Studies on the Dimensional Stabilization of Wood. XI

Location of the Mycelium in Balsa Wood Tissues Treated with Hydrogen Chloride-formaldehyde after Compulsive Decay Test*

Akinori UEYAMA**
Wood chemistry, Section 3 Mikio ARAKI
Wood physics, Section 1 Teruo GOTŌ

上山昭則・荒木幹夫・後藤輝男：木材の Dimensional Stability に関する研究（第11報）
強制腐朽試験に供した塩化水素—ホルムアルデヒド処理材の組織内における菌糸の行動

Introduction

In the previous paper of this series, the experiment on the improvement of dimensional stability and decay resistance through hydrogen chloride-formaldehyde treatment of wood was reported[3]. As shown in Table 1, Balsa wood (*Ochroma lagopus* SWARTZ), which is one of the lightest commercial wood in specific gravity, has less resistant for fungal attack. Furthermore, the grade of formalization of Balsa wood seems to relatively low when compared with that of MAKANBA or HINOKI wood.

Table 1. Improvement of decay resistance of wood treated with hydrogen chloride-formaldehyde (UEYAMA et al., 1961)[3].

Formaldehyde treatment	Fungi employed	Residual dry weight after compulsive decay test (%)		
		Balsa wood	HINOKI wood	MAKANBA wood
(−)	*P. vaporaria*	76.9	99.5	68.5
	T. sanguinea	23.6	101.2	53.6
(+)	*P. vaporaria*	98.6	102.3	99.1
	T. sanguinea	69.6	101.6	100.7

From this standpoint, an employment of Balsa wood as sample block is suitable not only for the preparation of thin section and the observation of mycelium in wood tissues, but also for the certification of formalization up to central part of sample blocks.

In the present paper, some observations on the location of the mycelium in

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** Laboratory of Phytopathology, College of Agriculture, Kyoto University, Kyoto.

Balsa wood tissues treated with hydrogen chloride-formaldehyde after compulsive decay test were carried out using the sample blocks of the same plot as previously reported[3].

Material and Method

The size of sample wood block : 1.5×1.5×3.0 cm (fibre direction)

The procedure of formalization to wood was reported elsewhere[3].

Fungi employed : *Poria vaporaria* (brown rot fungus)
Trametes sanguinea (white rot fungus)

After compulsive decay test (28±1°C, 75 days duration), the thin section of sample blocks was obtained with sliding microtome techniques, fixed with formaline-acetic acid-alcohol solution, stained with cootton blue solution, sealed with Canada balsam, and then observed under microscope. These results are as follows (Figs. 1-8).

Results and Considerations

The typical invading pathway of the mycelium of wood rotting fungi into non-treated Balsa wood tissues are shown in Fig. 1. The fungus employed here is *Stereum frustulosum*. The same tendency of mycelial behavior as *S. frustulosum* in non-treated wood was also observed in *T. sanguinea* and *P. vaporaria* (Figs. 2-4).

The mycelium proceeded from vessel elements into ray cells, and finally penetrated into wood fibres resulting the decrease of mechanical strength of wood[4].

After compulsive decay test of formaldehyde treated wood, some difference on the location of the mycelium in wood tissues was observed. They may be classified under four types.

Type 1 : The mycelium is floating on the surface of the sample blocks, but does not invade into wood tissues (Fig. 5).

Type 2 : The mycelium proceeds up to vessel cells, but further invasion into other wood tissues is not occured (Fig. 6).

Type 3 : The mycelium proceeds up to ray cells via vessels (Figs. 7-8).

Type 4 : The mycelium proceeds up to some of wood fibres, but the density of the mycelium in invaded wood fibres is lower than that of non-treated wood tissues.

The frequency of four types observed under microscope are as follows (Table 2).

After compulsive decay test of formaldehyde treated Balsa wood, 75% of the mycelium of *P. vaporaria* behaved as Type 1 (Fig. 5).

Table 2. The frequency of four types of mycelial location in formaldehyde treated Balsa wood after compulsive decay test.

Type	Frequency observed under microscope (%)	
	P. vaporaria	*T. sanguinea*
1	75	40
2	15	35
3	5	20
4	5	5

This seems to be the cause to bring about high residual dry weight after the decay test. In *T. sanguinea*-plots, 45, 35 and 20% were given in Type 1, 2 and 3 respectively. *T. sanguinea* differs from *P. vaporaria* on metabolic physiology, especially on the oxidative activity of polyphenol substances in wood tissues. *T. sanguinea* belongs to white rot fungus, while, *P. vaporaria* belongs to brown rot fungus.

