Stress in wood probed by X-rays

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Tension wood is widespread in the organs of woody plants. During its formation, it generates a large tensile mechanical stress, called maturation stress. Maturation stress performs essential biomechanical functions such as optimising the mechanical resistance of the stem, performing adaptive movements and ensuring long-term stability of growing plants. Although various hypotheses have recently been proposed, the mechanism generating maturation stress is not yet fully understood. In order to discriminate between these hypotheses, we investigated structural changes in cellulose microfibrils along sequences of xylem cell differentiation in tension and normal wood of poplar (*Populus deltoides* x *P. trichocarpa cv.* I45-51). Synchrotron radiation micro-diffraction was used to measure the evolution of the angle and lattice spacing of crystalline cellulose associated to the deposition of successive cell wall layers. Profiles of normal and tension wood were very similar in early development stages corresponding to the formation of the S1 and the outer part of the S2 layer. Subsequent layers were found with a lower MFA, corresponding to the inner part of the S2 layer of normal wood (MFA~10°) and the G-layer of tension wood (MFA~0°). In tension wood only, this steep decrease in MFA occurred together with an increase in cellulose lattice spacing. The relative increase in lattice spacing was found close to usual value of maturation strains. Analysis showed that this increase in lattice spacing is at least partly due to mechanical stress induced in cellulose microfibrils soon after their deposition, suggesting that the G-layer directly generates and supports the tensile maturation stress in poplar tension wood.