

## Natural Weathering of Wood Heat-Treated at 220 °C<sup>1</sup>

Ho-Yang Kang<sup>2</sup>

### ABSTRACT

When wood is exposed to natural weathering and UV radiation discoloration progresses. The color variation of heat-treated wood was investigated. Four domestic species were selected and heat-treated at 220 °C and naturally weathered for 42 days. Their colors were measured with a portable colorimeter. The color variations were different between species. The Korean red pine specimens were highly discolored by the natural weathering even though they were heat-treated. In contrast to Korean red pine, Korean pine is less discolored. The maximum color difference of larch was lower than Korean red pine. All specimens of birch exceeded the color difference criterion of 15 after 25 hours with the maximum of 28.

**Key words:** Heat treatment, natural weathering, *Pinus densiflora*, *Pinus Koraiensis*, *Larix kaempferi*, *Betula platyphylla*, colorimeter, CIE Lab.

### INTRODUCTION

A heat-treatment apparatus was recently made and was used to develop color-change technology for domestic species, such as Korean red pine, Korean pine, and Larch (Kang 2008a). Their colors were turned dark brown when heat-treated at 220 °C for 10hr. That the heat-treatment also improves the dimensional stability of wood was proved by using a saturated salt solution method (Kang 2008b).

Heat-treated wood is good for outdoor construction due to its improved dimensional stability. But rain and UV discolor wood. Lignin between cellulose is photo-chemically degraded and washed out easily. Cellulose left on wood surface results in the increase of hygroscopicity (Kalnins and Feist 1993).

Yata et al. (1995) investigated the progress of check development on the surfaces of cypress logs exposed to natural weathering. It was found that small checks developed in the beginning of weathering due to the combination reaction of rain and UV of less than 500 nm. They started from ray tissues and grew up by collapse of surface cells. They reported that the color of the photo-degraded area became gray to 0.2 mm deep after 6 months, and did not change any more afterward.

Hon and Feist (1986) conducted natural weathering and UV radiation tests for 51×51×19 mm

---

Received for publication: July 30, 2008.

1) This study was supported by Technology Development Program of the Ministry of Agriculture and Forestry, Republic of Korea.

2) College of Agriculture, Chungnam National University, Daejeon 305-764, Korea. Email: hykang@cnu.ac.kr.

specimens of red oak, yellow poplar, sweetgum and white oak. Both tests resulted in discoloration and the loss of lightness, progressing slower in white oak and sweetgum than in red oak and yellow poplar. It was observed that the surface cells were degraded in 30 days with sunlight and in 500 hours with UV radiation.

It was revealed that the discoloration of wood UV irradiated at high humidity was more marked than at low humidity (Mitsui et al. 2001).

Chemical modification with anhydride acetic acid and formaldehyde reduced the discoloration of wood exposed to natural and accelerating weather (Kang et al. 2003). It was reported that acetylation reduced significantly the loss of hemicellulose caused by weathering (Feist et al. 1991).

In this study the color variation of wood heat-treated at 220°C and naturally weathered was investigated.

## MATERIAL AND METHODS

Domestic species selected for this study were Korean red pine (*Pinus densiflora* S. et Z.), Korean pine (*Pinus Koraiensis* S. et Z.), Japanese larch (*Larix kaempferi*), and birch (*Betula platyphylla* Var. *japonica*). Heat-treatment procedure was the same as in the previous papers (Kang, 2008a; 2008b).

All logs were sawn into 30mm-thick boards and they were cut 800 mm long. All boards were end-coated with PVAc polymer glue and air-dried in shed for 3 months. Heat treatments were conducted at 220 °C with the equipment recently made (Kang, 2008a). The heat treatment intervals applied for this study were 2, 4, 6, 8, 10, 12 hours.

The heat-treated boards were cut into 100 mm wide and 200 mm long specimens. They were exposed to sunlight on the roof of a building for 42 days from July 30th, 2005 (Fig. 1).

The color of the specimens was measured with a HunterLab MiniScan XE Plus. Its light source was Xenon flash lamp with a wave length of 400-700 nm. Three measurements were taken from each specimen.



Fig.1. A photo of weathering specimens.

## RESULTS AND DISCUSSION

### *Korean red pine*

Before weathering serious differences in lightness ( $L^*$ ) were found between the heat treatment times, but disappeared after 42 day weathering (Fig. 2). It was interesting to notice that the lightness of 12-hour specimen was consistent during the test.

The redness ( $b^*$ ) decreased from the beginning to 25 days, and then leveled off. However the variations between the heat treatment times did not change much during the test. The yellowness ( $a^*$ ) showed the same pattern as the redness.

At 20 days the color difference indexes ( $E$ ) of all specimens except RP220/12 exceeded 15, a criterion above which the colors are distinctively different. In general the Korean red pine specimens were highly discolored by the natural weathering even though they were heat-treated.

