Faculty of Forestry and Wood Technology

COST Action FP1407 1st Conference
"Life Cycle Assessment,
EPDs and modified wood"

August 25. - 26. 2015, Koper

Peter Rademacher

Improvement of wood properties due to impregnation of wood with renewable liquids from different process residues of native origin

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Mendel University in Brno

THÜNEN

Overview

- Introduction
- Material
- Methods
- Results
- Discussion
- Conclusions

Introduction

- Work packages/ sub-group building in InWood-project:
  - Structure/ anatomy/ microscopy group (SG)
  - Physical/ mechanical/ moisture test + model. group (PG)
  - Chemical/ analytical group (CG)
  - Wood modification/ durability group (MG)
  - Wood fiber group/ WBP group (FG)
  - Wood processing/ design/ furniture/ product group (PF-G)

inwood
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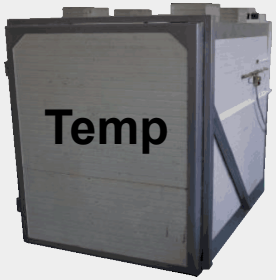
Materials and Methods

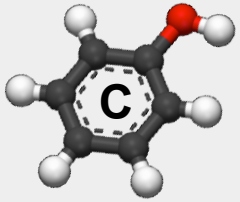
- Swelling measurement: 10 samples of 14 x 14 x 28 mm^3 for each treatment
- Durability: 9 samples of 5 x 10 x 30 mm^3 (Bravery Test) for each treatment
- Production of liquid residues from thermal treatment (TT)-, Hydro-Thermal-Carbonisation (HTC)-, and pyrolysis-processes; impregnation to increase weight-percent-gain (WPG)
- Impregnation of Beech and Poplar sets of samples using vacuum 20 kPa/ 1 hour (EN 113)
- Concentrations: Pyrolysis 1:10; 1:2, original (1:1 = 100%); TT and HTC concentrated 10:1
- Conditioning, drying, volume/weight, leaching, bulking measurement following standards
- Durability tests: Bravery Test; fungi: *Trametes versicolor,* decay 6 weeks acc. to EN 113
- UMSP: UV-light absorption at 278nm, using Zeiss-UMSP 80 (Koch and Grünwald 2004)

Impregnation of wood with solutions of native origin

Impregnation with liquids from different process origin:

Extracts from organic materials



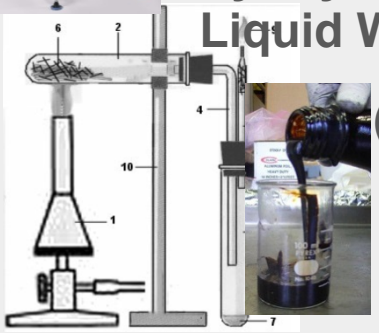


Thermal Treatmt. (TT)

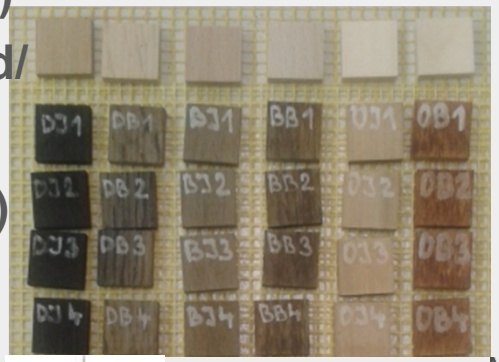
Wood Impregnation → Material Improvement → New Material → N. Product

Hydro Therm. Carbon. (HTC)

Pyrolysis Liquid/ Liquid Wood (PL, LW)



Oak heart. sap. Beech heart. sap Aspen heart. sap.



http://www.scheffel.og.bw.schule.de/faecher/scie Holz_Chemie_Pyrolyse_Website.pdf http:// de.wikipedia.org/wiki/Pyrolyse

HNE Eberswalde

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(Mendelu-Group + TI/ HH + HNEE + Ljublj. Univ.)

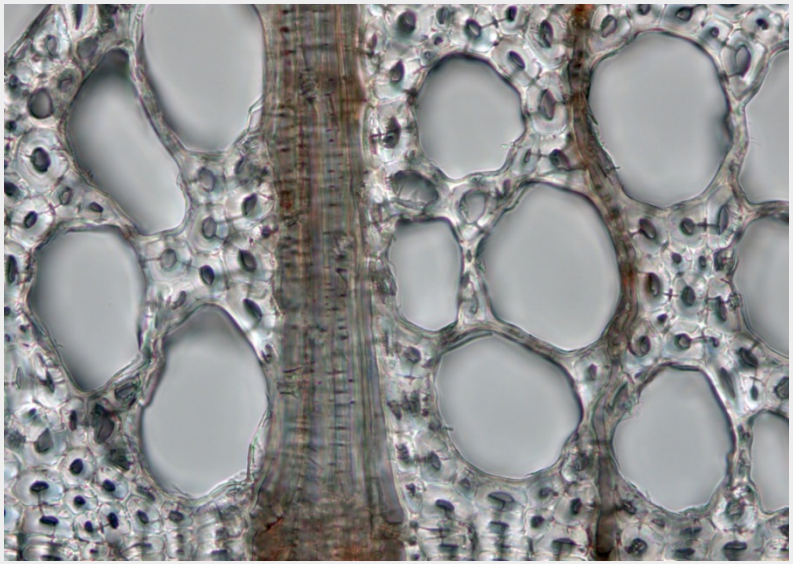
Impregnation of wood with solutions of native origin

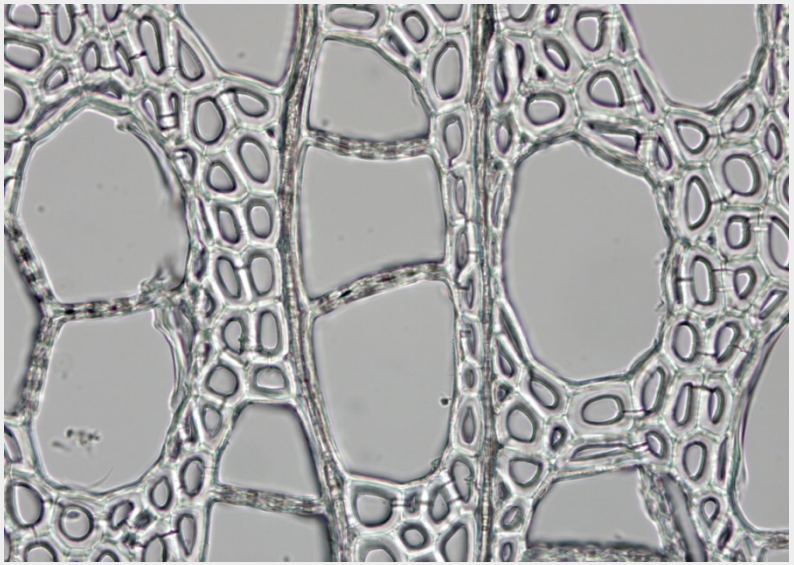
No.	Used Raw-Materials	Abbreviation	Synonym	Process Conditions	Solution Characteristics
1	Miscanthus sp.	HTC_Misc	HTC-AG, HTC- D. Tschok,Misc.3/2013	HTC, pressure, temp.	C-suspension with dissolved phenolic compounds
2	Spruce sawdust	HTC_Saw	HTC/ S. Vondran	HTC, pressure, temp.	C-suspension with dissolved phenolic compounds
2.2	Brewery residuest	HTC_Brew	HTC Schlamm	HTC, pressure, temp.	C-suspension with dissolved phenolic compounds
3	Mixed spruce, beech, oak, ash, poplar	TT_180	Thermal Treatment, Heat treatment, HT	TT, 180°C	Clear solution with dissolved phenolic compounds
4	Mixed spruce, beech, oak, ash, poplar	TT_200	Thermal Treatment, Heat treatment, HT	TT, 200°C	Clear solution with dissolved phenolic compounds
5	Canadian beech	Pyrol_Can	Bio-Oil, BO, Old Canadian	Fast pyrolysis, Canadian process (Dynamotive)	Dark, median viscous, phenolic compounds
6	European beech	Pyrol_ProF1	German 1	Slow pyrolysis, D-ProFagus process	Dark, strong viscous, phenolic compounds
7	European beech	Pyrol_ProF2	German 2	Slow pyrolysis, D-ProFagus process	Dark, strong viscous, phenolic compounds
8	European beech	Pyrol_ProF3orig	Chinese bio oil, crude Pro Fagus	Slow pyrolysis, D-ProFagus process	Dark, strong viscous, phenolic compounds
9	European beech	Pyrol_ProF3low	Chinese low fraction,CHNSCCO2	Slow pyrolysis, D-ProFagus proc., supercritical CO_2-extr. low molecular weight	Clear, less viscous, phenolic compounds
10	European beech	Pyrol_ProF3big	Chinese PH 200, residue	Slow pyrolysis, D-ProFagus proc., supercritical CO_2-extr. high molecular weight	Dark, very strong viscous, phenolic compounds
11	European beech	Pyrol_NLfre	Btg wood oil fresh, NL fresh	Fast pyrolysis, NL- BTG process, fresh production	Less dark, less viscous, phenolic compounds
12	European beech	Pyrol_NLold	Btg wood oil from storage, NL old	Fast pyrolysis, NL-BTG proc., stored/ old production	Less dark, less viscous, phenolic compounds
13	Robinia-heartwood, milled wood	Rob_Extr		Methanol-water 1:1 extract of heartwood, 3 concentrations	Clear, colored, heartwood extractives
14	Forest poplar	LW_Pop_for1:1	LW poplar 1:1	Liquified wood	Dark, high viscose solution
15	Forest poplar	LW_Pop_for1:3	LW poplar 1:3	Liquified wood	Dark, less viscose solution
16	Plantation poplar	LW_Pop_plant	LW poplar, fast growing	Liquified wood	Dark, high viscose solution
17	Forest spruce	LW_Spruce	LW spruce	Liquified wood	Dark, high viscose solution

