J Wood Sci (2000) 46:470–476

NOTE

Song-Yung Wang · Ming-Jer Tsai

Assessment of temperature and relative humidity conditioning performances of interior decoration materials in the Taipei area (II)

Received: July 16, 1999 / Accepted: December 15, 1999

Abstract The purpose of this study was to explore the conditioning effects of wood panels (used as interior decorating materials). We examined hourly the temperature and relative humidity (RH) in a living environment based on the average values during winters from 1974 to 1990 in the Taipei area. Thirty-six interior finish materials attached to one inside surface of a 35 cm^3 simulation aluminum container were used in this study. An A/V value (surface area of interior decoration materials attached to container/inside volume of container) of 2.86 m^{-1} or various other A/V values and panel thicknesses had no significant effect on the room temperature changing ratio. The hygroscopic conditioning performances of these decorative materials were classified into four types in accordance with b values: type I ($b > 0.0200$) included four solid woods (unfinished), two wood-based materials, three composite materials, and one inorganic material. Type II ($0.0170 < b < 0.0199$) included one solid wood, eight wood-based materials, and two inorganic materials. Type III ($0.0070 < b < 0.0169$) included 11 wood-based materials and four inorganic materials. The RH changing ratio decreased curvilinearly with increasing interior decorating panel thickness and A/V values in a sealed container, whereas b values increased with increasing interior decorating panel thickness and A/V values in a sealed container.

Key words Interior decorative materials · A/V values · Temperature changing ratio · Hygroscopic conditioning performance · Effectiveness of thickness

Introduction

It is highly desirable to live in a house with a safe, comfortable environment. In general, the interior climate of a living environment is controlled by a combination of room temperature, relative humidity (RH), air circulation, and heat radiation. It is recognized that these factors can be influenced by the design and construction of the building or house materials used and the facilities installed. However, when the relation between the materials used and the interior climate is considered, the effects of room humidity are greater than those of room temperature.

To explore the conditioning effects of interior decorating materials, Wang and Tsai[1] investigated 36 interior finish materials. The results revealed that an A/V value (surface area of interior decoration materials attached to container/inside volume of container) of 2.86 m^{-1} or various other values and the panel thickness had no significant effect on the room temperature changing ratio. For a better understanding of the conditioning effects of interior decoration with wood panels on the temperature and RH during different seasons in a living environment, we programmed the chamber used in our previous study,[1] first, using average hourly values temperature and RH changes during winters from 1974 to 1990 in the Taipei area. The same materials used in our former study were tested, and data were derived from measuring the temperature and RH changes inside the sealed container. The conditioning effects of various wood-based materials, thickness of wood panels, and A/V value on the changes of temperature and RH were evaluated.

Materials and methods

Materials

Thirty-six materials were investigated in this study, classified into four types: wood, wood-based material, composite material, and inorganic material. Their characteristics are

---

S.-Y. Wang (✉) · M.-J. Tsai
Department of Forestry, College of Agriculture, National Taiwan University, No. 1, Sec. 4, Roosevelt Road, Taipei, Taiwan, ROC
Tel. +886-2-23631736; Fax +886-2-23631736 or +886-2-23654520
e-mail: sywang@ccms.ntu.edu.tw.

Part of this report was presented at ICEUPT'99, Chi-Tou, Taiwan, ROC, May 21–23, 1999

depicted in Table 1. An aluminum container with no specimen inside was the control.

Methods

Effects of various materials on temperature and RH

Test specimens were cut into 35 × 35 cm blocks, with thicknesses varying with the materials. After conditioning at 20°C and 65% RH, the materials (one of each of the four types) were attached to one of the inside wall surfaces of a 35 cm^3 aluminum container and sealed with silicon. Only one surface of the test specimens toward inner space of the aluminum container was free of silicon. The A/V value inside the container was 2.86 m^{-1}. Because the thickness of the 36 interior decorative materials varied, when attached to one of the interior walls of the 35 cm^3 aluminum container the A/V values ranged from 2.87 to 2.99 m^{-1}, as shown in Table 1. These differences are due to the fact that the inside volume of the aluminum container slightly decreases with the increasing thickness of the interior decorating materials, resulting in a slight increase in the A/V value. The aluminum container was placed in a computer-controlled environmental chamber. The chamber temperature and RH were determined by the average hourly temperature and RH changes during winters from 1974 to 1990 in the Taipei area (Table 2). A temperature and RH detector was installed in the aluminum container. The data for temperature and RH variations were collected by a detector of the Labdas system, developed by Adventech Company, as shown in Fig. 1.