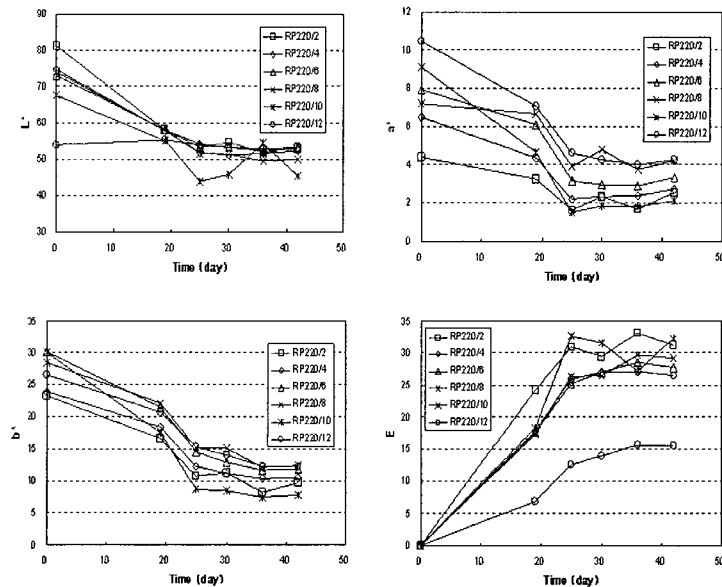


Fig.2. Color variation of Korean red pine specimens heat-treated at 220 °C and naturally weathered for 42 days.

### *Korean pine*

There were significant differences in lightness between the specimens before weathering (Fig. 3). The lightness of all specimens was stabilized after 25 days, but the discrepancy between the specimens still existed.

The variance of the redness between the specimens was great before weathering, but was decreased after 20 days. Their redness was stabilized after 25 days.

The yellowness of the specimens showed a different pattern from their redness. It was somewhat uniform before the natural weathering, but gradually decreased until 42 days.

In contrast to Korean red pine, only one specimen, KP220/2, exceeded the color difference criterion of 15, which implies that Korean pine is less discolored by UV radiation.

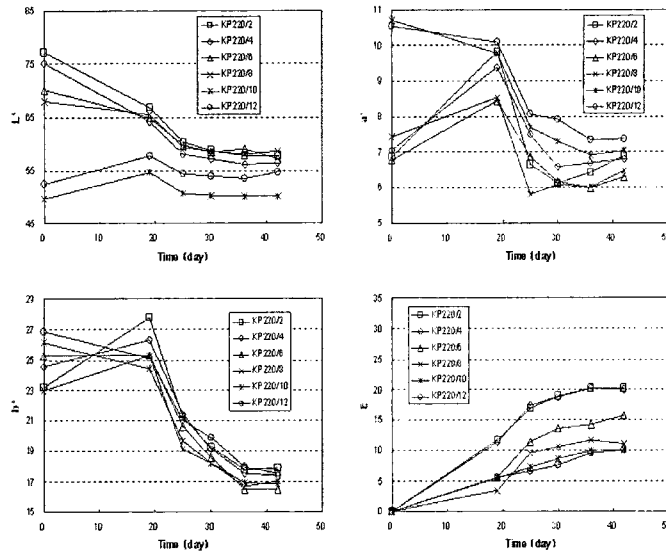


Fig.3. Color variation of Korean pine specimens heat-treated at 220 °C and naturally weathered for 42 days.

*Larch*

It is interesting to notice that the lightness of the specimens heat-treated for 10 and 12 hours was much lower than the others before the natural weathering, but they converged after 20 days (Fig. 4). The lightness was stabilized after 25 days, but discrepancy between the specimens still existed.

The redness changed steeply until 35 days, and then was stabilized. In contrast, the yellowness decreased gradually until 42 days.

The color difference of all specimens exceeded 15 after 25 days. The maximum color difference was 25, which was lower than Korean red pine. It may be attributed to the fact that the color of the untreated larch specimen is more reddish than Korean red pine.

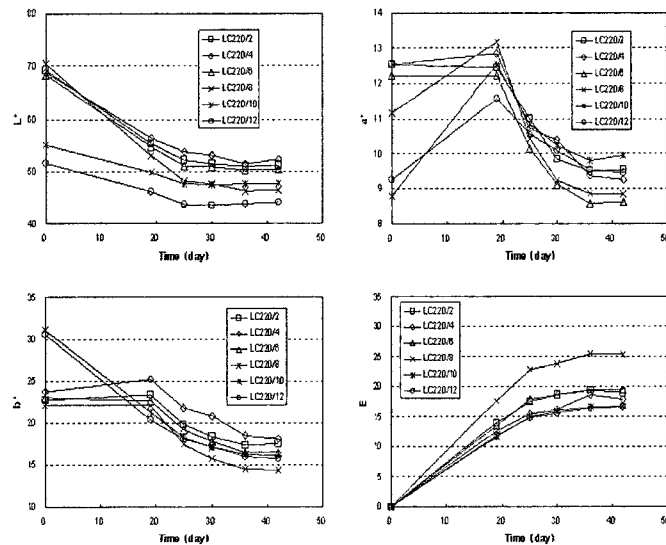


Fig.4. Color variation of larch specimens heat-treated at 220 °C and naturally weathered for 42 days.