(Mendelu-Group + TI/ HH + HNEE + Ljublj. Univ.)

Impregnation of wood with solutions of native origin: pyrolysis liquids

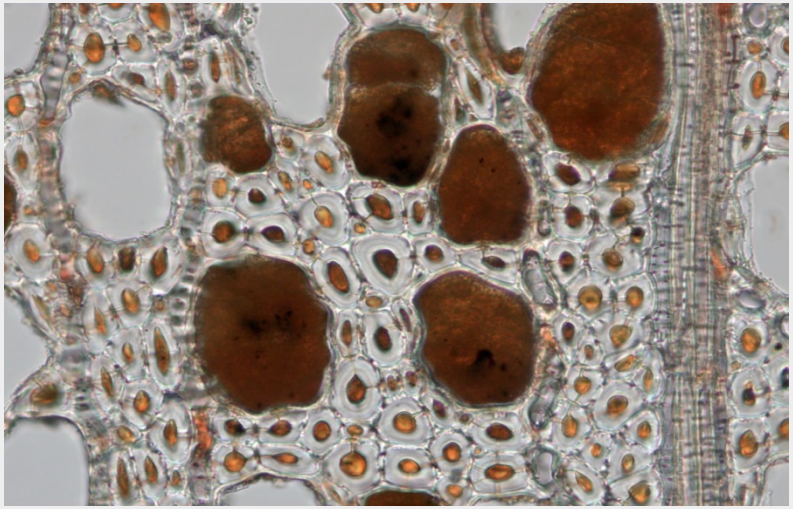
Be-

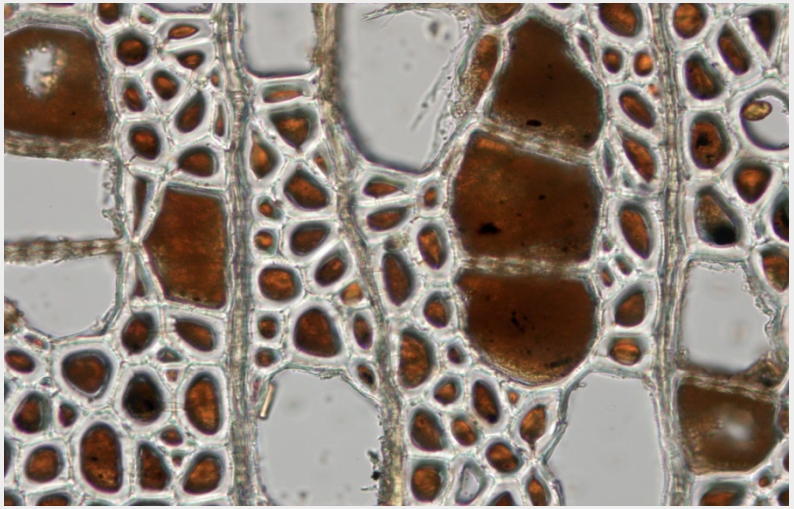




Po-

Be+





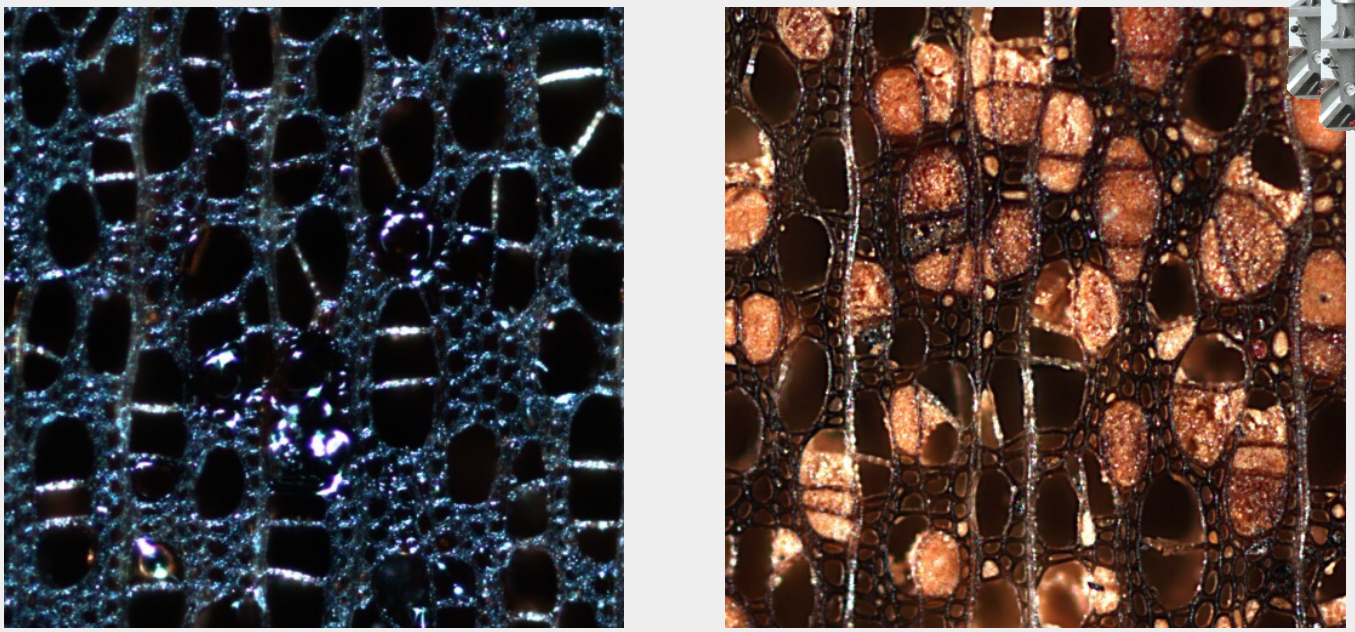
Po+

Natural (above) and pyrolysis-liquid impregnated (below) Beech (l) and Poplar wood (r)

(Paril, Meier)

