



**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 Palijsa, 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) 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 non-toxic chemical reagents.....	30
The potential application of Maillard-type reactions during thermal modification treatment.....	32
Effect of polymerization temperature during $\epsilon$ -caprolactone modification 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: United Kingdom case study .....	42
State of the art of wood modification in Spain. Researches, 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 on wood surface-coating interaction.....	72
Cutting forces assessment when machining wood over all grain orientations – example of thermally modified poplar .....	74
Experimental and numerical analysis of fracture toughness of thermally modified beech in mode II.....	76
Mechanosorptive creep tests on thermally modified wood .....	78

Characterisation of subfossil oak wood from central Serbia using SEM and FTIR spectroscopy .....	80
Generalised thermal modification kinetic model of poplar wood under different technologies .....	82
Properties of multi-layer plywood made from combinations of 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 <i>Nothofagus pumilio</i> and <i>Nothofagus antarctica</i> and the effect of annual width ring on modulus of hardness, and dynamical mechanical properties .....	96
Enhancing outdoor durability of heat treated wood surface by photo-stabilization 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 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: a focus to modulus and their calculation methods .....	116
Characterization of two liquefied agricultural wastes.....	118
Influence of hydrothermal modification on the properties of cellulose and lignin after-service-life valorisation of wood.....	120
Improving hydrophobicity and thermal stability of wood through esterification with fatty acids .....	122
Preservation of wood structures in non-controllable environment by the example of pre-stressed laminated timber bridge deck with two curved geometry.....	124
Sensitivity and reliable design of a timber beam considering crack growth and environmental effects .....	126
Creep response of European species under environmental and mechanical loadings in outdoor conditions .....	128
Understanding shrinkage and fracture process of 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 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 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

## Durability of modified wood and bio-based materials under outdoor conditions

Heikko Kallakas<sup>1</sup>, Kevin Visnapuu<sup>1</sup>, Triinu Poltimäe<sup>1</sup>, Jaan Kers<sup>1</sup>, Anna Sandak<sup>2,3,4</sup>

<sup>1</sup> Laboratory of Wood Technology, Department of Materials and Environmental Technology, TalTech University, Ehitajate tee 5, 19086 Tallinn, Estonia

heikko.kallakas@taltech.ee; kevin.visnapuu@mail.ee; triinu.poltimae@taltech.ee; jaan.kers@taltech.ee

<sup>2</sup> CNR-IVALSA (Trees and Timber Institute), via Biasi 75, San Michele all'Adige, Italy

<sup>3</sup> InnoRenew CoE, Livade 6, 6310 Izola, Slovenia

<sup>4</sup> University of Primorska, Faculty of Mathematics, Natural Sciences and Information Technology, Glagoljaska 8, 6000 Koper, Slovenia

annasandak@ivalsa.cnr.it

**Keywords:** modified wood, bio-based materials, natural weathering, durability, façade performance

Recent advances in the biomaterials modifications processes have delivered several innovative solutions for the building sector. However, in order to increase confidence for their use, a deep understanding of the material properties, structure, assembly, formulation and its performance along the service life is indispensable. This research was conducted in collaboration with BIO4ever, where the performance of 120 selected façade materials provided by over 30 industrial and academic partners was evaluated during an experimental campaign of natural weathering. Natural weathering was conducted in 2 different locations: Tallinn (Estonia) and San Michele (Italy). Additionally, durability field tests according to EN 252 standard were carried out in Oleron Island (France), Guadeloupe (France) and San Michele (Italy). The experimental samples were classified in seven categories, according to the type of material and treatment applied: natural wood (or other bio-based material), composites, chemically modified, thermally modified, impregnated, coated and/or surface treatment and hybrid modified materials. The last one included a combination of at least two different treatments.

This abstract presents a part of the natural weathering experiment conducted in Tallinn according to standard EN 927-3. Samples were exposed on the racks, inclined at an angle of 45° to the horizontal level and facing the southern direction. Evaluation protocol was similar as proposed by Round Robin Test conducted within COST Action FP1303. The materials performance was evaluated by measurement of the color change, visual assessment and the evaluation of cracks formation during outdoor exposure. High resolution photos were taken every month in order to document appearance changes during the test.

The performance of investigated samples after 12 months of exposure was varying depending on materials class and treatment process. The color measurement results indicated

that the most durable test-specimens were the coated materials (belonging to the class of surface treatments). The cracks occurred on 45 specimens among 120 tested façade materials. Natural wood of different species, as well as thermally modified wood, were among specimens changing appearance in the most apparent way. This included changes of the color parameters as well as cracks presence. Impregnated samples (e.g. furfurylated wood) and some of the hybrid modifications of samples (e.g., thermally modified + colored wood with ferrous sulphate) became patchy. The appearance of selected material (in this case belonging to composite class) is presented in Fig.1. As it can be seen, that this particleboard lost its bamboo coating entirely. Outdoor exposure tests for wood-based materials are still on-going and will be confronted with the natural weathering results from San Michele (Italy).

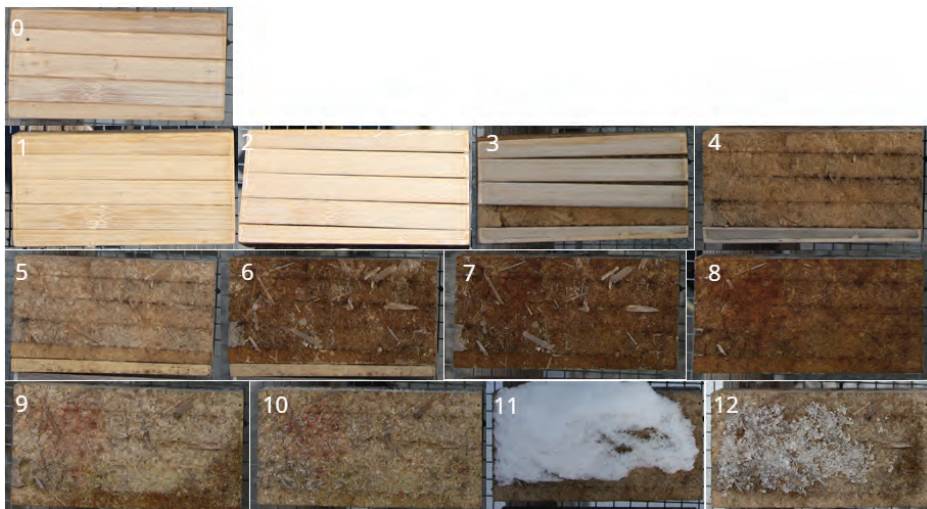


Figure 1: Change of appearance of particleboard with bamboo cladding during 12 months of exposure.

## References

- EN 252 (2014). "Field test method for determining the relative protective effectiveness of a wood preservative in ground contact," European standard
- EN 927-3 (2012). "Paints and varnishes - Coating materials and coating systems for exterior wood - Part 3: Natural weathering test," European standard

**Acknowledgments:** The authors gratefully acknowledge the BIO4ever (RBSI14Y7Y4) project funded within a call SIR by MIUR, European Commission for funding the InnoRenew CoE project (Grant Agreement #739574) under the Horizon2020 Widespread-Teaming program and the Republic of Slovenia (Investment funding of the Republic of Slovenia and the European Union of the European Regional Development Fund). Special acknowledgments to COST FP1303, FP1407 and TU1403 for funding STSMs that contributed to the project and all BIO4ever partners.

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