FROM NATURAL WOODS TO HIGH DENSITY MATERIALS: AN ECOFRIENDLY APPROACH

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Densified wood are a woody materials which an increase in density and mechanical properties. The materials obtained in this work showed an increase in density from 200% to 400%. The characterizations determine the chemical and structural change compositions after every step. These characterizations showed how different woods have comparable densities and final mechanical properties (+300% the initial one) after densification process.

INTRODUCTION:

Each plant species is characterized by different percentages of cellulose and lignin which impart different chemical, physical, and mechanical properties.[1-3] Density is the parameter that can be easily related to the percentage of cellulose and lignin contained in wood; every wood has its own characteristic density.

In recent years were developed a new methodology that can change chemical composition of wood, density and mechanical properties. These woody materials are called ***densified wood***.

After treatments, the chains of cellulose can form a network of hydrogen bonds, with neighboring chains, increasing the mechanical properties of the material.

In this work, were use two different types of wood: silver fir (Abies alba) and red larch (Larix decidua) with different density, and mechanical properties related to the percentages of lignin and cellulose.

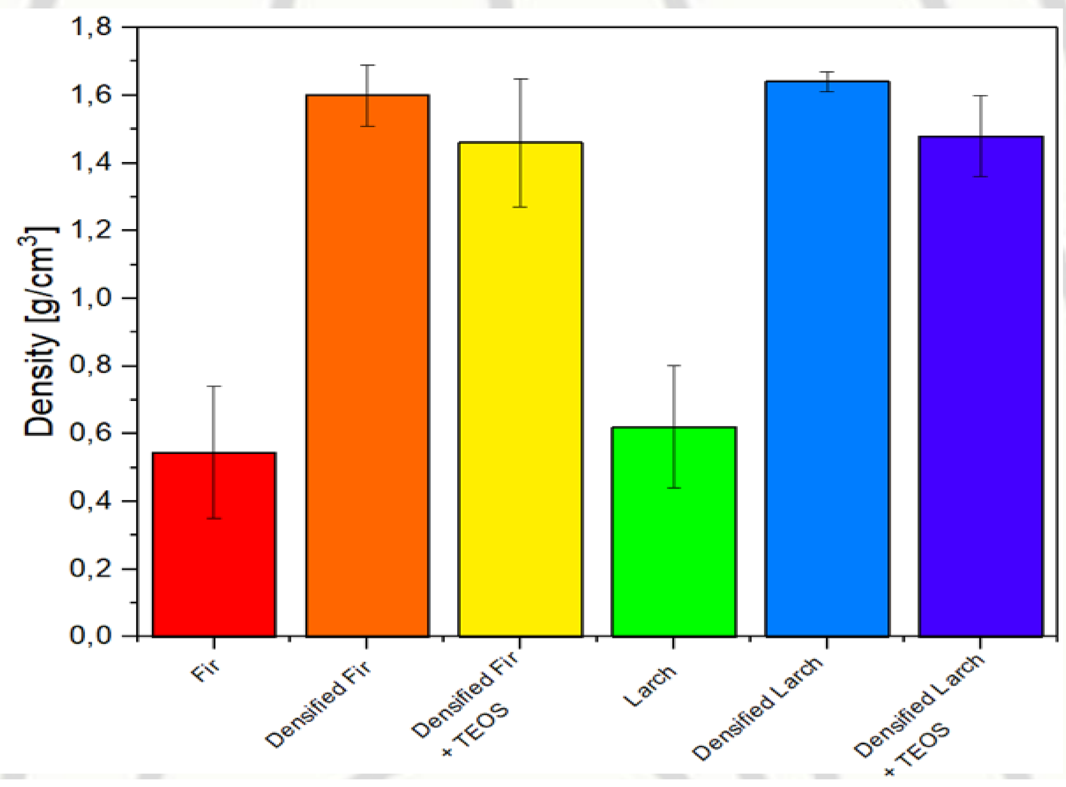


Figure 1. Comparison of densified wood density values with starting density

SAMPLES PREPARATION:

Delignification process was carried out placing woody materials in 30 mL of solution containing 2.0 g of NaOH and 5.0 mg of anthraquinone. The solution and the woody materials were heated at 170 °C for 24 h. After delignification process samples were washed with water until the solution was completely discolored. Samples were dried to constant weight at 50 °C.

