Study on the microstructural changes of thermo-hydro treated wood using X-ray computed tomography

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ABSTRACT

Microstructural changes in a selection of soft- and hardwoods (Figure 1) resulting from thermo-hydro treatment (THT) at 160°C were examined using a state-of-the-art micro CT scanner at the Ghent University Center for X-ray Tomography (UGCT). A dedicated X-ray scanning and volumetric processing protocol was developed. All reconstructed volumes had an approximate voxel pitch between 0.8 and 1.2 µm^3. The microstructures of the same needle-shaped specimens before and after THT were visualized (Figure 2), and individual parameters (maximum opening and lumen volume) for various cell types were quantified and compared. The highest values of wood substance volume were recorded for the ash sapwood and spruce specimens: 81% and 72%, respectively. A significant correlation between the wood substance gravimetrical mass loss and the X-ray volume loss after THT was found. When evaluating individual fiber parameters, the largest change was found in the lumen volume of several tissue component types (libriform, tracheid and ray parenchyma). The average volume reduction for the aspen fiber lumen after THT was 31%, a value 2.6 times higher than the volume reduction of the average vessel lumen. These results show that THT causes changes to the macroporosity and individual parameters of both soft- and hardwoods. Significant differences in porosity were observed between wood specimens. The porosity of ash sapwood increased from 41% to 56%, whereas the porosity of birch decreased from 34% to 29%. These results indicate that strength of interaction between the different types of fibers has an effect during treatment. Additionally, the results show that wood species with less cell wall material (with higher initial porosity) tend to exhibit large microstructural changes, such as a large decrease in total cell wall material volume. This is true for gray alder and ash sapwood, possibly due to increased heat and mass transfer during THT. Porosity increased for wood species with smaller amounts of cell wall material after THT (e.g., spruce and ash sapwood) because there was less shrinkage but an equal loss of cell wall material. Thus, the microstructural changes of THT wood can

be investigated by quantifying changes in wood volume, porosity and individual parameters using X-ray CT scanning.

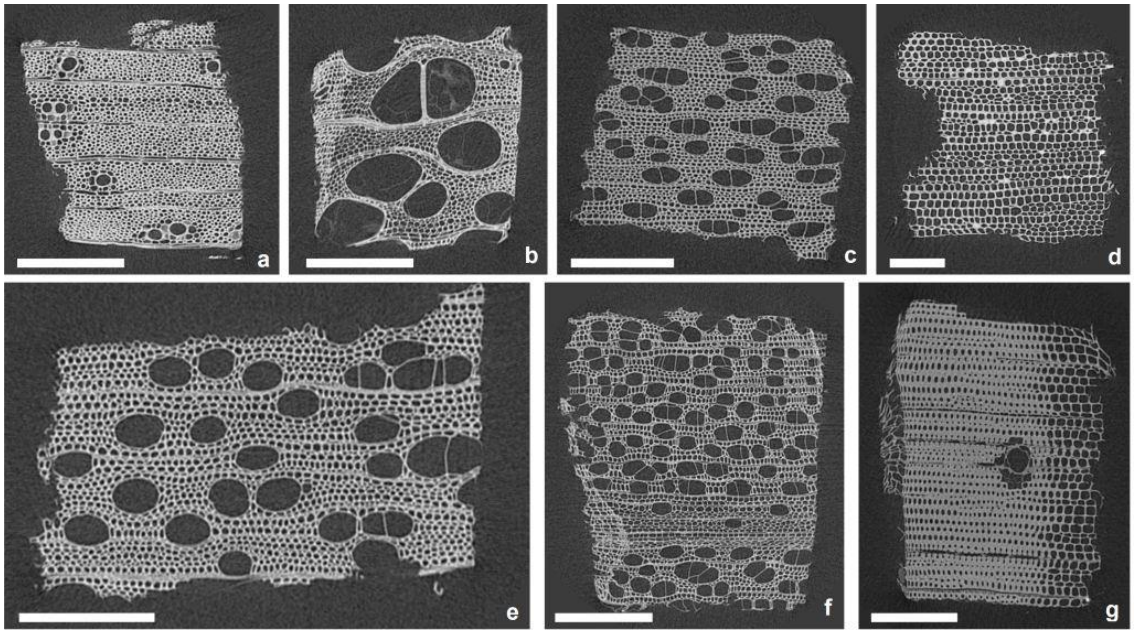

Figure 1. Image processing sequence, as exemplified by a reconstructed cross-section of birch wood: original (a), bilateral filtered (b), VOI (c), all cell types labeled (d), vessel lumens labeled (e), cell lumens labeled (f), and 3D rendering of labeled vessel and lumen volumes (g). Scale bar: 200 μm.

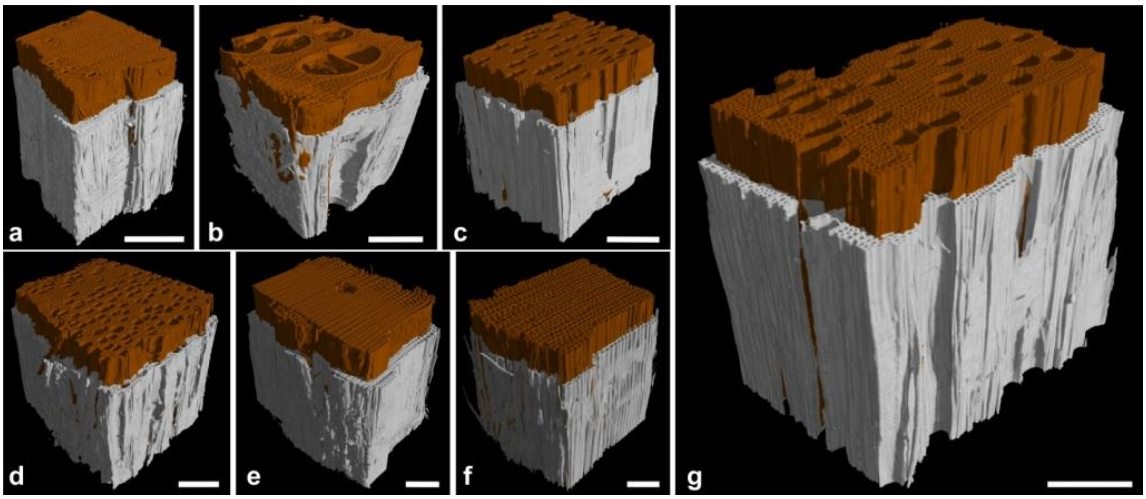

Figure 2. 3D renderings of X-ray tomography volumes: ash LW (a), ash EW (b), aspen (c), gray alder (d), pine (e), spruce (f) and birch (g). Untreated samples are grey, and treated specimens are dark brown. Scale bar: 200 μm.