Preliminary

Dimensional Change of Wood by Chemical Treatment*[1]

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The value of anti-swelling efficiency (ASE) has been used to evaluate the degree of dimensional stability of chemically treated wood. However, in order to investigate the relationship between the structure and properties of chemically treated wood, it is also essential to know the dimensional change of wood by the treatment. In this paper, the dimensional change of wood by chemical treatment and the swelling of treated wood by water absorption were analyzed.

Hinoki wood *(Chamaecyparis obtusa)* specimens, 50 mm (R) by 50 mm (T) by 5 mm (L), were used. After extracted with a methanol-acetone mixture and oven-dried, they were subjected to nine kinds of chemical treatments[1]. The treated specimens were oven-dried and then soaked in water until saturated. At each stage, the dimensions of specimens in T, R and L directions were measured. Dimensional changes of specimens were evaluated using the swelling coefficient, the ASE and ASE′ values. The ASE value was defined by $100(S_U-S)/S_U$, where S_U was the volumetric swelling coefficient of untreated wood between a dry state and a wet state and S was the value of treated wood under the same conditions. The ASE′ value was defined by $100(S_U-S')/S_U$, where S' was the volumetric swelling coefficient of treated wood calculated on the basis of the dimension of oven-dried specimen before treatment. An ASE′ value of 100% means that the dimension of specimen remains unchanged not only by chemical treatment but also by soaking in water after the treatment, whereas an ASE′ of 0% means that the dimension of treated specimen is equal to that of untreated specimen in a wet state.

Figure 1 shows the relationship between the swelling coefficients in R and T directions. Open circles indicate the swelling coefficients by chemical treatments and closed circles

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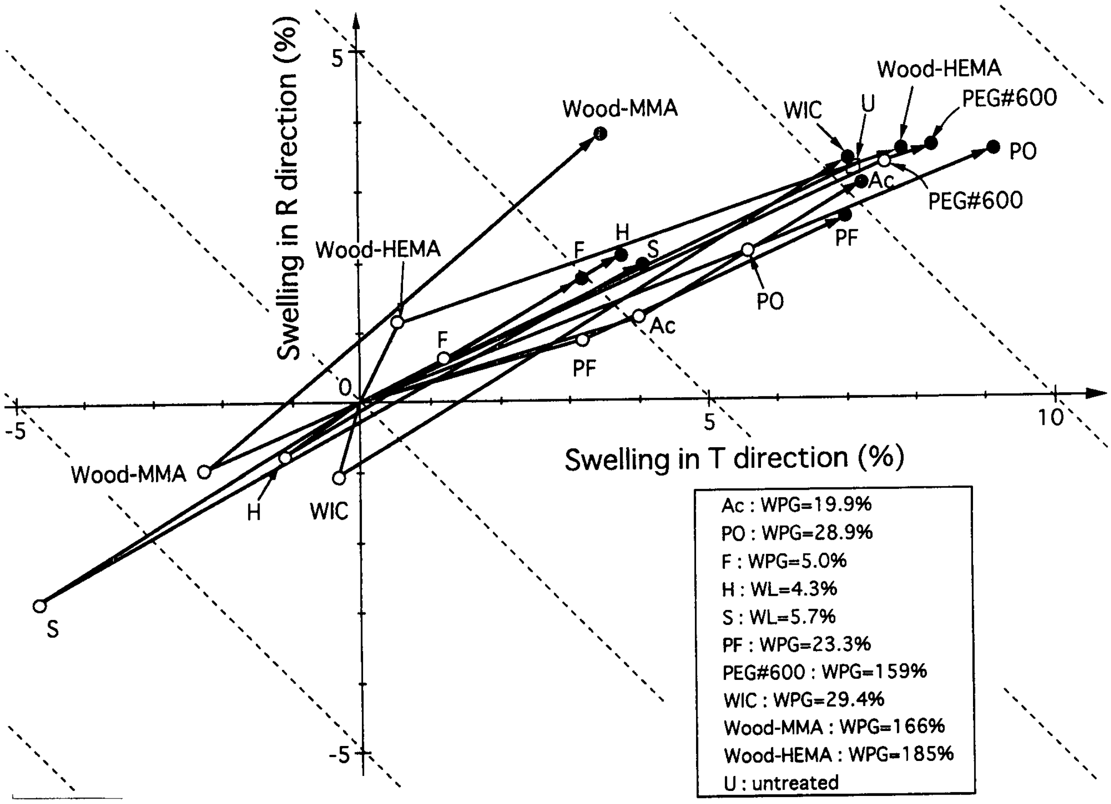

Fig. 1. Relationships between swelling coefficients in R and T directions.
Legend: ○: chemical treatment, ●: soaking in water, □: untreated.