Two different densification process were carried out:

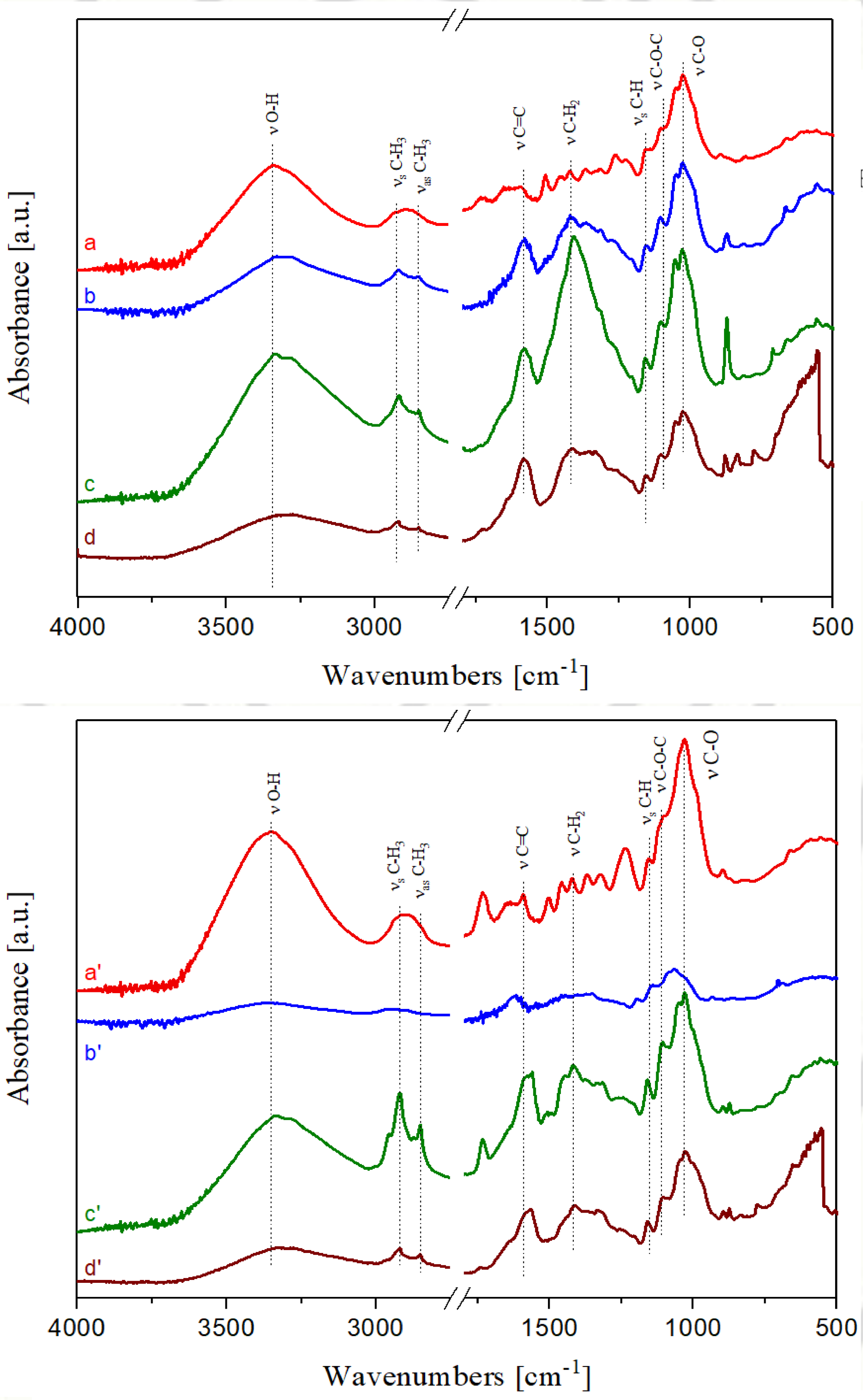
i) the first densification consist in a first step in which the wood samples were pressed at 8 MPa for 3h at 25 °C and in the second step the temperature was increased to 90 °C for 3 min maintaining the same pressure.

