The Hierarchical Structure of Wood Reproduced in Silica

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Wood has a complex structure, where the cell walls are composed of a composite material based on cellulose, hemicelluloses, and lignin. The cellulose microfibrils of the main part of the cell wall, the S2 layer, are arranged in fibrils that wind in a helical way around the lumen of the cells. The original wood is delignified in order to expose the bare fibrils. The material is then functionalized with maleic acid anhydride and infiltrated twice with TEOS. Calcification at 500°C leaves a material, where the fibrils are replicated in silica leaving helical pores, where the cellulose used to be [1].

Macroscopic sections of wood can be replicated still showing the structure of the annular rings. Microscopic investigations show that the cellular structure is also preserved. Small angle x-ray scattering reveals that the fibrils and the microfibrils can also be preserved down to a level of a few nanometers. Small angle scattering is also used for in situ experiments, showing the transformation of the cellulose microfibrils into pores in the silica matrix during the calcination process.

The porous material shows interesting mechanical properties making it considerably stronger, but not much less tough.

Microscopic images (left and centre) and 2D scattering pattern (right) of the silica replicated wood.