indicate those by soaking in water after treatments. These values were calculated on the basis of the dimensions of untreated specimens. For comparison the result of untreated specimen (U) is also shown in Fig. 1. The swelling coefficient in L direction was so small compared to those in R and T directions that the volumetric swelling coefficient could be represented by the sum of those in R and T directions. Dotted lines in Fig. 1 show equal volumetric swelling coefficient lines. Intersecting points of dotted lines and the axis of abscissas express volumetric swelling coefficients. Figure 2 shows the relationships between the ASE and ASE′ values for chemically treated specimens having different weight gains or losses. Acetylation (Ac) and polyethylene glycol impregnation (PEG♯600) showed small ASE′ values and large ASE values. These results showed that chemicals used in both treatments were introduced into the cell wall and this bulking led to a decrease in additional swelling by water. Propylene oxide treatment (PO) showed negative ASE′ values. This fact suggested that the treatment reduced the hoop effect of the S_1 layer in the cell walls. The ASE value increased with increasing weight gain up to about 30% and then showed a reduction. This reduction could be explained by check formation in the cell walls by the treatment[2]. Vaporous formalization (F) and heat treatment (H, 180°C; 3–48 hr) showed positive ASE′ and ASE values. It was speculated that a bridge was formed between

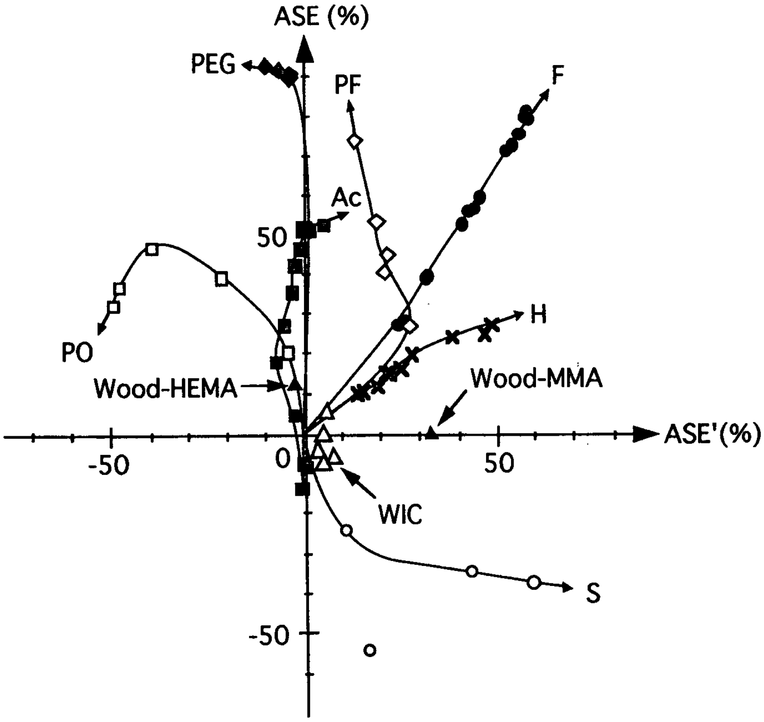

Fig. 2. Relationships between the ASE and ASE′ values for nine kinds of chemical treatments of hinoki wood.
Note: Weight gain and loss increase along an arrow.

adjacent OH groups by formalization and some cohesive structure was formed in the cell walls by heating. Although phenol-formaldehyde resin impregnation (PF) showed positive ASE′ and ASE values, the ASE value increased and the ASE′ value decreased with increasing weight gain in large weight gains. An increase in ASE′ and ASE values in small weight gains was considered to be due to the formation of some cohesive structure in the cell walls by the presence of a rigid benzene ring in the resin backbone and an increase in the ASE value with a decrease in the ASE′ value in large weight gains due to the bulking of the cell walls as is the case of Ac and PEG#600. In steam treatment (S, 140–180°C; 10 min, 200°C; 5 min), the ASE′ value was positive and the ASE value was negative. This result suggested that specimens contracted remarkably during drying because of the extraction of cell wall constituents by steaming and expanded remarkably in additional swelling by water. The ASE′ value of wood-inorganic composite (WIC, $Ba_3(PO_4)_2$, $BaHPO_4$) was almost 0%. This fact indicated that inorganic agent was not introduced into the cell walls, but deposited in the cell lumens. In the preparation of WPC specimens, methylmethacrylate (MMA) and hydroxyethylmethacrylate (HEMA) were used. The wood-MMA composite showed a positive ASE′ value and an ASE value of 0%, while the wood-HEMA composite showed a positive ASE value and an ASE′ value of 0%. These results suggested that a MMA solution was rarely introduced into the cell walls for its hydrophobic nature and MMA in the cell lumens contracted during polymerization, while a little amount of HEMA solution could be introduced into the cell walls for its hydrophilic nature and HEMA did not show the volumetric change during polymerization.

References

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