Effects of various thicknesses of wood panels on temperature and RH

Panels of Japanese cedar and red oak were chosen for evaluating the conditioning effects of various thicknesses of wood panels on temperature and RH. They were sliced into seven thicknesses: 0.3, 0.6, 0.9, 1.2, 1.5, 1.8, and 2.1 cm. The corresponding A/V values were 2.88, 2.91, 2.93, 2.96, 2.99, 3.01, and 3.04 m^{-1}, respectively. The inside volume of the aluminum container decreased slightly with the increasing thickness of the interior decorating materials, which resulted in a slight increase in A/V values. An aluminum container without a specimen was the control.

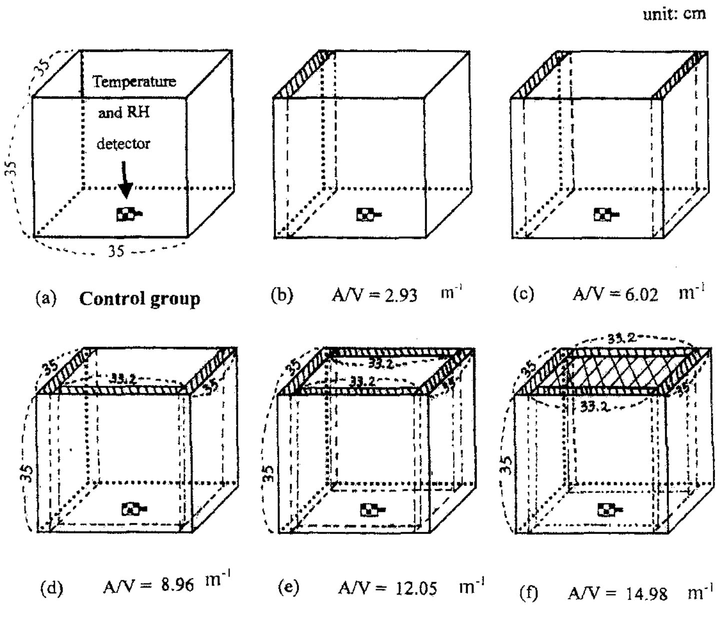
Effects of A/V value on temperature and RH

Japanese cedar and red oak panels (thickness 0.9 cm) were chosen to evaluate the conditioning effects of the A/V value on temperature and RH. They were attached to one, two, three, four, or five surfaces of the inner wall in a 35 cm^3 aluminum container, as shown in Fig. 1b–f. The A/V values inside the container were 2.93, 6.02, 8.96, 12.05, and 14.98 m^{-1}. An aluminum container without a specimen was the control (Fig. 1a).

Results and discussions

Efficiency index of conditioning effect on temperature and RH

In our former study[1] the ratio of indoor ΔT (difference of temperature between maximum and minimum values) to outdoor ΔT ($\Delta T_{indoor}/\Delta T_{outdoor}$) and the ratio of indoor ΔRH (difference of RH between maximum and minimum values) to outdoor ΔRH ($\Delta RH_{indoor}/\Delta RH_{outdoor}$) was used as an efficiency index of the temperature and RH (temperature and RH changing ratio). There was no conditioning effect on temperature and RH when the temperature and RH changing ratio equaled 1. The lower the ratio, the better was the conditioning effect of the interior decorating materials.



(a) Control group (b) A/V = 2.93 m^{-1} (c) A/V = 6.02 m^{-1}

(d) A/V = 8.96 m^{-1} (e) A/V = 12.05 m^{-1} (f) A/V = 14.98 m^{-1}

Fig. 1. Experimental aluminum box (35 cm^3) lined without any material (**a**) and with one, two, three, four, or five pieces of wood panels (**b–f**) in its inner wall. *A*, surface area of decoration material; *V*, inside volume of container

Table 1. Decorative materials used as linings in an aluminum container and their temperature and humidity conditioning performance indexes

