PhD award

The International Academy of Wood Science (IAWS) wishes to provide recognition to outstanding thesis/dissertation research at the PhD level by students throughout the world. This years awardees are:

First place: **Dr Mahdi Mubarak**, (Indonesia)

Université de Lorraine, INRAE, LERMAB, F-54000, Nancy, France
Wood Biology and Wood Product, Faculty of Forestry, Göttingen University, Germany
Forest Products Science and Technology, Faculty of Forestry, IPB University, Bogor, Indonesia

Second place: **Dr Subir Kumar Biswas**, (Bangladesh)

Kyoto University, Japan

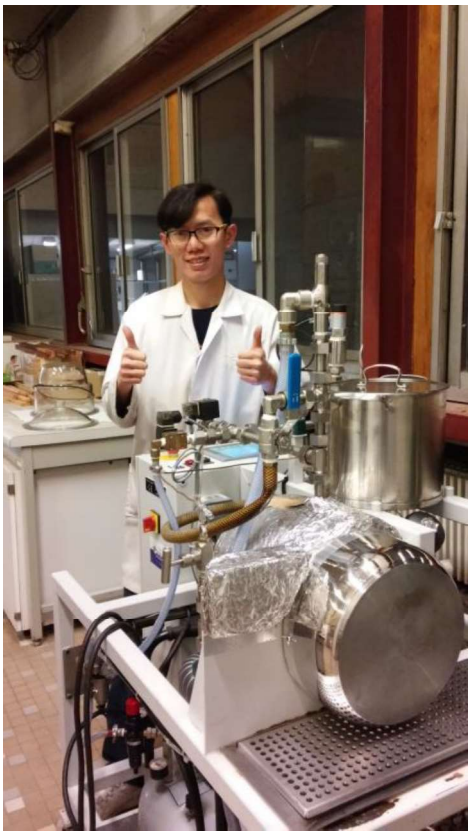
Third place: **Dr Muhammad Adly Rahandi Lubis**, (Indonesia)

Kyungpook National University, Korea

PhD award – First place

VALORIZATION OF BEECH WOOD THROUGH DEVELOPMENT OF INNOVATIVE AND ENVIRONMENTALLY FRIENDLY CHEMICAL MODIFICATION TREATMENTS

Mahdi Mubarok[1,2,3], Holger Militz[2], Stéphane Dumarcay[1], Philippe Gerardin[1]
[1] Université de Lorraine, INRAE, LERMAB, F-54000, Nancy, France
[2] Wood Biology and Wood Product, Faculty of Forestry, Göttingen University, Germany
[3] Forest Products Science and Technology, Faculty of Forestry, IPB University, Bogor, Indonesia



Aside from its renewable and biodegradability properties, wood is a unique and versatile material, being used for various applications. However, the term "renewable" would still be reasonable if the rate of its exploitation is the same or lower than the rate of its growth. Besides afforestation and plantation activities, some technologies are needed to slow down the rate of its exploitation, such as an implementation of recycling technologies for the used wood-based products. Other techniques, including an expansion of its service time during utilization, are needed through improvements of its properties, particularly its biological durability, corresponding to its destined applications.

European beech (*Fagus sylvatica*) is one of the most important hardwood species in Europe. Its acceptable mechanical properties and ease in workability have led to it being used for many applications, especially for interior destinations. However, its low dimensional stability and poor biological durability are the main drawbacks limiting its utilization for exterior purposes, especially in hazard class 3 (exterior above ground) and hazard class 4 (exterior in the ground and/or contact with fresh water). Commonly, improvement of wood biological durability can be performed through various techniques, including the utilization of wood preservatives. However, due to the rising environmental issues since the last decade, some of these wood preservatives are limited or even restricted due to their negative effect on the environment or human health. As alternatives for these issues, wood modification techniques, such as wood thermal treatment and wood chemical modification still get much interest in the future.

The wood thermal treatment has been investigated for decades. However, a preferred improvement in biological durability of this thermally modified wood is not enough to protect the wood against termites. On the other hand, wood chemical modification is believed to improve almost all wood properties, particularly physical and biological durability properties. However, a meaningful change in wood properties sometimes needs a higher quantity of the chemicals or chemicals with high reactivity, resulting in higher investment in chemicals and/or handling during modification. Based on these reasons, this study aimed to improve European beech properties through different environmentally friendly wood modification techniques.