Impregnation of wood with solutions of native origin: pyrolysis liquids

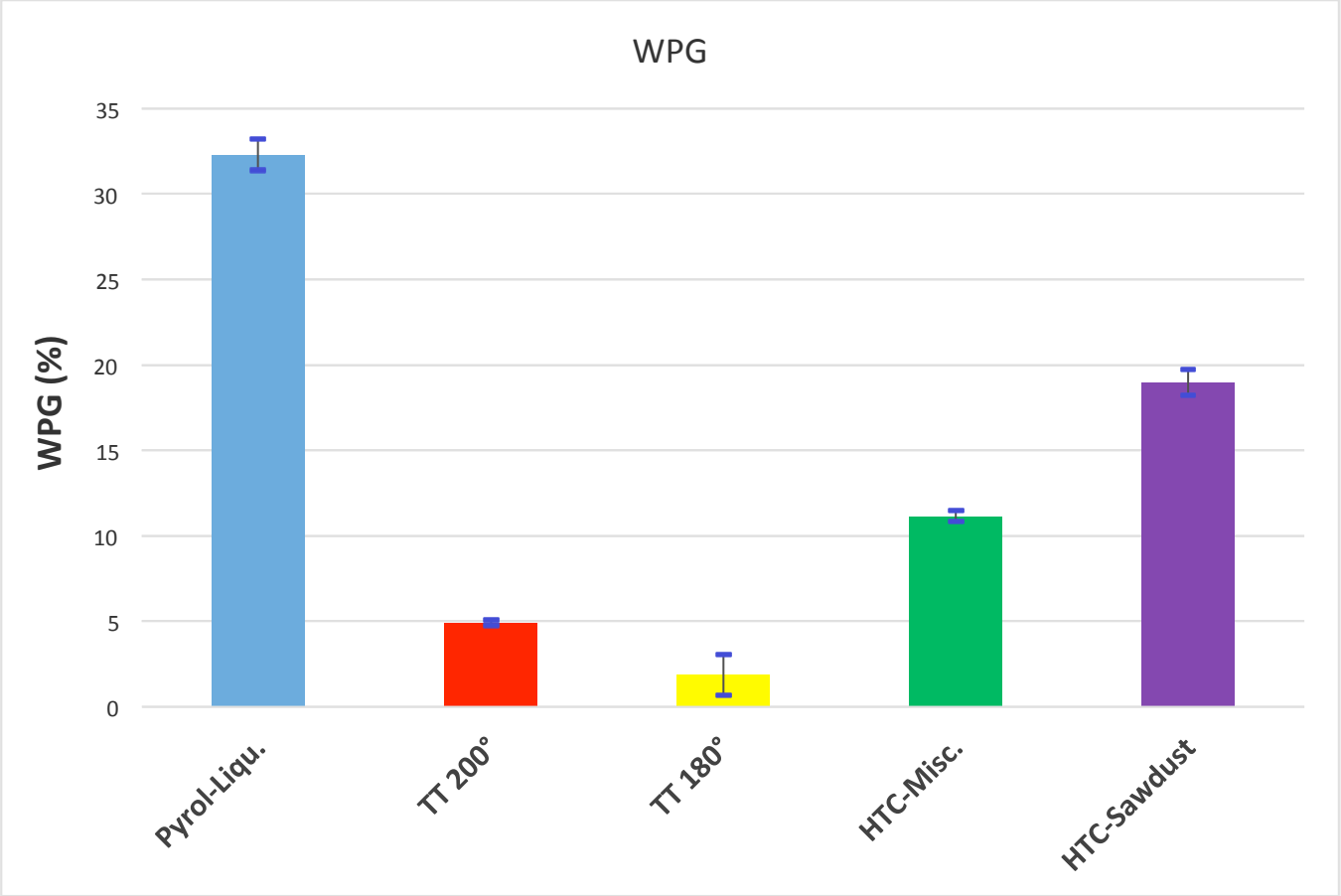
Impregnation of Poplar wood with pyrolysis – liquid



Surface images of **poplar** impregnated with 50% pyrolysis liquid (left) and samples after leaching (right)

(Paril, Meier)

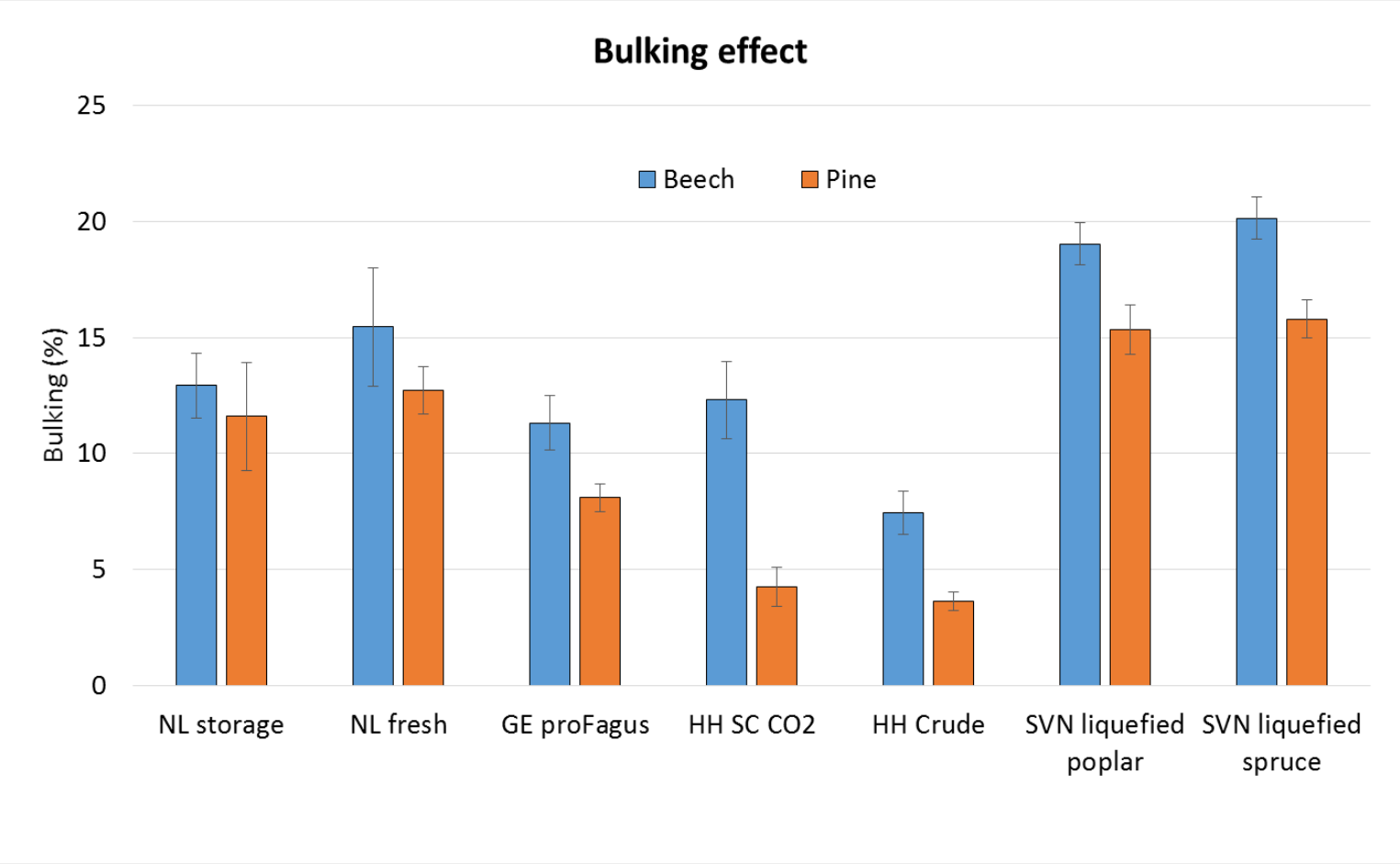
Impregnation of wood with solutions of native origin: pyrolysis, TT, HTC



Weight-percent-gain (WPG) of impregnated poplar using wood-processing residues (pyrolysis-liquid, thermal treatment (TT: 180 and 200°C), hydro-thermal-carbonisation (HTC: Miscanthus, spruce-sawdust))

(Paril, Meier, Cermak, Murach)