According to the unpublished data of the author's experiment, the relations between fixed formaldehyde and logarithmic decrement suggest that formaldehyde treatment gives rise to less orientation of chain molecules and induces the defective structure which results in inhomogenities in stress distribution.

The frequency of Type 4 is 5%. This shows the partial insufficiency of formalization up to central part of Balsa wood tissues when compared with the surface of wood blocks. But, good results in residual dry weight after decay test were obtained from formaldehyde treated MAKANBA and HINOKI wood[3]. In fact, it is very difficult to dissolve the formaldehyde treated wood element into solution by SCHWEIZER's reagent.

As shown in Table 1, the virulence of *T. sanguinea* for both non-treated and treated wood is stronger than that of *P. vaporaria.*

The result suggests that the grade of the improvement of decay resistance in crystalline region is better than that in amorphous region through formalization of wood elements. This fact is also supported by the previous report of the author's experiment on the hygroscopicity of formaldehyde treated wood that most of the lost surface was caused by cross-links between sorptive sites in primary surface followed by closure of additional secondary surface[2].

The search started from three directions, i.e. physical, chemical, and microbiological standpoint, supports the finding which has been reported on the mechanism of dimensioanl stabilization of wood through hydrogen chloride-formaldehyde treatment[1,2].

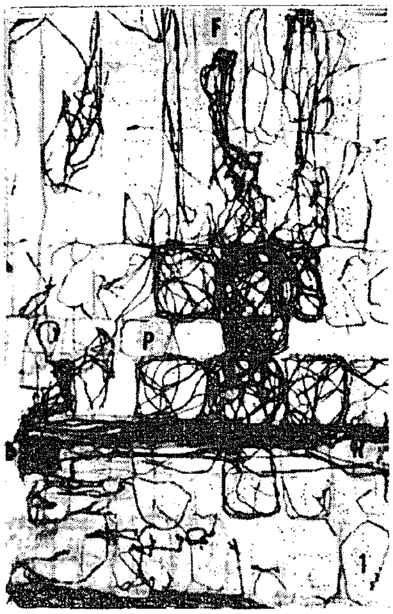

Fig. 1.

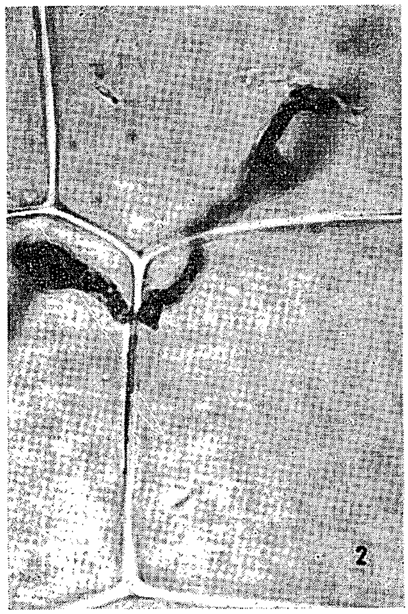

Fig. 2.

Fig. 3.


Fig. 4.

Explanations of the Figures

Abbreviation F : wood fibre

M : mycelium of wood rotting fungus R : wood ray cell

P : wood parenchyma cell V : vessel element

Fig. 1. Typical invading pathway of the mycelium of wood rotting fungi (non-treated Balsa wood infected by *Stereum frustulosum*). (190×)

Fig. 2. The mycelium passing through wood cell wall of parenchyma cells (non-treated Balsa wood infected by *Trametes sanguinea*). (600×)

Fig. 3. Location of the mycelium in parenchyma cells (non-treated Balsa wood infected by *Poria vaporaria*). (600×)

Fig. 4. The mycelium in wood fibre cells (non-treated Balsa wood infected by *T. sanguinea*). (490×)

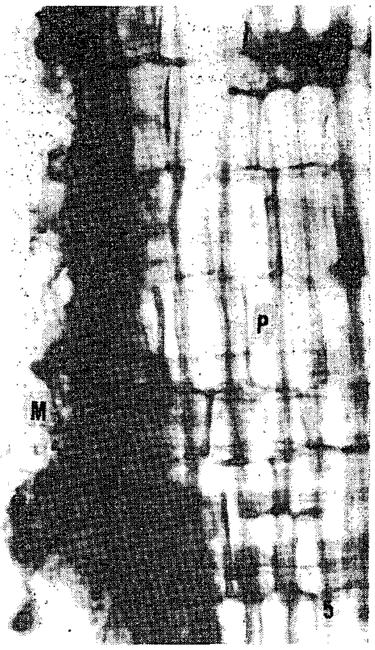

Fig. 5.

