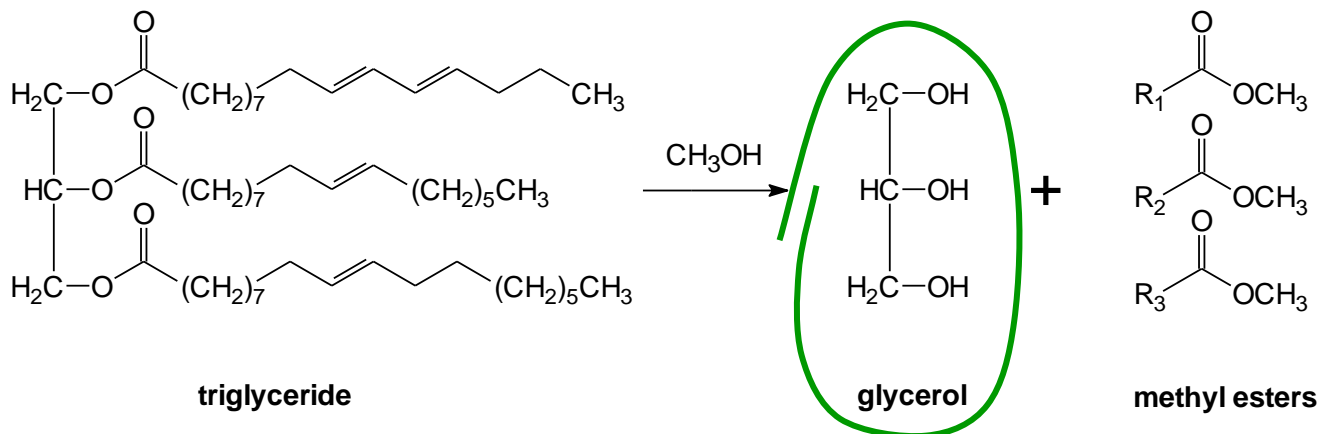
Glycerol - byproduct of 1st generation biomass



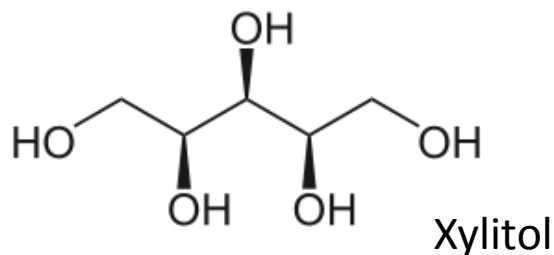
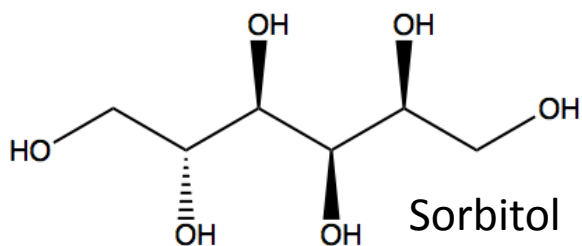
A. M. Ruppert et al., *Journal of Catalysis* 268 (2009) 251–259



A. M. Ruppert, J.s D. Meeldijk, B. W. M. Kuipers, B. H. Erne, B. M. Weckhuysen *Chem. Eur. J.* 14 (7) (2008) 2016.



Hydrolytic hydrogenation of biomass



A Journal of the Gesellschaft Deutscher Chemiker
Angewandte Chemie
International Edition
www.angewandte.org
GDCh
2012-51/11

About the Nonsense of Biofuels
Editorial by H. Michel
Renewable Feedstocks
Directed by G. Piskovits et al.
Stereoselective Synthesis
Milestone by M. Brown
Highlights: Molecular Knots • Coffee Rings

