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

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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

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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

Review: wood modification techniques based on cell wall bulking with non-toxic chemical reagents

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Keywords: cell wall bulking, esterification reaction, Maillard reaction, non-toxic reagents, wood modification

Wood modification is used to improve key properties of wood used as building material. Recently, developments in the area of cell wall bulking with chemical reagents have grown considerably. By cell wall bulking, a dimensionally stable material is created because the cell wall itself will be in a permanently swollen state that will attract no or very little water. Often the treated wood is no longer recognised as a nutrient medium by the specific enzyme systems of degrading fungi or the lowered equilibrium moisture content prevents decay. Several impregnation methods are available (some already commercialized), however development of new, enhanced treatments is still on-going, mostly in steering the modification systems to meet following criteria:

- use of cheap, readily available (coming from renewable resources), non-leachable, non-toxic and small enough to penetrate the cell wall chemical reagents;
- economically and ecologically feasible (no use of solvents, expensive or harmful catalysts or strong acids/ bases) impregnation technology;
- recyclability at the end of its life cycle (absence of heavy metals).

The focus of this abstract is to present information regarding the different types of bulking treatments which try to meet those criteria, and their progress.

One system fulfilling above requirements is based on esterification reactions by a condensation of hydroxide groups from chemical reagents or wood with carboxylic acids under moderate temperatures. In NIBIO (Norway), they examined the potential of the polyesterification of sorbitol and citric acid in wood as a wood modification process. Pine wood was impregnated with the aqueous reagent solution and was cured at 103 or 140°C for 18 hours. Impregnated samples cured at 140°C showed a permanent (leach-resistant) increased dimensional change, but samples treated at 103°C did not. However, samples treated at both temperatures showed resistance to white-rot (*Trametes versicolor*) and brown-rot decay (*Postia placenta*) even after a leaching procedure. The leached and non-leached samples were also less susceptible to blue-stain fungi.

At the Bern university (Switerland), they studied the use of bio-polyesters for wood chemical modification by the vacuum/pressure impregnation of mono- or oligomers of lactic acid (LA) or oligomers of polybutylene succinate (PBS), in bulk or water solutions. Subsequently, thermal treatment enables the LA to diffuse into the cell wall, whereas wet heat treatment is necessary for PBS diffusion. Optimized treatments confer excellent biological resistance and dimensional stability, with good fixation in wood. Slight increase in material brittleness and diminished ability to gluing and coating must still be overcome. Easier to implement (simple treatment process), LA modification is considered for industrial up-scaling, which would allow positioning new modified wood variant with intermediate properties, between thermo-treated wood and chemically modified wood.

Dealing as well with poly-esterification, the university of Lorraine (France) investigated the combination of glycerol (G) with citric acid (CA), tartaric acid (TA) or succinic anhydride (SA). Waterborne mixture (about 40% solid ratio) were vacuum/pressure impregnated in wood, then thermal treatment was performed to induce in situ polymerization. For each variant, molar ratio, temperature and duration were optimized regarding material properties. Best results were obtained using GCA and GSA formulations, keeping leaching under 1%, reducing swelling up to 60%, ensuring high durability against white and brown rot fungi and maintaining bending mechanical performances compared to untreated wood. 160°C and 6h were found to be the optimum curing conditions. On-going research is focused on the extension to other biobased monomers and the preparation to numerical modelling-supported up-scaling, which will ensure optimal material performances.

Another possibility to bulk wood cell walls is the Maillard reaction, where amine groups are reacted with the reductive ends of sugars according to a complex mechanism. The feasibility thereof was recently investigated by InnoRenew CoE (Slovenia) and NIBIO. They scanned different combinations of chemical reagents and found that the combination of 0.1 mg L^{-1} lysine/glucose/ citric acid reacted at 120°C obtained the highest weight percentage gain, albeit with significant leaching. In continuation, they found that at 120°C mainly esterification between glucose and citric acid occurs and a reaction temperature of 160°C is necessary to achieve Maillard reaction and no leaching. Another reagent combination (0.1 mg L^{-1} ascorbic acid/Trizma base/citric acid) appeared to work, but SEM images showed that it could damage the wood. On-going research is focused on the resistance of the treatment against fungal decay and obtaining a repeatable, high-volume change.

Whilst the Maillard reaction classically involves primary amines, secondary amines could be used, too. On-going studies between LTU in Sweden and University of Ljubljana in Slovenia are considering how to combine these Maillard-type reactions within a thermal modification process. Initial experiments considered tricine and the tertiary amine bicine, and whilst the work has yet to be fully published, spectroscopic analysis by FTIR has identified that some degree of reaction has occurred.

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

a) Дрвна индустрија - Апстракти b) Дрвена грађа - Апстракти

COBISS.SR-ID 271107084

cost
EUROPEAN COOPERATION
IN SCIENCE & TECHNOLOGY

FP1407
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