Group	Specimen	Surface treatment	Thickness (cm)	A/V (m^{-1})	$\Delta T_1/\Delta T_2$	$\Delta RH_1/\Delta RH_2$	$\overline{T}$ (°C)	$\overline{RH}$ (%)	*b*
Solid wood									
1	Taiwan red cypress (flat-sawn face)	None	0.9	2.93	1.09	0.30	17.7	70.0	0.0238
2	Japanese cedar (flat-sawn face)	None	0.9	2.93	1.03	0.42	17.7	73.4	0.0193
3	China fir (flat-sawn face)	None	0.9	2.93	1.04	0.50	17.6	71.9	0.0208
4	Taiwania (flat-sawn face)	None	0.9	2.93	1.06	0.41	17.6	70.3	0.0248
5	Red oak (flat-sawn face)	None	0.9	2.93	0.95	0.15	17.4	71.7	0.0250
Wood-based materials									
6	Plywood	None	0.55	2.90	1.03	0.36	17.2	69.5	0.0172
7	Plywood	None	1.1	2.95	1.01	0.43	17.2	68.4	0.0171
8	Particleboard	None	1.2	2.96	0.85	0.97	16.9	78.7	0.0173
9	Medium density fiberboard (MDF)	None	0.8	2.92	1.01	0.67	17.4	75.6	0.0126
10	Fiberboard	None	0.4	2.89	0.98	0.66	17.3	73.2	0.0198
11	Insulation fiberboard	None	0.9	2.93	0.86	0.42	17.2	76.5	0.0197
12	Paper overlaid fiberboard	None	0.4	2.89	0.94	0.49	17.5	74.8	0.0198
13	Oriented strand particleboard (OSB)	None	0.9	2.93	0.97	0.67	17.6	73.0	0.0153
14	Fancy plywood	Coated with NC lacquer	0.7	2.92	0.92	0.52	17.3	77.7	0.0160
15	China fir panel	Coated with NC lacquer	0.2	2.87	1.00	0.64	17.4	75.3	0.0146
16	Maple flooring	Coated with PU	1.3	2.97	1.08	0.77	17.3	76.3	0.0117
17	Japanese cedar flooring	Coated with PU	1.5	2.99	0.95	1.00	17.4	74.7	0.0103
18	Red oak flooring	Coated with PU	1.5	2.99	0.99	0.82	17.2	77.6	0.0103
19	Plywood	Coated with NC lacquer	0.9	2.93	0.91	0.56	16.8	75.2	0.0151
20	Plywood	Coated with PU	0.5	2.90	0.91	0.68	16.9	71.9	0.0121
21	Fire-proof plywood	None	0.55	2.90	0.91	0.46	16.8	70.2	0.0268
22	Fire-proof plywood	77°C, 55% RH for 80 days	0.55	2.90	1.01	0.56	17.5	70.7	0.0175
23	Fire-retardant plywood	None	1.1	2.95	1.11	0.71	18.2	63.3	0.0279
24	Fire-retardant plywood	77°C, 55% RH for 80 days	1.1	2.95	1.04	0.58	17.7	63.5	0.0178
25	Polyester resin (PE) overlaid plywood	None	1.1	2.95	0.98	0.71	17.0	76.1	0.0116
26	Melamin resin (MF) overlaid plywood	None	0.8	2.92	0.99	0.58	17.1	74.6	0.0126
Composite materials									
27	Cemented excelsior board	None	1.4	2.98	0.97	0.63	17.6	69.9	0.0217
28	Insulation plaster fiberboard	None	1.5	2.99	0.96	0.57	17.0	73.4	0.0203
29	Perforated plaster fiberboard	None	0.8	2.92	0.97	0.36	17.0	76.2	0.0233
Inorganic materials									
30	Glass	None	0.5	2.90	0.92	0.81	17.2	77.1	0.0070
31	Fire-retardant plastic flooring	None	0.2	2.87	0.95	0.72	17.2	76.7	0.0116
32	Concrete board	None	1.4	2.98	0.98	0.56	17.1	76.1	0.0183
33	Concrete board	White cement paint coated concrete plate	1.4	2.98	0.98	0.60	17.0	75.7	0.0174
34	Tile	None	0.9	2.93	1.16	0.65	17.0	78.9	0.0161
35	Plaster board	None	1.0	2.94	1.01	0.72	17.2	74.3	0.0213
36	Marble	None	0.9	2.93	0.95	0.90	17.0	76.5	0.0072
Control group aluminum container									
37		None	–	–	0.99	0.99	17.1	77.9	0.0069
Climate condition									
38		None	–	–	–	–	16.4	78.9	0.0052

T, temperature; $\Delta T_1 = (T_{max} - T_{min})_{indoors}$; $\Delta T_2 = (T_{max} - T_{min})_{outdoors}$