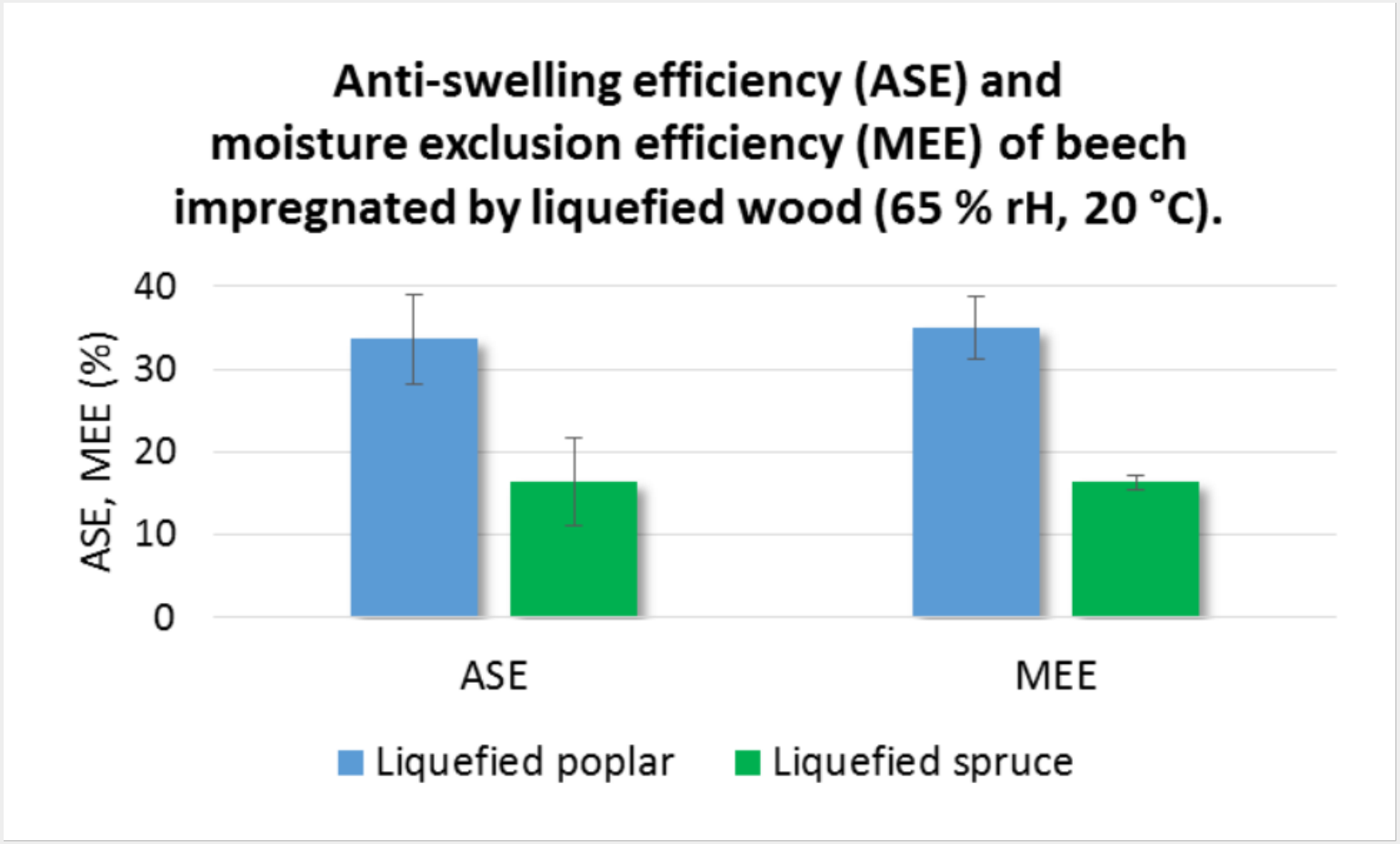
Impregnation of wood with solutions of native origin: pyrolisis liquids, LW



Bulking effect (%) of Beech and Pine wood impregnated with pyrolysis liquids from different wood residue origins and liquefied wood from Spruce (Picea abies) and Poplar (Populos nigra) sawdust residues

(Paril, Meier, Feng, Sernek)

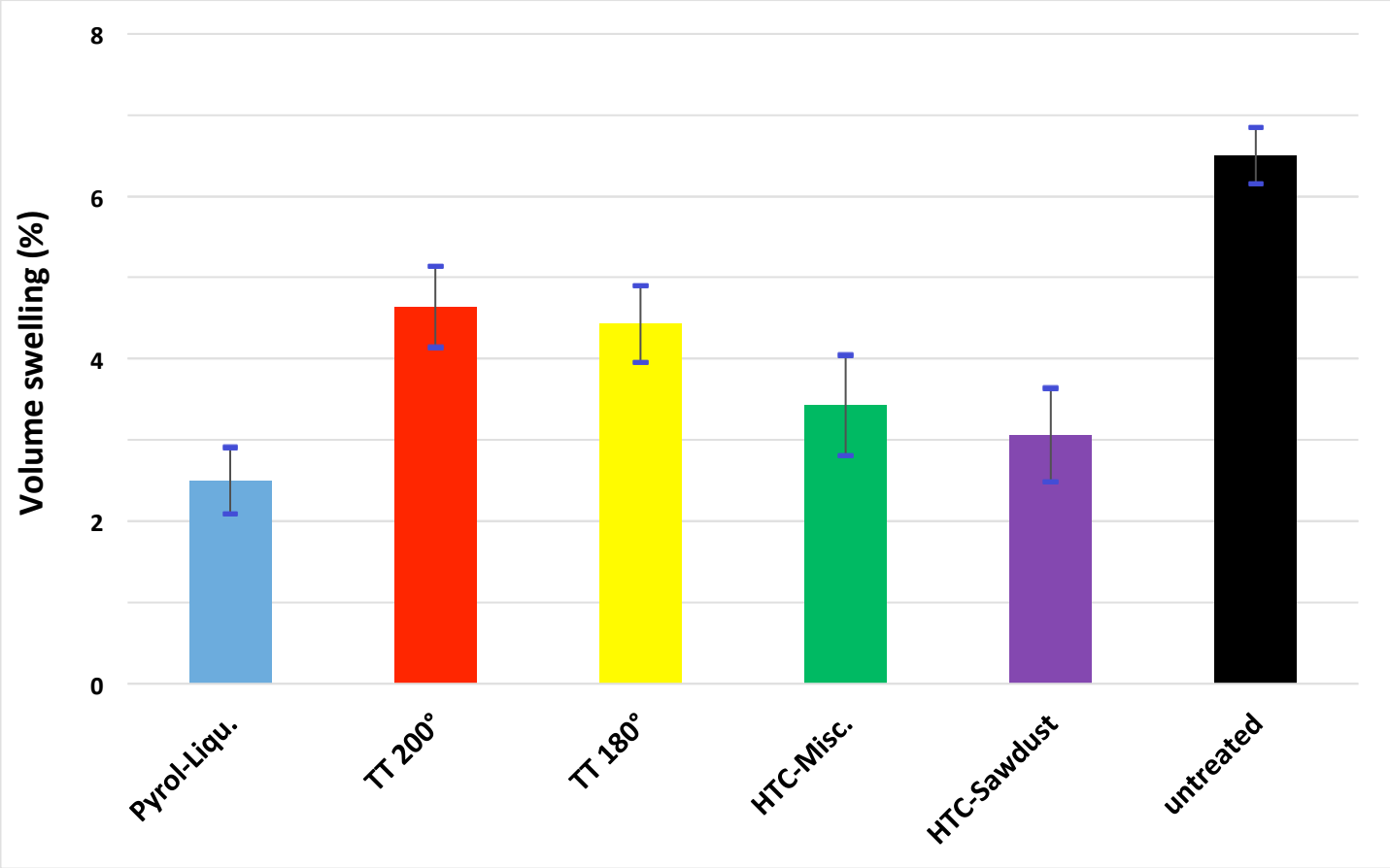
Impregnation of wood with solutions of native origin: liquid wood



ASE+ MEE (%) of Beech wood with liquefied wood impregnation from Spruce (Picea abies) and Poplar (Populos nigra) sawdust residues

(Sernek, Paril)

