

# Modelling the Hygroexpansion of Normal and Compression Wood Tracheids

**Modelling the Hygroexpansion of Normal and Compression Wood Tracheids**


R. Cristian Neagu†, E. Kristofer Gamstedt†\*, and Stig L. Bardage‡

**Objective**  
Improve understanding of hygroexpansion of normal wood (NW) and compression wood (CW) tracheids through micro-mechanical modeling

**Modelling**  
Two steps on different scales, (1) homogenisation of the cell-wall ultrastructure (Mankund, 2007), and (2) analysis of the hygroelastic deformation of concentric cylinders on the fibre level (Neagu and Gamstedt, 2007)

**Input needed**  
Material data - wood polymer content, hygroelastic parameters as function of the relative humidity (Mankund, 2007)  
Structural - microfibril angle (MFA), layer thickness

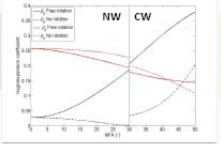
**CW: NO S2 layer, S1 is about 17%**      **CW: S2 MFA varies from 30°-50°**



**Results and discussion**  
The hygroexpansion properties of the constrained tracheids (as in wood) or free fibres (as in pulp) were simulated


Longitudinal hygroexpansion ( $\beta_L$ ) increases and the transverse or circumferential hygroexpansion ( $\beta_C$ ) decreases with increasing MFA. If a fibre (NW or CW) is allowed to expand freely. This is expected since the hygroexpansion strains and elastic properties are inversely related.

$\beta_L$  of constrained NW fibres decreases with increasing MFA. The  $\beta_C$  of constrained CW fibres is reduced significantly but it is still increasing with increasing MFA.



Results are in accordance experimental data that show opposite deformation response upon swelling of tracheids of NW (shrinkage) and CW (elongation), under the constraint of no torsional deformation (Burgert et al., 2007)

**References**  
E. Mankund, J. Veith, Composites Science and Technology, 69 (2009), 1108-1114.  
R.C. Neagu, E.K. Gamstedt, Journal of Materials Science, 42 (2007), 10224-10274.  
I. Burgert, M. Kretz, W. Gierlinger, R. Fretz, Planta, 222 (2007), 981-987.



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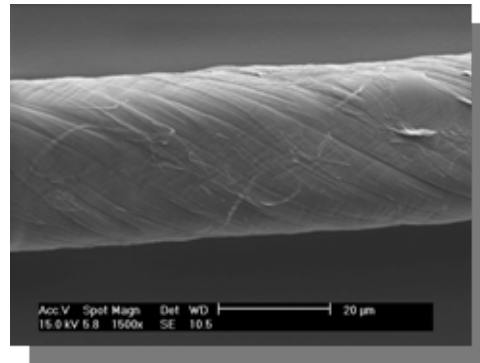
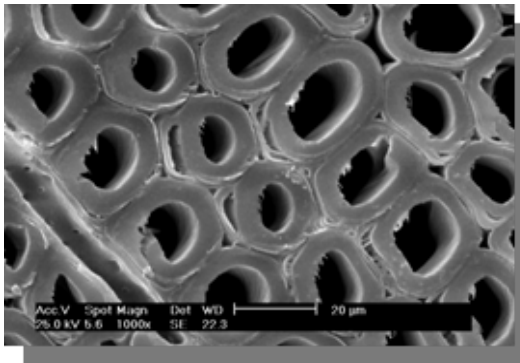
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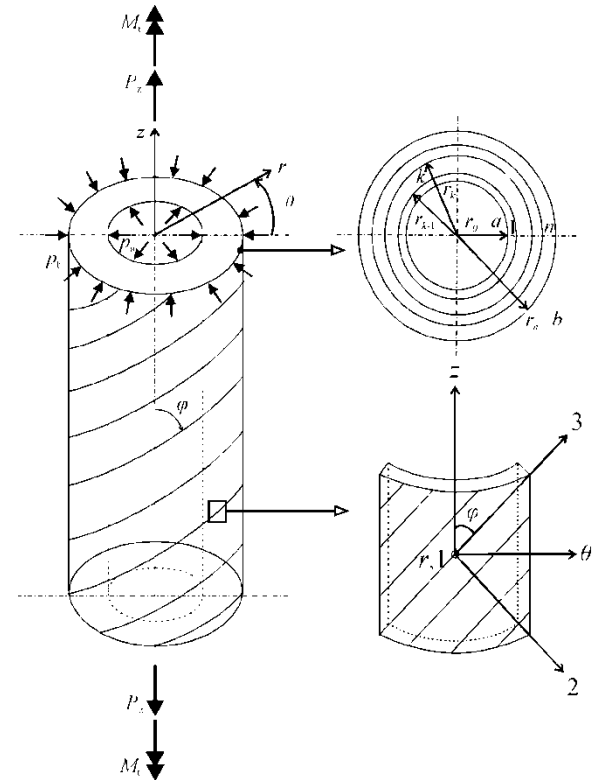
# Composite micromechanics