RH, relative humidity; $\Delta RH_1 = (RH_{max} - RH_{min})_{indoors}$; $\Delta RH_2 = (RH_{max} - RH_{min})_{outdoors}$

$\overline{T}$ (°C) and $\overline{RH}$ (%), average temperature and RH, respectively, for 24 h, in a sealed container; A/V, surface area of interior decoration materials attached to container/inside volume of container; *b*, slope of line in Eq. 3; NC, nitrocellulose lacquer; PU, polyurethane resin

Table 2. Average values of hourly changing temperatures and relative humidity in the Taipei area, winter 1974–1990

Hour	t (°C)	RH (%)
1	15.5	83
2	15.3	83
3	15.2	84
4	15.1	84
5	15.0	84
6	14.9	84
7	14.9	84
8	15.3	83
9	16.1	80
10	17.1	76
11	17.9	73
12	18.4	71
13	18.5	70
14	18.3	71
15	18.0	72
16	17.6	73
17	17.1	75
18	16.7	77
19	16.4	79
20	16.2	80
21	16.0	81
22	15.9	81
23	15.8	82
24	15.6	83

t, temperature; RH, relative humidity

Influence of interior decorating materials on temperature and RH changing ratio

The temperature and RH changing ratios of various interior decorative materials (A/V 2.87–2.99 m^{-1}) under the designed conditions of the temperature cycle are summarized in Table 1. Generally, the changing ratios were seldom altered. A possible reason for these results were that the A/V value was 2.87–2.99 m^{-1}. The heat energy was transferred inward from the other five sides of the aluminum container owing to thermal conductivity, thermal convection, and heat radiation. Therefore, the temperature of the container was higher. Smaller RH changing ratios were found in the following test samples: five untreated solid woods of different species, plywood, insulation fiberboard, and perforated plaster fiberboard. Higher RH changing ratios were seen with the materials combined with or coated (sprayed) with adhesives, although their surfaces still had the characteristics of wood; these materials included fiberboard, particleboard, oriental strandboard (OSB), concrete board, and plaster fiberboard. When the surface of wood-based materials was treated with resin or inorganic material (e.g., glass, tiles, marbles), relatively larger RH changing ratios were seen.

The results of this study showed no significant differences from the results of our former study.[1] This might be due to the fact that the designed climate conditions in this study and in our former study were based on the average values of hourly temperatures and RH within 24 h on one day in a year (temperature 20.5°–25.2°C; RH 66.0%–85.0%) or during winter (temperature 14.9°–18.5°C; RH 70.0%–84.0%); therefore the changes in temperature and RH within 24 h are much less than those during 1 year (e.g., in 1991 the temperature was 12.2°–30.9°C and the RH 55.0%–90.0%).

Effect of panel thickness on the temperature and RH changing ratio

The changes in temperature and RH with time inside an aluminum container lined with Japanese cedar or red oak panel (A/V 2.88–3.04 m^{-1}) with different thicknesses on the temperature and RH can be summarized as follows: It was found that the $\Delta T_1/\Delta T_2$ ranged from 0.92 to 1.03 for Japanese cedar panels and from 0.87 to 0.99 for red oak panels. The values were similar to that for the control (0.99). The panel thickness showed poor conditioning performance, even though the winter climate data were used. The conditioning effects on RH showed that the $\Delta RH_1/\Delta RH_2$ value ranged from 0.09 to 0.42 for Japanese cedar panel with various thicknesses and from 0.11 to 0.45 for red oak panels. For the aluminum container without a specimen inside, the $\Delta RH_1/\Delta RH_2$ value was 0.99. It could be concluded that a wood panel thickness of as little as 0.3 cm was therefore enough to have a conditioning effect on the RH.

Effects of A/V value on the temperature and RH changing ratio

The changes in temperature and RH with time inside an aluminum container lined with Japanese cedar panels or red oak panels (thickness 0.9 cm) with various A/V values were as follows: The $\Delta T_1/\Delta T_2$ ranged from 0.91 to 1.04 for Japanese cedar panels and from 0.86 to 0.99 for red oak panels. The values were similar to that of the control (0.99). There was therefore no conditioning effect on temperature even when the A/V value reached 14.98 m^{-1}. In terms of the conditioning effect on the RH, the $\Delta RH_1/\Delta RH_2$ decreased as the A/V value increased. The $\Delta RH_1/\Delta RH_2$ values were 0.42–0.17 for Japanese cedar panels and 0.20–0.14 for red oak panels. For the aluminum container without a specimen inside, the $\Delta RH_1/\Delta RH_2$ was 0.99. Thus an A/V value as small as 2.93 m^{-1} provided a conditioning effect on the RH.