In general, wood modification in this research was performed through a polyesterification-based bulk impregnation modification technique. In the first section, a low concentration of the aqueous additive solution (10% or 20% w/w) made from vinylic derivatives of polyglycerol or glycerol was used in this study (**Fig. 1** below). Wood impregnation followed with different curing conditions in an open or in a closed system was demonstrated. Through various evaluated characterizations during and after modification, certain modified woods presented better dimensional stability and excellent biological durability properties against white-rot, brown-rot, soft-rot, and subterranean termites in a tropical field (grave-yard test) for one-year duration compared to untreated wood (**Fig. 1** below). However, due to the acidic property of the additives, certain wood mechanical properties decreased considerably.

Figure 1 General principle of wood modification in the first section of the study (left) and appearances of certain modified woods after one-year duration of grave-yard test in a tropical country, Indonesia (right).

In the second section of the study, wood modification was performed through an in-situ polyesterification of sorbitol and citric acid (Fig. 2 left), the well-known renewable chemicals commonly used in the food and beverage industries. Impregnation of the aqueous solution of sorbitol-citric acid at different concentrations (10, 20, 30, 55% w/w) into the wood followed with drying and different curing conditions at 140 or 160°C was conducted (Fig. 2 right). Through various parameter analysis investigated during and after modification, the sorbitol-citric acid solution at 30% w/w was considered as the optimum concentration for the beech wood modification. The modified wood has better dimensional stability and was classified as very durable against white-rot, brown-rot, and soft-rot. In addition, a thermogravimetric study evidenced that the modified wood possibly has a fire-retardant property. However, certain wood mechanical properties were also found to decrease due to treatment.

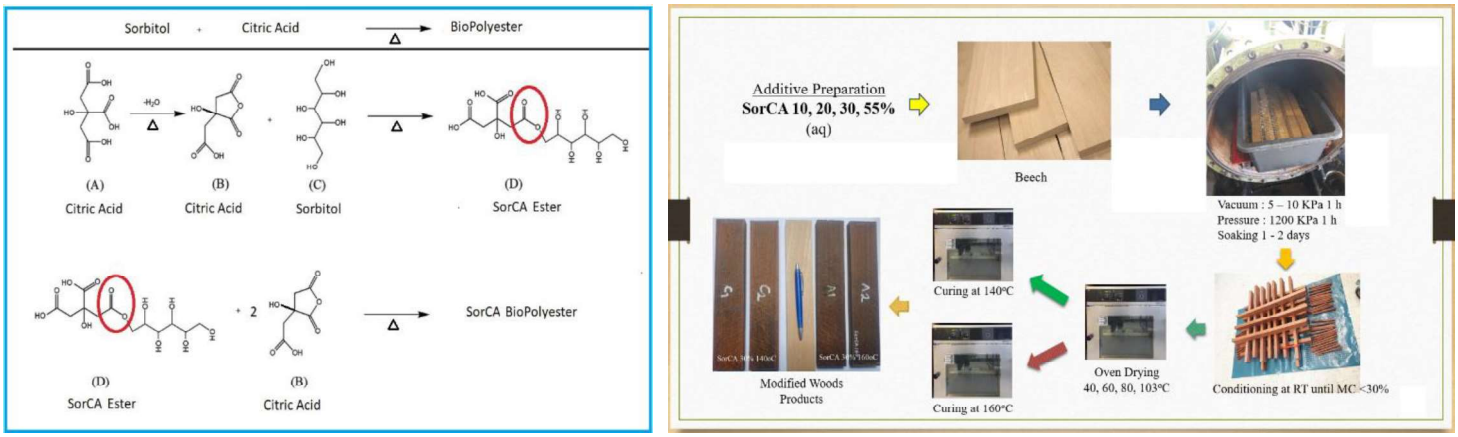


Figure 2 Polyesterification of sorbitol-citric acid (left) and wood modification process conducted in the second section of the study (right).

Overall, this study has provided various wood modification techniques that can improve beech wood characteristics, especially its physical and biological durability properties. Moreover, these techniques can also be implemented on an industrial scale for certain considerable applications, promoting other alternatives for environmentally friendly wood modification treatment.

Keywords: Biological durability, citric acid, *Fagus sylvatica*, field test, glycerol, mechanical properties, polyesterification, polyglycerol, sorbitol, thermal modification.