A NOTE ON THE EFFECT OF AIR-DRYING ON VESSEL OPENINGS AND AIR-BLOCKAGE IN YELLOW-POPLAR

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ABSTRACT

The scalariform vessel perforation plates of yellow-poplar were examined and photographed microscopically in the green condition and after air-drying. The saturation moisture content of green and once air-dried yellow-poplar was also studied.

Air-drying distorted but did not break bars in the scalariform plates, and it probably had no effect on increasing permeability of yellow-poplar. Air-drying and then rewetting, however, increased the saturation moisture content of the yellow poplar by eliminating the air bubbles entrapped in the green specimens. It is suggested that elimination of air blockage caused the increased permeability.

Additional keywords: Liriodendron tulipifera, Fagus americana, Quercus rubra, scalariform vessel perforation plate, saturation moisture content, specific gravity determination.

INTRODUCTION

Previous research has shown that air-drying of softwoods reduces both longitudinal and lateral permeability because of the closure of bordered pits (Comstock 1968; Liese and Bauch 1967; Sucoff et al. 1965). Recently the author, using the same technique used by several researchers (Kelso et al. 1963; Sucoff et al. 1965; Comstock 1968; Chen et al. 1970) in the past and the permeability cell devised and fully described by Comstock (1968), unexpectedly found that air-drying significantly increased the longitudinal permeability of yellow-poplar (*Liriodendron tulipifera* L.), American beech (*Fagus americana* Ehrh.), and red oak (*Quercus rubra* L.) by 31%, 83%, and 9%, respectively (Table 1). However, the reason for an increase in longitudinal permeability in hardwoods after air-drying and rewetting was not immediately clear. In an attempt to explain this, it was hypothesized that because the longitudinal flow of water in hardwoods is confined mainly to the vessels, removal of water by air-drying enlarged the vessel openings by breaking bars and webs (Meyer and Muhammad 1971) of the vessel perforation plates. Furthermore, it was hypothesized that air-drying and rewetting eliminated the air-blockage that existed in green specimens. An experiment was carried out to test these two hypotheses.

EXPERIMENTAL

The effect of air-drying on the vessel opening was studied in 30 green specimens (¼-inch square by ½-inch long along the grain) that were cut from a green yellow-poplar log. One end of each specimen was smoothly shaved on a sliding microtome to prepare the surface for microscopic inspection. The vessel openings at two locations per specimen were inspected, and photographs were made of the scalariform plates using reflected light. Then the specimens were air-dried to about 3% moisture content in about 20 hr in a drying chamber, using compressed air passed through a drying tower. The air-dried specimens were reinspected microscopically at the same locations and rephotographed to record changes in the scalariform plates. After air-drying, 10 specimens were rewetted, examined, and photographed at the same locations to show the vessel openings in a rehydrated condition.

The effect of air-drying on saturation

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TABLE 1. *Longitudinal permeability of three hardwood species before and after air-drying*[a]

Species	Green (Kgl)	Air-dried (Kal)	Difference (Kal-Kgl)	Increase due to air-drying
	- - - - - (Darcy)	- - - - - -		(Percent)
Yellow poplar	12.131	15.926	3.795	31**
American beech	1.614	2.952	1.338	83**
Red oak	18.700	20.310	1.610	9**

a/ Each permeability value is an average of 32 specimens. Same specimens were used to measure green and air-dried permeability.
** Significant at 1% level.

moisture content was also studied using five green specimens (½-inch in diameter and ½-inch long along the grain) per replication with four replications. Green specimens were evacuated over distilled water in a desiccator jar under a vacuum of 29 inches of Hg for 15 min and then submerged in the distilled water before releasing the vacuum. After the specimens were soaked for 15 min, saturation weights were taken immediately after the surface water was removed by rolling the specimen over once in a clean tissue. Then the specimens were air-dried to about 2% moisture content for 22 hr before they were reevacuated over water and resaturated with distilled water under the same conditions as before. The specimens were reweighed to determine the second saturation moisture content before they were oven-dried at 105 C for 24 hr. The saturation moisture content was used instead of saturation weight in the statistical analysis to eliminate the possible variation of specimen size among and within replications.

