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Study of the effects of the wood natural variability for optimizing the utilization of the forest resource and to improve the quality of thermally treated European wood

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Context — Wood heat treatment by mild pyrolisis is an attractive alternative to improve decay resistance of low natural durability wood species. Even if it is now well recognized that conferred properties depend directly on the level of wood thermal degradation resulting from the heat treatment intensity conditioned by process parameters, no studies exist to our knowledge on the effects of the intrinsic properties of a given wood species on its behaviour during thermal treatment.

Objectives — The aims of this project are to study the effect of the initial intrinsic properties of wood like its density or chemical composition directly connected to wood's natural variability on its susceptibility to thermal degradation recorded for similar curing conditions and consequently on conferred properties to the final end products. Such data may be of valuable interest for the improvement of industrial scale treatments performed generally on a single wood species.

Approach — Effects of natural variability on wood's polymers thermo-degradation and consequences of these modifications on wood properties have been investigated at two different scales:

- A macroscopic scale performed on boards allowed characterization of the effect of natural variability on the process, properties and performance of the heat treated materials. Boards have been selected from different positions in the same tree and/or from trees with different sivicultural history in order to obtain boards of homogeneous density determined by X-ray tomography. The influence of the initial inter- and intra-tree heterogeneity on the mass loss during the heat treatment process and the final product properties has been studied.

- A small scale study performed on few mg of sawdust taken within annual rings of the same cross section of trunk aimed to study the effect of the intra-ring variability on wood thermal degradation. The sampling has been made for different part of the wood: sapwood versus heartwood, earlywood versus latewood, different positions within the heartwood. Heat treatment has been performed on small samples of sawdust using thermogravimetric analysis and thermodesorption coupled to gas chromatography coupled to mass spectroscopy (TD-GC–MS) in order to evaluate the thermal behavior of each kind of tissues. According to the results obtained, it is possible to propose recommendations to improve the efficiency of heat treatment process and improve quality and homogeneity of heat treated materials.

Year 2016 continued in the logic of the works developed until then by widening our study to the case of the fir tree (*Abies alba*), more representative of wood species used for thermal modification in the industry. The sampling was realized in collaboration with LERFOB from forests of the ONF having

undergone different forest management. Two kinds of forest management were retained for our study: one without human intervention, leading to wood of smaller diameters with small rings growths, another with human intervention like pruning leading to wood of bigger diameters with larger growth rings.

Key results — Intra rings studies highlighted that for both species studied, European oak (*Quercus petraea L.*) and fir (*Abies alba*), earlywood was more susceptible to thermal degradation than latewood indicating that ring width could be an influencing parameter during heat modifications. In both cases, higher stability of latewood compared to earlywood was ascribable to higher cellulose content. Other more specific factors, as the presence of extractives, can influence the behavior of the various compartments of the wood in a more or less important manner according to the wood species.

Main conclusions including key points of discussion — Various intra specific factors affect the thermal stability of the wood. The mode of forestry, which determines the wood radial growth and the proportions of earlywood and latewood leading to more or less larger rings growth, influences directly the thermal stability of the wood. The intra-specific variability linked to earlywood/latewood ratio, heartwood/sapwood ratio or the presence of extractives in the different part of wood, constitutes therefore a source of variability explaining partially the difficulties encountered on industrial scale to obtain thermally modified materials of constant quality.

Future perspectives — The obtained kinetic data of the thermo-degradation reaction will be used to improve the modeling and the simulation of the wood heat treatment by conduction in order to develop of a prediction tool. Based on results obtained by TGA, we will try to predict the overall weight loss of a board according to its earlywood / latewood ratio.

Valorization —

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Effect of forest management on Abies alba wood thermal modification.

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