

# X-ray Microtomography of Wood-Based Materials: Pulp-Fibre Reinforced Thermoplastics and Polyethylene Glycol-Impregnated Oak

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Recently, the microstructure of several wood-based materials has been characterized by x-ray microtomography at HASYLAB. The raw data files are currently being analyzed, but some initial results can be presented already. The image analysis implies development of codes for data reduction to quantify key microstructural parameters that are known to control the macroscopic mechanical properties of the investigated structural materials. The materials under investigation are (i) composites composed of pulped wood fibres in a thermoplastic matrix consisting of polylactide or polypropylene, or a mixture of both, and (ii) oak wood, with a reference of untreated moist wood, and a corresponding sample impregnated with polyethylene glycol.

The purpose of the analysis of composite materials is to investigate the quality of the microstructure with special emphasis on feature that affect the mechanical performance of the material, i.e. fibre dispersion, presence of voids, delaminations, and spatial distribution of the mixed matrix system. The findings should be correlated to previously measured mechanical properties, with the aim to identify means to improve the microstructure with regard to specific mechanical properties, e.g. stiffness, strength and dimensional stability during moisture uptake. As an example, the role of fibre-fibre bonds on the strength of composite materials has been studied [1]. Secondly, the purpose of the study of the effect of polyethylene glycol impregnation of wood is to gain understanding of the bulking and stabilizing process on the cell-wall level, and its relation to the mechanical properties in the grain direction. This impregnation method is warranted by stabilization of waterlogged archaeological wood structures which is known to have positive effects on the dimensional long-term stability at the expense of loss of mechanical integrity, e.g. accelerated creep rates and softening of the material. The idea is to address the mechanisms of these issues on the micromechanical level, in order to identify the weak link in the mechanical behaviour of the treated wood material.

In Figure 1, a two-dimensional cross section of a wood fibre reinforced polylactide sample is shown. At this stage, a third phase is visible which does not belong to the category fibre or matrix. This phase is attributed to voids or air enclosures, which are found in the lumens of the fibres, or in the matrix between the fibres. The void content can be quantified, and serve as a measure of the quality of the material. The process parameters can then be tuned to minimize the void content. Filling the interior of the uncollapsed wood cells, i.e. the lumen of the fibres, is not probably not possible due to the high viscosity of the polymer melt during the compounding process of the commingled wood fibre/thermoplastic fibre mat.

Figure 2 illustrated the microstructure of the two-dimensional section of oak material. Three distinct features can be identified, i.e. the foraminant vessels, the hardwood fibres and the ray cells. This architecture of these phases will influence the polyethylene glycol impregnation, and the bulking of the various cell walls since the different parts do not have the same accessibility. This will also influence the load-bearing capacity of the wood material. The microstructure-property relation is being investigated.

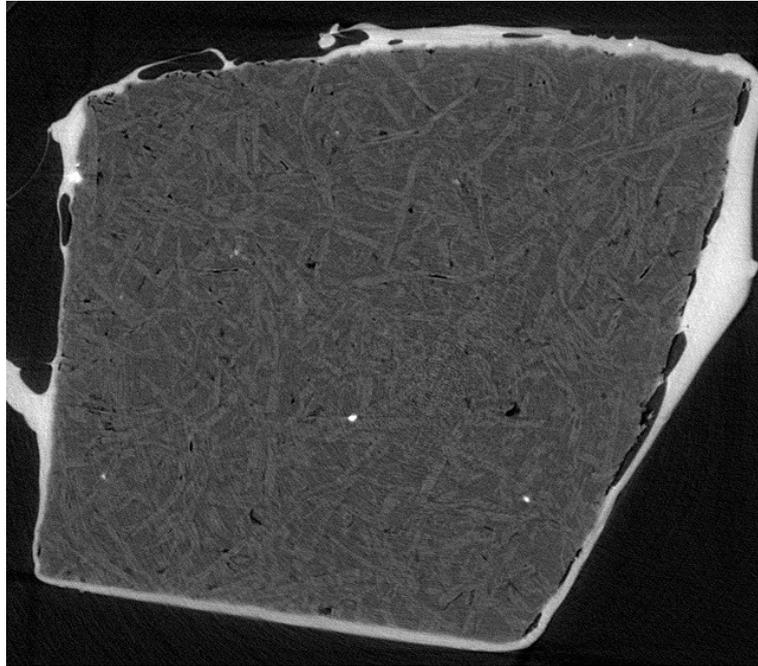


Figure 1: Cross-section of a pulp-fibre reinforced composite in a polylactide matrix. The fibre volume fraction is about 60%. The approximate width of the sample is 1.5 mm.

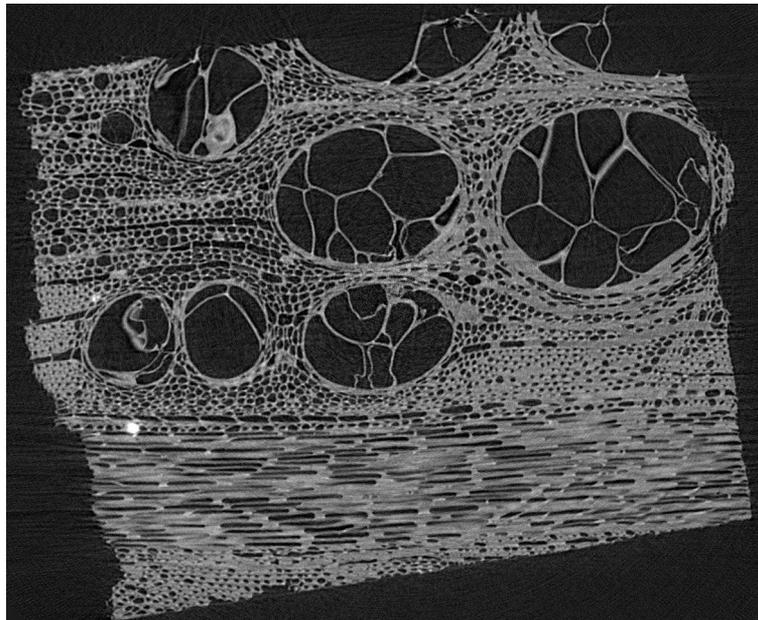


Figure 2: Cross-section of oak sample. The approximate width of the sample is 1.5 mm. The vessels are clearly distinguishable from the hardwood fibres and the ray cells.

## References

- [1] Bogren, K., Gamstedt, E.K., Nygård, P., Malmberg, F., Lindblad, J., Svensson, S., Berthold, F. and Lindström, M., "Stress transfer and failure in pulp-fibre reinforced composites: Effects of microstructure characterized by x-ray tomography" in *Proceedings of the 2006 Progress in Paper Physics Seminar: An Annual Meeting of the International Paper Physics Community*, Coffin, D.W. (Ed.), Miami University, Oxford, 2006, pp. 16-19