Impregnation of wood with solutions of native origin

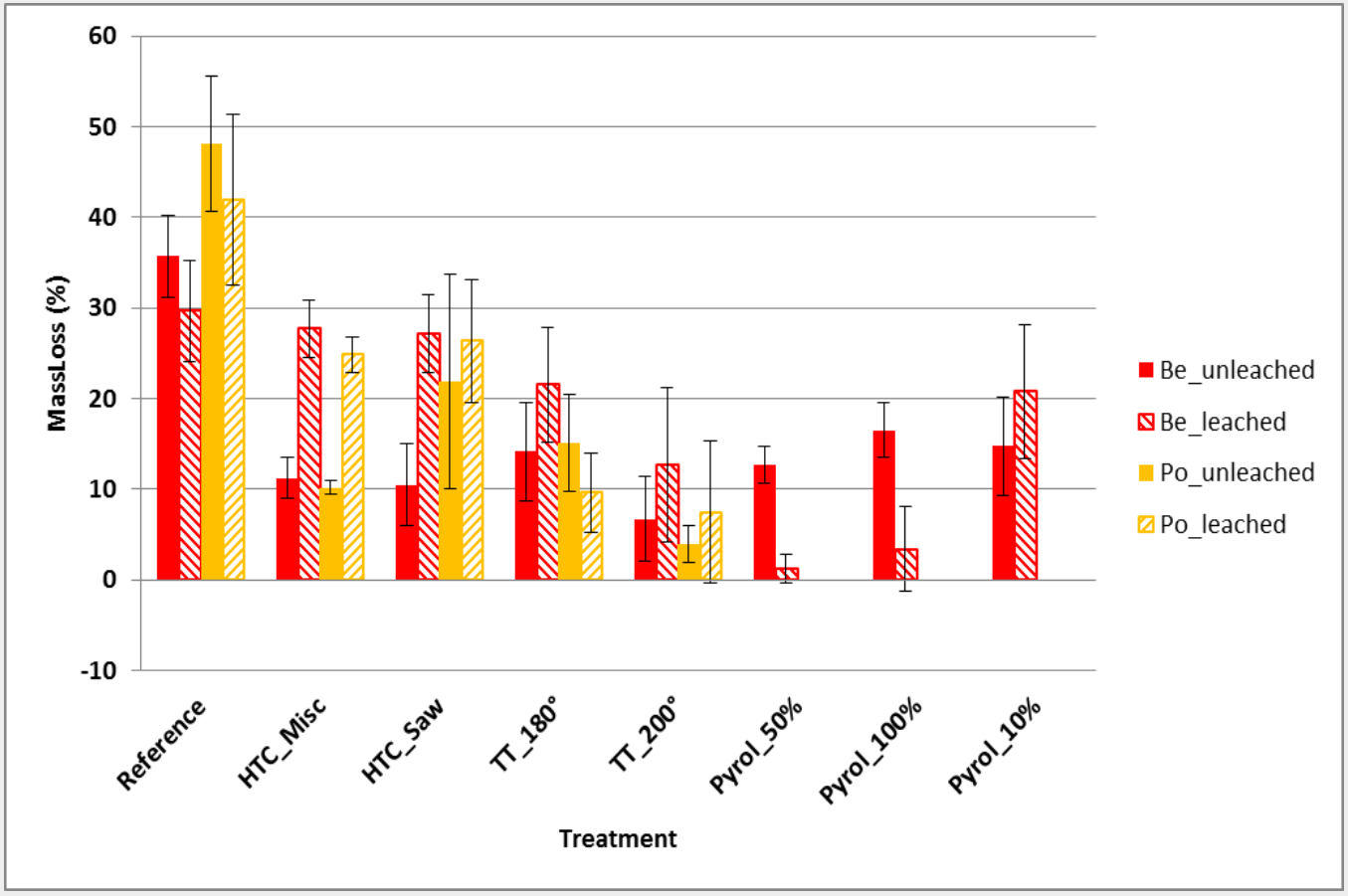


Reduced volume-swelling (%) of impregnated poplar using wood-processing residues (pyrolysis-liquid, thermal treatment (TT: 180 and 200°C), hydro-thermal-carbonisation (HTC: Miscanthus, spruce-sawdust))

(Paril, Meier, Cermak, Murach)

Impregnation of wood with solutions of native origin

Mass loss of Beech and Poplar wood impregnated with native residues from technical processes

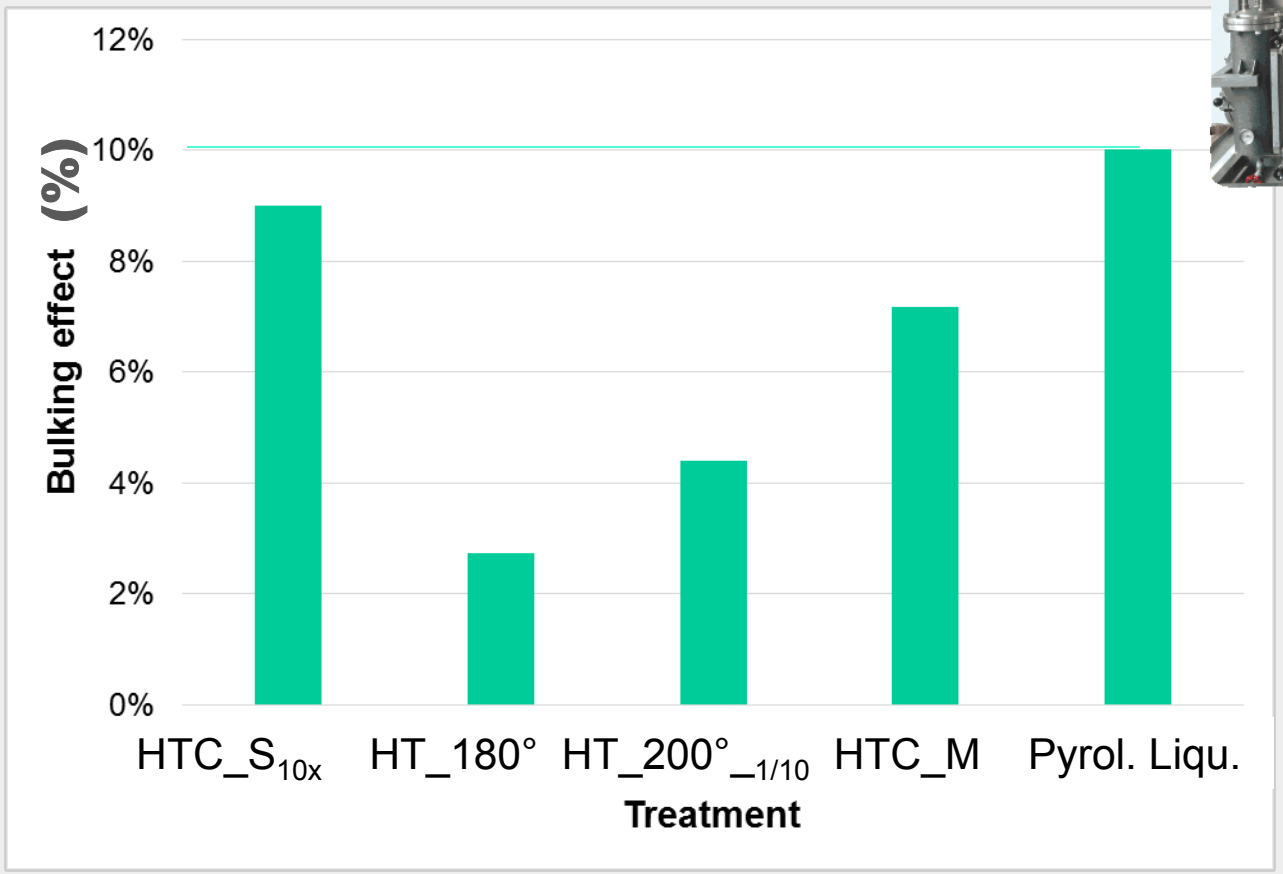


- Pyrolysis-Liqu.
- TT = Thermal-Treatment res.
- 180 rsp. 200°C
- HTC solution = Hydrothermal Carbonisation
- Miscanthus
- Spruce sawdust

(Baar, Paril, Meier [TI-HH], Murach [HNEE])

