

An abstract sculpture made of various types of wood, including light-colored pine and dark-stained wood. The pieces are cut into geometric shapes like beams and blocks, which are interlocked and arranged in a star-like pattern. The lighting is dramatic, with strong highlights and shadows, emphasizing the textures and grain of the wood.

**Book of Abstracts**

**COST Action  
FP1407  
Final Conference**

**LIVING  
WITH  
MODIFIED  
WOOD**

**Belgrade, Serbia**  
12-13 December 2018



University of Belgrade – Faculty of Forestry

**COST Action FP1407**

Understanding wood modification through an integrated scientific and environmental impact approach (ModWoodLife)

**Living with modified wood**

Final COST Action FP1407 International Conference

Belgrade, Serbia, 12 – 13<sup>th</sup> December 2018

**Book of Abstracts**

**Editors:** Goran Milić, Nebojša Todorović, Tanja Palija, Andreja Kutnar

Belgrade, 2018.

*Proceedings of the Final COST Action FP1407 International Conference - Living with modified wood*

Edited by ■ Goran Milić, Nebojša Todorović, Tanja Palija, Andreja Kutnar

Organiser ■ University of Belgrade – Faculty of Forestry, Department of Technologies, Management and Design of Furniture and Wood Products

All papers have been reviewed.

Cover design ■ Jelena Matić, University of Belgrade – Faculty of Forestry

*Published by* ■ University of Belgrade – Faculty of Forestry, Kneza Višeslava 1, 11030 Belgrade

*Print* ■ Planeta print, Belgrade

*Print-run* ■ 100 copies

ISBN 978-86-7299-280-9 (printed edition; not for sale)

ISBN 978-86-7299-283-0 (digital edition)

The organisers would like to acknowledge the scientific committee of the Final COST Action FP1407 International Conference “Living with modified wood”:

Andreja Kutnar – Slovenia

Dennis Jones – Sweden

Dick Sandberg – Sweden

Robert Németh – Hungary

Christelle Ganne-Chedeville – Switzerland

Lars Tellnes - Norway

Callum Hill – The United Kingdom

Ana Dias – Portugal

Edo Kegel – Netherlands

Michael Burnard – Slovenia

Lauri Rautkari – Finland

Goran Milić - Serbia



**Table of contents**

|  |           |
|--|-----------|
| Local organiser preface .....  | 7         |
| Preface.....   | 8         |
| Conference Program .....   | 9         |
| <b>Keynote .....</b>   | <b>15</b> |
| Shift Your Thinking for Research Innovation .....  | 16        |
| <b>Session 1: <i>Modified wood in use</i> .....</b>  | <b>19</b> |
| Human interaction with wood – what to measure, how to measure? .....   | 20        |
| Can modified wood compete with untreated wood in preference of people? .....   | 22        |
| EcoModules - an on-line Eco-design Tool .....  | 24        |
| Online tool for generating Environmental Product Declarations (EPD-tool)<br>for modified wood products.....                      | 26        |
| <b>Session 2: <i>Novel modification technologies</i>.....</b>  | <b>29</b> |
| Review: wood modification techniques based on cell wall bulking with<br>non-toxic chemical reagents.....                         | 30        |
| The potential application of Maillard-type reactions during thermal<br>modification treatment.....                               | 32        |
| Effect of polymerization temperature during $\epsilon$ -caprolactone modification<br>on wood properties .....                    | 34        |
| Wood sawdust and alkali activated slag bio-composite .....   | 36        |
| Wood protection from the olive industry .....  | 38        |
| <b>Session 3: <i>Projections and monitoring of modified wood</i>.....</b>  | <b>41</b> |
| Projection of the effects of climate change on decay risk of external timber:<br>United Kingdom case study .....                 | 42        |
| State of the art of wood modification in Spain. Researches,<br>industrial treatments and examples of end uses in real cases..... | 44        |
| Monitoring of the performance of thermally modified wood in buildings.....   | 46        |
| Durability of modified wood and bio-based materials under outdoor conditions .....   | 48        |
| Furfurylated wood durability in a cyclic hydrothermal environment .....  | 50        |
| Termite and decay resistances of Bioplast-spruce green wood plastic composites.....  | 52        |
| <b>Session 4: <i>Beyond wood modifications</i>.....</b>  | <b>55</b> |
| Wastewater remediation with formaldehyde free tannin-furanic foam powders.....   | 56        |
| The application of water pretreatment in the pellet production process.....  | 58        |
| Charring of Norway spruce wood surface as a surface modification technique.....  | 60        |
| Wood modification related researches at the University of Sopron .....   | 62        |
| Networking in European wood research.....  | 64        |
| <b>Session: <i>Short Term Scientific Missions</i>.....</b>   | <b>67</b> |
| Engineered wood products in contemporary architecture .....  | 68        |
| Effect of silane treatment on mechanical properties of degraded wood .....   | 70        |
| The impact of temperature increase rate during thermal modification<br>on wood surface-coating interaction.....                  | 72        |
| Cutting forces assessment when machining wood over all<br>grain orientations – example of thermally modified poplar .....        | 74        |
| Experimental and numerical analysis of fracture toughness of<br>thermally modified beech in mode II.....                         | 76        |
| Mechanosorptive creep tests on thermally modified wood .....   | 78        |