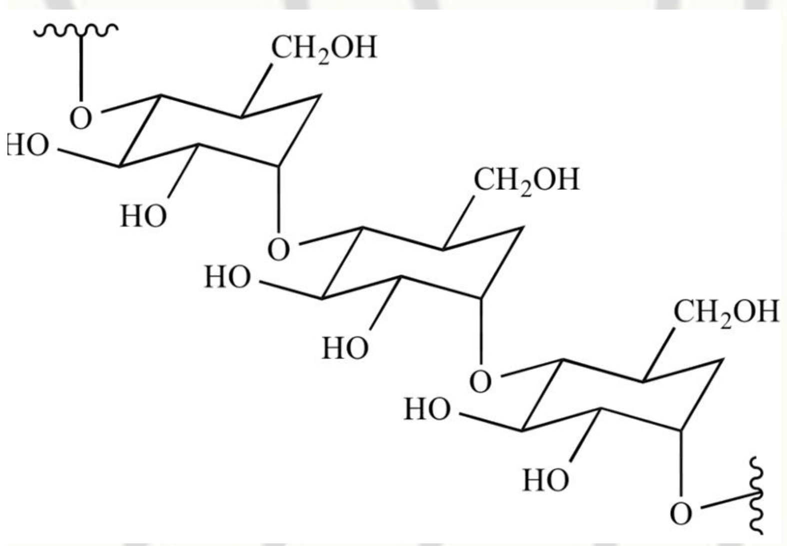
ii) the second densification process was divided into three steps. A first step, in which the woods were immersed in a TEOS bath for 24 h at a temperature of -20 °C. In the second step, the wood samples were pressed at 8 MPa for 3 h at a temperature of 40 °C, and successively in the third step, the samples were heated to 140 °C for 3 min maintaining pressure at 8 MPa. The density of the obtained materials are compared to the starting materials in Fig.1.

SAMPLES CHARACTERISATION:

The FT-IR was used in two different variants, the FT-IR ATR to determine the difference between each sample before and after the delignification and densification process, all the spectra are show in Fig.2.

The micro-IR was used to determine the distribution of hydroxyl groups on the surface of the material, all maps are show in Fig.3.





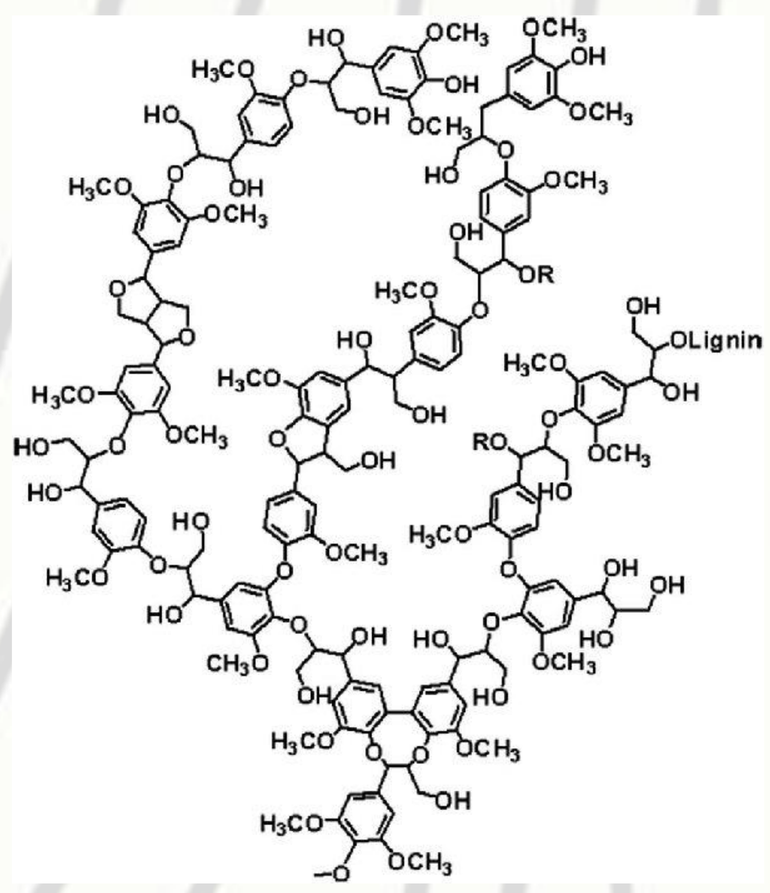


Figure 2. (**A**) FTIR-ATR spectra of fir wood (a) before treatments NF, (b) after delignification process FD, (c) after densification FP and (d) after densification with TEOS FPT; (**B**) FTIR-ATR spectra of larch wood (a') before treatments LN, (b') after delignification process LD, (c') after densification LP and (d') after densification with TEOS LPT