Impregnation of wood with solutions of native origin

Bulking-effect of beech after different treatments



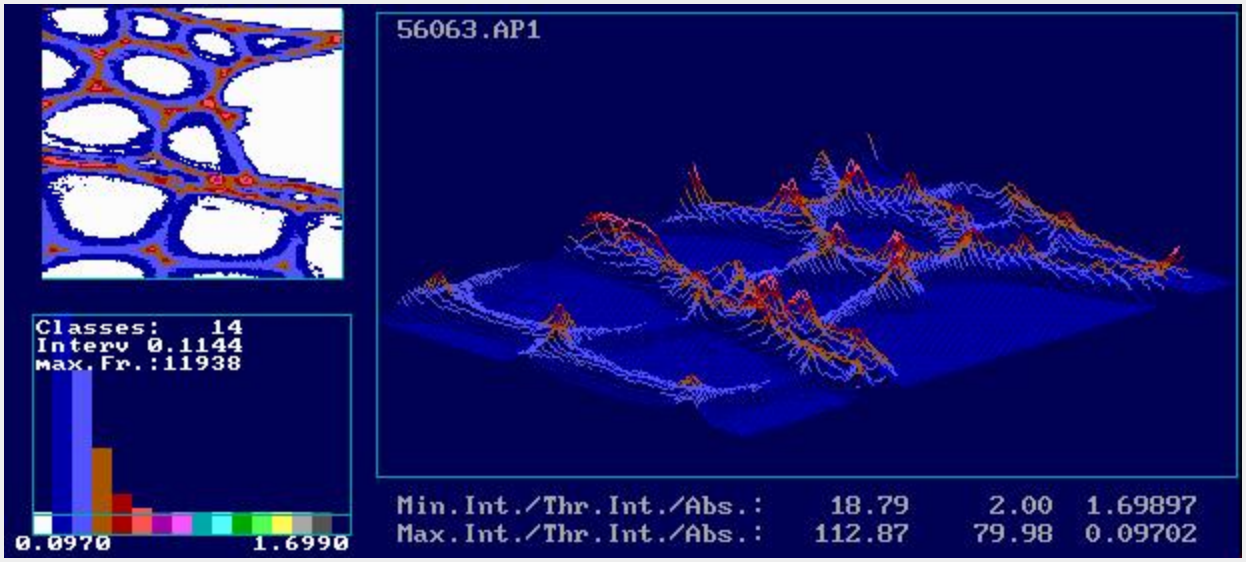
Bulking =

permanent swelling of wood material due to reaction of impregnation agent in cell wall

(Paril)

Impregnation of wood with solutions of native origin

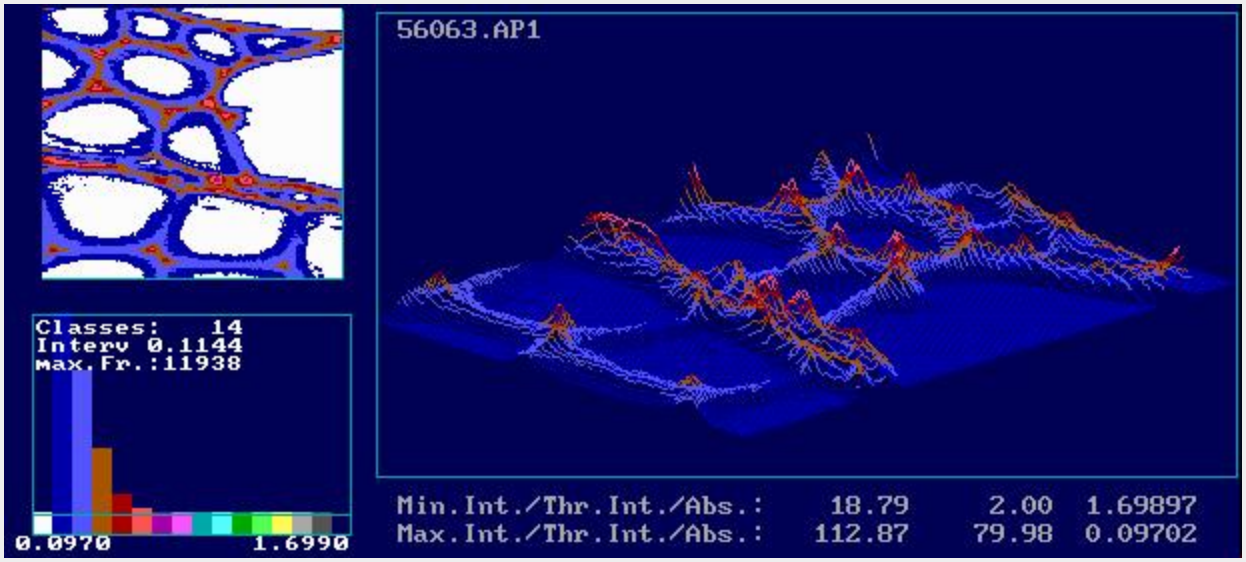
UMSP field-scans of poplar fibre-cells:
Reference (right)

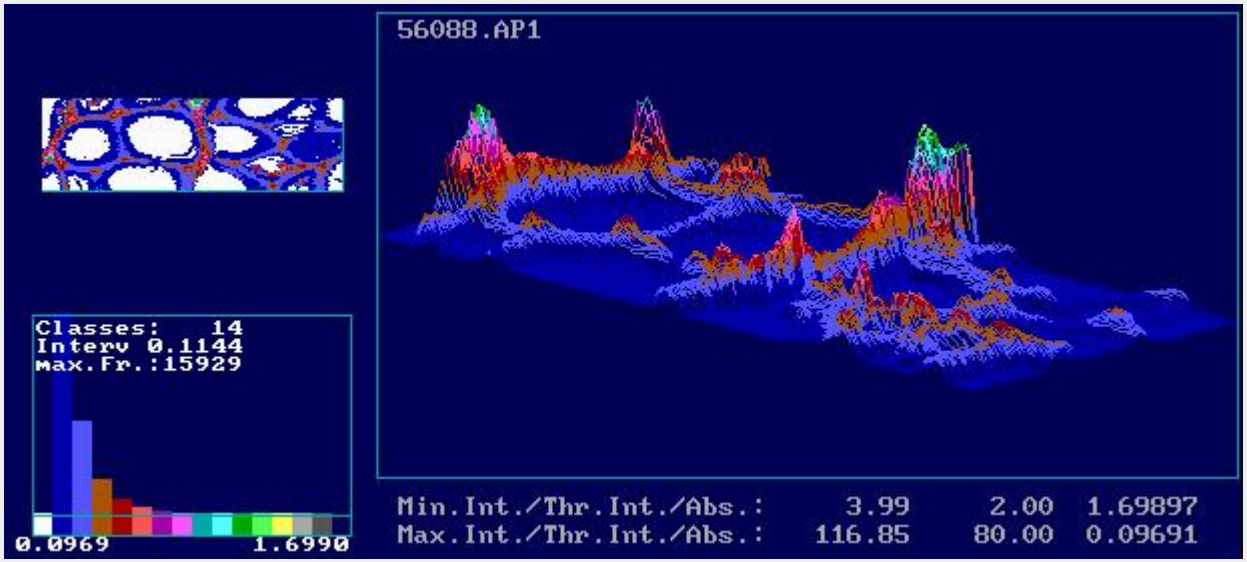


(Rousek, Rademacher; Koch, Schmitt, Potsch, Paul [TI-HH])

Impregnation of wood with solutions of native origin

UMSP field-scans of poplar fibre-cells:
Reference (right) and Bio-Pyrolysis-treated (below) → increase of absorption due to cell wall condensation of phenolic compounds