|   |            |
|---|------------|
| Characterisation of subfossil oak wood from central Serbia<br>using SEM and FTIR spectroscopy .....   | 80         |
| Generalised thermal modification kinetic model of<br>poplar wood under different technologies .....   | 82         |
| Properties of multi-layer plywood made from combinations of<br>densified and non-densified veneers in one structure .....   | 84         |
| Decay and insect resistance of modified wood with epoxidized plant oils .....   | 86         |
| <b>Poster Session .....</b>   | <b>89</b>  |
| Strategies for improvement of visibility and acceptance of modified wood .....  | 90         |
| Volatile organic compounds emitted from heat and vacuum-heat treated wood .....   | 92         |
| In-service performance of floorings with modified wood top layer.....   | 94         |
| Thermo-hydro mechanical densification process of<br><i>Nothofagus pumilio</i> and <i>Nothofagus antarctica</i> and the effect of<br>annual width ring on modulus of hardness, and dynamical mechanical properties ..... | 96         |
| Enhancing outdoor durability of heat treated wood surface by photo-stabilization<br>with waterborne acrylic coating using bark extract.....   | 98         |
| Changes in wood surface properties caused by aging techniques .....   | 100        |
| Photostability of thermally modified poplar wood coated with alkoxysilanes .....  | 102        |
| Wood properties and extractive exploitation from thermally modified chestnut wood .....   | 104        |
| Antimicrobial particleboards – part 1: preparation and strength .....   | 106        |
| Antimicrobial particleboards – part 2: resistance to bacteria and fungi .....   | 108        |
| Selected mechanical properties of lignocellulosic layered<br>composites produced in various temperature conditions .....  | 110        |
| Assessment of lignocellulosic-substrate fungi-based materials .....   | 112        |
| The compressive resistance of low density mycelium boards.....  | 114        |
| Variability of hemp concrete material performance:<br>a focus to modulus and their calculation methods .....  | 116        |
| Characterization of two liquefied agricultural wastes.....  | 118        |
| Influence of hydrothermal modification on the properties of<br>cellulose and lignin after-service-life valorisation of wood.....  | 120        |
| Improving hydrophobicity and thermal stability of<br>wood through esterification with fatty acids .....   | 122        |
| Preservation of wood structures in non-controllable environment by the example of<br>pre-stressed laminated timber bridge deck with two curved geometry.....  | 124        |
| Sensitivity and reliable design of a timber beam considering crack growth and<br>environmental effects .....  | 126        |
| Creep response of European species under environmental and<br>mechanical loadings in outdoor conditions .....   | 128        |
| Understanding shrinkage and fracture process of<br>green wood using X-ray microtomography .....   | 130        |
| Modified wood – research on selected physical and mechanical properties .....   | 132        |
| Paper tissue reinforcement – coating with nanocellulose and silanes.....  | 134        |
| Preliminary analysis of bio-sourced hybrid resins as coatings for wood protection.....  | 136        |
| Nano-modified adhesives for composite wood panels manufacturing.....  | 138        |
| <b>Session 5: Thermally modified wood – properties.....</b>   | <b>141</b> |
| Influence of heating rate during thermal modification on<br>some properties of maple wood .....   | 142        |
| The evaluation of the quality control methods for thermally modified wood .....   | 144        |
| Physical and elastomechanical properties of full-size fir ( <i>Abies alba</i> ) sawnwood<br>after heat treatment with different intensities .....   | 146        |



## Local organiser preface

It is both a pleasure and a privilege for the Department of Technologies, Management and Design of Furniture and Wood Products, Faculty of Forestry to host the final conference of COST Action FP1407. This honour has given us an opportunity to establish a more visible position within the European network of wood related institutions.