Index of humidity conditioning performances

In this study the method for estimating the conditioning effect was based on the hypothesis that the total vapor content in a closed space is equal to the moisture content in the material plus the absolute vapor content in the space. If a material had no conditioning effect, the contact surface in the space would show no moisture-absorbing power, and the absolute humidity in this system would remain constant. However, the saturated absolute humidity would increase exponentially with an increase in temperature. This relation can be expressed as:

$$hs(t) \fallingdotseq 6.26 \times 10^{0.022t} \tag{1}$$

where $hs(t)$ is the saturated absolute humidty (mmHg) and t is the temperature (°C). The relative humidity (RH) is defined as:

$$\mathrm{RH}\,(\%) = \frac{\text{absolute vapor pressure}}{\text{saturated absolute vapor pressure}} \times 100(\%) \qquad (2)$$

In general, the absolute humidity in a sealed environment is not influenced by nonhygroscopic materials, and hence its absolute humidity may remain constant. However, its saturated absolute humidity changes with the changes in temperature; hence the RH is changed. RH values decrease with increased temperature and vice versa.

For a hygroscopic material, the absorption and desorption phenomena occur and oscillate with the fluctuations of temperature and RH until reaching its equilibrium moisture content (EMC). Therefore, in a sealed environment when the temperature increases and the RH decreases, moisture is desorbed from the interior material, and the absolute vapor content increases. This situation is described as a desorption phenomenon. In contrast, the absorption phenomenon occurs when the temperature decreases and the RH increases in the sealed environment.

Because the absolute humidity cannot be changed as can the temperature in a sealed environment lined with nonhygroscopic material, the change in RH shows a tendency contrary to that of the temperature. For a sealed environment lined with hygroscopic material, the absolute humidity increases or decreases proportional to the change in temperature, but the RH shows no significant change. Therefore, the relation between the temperature and the logarithmic value of the absolute humidity in a sealed environment can be applied during a discussion of the conditioning effect as follows:

$$\log h(t) = \log h(a) + b \cdot t \qquad (3)$$

where $h(a)$ is the absolute humidity (mmHg) at temperature 0°C, $h(t)$ is the absolute humidity (mmHg) at temperature t°C, and b is the the slope of a linear equation. The logarithmic values of absolute humidity, $\log h(t)$, increase linearly with an increase in temperature; its relation can be represented by Eq. (4).

$$\log h(t) = 0.675 + 0.028t \qquad R^2 = 0.999^{**} \qquad (4)$$

With any temperature, the RH ($\varphi_{(\%)}$) is the ratio of water vapor pressure [$h(t)$, in mmHg] to saturated water vapor pressure [$h(s)$]. We can use the formula:

$$\varphi_{(\%)} = h(t)/h(s) \times 100 \qquad (5)$$

We then determine the absolute humidity, $h(t)$, by multiplying the saturated water vapor pressure, $h(s)$ (mmHg), by the RH ($\varphi_{(\%)}$). Because our data were the temperature and RH for each hour, we obtained the absolute humidity [$h(t)$] inside the container for each temperature using Eq. (4).

We found that the linear equations between logarithmic values for the absolute humidity and temperatures for various materials were highly significant at the 0.01 confidence level by the F-test. The b value varied with the material used, as shown in Table 1; hence this value can be used as an index to predict the material's humidity conditioning performance. When the b value was 0.022, the absolute humidity in a sealed environment increased with an increase in temperature, so the RH remained constant. This means that ΔRH = 0; that is, it exhibited a perfect humidity conditioning effect. If the b values were smaller, the absolute humidity could not be changed significantly, which means that the hygroscopic conditioning performance of the material was relatively poor. On the other hand, if the b values were higher, the material exhibited a significant hygroscopic conditioning performance. Based on these observations, the unfinished and non-resin-processed wood-based materials were the best for humidity conditioning. However, when the b value was >0.022, the materials with large b values had large RH values because the moisture in a material was desorbed during the period of temperature increase, which triggered an increase in absolute humidity owing to the initiation of the temperature increase.