**CW:** No S3 layer, S1 is about 17% of the cell wall thickness with a MFA of  $90^\circ$  while S2 MFA varies from  $30^\circ$ - $50^\circ$ )

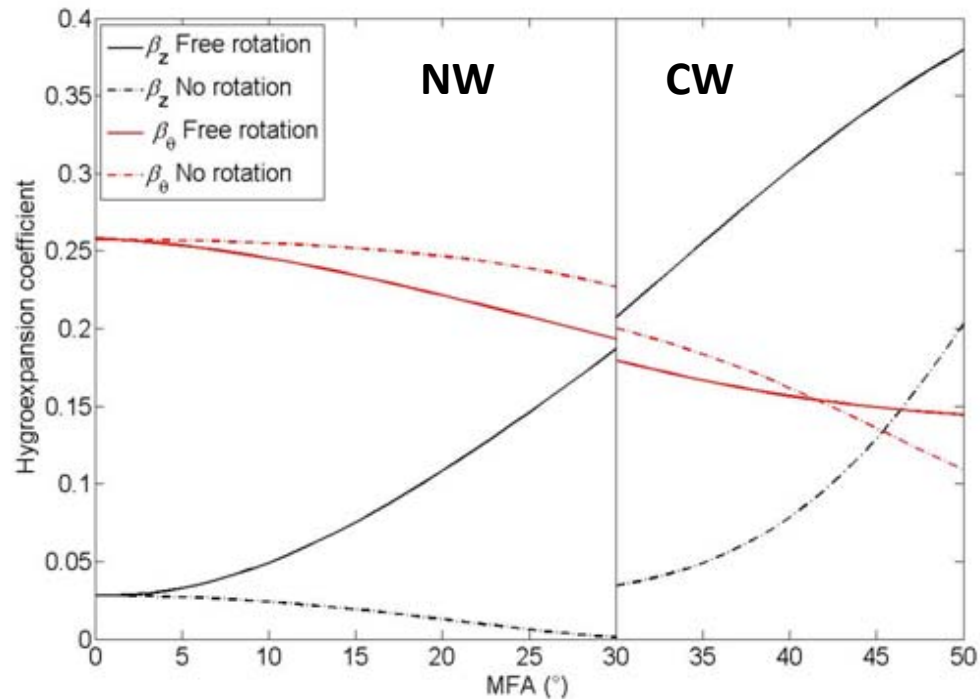


**NW:** MFA in S1 =  $90^\circ$  and constitutes 9% of the cell wall thickness, S2 MFA from  $0^\circ$ - $30^\circ$  and thickness fraction of 88%, S3 MFA is  $-75^\circ$ )

3D framework, combining a homogenization method (layer level) and exact elasticity theory (fibre level)



# Hygroexpansion behavior



Also experimental data that show **opposite deformation response upon swelling of tracheids of NW (shrinkage) and CW (elongation), under the constraint of no torsional deformation.**