Wording of the title - “Living with modified wood” - signifies that the time in which we live has provided us with technologies of wood modification that will ensure that never again will this material be regarded as a lesser material with a short life-span. Wood, as one of the rare living materials, is experiencing a worldwide renaissance, one that could not have been considered possible just a generation ago. For these very reasons, the primary goal of this conference is to foster, forge and encourage the cooperation and exchange of ideas between wood modification researchers and experts in related fields and, hopefully, help them grow.

Belgrade, as a city with a long and rather eventful history, is an environment where sparse moments of peace and prosperity have instilled a way of thinking that appreciates the little things in life. This setting emphasises even more the pressing need of the modern age to live more organically, ethically and above all, ecologically – and what better way than living with an organic material such as wood.

Success of this event would not have been possible without the effort of the entire team of my colleagues. I would like to thank them and to express my deepest gratitude to Andreja Kutnar, Chair of COST FP1407, for leading this fantastic Action, and for her continuous help in organising this Final Conference.

Last but not least I would like to thank all of the participants and contributors of the Final COST FP1407 Conference. I wish you to have a memorable time in Belgrade.

So let us look forward to an exciting conference!

Goran Milić

## Preface

Welcome to the fourth and final international conference of COST Action FP1407 “Understanding wood modification through an integrated scientific and environmental impact approach” (ModWoodLife). This conference, “Living with modified wood”, held in Belgrade, Serbia December 12 and 13, 2018 brings researchers and professionals together to share and disseminate their work. Their research contributes significantly to our Action’s objectives. It is especially rewarding too see contributions that have resulted from collaborations developed and strengthened through this network. Since the beginning of the Action in 2015, we have delivered new knowledge in the field of wood modification and environmental impact assessment. We can all be proud that during our Action, the European Union recognized the need to strategically approach activities, research, and policy to reduce climate change. Among the key strategies that were accepted in the past three years are the Circular Economy (2015), the Paris Agreement (2016), the Research and Innovation Roadmap 2050 – A Sustainable and Competitive Future for European Raw Materials (2018), as well as the recently renewed Bioeconomy strategy. Although our Action did not directly contribute to these documents, I am convinced that the activities of our network and its participants accelerated their adoption. At the same time, it is clear that our collaboration must continue after the Action ends on March 9, 2019. Going forward we should jointly contribute to “closing the loop” of product lifecycles through greater recycling and re-use and bring benefits for both the environment and the economy.

I would like to thank you for your great collaboration. Besides the new knowledge we created, our new friendships will continue for many years more!

Wishing you a successful and memorable conference in Belgrade.

Andreja Kutnar  
Chair, COST FP1407

## Assessment of lignocellulosic-substrate fungi-based materials

Laetitia Marrot<sup>1</sup>, Marica Mikuljan<sup>1</sup>, Franc Pohleven<sup>2</sup>

<sup>1</sup> InnoRenew CoE, Livade 6, 6310 Izola, Slovenia

laetitia.marrot@innorenew.eu; marica.mikuljan@innorenew.eu

<sup>2</sup> Biotechnical Faculty, University of Ljubljana, Jamnikarjeva 101, 1000 Ljubljana, Slovenia

franc.pohleven@bf.uni-lj.si

**Keywords:** fungi, wood, hemp, lignocellulosic

### Introduction

Nowadays the population is facing the effects of an excessive and reckless consumption of limited resources and energies. Global warming, the Great Pacific Garbage Patch, and air pollution are critical warning indicators for the need to develop more sustainable alternatives to our current lifestyle. Using renewable resources to produce materials is a partial solution to lower our impact on the environment. The specificity of the fungi mechanisms of growth makes them attractive as bioconversion agents (Dashtban *et al.* 2009) and potential advanced materials (Haneef *et al.* 2017). The present study investigates the properties of lignocellulosic-substrate fungi-based materials. Fungi secrete enzymes that decay lignocellulosic materials to convert them into glucose, which will provide the energy for the fungi to grow. Fungi grow by creating a net of hyphae (Fig. 1a) as they decompose organic substances. If stopped before the complete degradation of the substrate, these intra lignocellulosic hyphae threads form an interesting composite structure (Fig. 1b).