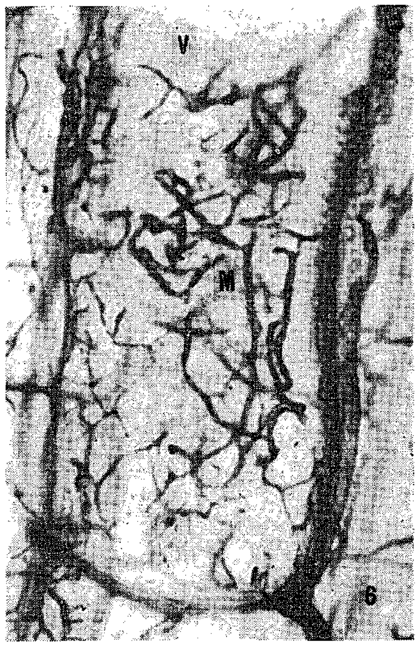

Fig. 6.

Fig. 7.

Fig. 8.

Fig. 5. The mycelium is floating on the surface of sample blocks, and does not invade into wood tissues (hydrogen chloride-formaldehyde treated Balsa wood infected by *P. vaporaria*). (190×)

Fig. 6. The mycelium in vessel element (hydrogen chloride-formaldehyde treated Balsa wood infected by *T. sanguinea*). (490×)

Figs. 7 and 8. The mycelium in ray cells or wood parenchyma cells (hydrogen chloride-formaldehyde treated Balsa wood by *T. sanguinea*). (490×)

Finally, let us consider the significance of the use of wood rotting fungi in the study of this series. One reason is as follows. Wood rotting fungi are uninvited guest for tree and wood products. To study the improvement of decay resistance, the compulsive decay test may be performed in laboratory level[4]. However, this is not all wood rotting fungi have. Another reason is the use of wood rotting fungi as an analytical tool to know constitutional and functional characteristics of modified wood or wood elements.

Some attention in the use of wood rotting fungi or their enzymes must be attracted as a kind of organic reagents. Further study of this field is necessary.

Summary

After compulsive decay test using the same Balsa wood treated with hydrogen chloride-formaldehyde as reported in previous paper[3], thin section was prepared with sliding microtome techniques and observed to ask for the location of the mycelium in wood tissues. The mycelium of *T. sanguinea*, which belongs to white rot fungus, is able to penetrate up to some of fibres, while, the mycelium of *P. vaporaria*, which belongs to brown rot fungus, is limited up to vessels. This suggests the difference in residual dry weight between *T. sanguinea* and *P. vaporaria* after compulsive decay test of formaldehyde treated Balsa wood.

Literature Cited

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摘　　要

塩化水素—ホルムアルデヒド処理バルサ材を強制腐朽試験に供したとき材組織内で菌糸がどのような行動をとるかを観察した。バルサ材は，ヒノキあるいはマカンバ材に比してホルムアルデヒド処理効果はややおとるが切片作成が容易であるので採用した。その dimesional stability と耐朽性についてはすでに発表した。

試料は滑走式ミクロトームをもちいて約 30μ の切片として観察した。

無処理材組織内の菌糸は道管→放射組織細胞→木部柔細胞→木部繊維の順にきわめて容易に侵入する。ホルムアルデヒド処理材では，菌糸は材表面をうすくおおうが，組織内における菌糸の行動はやや異なる。すなわち腐朽初期には，1) 道管から侵入した菌糸は塊状をなして，以後放射組織細胞に侵入しない場合,（ワタグサレタケ—林試標準菌—に多い），2) 木部柔細胞

までは入るが，それ以後木部繊維への侵入がさまたげられる場合（ヒイロタケに多い）がある。強制腐朽75日後の一部の材では菌糸が木部繊維にまで侵入しているときもみとめられた。しかし菌糸の分布密度は無処理材に比して低い。

なおホルムアルデヒド処理にもとづく木材細胞膜の微細構造の変化と菌糸侵入との関係についてはさらに研究を要する。