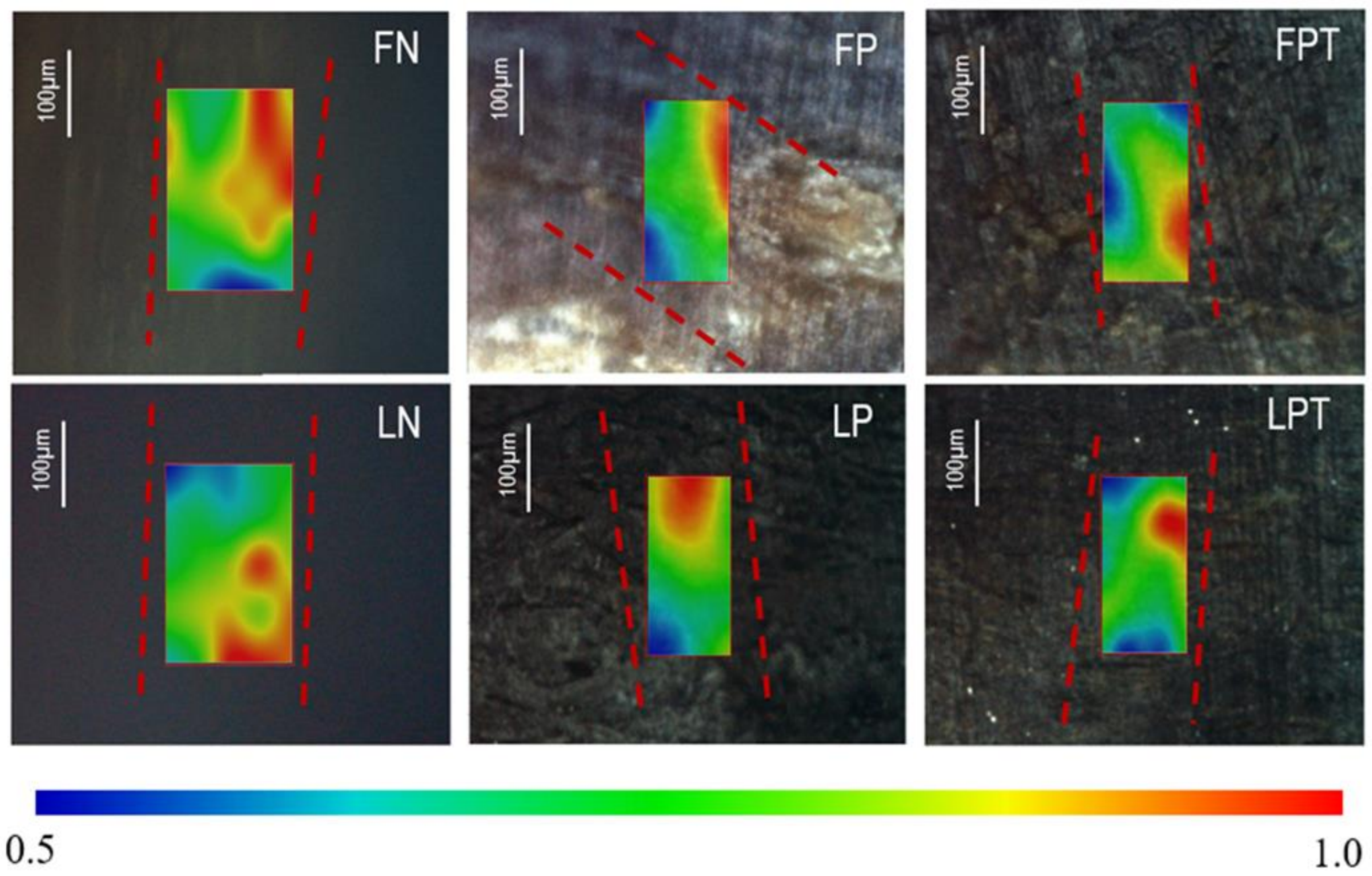


Figure 3. Infrared distribution on the samples surface band at 3500 cm^{-1} of fir wood before treatments (NF), after densification (FP) and after densification with TEOS (FPT) and larch wood before treatments (LN), after densification (LP) and after densification with TEOS (LPT); the contours of the analyzed fibers are highlighted with red dotted lines.

CONCLUSIONS:

The results obtained after the densification process led to a greater increase in density than the values found up to now in the literature. [4] Increased density values are shown in Table 1. From the FT-IR spectra and mapping, the interactions between cellulose chains and the superficial distribution of hydroxyl groups were determined. The high interactions between cellulose chains and the low distribution of hydroxyl groups on samples' surfaces explain the high-density values obtained. The mechanical traction test shows the increase in force necessary for yielding the materials. The increment is more evident for densified fir wood (three time the initial one) while the densified larch wood shows the increment of the force necessary to yield +10% of the initial one. The materials obtained demonstrate that it is possible to obtain a natural material with high density and high mechanical properties without reverting to using the composite material currently used as reinforcement in the construction industry.

Reference:

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