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**Examiner report on PhD Thesis “Microwave modification of wood” of ing. Jakub Domyň**

**Dear Doc. Ing. Radomir Klvač, Ph.D.,**

Mendel University in Brno appointed me on February 19<sup>th</sup>, 2016 to review a PhD Thesis “Microwave modification of wood” of Ing. Jakub Domyň, who prepared the PhD thesis in the frame of doctoral study programme “Wood Engineering” in the field “Wood Processing Technology”.

I have carefully reviewed the doctoral thesis of Ing. Jakub Domyň and my objective assessment of the doctoral dissertation is as follows:

**A. Objective assessment of the dissertation thesis**

Doctoral thesis of Ing. Jakub Domyň “Microwave Modification of Wood” consists of introduction, 5 published papers, 1 unpublished paper and conclusions. Four papers were published in BioResources journal, which impact factor in 2014 was 1.425 (last available data). One paper was published in Pro Ligno, peer reviewed journal without impact factor. All five papers are published in open access.

The main aim of the doctoral thesis was to examine the potential of microwave treatment in wood technology. This included the development and optimization of various microwave modification techniques and investigation of the relationship between microwave modification and selected physical and mechanical properties of wood. The doctoral research included:

- Microwave radiation effect on axial fluid permeability
- Impregnability of wood after microwave treatment
- Microwave treatment as continuous modification of wood
- Application of microwave treatment for the plasticization of wood prior to wood densification
- Density profile and microstructure of densified wood plasticized by microwave treatment
- Application of microwave heating for acetylation of wood

In most of the studies beech wood (*Fagus sylvatica* L.) was used. Hybrid poplar (*Populus hybrids*) was used in the research of application of microwave heating for acetylation of wood and Norway spruce (*Picea abies* L.). Microwave treatments were performed in discontinuous and continuous laboratory microwave device. Wood densification was performed in hydraulic press (HL 400, Strozatech). Testing methods followed commonly used European standards.

Main results of the doctoral thesis are:

- Microwave radiation can influence the permeability of the wood in all anatomical directions of wood. The results showed that milder treatment mode increases the permeability, while more severe mode decreases the permeability.
- Process parameters of microwave treatment (power and time of exposure) influence the physical and mechanical properties of wood. Only low microwave power and time of exposure can maintain the strength properties of microwave treated wood.
- Microwave treatment can effectively be used for rapid plasticization of wood as pre-treatment to wood densification.
- Microwave heating can accelerate the chemical reaction in the acetylation process.

## **B. Dissertation results appraisal**

The results of the doctoral thesis are of high importance to the wood science community. The doctoral dissertation provided foundation for further development of microwave treatments in wood technology. The doctoral thesis focused on broad application of microwave treatment in wood technology and delivered the relations among the parameters of microwave treatment and wood properties. Results of the doctoral thesis delivered important new knowledge, while further research is needed to completely understand the microwave treatment of wood. The parameters of microwave treatment should be studied in more detail in relation to different wood species and intended utilization of microwave treatment – permeability, plasticization or acetylation. The results delivered in the doctoral dissertation of Ing. Jakub Domeny are of great importance in these future research, which the wood science community will have a high interest to investigate in the future.

## **C. Importance of dissertation for practice**

The topic of the doctoral dissertation is at the core of forest-based sector trends. Forest-based sector is aiming to play an important role in European development of bioeconomy and circular economy. Therefore, forest-based industries are continually developing advanced processes, materials and wood-based solutions to meet evolving demands and increase competitiveness. Several emerging environmental-friendly processes of wood modification (chemical, thermal and impregnation/polymerization) have been developed, which can improve the intrinsic properties of wood, and provide desired form and functionality. The wood modification by microwave treatment developed in this doctoral thesis can lead to new advance process that will increase the competitiveness of forest-based sector. The forest-based sector can become a leader in achieving the European Commission's ambitious CO<sub>2</sub> emissions reductions goal (Roadmap 2050) with innovative production technologies, reduced energy consumption, and increased wood products recycling. Therefore, future research and development of microwave treatments of wood should examine also environmental impacts of the treated wood in the whole life cycle, including recycling. The use of forest products in long life products, such as in the built environment, allows for the possibility of extended storage of atmospheric carbon dioxide. Future studies should examine if the global

environmental impact of wood modification processing with microwave treatments and further uses of the resulting products comparable with the impact of native, untreated wood.

#### **D. Overall appraisal**

As a Management Committee Chair of the COST Action FP1407 *Understanding wood modification through an integrated scientific and environmental impact* approach I am following research and development in the field of wood modification in great detail and can confirm that the research of this doctoral thesis is of high interest to wood science community and the wood industry. Results of this doctoral thesis delivered important new knowledge and provided basis for development of new wood technologies.

As the doctoral thesis is dealing with wood technology of a great potential, it is a shame that the results were not published in different relevant peer reviewed journals which would give a stronger confirmation of the importance and quality of the doctoral thesis. Furthermore, in some experiments small number of replicates was used. For example, experiments of wood densification were based on one batch – all specimens were densified at the same time. Different experimental design could avoid this and deliver results with stronger confirmation of conclusions of this doctoral thesis.

#### **E. Presumptions and recommendations for PhD declaration**

Doctoral thesis of Ing. Jakub Domeny “Microwave Modification of Wood” is strong, delivers new knowledge and is of high importance for the development of the field. Therefore, I recommend acceptance of this document for the PhD in Wood Processing Technology at the Mendel University in Brno.



A handwritten signature in blue ink, reading 'Andreja Kutnar'.

Assoc. Prof. Andreja Kutnar