MICROMECHANICS OF NON-EMBEDDED SPRUCE WOOD: NOVEL POLISHING AND INDENTATION PROTOCOL

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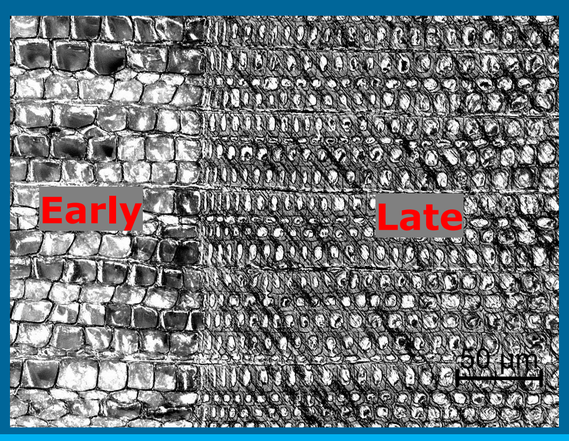
Motivation

In order to preserve and protect wood against fire, insects and fungal infestation, one can impregnate it with a biological wood preservative containing abietic acid, potassium carbonate, silicate solution, cellulose, lignin, and starch. However, how are the material properties after such **preservation** treatments?

Overview

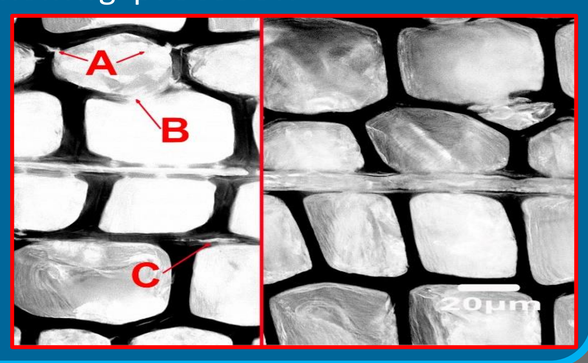


Wood is a biological material with a complex well-organized microstructure. The “honeycomb” cellular structure can be divided into early and late wood.
To locally probe the material microstructures like the found in wood, Oliver and Pharr [1] proposed a technique known as nanoindentation. Nevertheless, extremely flat surfaces with low roughness are needed to perform indentation campaigns.

Material & Methods

Sample preparation

24 cubes of Norway spruce *(Picea abies)* with dimensions of approximately 2x2x2 cm³ were harvested from 12 different boards by means of several circular saws. 12 samples were then treated with wood preservative, while 12 were let in a “natural” state. Next, the surface perpendicular to the grain direction was polished by means of an ultra-miller with a diamond tip attached (Leica Microsystems GmbH, Germany). Subsequently, the samples were kept in a climate chamber at 21 centigrade and 35% relative humidity. Finally, the roughness (approximately 20 nm) were examined by means of light microscope and a Triboindenter. Damages **A B C** , such as cracks, cell failure, and delamination, were observed as a result of the polishing protocol.



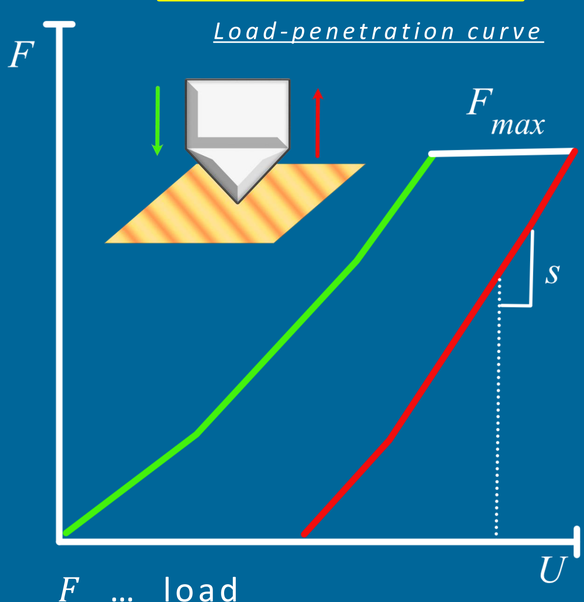
Indentation

2 locations at the early wood and 2 locations at the late wood were selected from the 12 “natural” and 12 “treated” cubes. Indentation grids of 10x10 were performed at each of the locations, resulting in a total of 9600 individual indents. All the campaign was performed in a Triboindenter (Hysitron Inc., USA), equipped with a three-sided pyramid-shaped tip (Berkovich type). Additionally, the relative humidity was regulated to 35% by means of a regulator attached to a nitrogen gas source.