RESULTS AND DISCUSSION

Air-drying resulted in distortion of the parallel bars in the scalariform plates (Fig. 1). However, only 1 out of 1,323 bars examined was broken (Fig. 2). All of the 453 bars examined on the 10 rewetted specimens returned to their green condition after rewetting (Fig. 1). Assuming that the internal vessel plates reacted the same as the outside vessel plates, it was concluded that air-drying distorted but did not enlarge the vessel openings. This occurred without its

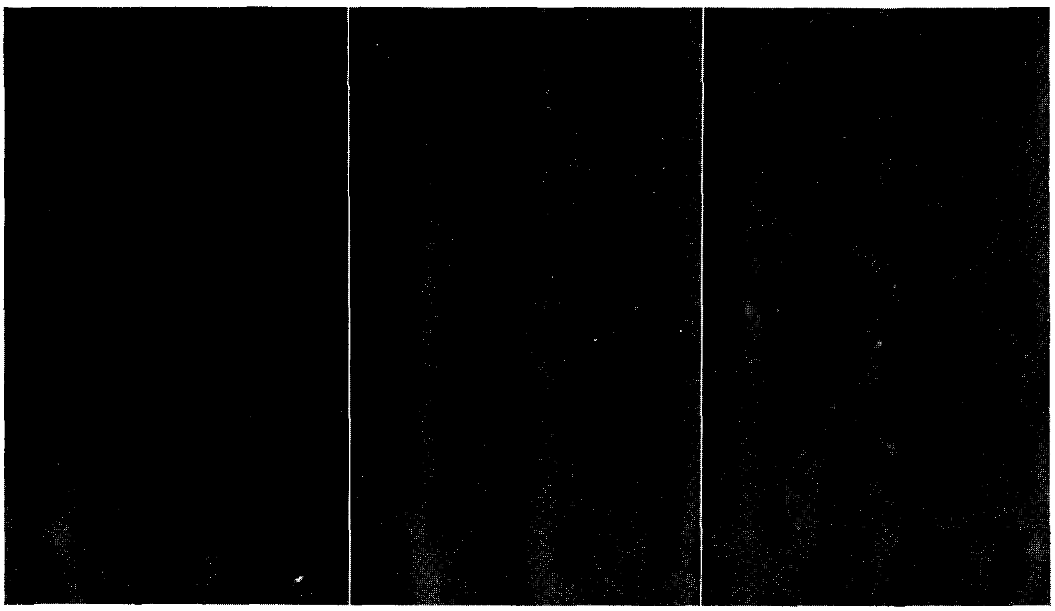

FIG. 1. Photo 1a shows the undistorted bars in a green wood specimen; 1b shows the same specimen in an air-dried condition; and 1c shows that the bars have returned to their green condition after rewetting.

breaking the bars in the scalariform plates and probably had no effect on increasing longitudinal permeability.

Because air is much lighter than water, the saturation weight or the saturation moisture content of a specimen would be lower if entrapped air bubbles were present than if there were no air bubbles. Thus, the effect of air-drying and rewetting on eliminating air bubbles was shown by comparing the saturation moisture content of the green wood with the saturation moisture content of the air-dried and rewetted wood.

The average saturation moisture content of air-dried and rewetted wood was significantly higher than the average saturation moisture content of the green wood specimens (Table 2). The average increase in moisture content, due to air-drying, was about 7%. All 20 specimens tested had a higher second saturation moisture content than the first saturation moisture content. This indicated that a small quantity of air trapped in the green specimens was not readily removed during the first 15 min of evacuation before the first saturation. Others have also found that green wood in general is not fully saturated and that the air trapped within it is not always

TABLE 2. *Comparison of the saturation moisture contents of green and air-dried rewetted yellow poplar specimens*