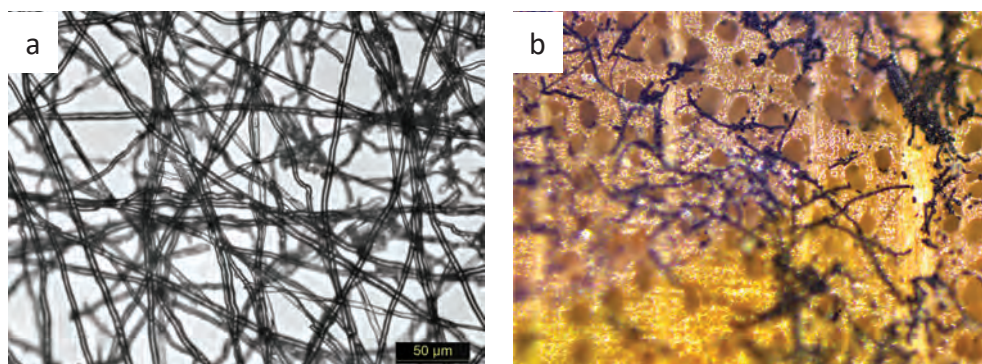


Figure 1: Microscopical observation of a) Net of hyphae, b) Hyphae on a wood substrate.

### Materials

*Ganoderma Lucidum* fungi was inoculated in four different substrates (Table 1). Beech wood and hemp were milled at a particle size ranging between 5 and 15 mm. The compo-

sition and particle size of the substrate, and the amount of water, are crucial parameters for the growth of the fungi.

Table 1: Description of the substrates

| Specimen       | Substrate Composition           | Water intake [%m] |
|----------------|---------------------------------|-------------------|
| 1              | 100% Beech wood                 | 70                |
| 2 <sup>a</sup> | 100% Beech wood                 | 126               |
| 3 <sup>b</sup> | 50% Beech wood + 50% Beech dust | 70                |
| 4              | 100% Hemp (shivs + fibres)      | 68                |

<sup>a</sup> Influence of the water content (x2 vs specimen 1), <sup>b</sup>Influence of the particle size vs specimen 1

The resulting lignocellulosic-substrate fungi-based materials are presented in Fig.2.



Figure 2: Lignocellulosic-substrate fungi-based materials.

## Results and perspectives

The characteristics of the lignocellulosic-substrate fungi-based materials will be assessed. The physical and mechanical properties (density, thermal conductivity, moisture absorption, UV resistance, mechanical strength), the environmental and health impact, and the safety of use will be considered. Based on the results of the analysis, the most suitable applications (insulation, packaging, building, substitute for single use plastic materials) will be defined for every formulation (substrate/fungi couple).

## References

- Dashtban M., Schraft H., Qin W. 2009. Fungal Bioconversion of Lignocellulosic Residues; Opportunities & Perspectives. *International Journal of Biological Sciences*, 5, 6: 578–595
- Haneef M., Ceseracciu L., Canale C., Bayer I., Heredia-Guerrero J., Athanassiou A. 2017. Advanced Materials From Fungal Mycelium: Fabrication and Tuning of Physical Properties. *Scientific Reports*, 7, 41292

**Acknowledgments:** Funding provided by Horizon 2020 Framework Programme of the European Union; H2020 WIDESPREAD-2-Teaming: #739574 and the Republic of Slovenia. Investment funding of the Republic of Slovenia and the European Union of the European Regional Development Fund.

CIP - Каталогизација у публикацији  
Народна библиотека Србије, Београд

674(048)  
630\*82(048)

FINAL COST Action FP1407 International Conference - Living with modified wood (2018 ; Beograd)

Living with modified wood : COST Action FP1407, understanding wood modification through an integrated scientific and environmental impact approach (ModWoodLife) : Book of Abstracts / Final COST Action FP1407 International Conference Belgrade, Serbia, 12 - 13th December 2018 ; editors Goran Milić ... [et al.]. - Belgrade : University, Faculty of Forestry, 2018 (Belgrade : Planeta Print). - 146 str. : ilustr. ; 24 cm

Tiraž 100. - Bibliografija uz većinu apstrakata.

ISBN 978-86-7299-280-9

а) Дрвна индустрија - Апстракти б) Дрвена грађа - Апстракти

COBISS.SR-ID 271107084







**cost**  
EUROPEAN COOPERATION  
IN SCIENCE & TECHNOLOGY

**FP14**  **7**

ModWoodLife

UNIVERSITY OF BELGRADE  
FACULTY OF FORESTRY