$$S = {}^{\partial F}/_{\partial U}\Big| U = U_{max}$$

$$E = \frac{\sqrt{\pi} S}{2\sqrt{A_c}}$$

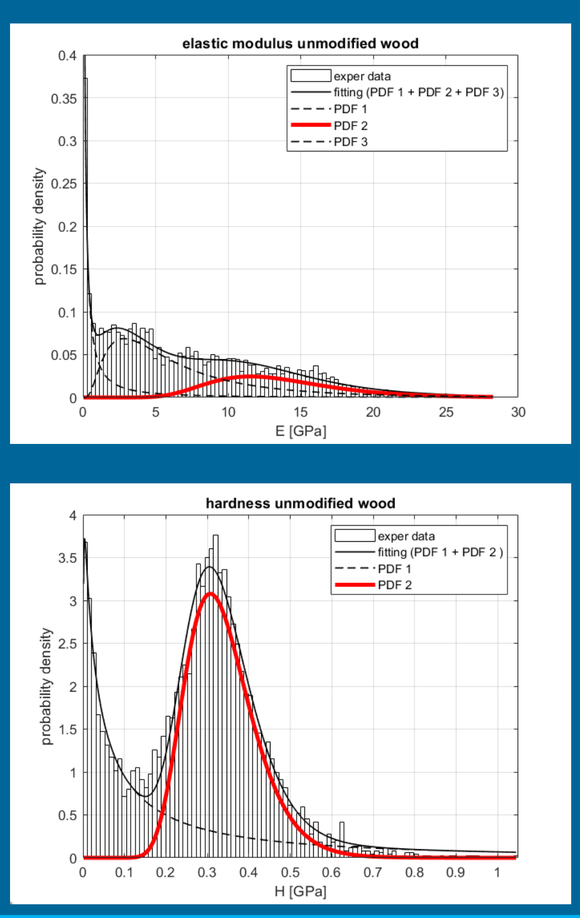
$$H = \frac{F_{max}}{A_c}$$

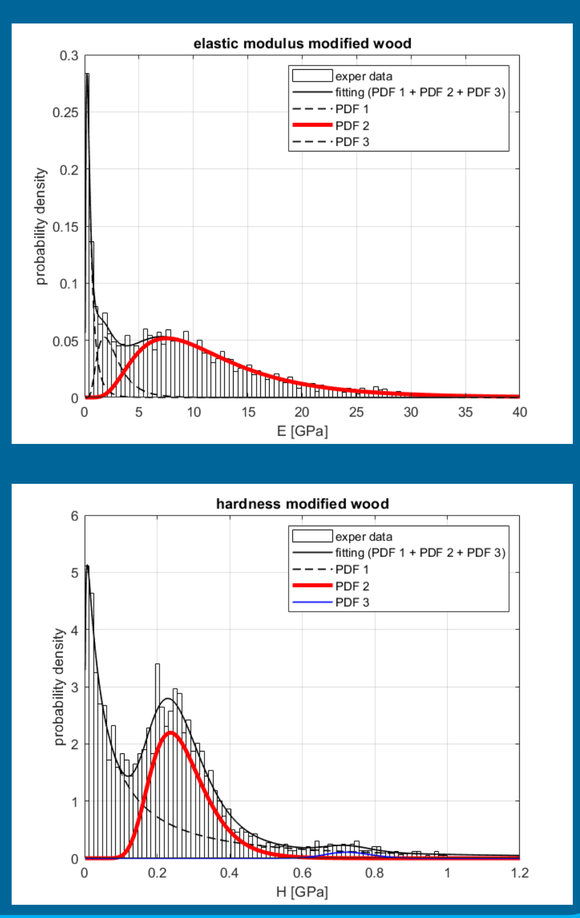


F … load
U … penetration depth
S … initial unloading
E … indentation modulus
A_c … contact area
H … hardness

Results & Discussion

We fitted the elastic modulus and hardness histograms with a linear combination of log-normal Probability Density Functions (PDF). The obtained results suggest a physical interpretation of 3 different material phases: air, damaged, and undamaged.





Discussion

Attacks from insects and fungi on wood can be prevented by applying biological preservation treatments. Furthermore, observing the statistical distribution of elastic modulus, the volume fraction of undamaged material **doubles values**. Finally, the mean value of hardness is also increased, and a third high performance material phase is detected by the fitting automatic algorithm.

Reference:

[1] Oliver, W.C. and Pharr, G.M. (1992). J. Mater. Res., 7, 1564-1583.