Ultrastructural and Chemical Investigation of Functionalized Wood Cell Walls Using Raman Microscopy

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In nature, combinations of different materials, such as polymers and minerals, are abundantly used to achieve outstanding properties and multifunctionality.
Wood, a hierarchical structured material down to the nanoscale can serve as a scaffold for the formation of new multifunctional materials through in-situ polymerization, mineralization and nano-particle infiltration.
In polymerization, the presence and penetration of the monomer into the cell wall is hardly distinguishable in electron microscopy due to the similar electron densities of wood and the polymer. Raman Microscopy, combined with multivariate methods allows for a visualization of the chemical features of the synthetic organic compound (1).
In terms of the mineralization of wood by calcium carbonate, Raman-based Vertex Component Analysis shows the distribution of different crystalline phases formed in different anatomical regions of the wood structure (2).
The infiltration of pre-synthesized nanoparticles into the cell wall structure opens a new path for cell wall modification and a fundamental study of the nanoporous system. Due to resolution limits especially in organic materials, scanning electron microscopy does not allow for a detection of these ultra-small particles in the nano-porosity of the cell wall, while a spatially resolved chemical detection using Raman Microscopy is feasible (3).
In combination with Light and Electron Microscopy, Raman Microscopy can be meaningfully used to monitor the ultra-structural and chemical changes during functionalization procedures. Especially through the application of multivariate analysis methods, a simultaneous monitoring of cell wall components and integrated functionalizing materials is possible, yielding a detailed picture of the presence and penetration depth in cell wall structures.

References

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