ACS 51 (11) 2553-2784 (2012) ISSN 1433-7851 Vol. 51 No. 11

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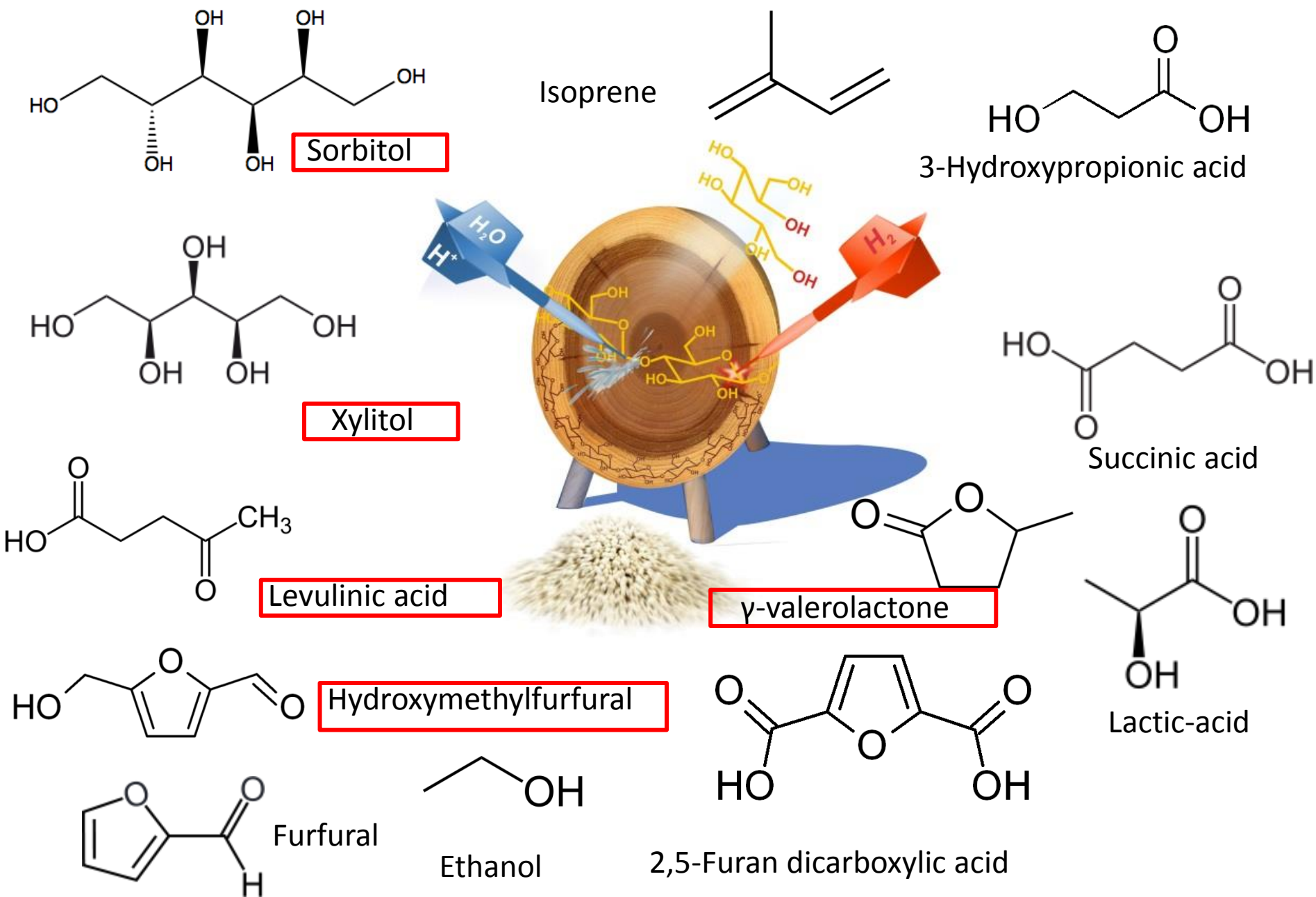
R. Palkovits, K. Tajvidi, A.M. Ruppert, J. Procelewska, *Chemical Communications* 47, Issue 1, 7 (2011), 576-578.
R. Palkovits, K. Tajvidi, J. Procelewska, R. Rinaldi, A.M. Ruppert, *Green Chemistry* (2010), 12(6), 972-978.
A.M. Ruppert, K. Weinberg, R. Palkovits, *Angewandte Chemie (International Edition)* 51, 11, 2564-2601



