Characterization of Eucalypt Wood by Mercury Porosimetry - DataInterpretation

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ABSTRACT

Although mercury intrusion has been largely used to determine porosity and pore size distribution of a great number of porous materials, its application to the study of wood and in particular the eucalypt wood has been scarcely reported. The present work presents some typical intrusion data of this wood and focuses mainly on their interpretation.

INTRODUCTION

The wood of various species of the genus Eucalyptus has become an important source of papermaking fiber. Eucalypt pulps are one of the most appreciated pulps because their characteristics are particularly well suited for writing and printing papers.

In paper production, fibers are separated from wood in the pulping process. For the production of high quality chemical and semi-chemical pulp it is necessary for pulping liquors to thoroughly impregnate the wood. The porosity and pore size distribution of the wood has a large impact on the pulping process.

Eucalypt wood, and wood in general is highly porous because of the presence of cells such as fibers and vessel elements. Fiber cells occupy volumes that can range from 25 to 75%, whereas vessel volumes can vary from 10 to 50% depending on the species [1] . Eucalypt fibers are spindle-shaped cells with abundant small openings called "pits" which allow intercellular communication. Fiber dimensions vary from about 0.8 to 1.4 mm in length and from 12 to 21 µm in diameter[1]. The vessel elements are short, and non-fibrous cells join end-to-end in a vertical series to form tube-like structures whose diameter can range from 20 to 300 µm. This is easily seen on the wood cross section (Figure 1).

RESULTS AND DISCUSSION

Porosimetry data were obtained using a Poresizer 9320 from Micromeritics. The data output is the mercury intrusion volume as a function of applied pressure, P. Pore diameter, D, is related to the applied pressure by the Washburn equation:

$$D = \frac{220}{P}$$

assuming a contact angle of 137º and a surface tension of 520 dyne/cm^3, being D is µm and P in psia. Intrusion volume data were obtained up to 30,000 psia in cubic wood samples (1.2 cm side).

Figure 2 shows typical plots for the eucalypt wood: the cumulative and the differential intrusion volumes as a function of the pore diameter, calculated by the above equation. The intrusion in the range 140-10 µm, corresponding to the first peak on the left, represents most probably the penetration of mercury into the vessels (tube-like structures of 70 to 130 µm in diameter[2]). The other two large peaks, which in principle correspond to the fiber lumens, are displaced to a much lower diameter than expected (E. globulus fiber

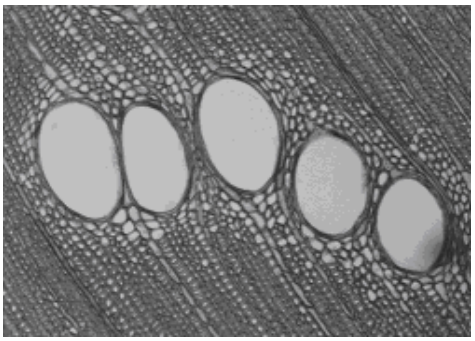

Figure 1 – Cross-section of eucalypt wood showing vessels and fibers.

lumen diameter is about 10 μm^2). This is most certainly due to the fact that the mercury intrusion into the fibres, as can be depicted in Figure 3, takes place through the pits whose diameters are in the range of the first large peak (0.3 µm mode). This illustrates well the "ink-bottle theory." Indeed, fibers can be compared to pores shaped like ink bottles for which the intrusion pressure does not correspond to the actual fiber diameter but to the pit aperture. In other words, although the mercury volume intruded corresponds to the fulfillment of the fiber lumens, the assigned diameters are those of the pit apertures. The second large peak, around 0.07µm, could be related to the presence of smaller pit apertures or to wood pits that include a pit membrane (Figure 3). In either case, the mercury will penetrate the pit at a higher pressure and, consequently, the calculated pore diameter will be smaller. Nonetheless, the assumption that at high pressures some pores may collapse, ultimately modifying the wood structure, cannot be ignored.

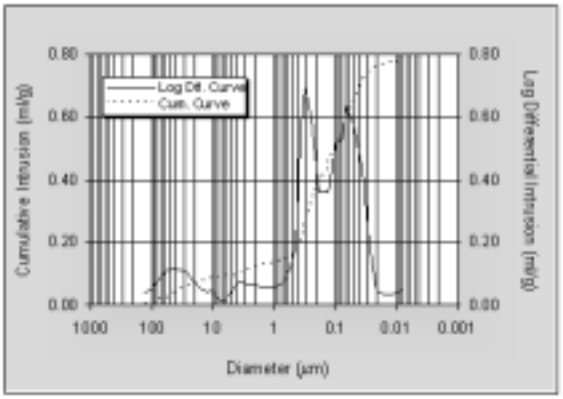

Figure 2 – Typical pore size distribution curves for eucalypt wood.

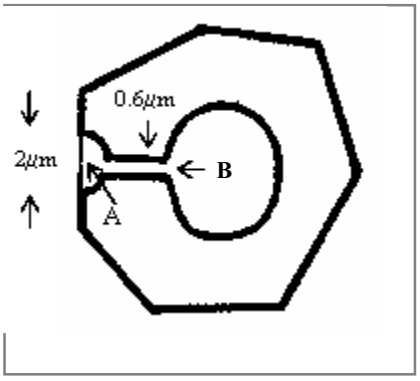

Figure 3 - Cross-section of a eucalypt fiber. A-pit membrane; B-pit aperture [4].

With respect to the total porosity, the samples analysed exhibited an average porosity of 53%, confirmed by other independent measurements[2].

CONCLUSION

Mercury intrusion can be used to determine wood porosity as it is a fast and accurate technique. However, some caution is needed to interpret pore size distributions. As a matter of fact, a basic knowledge of the physical constitution of wood as well as of the operating principle of mercury porosimetry and data handling (based mainly on cylindrical pores) is essential to explain the resulting data.

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