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| Title | <Preliminary>Changes to the Permeability of Wood Resulting from Carbonization |
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| Citation | Wood research : bulletin of the Wood Research Institute Kyoto University (1999), 86: 49-50 |
| Issue Date | 1999-09-30 |
| URL | http://hdl.handle.net/2433/53165 |
| Right | |
| Type | Departmental Bulletin Paper |
| Textversion | publisher |

Preliminary

# Changes to the Permeability of Wood Resulting from Carbonization*[1]

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(Received May 31, 1999)

*Keywords:* carbonization, charcoal, permeability, penetrability

## Introduction

The development of micropores during carbonization is one important feature characterizing the physical properties of charcoal[1,2]. Such structural changes might be expected to improve the permeability of wood and enhance the penetration of liquid, especially for less permeable and less penetrable woods, such as Japanese larch. In this study, changes in air permeability and water penetrability due to carbonization were investigated in conjunction with scanning electron microscope (SEM) observations of microstructure.

## Materials and Methods

Heartwood portions of Japanese cedar *(Cryptomeria japonica)*, Japanese larch *(Larix leptolepis)* and Douglas fir *(Pseudotsuga menziesii)* were cut into 50 mm (longitudinal) × 10 mm (radial) × 10 mm (tangential) blocks. The mean specific gravities of the specimens were 0.299, 0.629 and 0.471, respectively. The specimens were vacuum dried at 60°C for 48 hrs, and were subjected to carbonization in a nitrogen gas atmosphere in an electric furnace by increasing the temperature by 4°C/min up to the target temperature (170–440°C). After the target temperature was attained, it was maintained for 12 hrs, then allowed to cool naturally to 150°C.

After carbonization, the surfaces of the specimens were sealed with epoxy resin, except for their cross sections. Air-permeability in the longitudinal direction was evaluated at steady flows using the permeability constant, K, which is calculated from Darcy's law using the pressure differences between the two ends of each specimen[3].

Water penetrability in the longitudinal direction was evaluated by the weight gain due to water absorption. The oven-dried specimens were soaked in water under a reduced pressure for 20 min, then at ambient pressure for 30 min (step 1) before measuring weight. Next, the specimens were soaked in water again under a reduced pressure for 20 min, then at 1 kgf/cm$^2$ for 30 min (step 2). The vacuum-pressure process was repeated, increasing the pressure at every step from 0 (step 1) to 11 kgf/cm$^2$ (step 6).

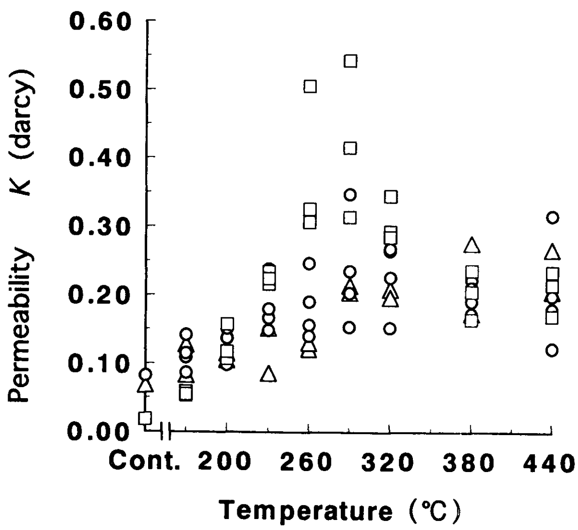


Fig. 1. The effects of carbonized temperature on air permeability. □: Japanese larch, ○: Douglas fir, △: Japanese cedar.

## Results and Discussion

Figure 1 shows the air permeability of the specimens after carbonization. The data suggest that carbonization increased wood permeability significantly in all species examined. This was especially evident for Japanese larch, which exhibited K values more than 10 times higher than untreated samples, when treated at 260 or 290°C. This result could be attributable to the evaporation of volatile substances during the carbonization process, which are abundant in Japanese larch.

Figure 2 shows the degree of water absorption of the specimens after step 1 and step 6. The results obtained after step 1 showed that the effects of carbonization on water absorption were not as clear as those observed for air-permeability. However, a remarkable reduction of penetrability was observed in Japanese larch treated at 200°C. The results obtained after step 6 showed that the degree of water absorption increased with the applied pressure, and the differences among the species became small. However, the effects of carbonization could not be detected. It is suggested that changes in microstructure during carbonization increase the permeability of wood,

*[1] This work was presented at the 49th Annual Meeting of the Japan Wood Research Society in Tokyo, April, 1999.
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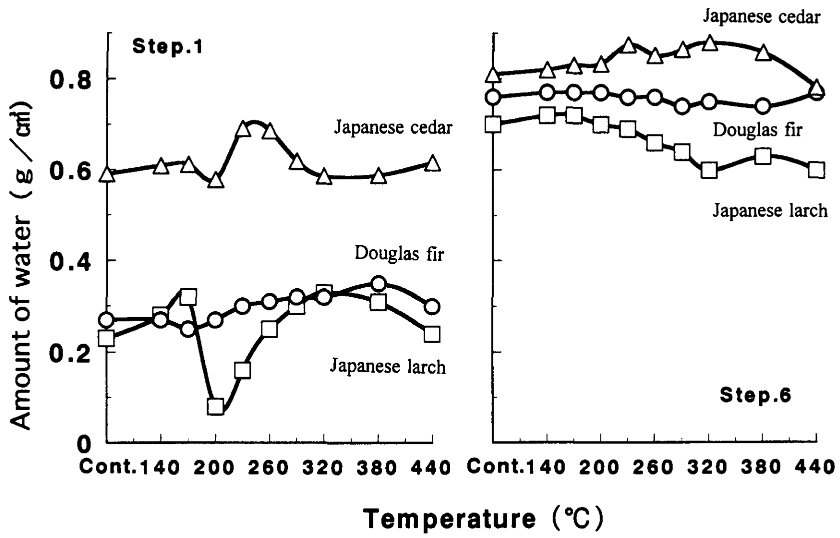


Fig. 2. The effects of carbonized temperature on water penetrability. □: Japanese larch, ○: Douglas fir, △: Japanese cedar.

but do not improve water penetrability. SEM studies could not find any clear evidence of structural changes, such as destruction of bordered pit or cracks in the middle lamella or cell wall, and from these observations it appears that the increases in permeability resulting from carbonization may be associated with changes in the cell wall.

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