The conditioning performances of investigated materials in our study were classified into four types in accordance with their b values.[2,3]

Type I ($b > 0.0200$ – best performance): Solid woods included Taiwan red cypress, China fir, taiwania, and red oak; fire-proofed plywood (retention 70 g/m^2); fire-retardant plywood (retention 69 kg/m^3); cemented excelsior board; insulation plaster fiberboard; perforated plaster fiberboard; and plaster board.

Type II ($0.0170 < b < 0.0199$ – good performance): Japanese cedar, plywood, particleboard, fiberboard, insulation fiberboard, paper overlaid fiberboard, heat-treated (77°C and 55% RH for 80 days) fire-proofed and fire-retardant plywood, concrete board, and white cement-paint-coated concrete plate.

Type III ($0.0070 < b < 0.0169$ – fair performance): medium-density fiberboard (MDF), OSB, nitrocellulose lacquer (NC)-coated fancy plywood, NC-coated China fir panel, polyurethane resin (PU)-coated maple flooring, PU-coated Japanese cedar flooring, PU-coated red oak flooring, NC-coated plywood, PU-coated plywood, polyester resin (PE) overlaid plywood, melamine resin (MF) overlaid plywood, glass, fire-retardant plastic flooring, tile, and marble.

Type IV ($b < 0.0069$ – poor performance): Control group aluminum container and given climate condition.

From these findings, it seemed that the unfinished and non-resin-treated wood-based materials could be characterized as excellent interior decorating materials based on their humidity conditioning performances. However, such performances would be weakened when the surfaces of these wood-based materials were treated with resinous substances. These observations were similar to these from the study reported by Maki et al.[4] and our previous studies.[5–7]

Effect of wood panel thickness on humidity conditioning indexes

When one side of the sealed container was lined with various thicknesses (0.3–2.1 cm, A/V 2.88–3.04 m^{-1}) of Japanese cedar and red oak wood panels, it was found that the linear equations between logarithmic values of absolute humidity [log$h(t)$] and temperature (t) were obtained. Their correlation coefficients (r) were 0.914–0.987 for Japanese cedar wood panels and 0.908–0.983 for red oak wood panels, which were highly significant at the 0.01 confidence level by the F-test, and the b value; the slopes of these linear equations were 0.0193–0.0273 for Japanese cedar panels and 0.0173–0.0258 for red oak panels, respectively. The b values increased rapidly with the increasing thickness of wood panels, as shown in Fig. 2. It was found that the b values were 0.0262 for Japanese cedar panel and 0.0247 for red oak panels; when the panel thickness increased to 0.3 cm, the humidity conditioning was not affected by panel thickness. This suggested that the effective thickness of interior decorating panels was 0.3 cm under daily cyclically changes of temperature and RH climate condition in the Taipei area. This finding is consistent with the results reported by Cho,[8] Yamada,[9] and Okano.[10]

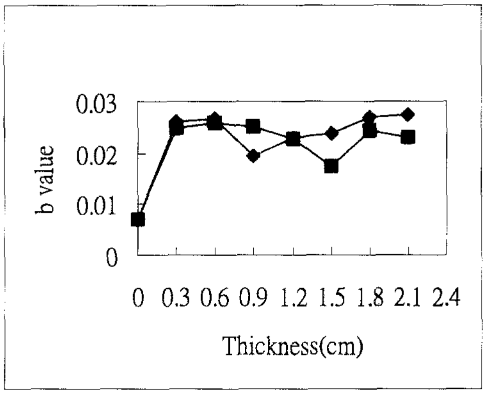


Fig. 2. Relation between the b value and the thickness of wood panels inside a 35 cm^3 aluminum box lined with a Japanese cedar panel (*diamonds*) or a red oak panel (*squares*) (A/V 2.88–3.04 m^{-1})

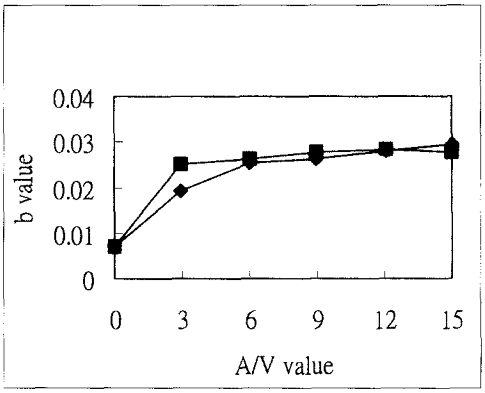


Fig. 3. Relation between the b value and the A/V value inside a 35 cm^3 aluminum box lined with a Japanese cedar panel (*diamonds*) or red oak (*squares*) panel of different A/V values