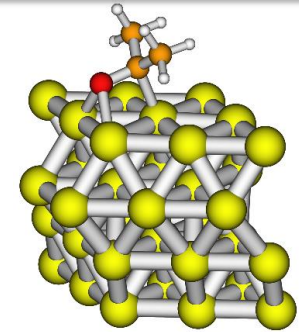
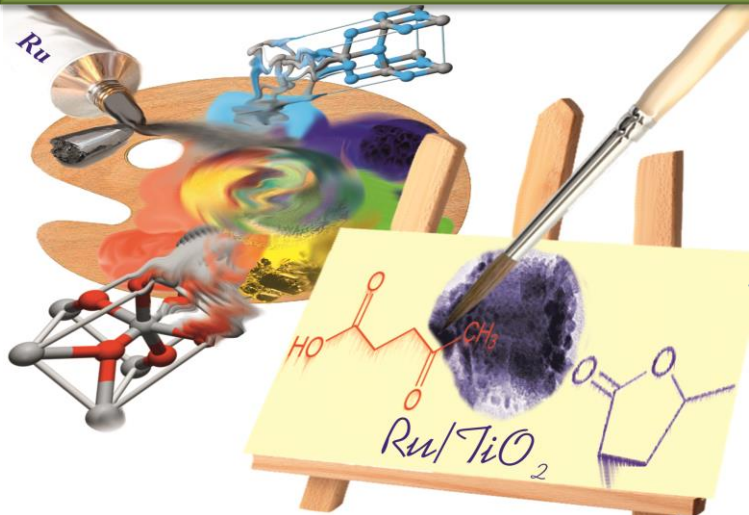
MPI Mulheim

Prof. dr. F. Schüth, Prof.dr. Regina Palkovits

Valorization of lignocellulosic biomass



Valorization of lignocellulosic biomass

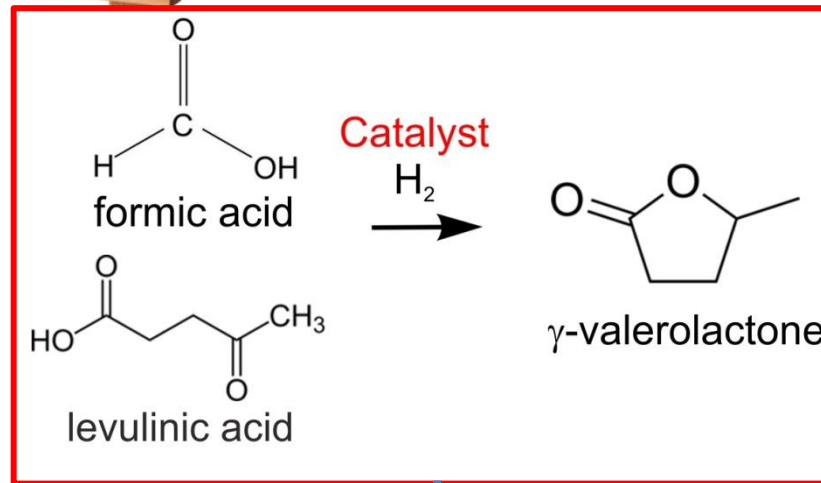


Formic acid as a source of hydrogen in LA hydrogenation on different catalysts (DFT calculation)

Influence of the material properties on reaction performance

Collaboration with Dr. Nicolas Keller

ICPEES, CNRS University of Strasbourg France



Collaboration with Prof. Philippe Sautet
Lyon Universitet , France
with in a frame of Polonium program