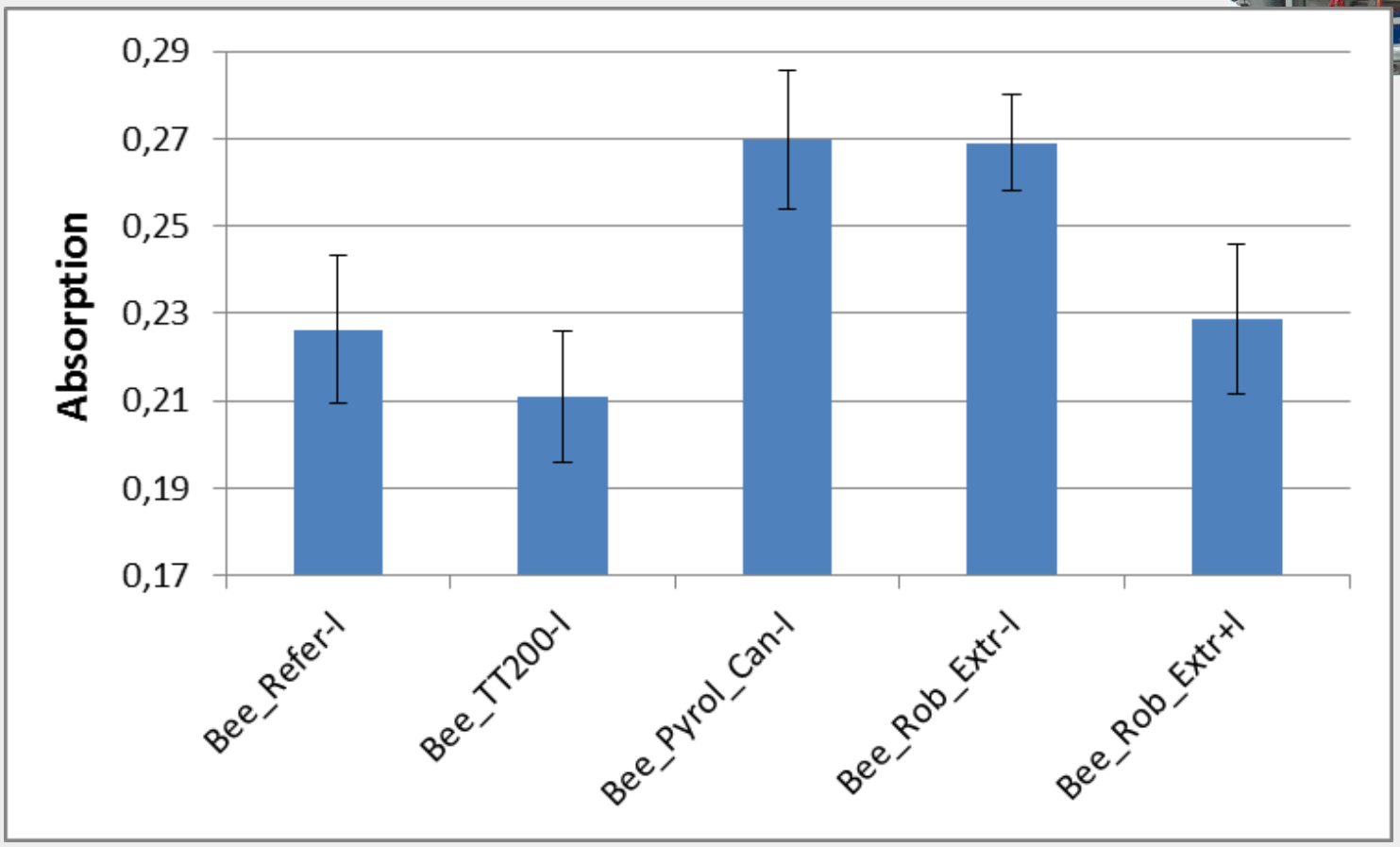




(Rousek, Rademacher; Koch, Schmitt, Potsch, Paul [TI-HH])

Impregnation of wood with solutions of native origin

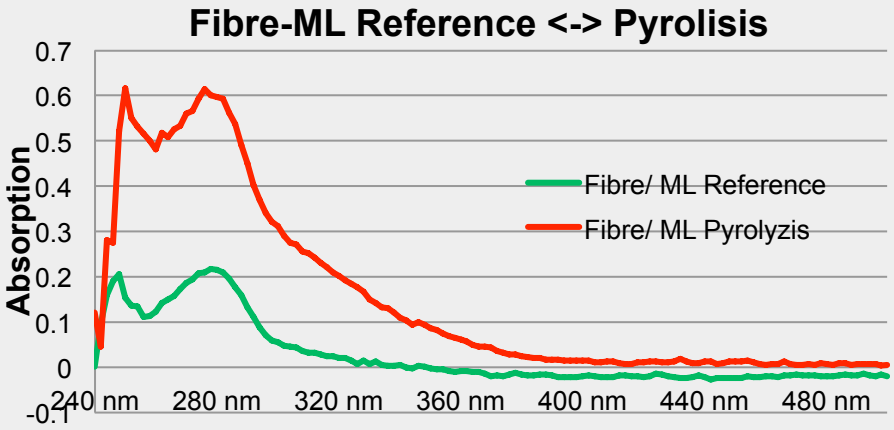
UMSP field-scans of impregnated beech cells:
Reference (left), TT, pyrolysis-treated and Robinia-extract
→ increase of absorption due to cell wall condensation of phenolic compounds

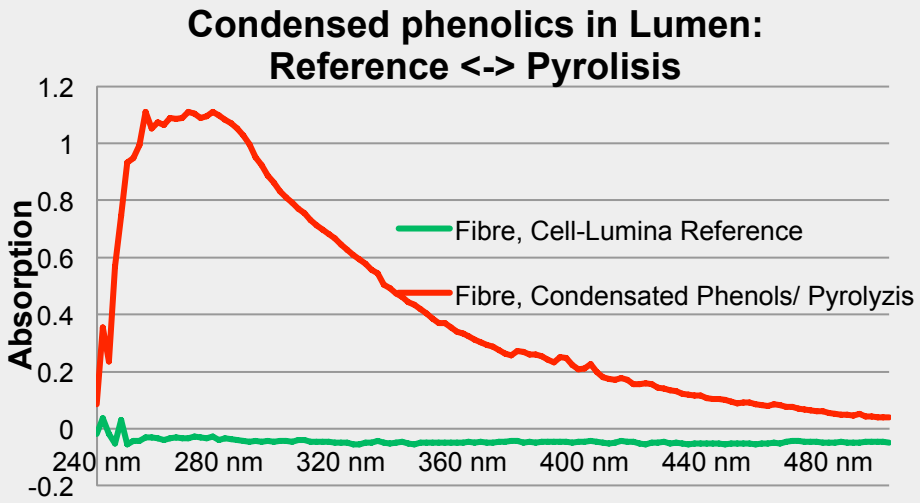


(Rademacher, Koch, Rousek, Potsch, Paul)