### Birch

The lightness was diverse between the specimens before the natural weathering, and converged after 20 days (Fig. 5). It was consistent and stabilized after 25 days.

The redness of the specimens steeply decreased until 25 days and then was stabilized, but the differences between the specimens still existed after 42 days.

The yellowness of the specimens gradually decreased until 30 days and then was stabilized as the redness.

All specimens exceeded the color difference criterion of 15 after 25 hours with the maximum of 28.

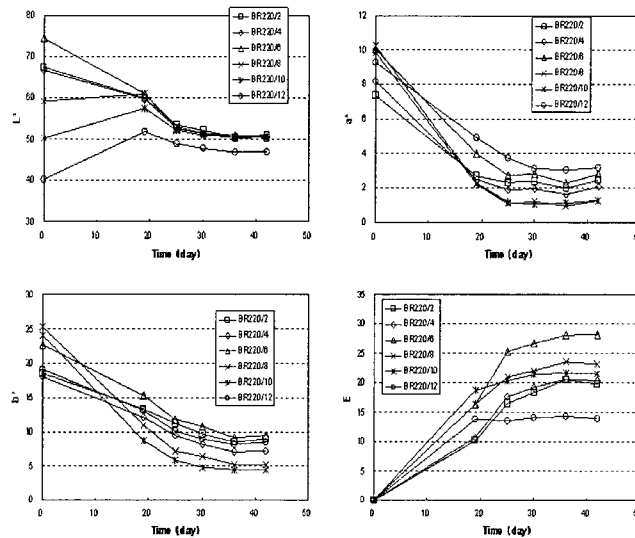


Fig. 5. Color variation of birch specimens heat-treated at 220 °C and naturally weathered for 42 days.

### SUMMARY

Four domestic species were heat-treated at 220 °C and their color variation was investigated during naturally weathered. The Korean red pine specimens were highly discolored by the natural weathering even though they were heat-treated. In contrast to Korean red pine, only one specimen, KP220/2, exceeded the color difference criterion of 15, which implies that Korean pine is less discolored by UV radiation. The maximum color difference of larch was 25, which was lower than Korean red pine. It may be attributed to the fact that the color of the untreated larch specimen is more reddish than Korean red pine. All specimens of birch exceeded the color difference criterion of 15 after 25 hours with the maximum of 28.

### REFERENCES

- Feist, William C., R. M Rowell and W. D. Ellis. 1991. Moisture sorption and accelerated weathering of acetylated and methacrylated aspen. *Wood Fiber Sci.* 23(1): 128-136.
- Hon, D. N.-S. and W. C. Feist. 1986. Weathering characteristics of hardwood surfaces. *Wood Sci. Technol.* 20: 169-183.

Kalnins, M. A. and W. C. Feist. 1993. Increase in wettability of wood with weathering. *Forest Products J.* 43(2): 55-57.

Kang, H. Y. 2008a. Development of Color Changing Technology for Domestic Softwood. *J. Korea Furnit. Soc.* 19(3): 156-162.

Kang, H. Y. 2008b. Hygroscopicity and Surface Hardness of Domestic Wood heat-Treated at 220 °C. *J. Korea Furnit. Soc.* 19(4): 229-234.

Kang, H. Y., S. W. Kim and S. J. Park. 2003. Weathering of *Prunus sargentii* specimens modified with acetic anhydride and formaldehyde vapor. *MokJaeKonhak.* 31(5): 57-64.

Mitsui, K., H. Takada, M. Sugiyama and R. Hasegawa. 2001. Changes in the properties of light-irradiated wood with heat treatment. *Holzforschung.* 55(6): 601-605.

Yata S. and T. Tamura. 1995. Histological changes of softwood surfaces during outdoor weathering. *Mokuzai Gakkaishi.* 41(11): 1035-1042.

## Membership Admissions Fee Information

This society is managed based on the admission fee of our members. Please send us the 2008 admission fee to below address. Furniture Society Membership Admission Fee Information

President	200,000 won/ year
Vice President/ Library Member / Company President	100,000 won / year
Executive Director / General Director	50,000 won / year
Standard Member	10,000 won / year
Joining Admission Fee	10,000 won / year
Account No. 110-215-381700 (Shinhan Bank)	
Account Holder: Su Kyoung Chun (Korea Furniture Society)	