Valorization of biomass to GVL on metallic catalysts
Further transformation of GVL to valeric biofuels

Work was financially supported by the NCN grant : NN 209 75 83 40

Valorization of lignocellulosic biomass

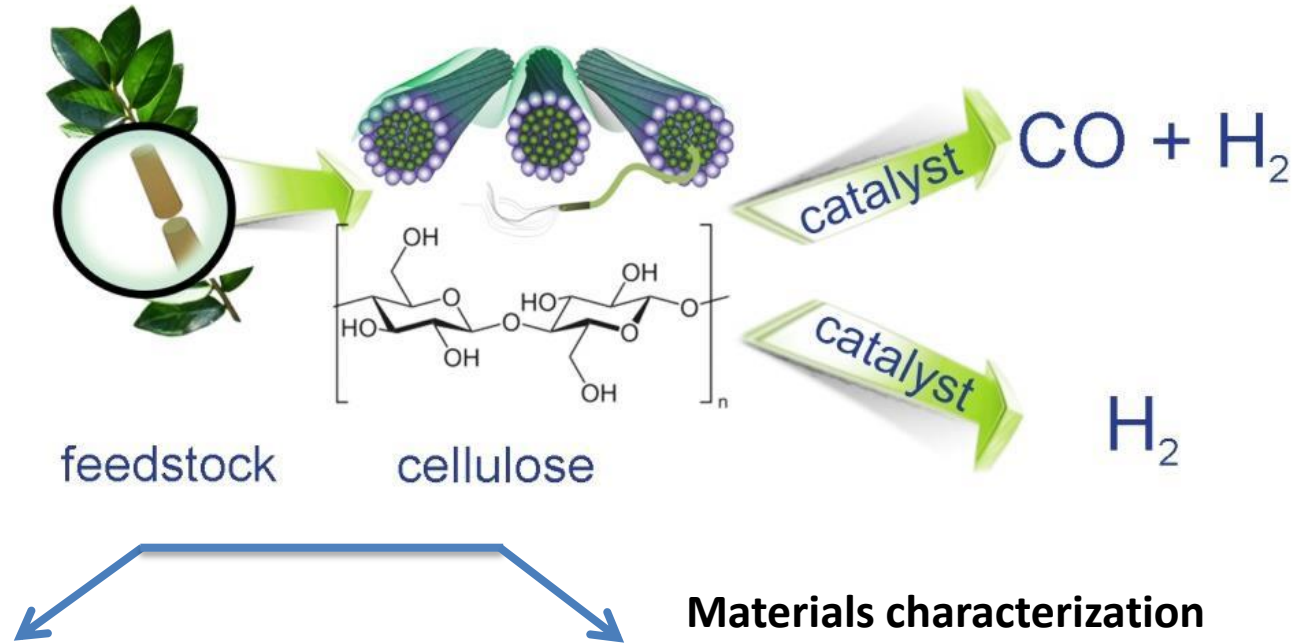
Gasification and pyrolysis of biomass

Optimization of catalytic performance of materials for enhanced hydrogen production.

Biomass pyrolysis on different materials

**Colaboration with
Dr. Witold KWAPIŃSKI,
University of Limerick, Irland**

Ruppert A.M., Niewiadomski M., Grams J.,
Kwapinski W.
Applied Catalysis B: Environmental 2014



Materials characterization
**Colaboration with
Prof. Izabela Rzeźnicka,
Tohoku University, Sendai,
Japonia**

Work was financially supported by the NCN grant : 2011/03/B/ST5/03270

Concluding remarks

TUL research in the field of biomass remains in accordance with the most recent trends and standards, swiftly moving from 1st to 2nd generation biomass valorisation and further beyond.

The research scope is broad, ranging from cellulose- and biopolyester-based fibrous polymer composites to cellulose gasification/pyrolysis and cellulose valorisation towards fuel additives and other chemicals.