Impregnation of wood with solutions of native origin

UMSP point-measurement 240 – 500nm in Poplar

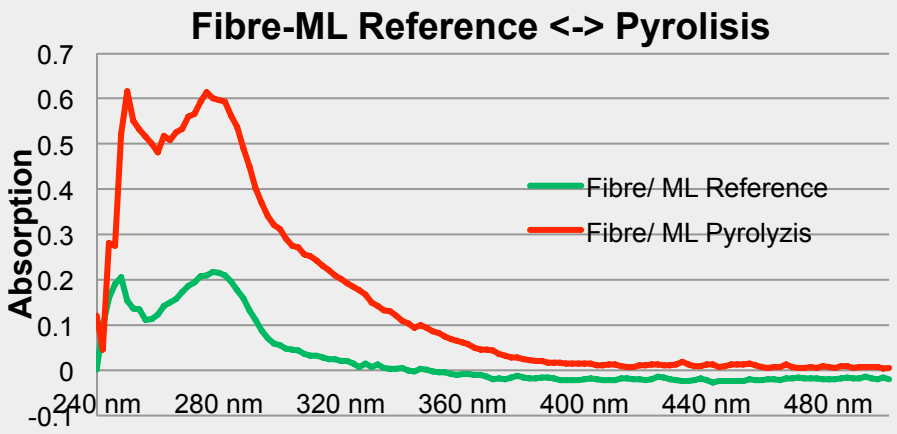


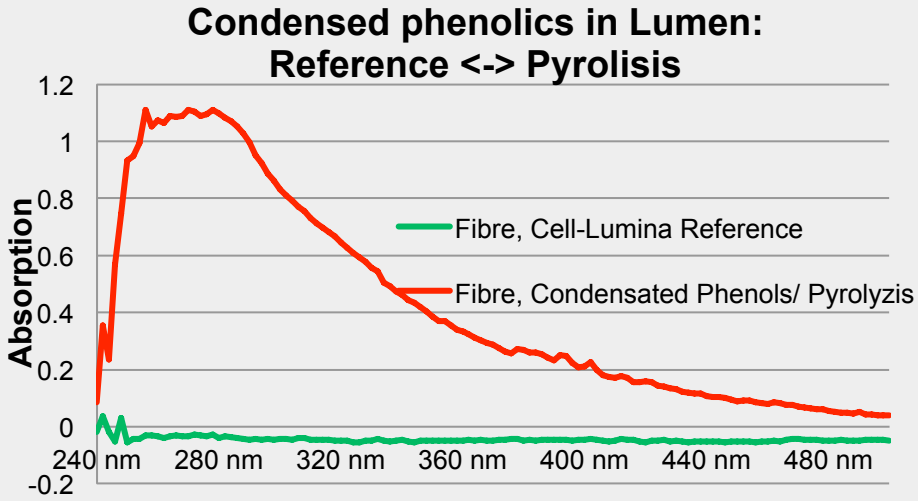


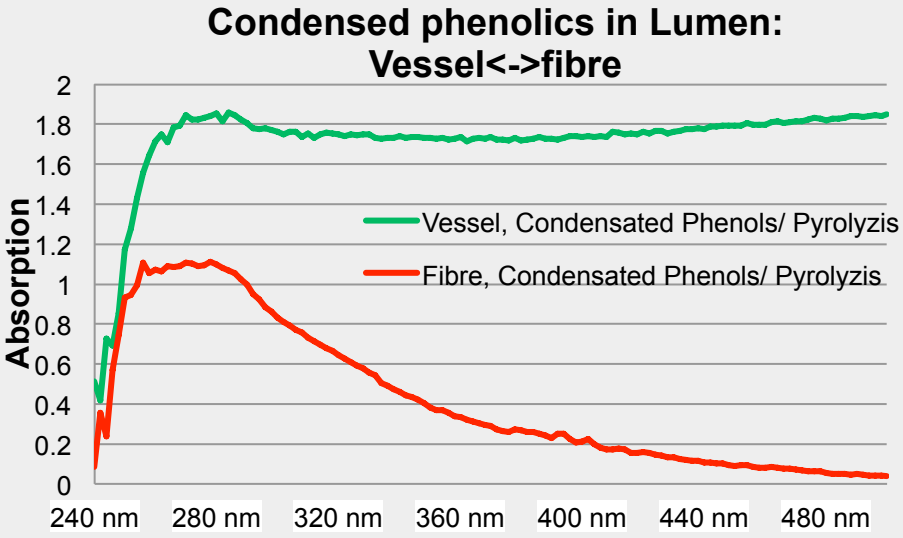
(Rademacher, Koch, Rousek, Paul)

Impregnation of wood with solutions of native origin

UMSP point-measurement 240 – 500nm in Poplar







(Rademacher, Koch, Rousek, Paul)

New Wood Modification Treatments

Examples of actual impregnation agents

Treatment-Code	Vacuum impregnation (10 kPa 20 °C, 2 h)
R	reference
I	PNZ oil
II	Hemp oil
III	Hemp + soya + linseed oil
IV	Nanoparticles (Fe, Cu, Ag..)
V	Nanoparticles (Fe,..) + Hemp oil
VI	Nanoparticles (Fe,..) + Hemp + soya + linseed oil
VII	Sodium chloride treatment (5 concentrations)
VII	Sucrose treatment (5 concentrations)
VIII	Sucrose + thermal treatment (1 concentration)
T/Ph	Technical Phenolics
Ro	Robinia extracts
X/Ba	Non-Wood extracts (Bark, plant residues)
HT/C	Process-water residues (HT, HTC)
PO/LW	Pyrolysis liquids/ Oils; Liquid Wood

Impregnation plant

(Paril, Sablík, Baar, Cermák)

Partner Companies

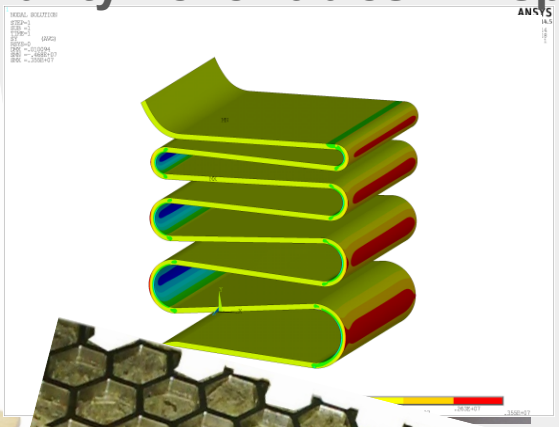
Examples of partner companies

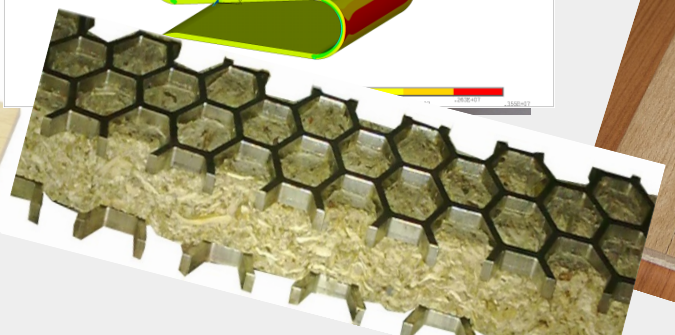
Company	Adress	Common work
Frit	Dr. Milady Horákové 591/69 460 07 Liberec	Impregnation and testing their products
ROmiLL	Tkalcovská 799/14 602 00 Brno	Cooperation in the development of devices for microwave treatment of wood, consultation experimental results
Novemcar		
Accoya		
Impregnace Soběslav	Na Pískách 420/II, 392 13 Soběslav	Impregnation, microwave drying and treating
Bochemie	Lidická 326, 735 95 Bohumín	Impregnation, nanoparticles
Katres	Na Dolech 6, 586 01 Jihlava	New device for heat treatment, consultation experimental results
Hemp production	Chraštice 7, 262 72 Březnice	Natural oils (hemp, soya, linseed)
Mabeko	Na Dionýsce 1755/8, 160 00 Praha 6 – Dejvice	
Strozatech	Cejl 837/10a, 602 00 Brno	Development of ammonia chamber, future cooperation (testing and lignamon research)
Chemont	Zelný trh 12, 602 00 Brno	Development of ammonia chamber, future cooperation (testing and lignamon research)

(Paril, Kois, Dömény, Cermák)

Conclusions and outcome of InWood project

- **Establishing of new/ young group; education; international exchange**
- **Material-Development: → Mater. Property → Improvement → New Products**
  - Investigation → low properties for in-/ or exterior use of many native wood species!
  - Most wood modification treatments improved properties!
  - Several new materials + first new innovative products made out of new materials!!!
  - **Admission procedure: sustainability/ renewables <-> specification acc. to law**





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MINISTRY OF EDUCATION, YOUTH AND SPORTS

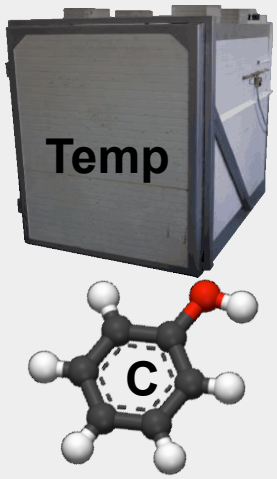
OP Education for Competitiveness

INVESTMENTS IN EDUCATION DEVELOPMENT

Modification of wood with different treatments

Peter.Rademacher@mendelu.cz

Extracts



Thermal Treatmt.

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Thank you very much for your attention.

inwood

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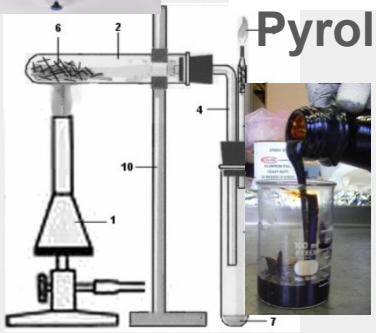
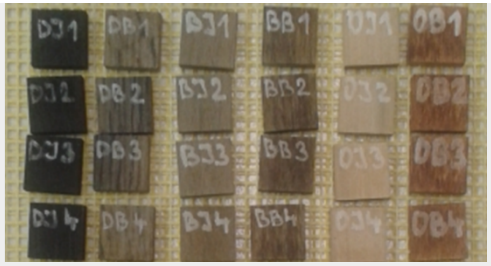


Pyrolisis

http://www.scheffel.og.bw.schule.de/faecher/s Holz_Chemie_Pyrolyse_Website.pdf http://de.wikipedia.org/wiki/Pyrolyse



Supported by the European Social Fund and the state budget of the Czech Republic, project "The Establishment of an International Research Team for the Development of New Wood-based Materials" reg. no. CZ.1.07/2.3.00/20.0269.

(Mendelu-Group)

Mendel University in Brno

Thanks also to all active partner institutions!!!

Faculty of Forestry and Wood Technology

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Univ. of Western Hungary

Bildmarke

Wortmarke

LMU-Logo

HOCHSCHULE FÜR ANGEWANDTE WISSENSCHAFT UND KUNST

Hildesheim
Holzminden
Göttingen

Acknowledgments:

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