Study on the aging mechanism of wood and its application
- Analysis of color properties by comparing the accelerated aging wood with the natural aging wood from historical buildings –

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Introduction

The deterioration of wood as a material is due to biodegradation, weathering, and aging. In appropriate conditions which can avoid biodegradation and weathering, the service life of wood can exceed a thousand years and aging becomes a main source of the wood deterioration. The elucidation of wood aging mechanism is important not only for the preservation and restoration of wooden historical buildings but also for basic wood research which provides the effective use of wood materials. Though some empirical data have suggested that wood aging is a mild thermal oxidation at room temperature, a few papers have reported on its theoretical evaluation and the detailed mechanisms. On the other hand, sculptors and carpenters have used the color of wood as a criterion of aging. This may be because the color properties conspicuously express the aging of wood. This study deals with the aging on wood color; the color changes of natural aging wood were compared with those of accelerated aging wood by using the kinetic analysis to discuss the mechanism of color change during aging. In addition, color changes of cellulose were also compared with those of wood to evaluate the contribution of cellulose to the color changes of wood.

Materials and Methods

Specimens for accelerated aging were cut out from 360-years-old Hinoki (*Chamaecyparis obtusa* Endl.) from Kiso, Japan. Oven dried specimens were heated in an air-circulating oven at 90, 120, 150, and 180 °C for a duration ranging from 0.5 hour to approximately 2 years. Natural aging wood samples were cut out from eight natural aging wood samples collected from historical buildings. The aging times of these samples, which were determined by dendrochronology and radiocarbon dating, ranged from 569 to 1573 years. Cellulose specimens (Whatman No.1 filter paper, made of cotton cellulose) were heated in an air-circulating oven at 180 °C. The color of the specimens was measured with a spectrophotometer (KONICA MINOLTA CM-2600d). The CIELAB color parameters (L^*, a^*, b^*) and the color differences (ΔE^*_{ab}) were used for the analysis. Three locations in each specimen were measured, and the average color values with the standard deviations were calculated.

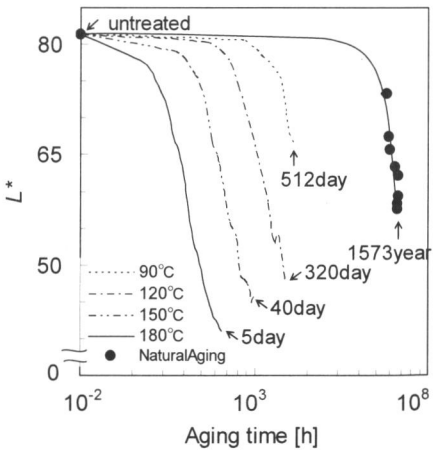

Figure 1. Changes of L^* during natural aging and accelerated aging as a function of aging time.

Results and Discussion

Figure 1 shows the changes of L^* during accelerated aging and natural aging wood samples as an example. Similar behaviors were observed irrespective of accelerated aging or natural aging, suggesting that the same processes might cause these color changes. The Arrhenius plots, which described the relationship between the changes of L^* during accelerated aging and heating temperature, were extrapolated to an ambient temperature to predict the changes during natural aging. By comparing the natural color changes with the prediction, it was concluded that color changes during natural aging were mainly explained as a thermal oxidation process. This conclusion was supported by the result that color changes of heat-treated natural aging wood exhibited the similar behavior with that of accelerated aging wood. However, the natural color changes were somewhat faster than the prediction. The color changes of cellulose heated at 180 °C showed the similar behavior with that of natural and accelerated aging wood. This result indicates that cellulose is one of major components that contribute to wood color change during aging.