Replication	Initial green	Green saturation	Air-dried rewetted saturation	Difference of saturation
	(Percent moisture content)			
1	64.2	148.6	155.7	7.1
2	70.0	146.9	152.8	5.9
3	74.3	145.6	152.5	6.9
4	69.3	147.6	154.5	6.9
Average	69.5	147.2	153.9	6.7**

** Significant at 1% level (F-test).

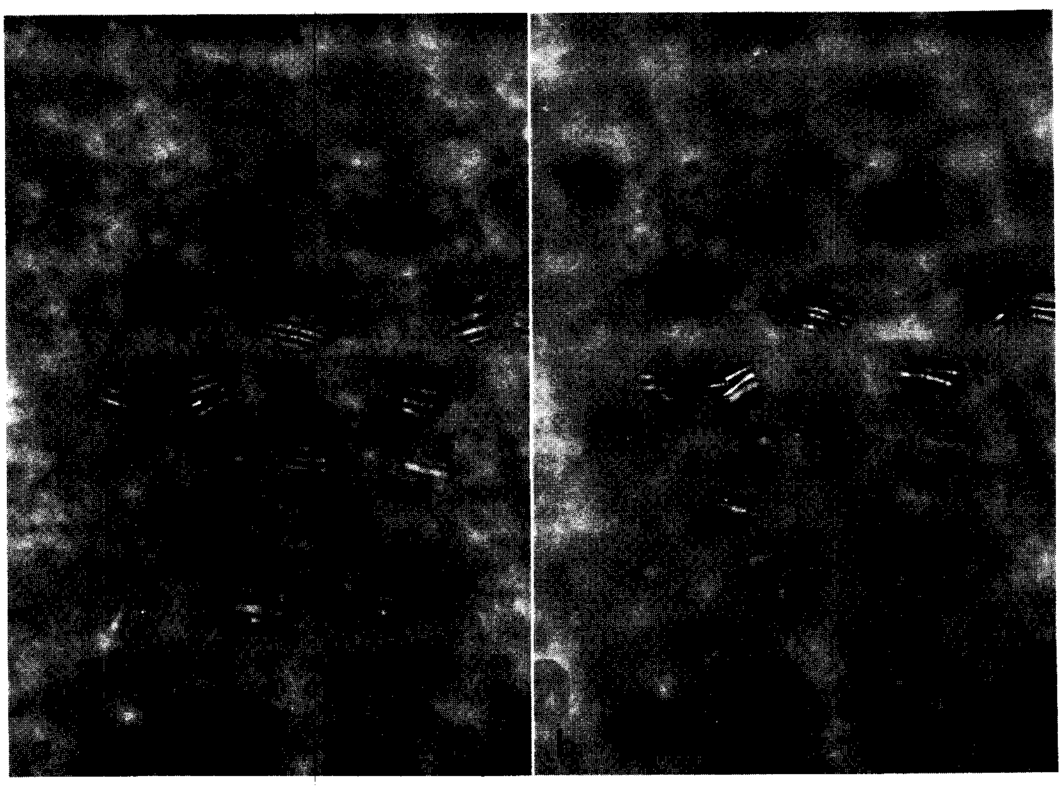

FIG. 2. Only one example of bars being broken was observed: 2a shows the wood green; 2b shows the same wood specimen air-dried; note the broken bar in one of the vessel openings.

readily removable upon evacuation (Cooper 1960; Smith 1954). However, the present research suggests that the air bubbles were removed in the second evacuation after the specimens were air-dried.

The "maximum-moisture-content" method of determining the specific gravity of wood depends upon obtaining the green saturated moisture content. Saturation is achieved by evacuating the immersed specimen (Stamm 1964). This result suggests that an air-dried specimen should be used instead of a green specimen. Furthermore, the specimen should be evacuated above the distilled water and then impregnated with water to reach the "maximum moisture content."

CONCLUSIONS

Air-drying and then rewetting increased the saturation moisture content of the yellow-poplar by eliminating the air bubbles entrapped in the green specimens. Eliminating air-blockage would account for the increased permeability.

Because only one bar in the scalariform plates was broken, air-drying probably does not increase longitudinal permeability by changing vessel openings.

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