Effect of A/V value on humidity conditioning performances

To investigate whether the RH in a sealed space could be controlled at a designated level by lining more solid wood materials on the inside walls, Japanese cedar and red oak (0.9 cm thick) panels were attached to one wall (A/V 2.93 m^{-1}) and to five walls (A/V 14.98 m^{-1}) inside the cylinder to observe any changes in RH. The linear equations between logarithmic values for absolute humidity [log$h(t)$] and temperature (t) were obtained. Their correlation coefficients (r) were 0.958–0.991 for Japanese cedar panels and 0.956–0.982 for red oak panels, which were highly significant at the 0.01 confidence level by F-test and the b value: The slopes of these linear equations were 0.0193–0.0294 for Japanese cedar panels and 0.0250–0.0283 for red oak panels; and the b values increased with the increasing A/V value, as shown in Fig. 3. These experimental results suggest that when the more solid wood materials line the interior walls it improves the humidity conditioning effect. However, with this climatic condition, when the A/V value reached 2.93 m^{-1} (one side of sealed container was lined with a wood panel) its humidity conditioning performance was that of type I. These results are consistent with those from previous studies.[4–8,11]

Conclusions

Based on the experimental work conducted in this study, the following conclusions are drawn. When the A/V value was 2.87–2.99 m^{-1} and one side of the sealed container was decorated, there was no significant effect on the room temperature changing ratio. There was a marked hygroscopic conditioning effect, and the hygroscopic conditioning performance of 36 interior decorative materials could be classified into four types in accordance with the b values: type I (best performance), including four solid woods (unfinished), two wood-based materials, three composite materials, and one inorganic material; type II, including one solid wood, eight wood-based materials, and two inorganic materials; type III, including 11 wood-based materials and four inorganic materials.

The thickness of the interior decorating wood panels had no significant effect on the room temperature changing ratio when the A/V value was 2.88 m^{-1}. However, the RH changing ratio decreased curvilinearly with increasing thickness of the wood panels, whereas their b values increased linearly with the increasing thickness. This finding suggested that the effective wood panel thickness was about 0.3 cm for satisfactory hygroscopic conditioning for an environment with daily fluctuation of winter climate, as in the Taipei area.

The A/V value had no significant effect on the room temperature changing ratio. The RH changing ratio decreased curvilinearly with increasing A/V, whereas the b values increased curvilinearly. This finding indicated that sufficient hygroscopic conditioning could be obtained when the A/V value reached 2.93 m^{-1}.

Acknowledgment The investigation reported in this paper was supported financially by the National Science Council of the Republic of China (NSC86-2313-B-002-101-A09).

References

1. Wang SY, Tsai MJ (1998) Assessment of temperature and relative humidity conditioning performances of interior decoration materials. J Wood Sci 44:267–274
2. Ohgama T, Norimoto M, Kohara J (1986) Humidity conditions by wall papers for decorative finish. Wood Ind 41(10):14–18
3. Ohgama T, Norimoto M, Kohara J (1988) Humidity conditions by wall papers for decorative finish. II. Wood Ind 43(1):14–18
4. Maki F, Norimoto M, Aoki T, Yamada T (1981) Estimation of humidity conditions caused by interior wall materials. Wood Ind 36(10):16–20
5. Wang SY, Cho CL (1994) Assessment of hygroscopic-conditioning performance of interior decorative materials. I. Mokuzai Gakkaishi 40:220–230
6. Wang SY, Cho CL (1994) Assessment of hygroscopic-conditioning performance of interior decorative materials. II. Mokuzai Gakkaishi 40:648–655
7. Wang SY, Liau CF (1997) Assessments of hygroscopic-conditioning performances of interior decorative materials. III. Mokuzai Gakkaishi 43:24–37
8. Cho CL (1992) The conditioning effect on the temperature and relative humidity of wooden environment. PhD thesis, Institute of Forestry, National Taiwan University, p 209
9. Yamada T (1987) Wood environmental science (in Japanese). Kaisei Publishing, Kobe pp 295–312
10. Okano T (1987) Moisture and interior finish. Wood Ind 42(2):3–9
11. Wang SY, Cho CL (1996) The conditioning effect of wooden interior finish on room temperature and relative humidity in Taiwan. Mokuzai Gakkaishi 42:16–24