Experimental Study on the Reduction of Indoor Total Volatile Organic Compounds and Formaldehyde by an Architectural Method, and on the Prediction of the Concentrations in Multi-Family Houses

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Introduction

In recent years, indoor volatile organic compounds (VOCs) and formaldehyde (HCHO) originating from interior finishing materials has come to the fore as a social problem, here in Japan, because of its adverse effect on health of occupants.

The authors carried out experiments in order to investigate the influence of the substances from the interior finishing materials on the quality of indoor air (1, 2). Three experimental rooms (see Figure1), Type A, Type B and Type C (see Table1), were pro-

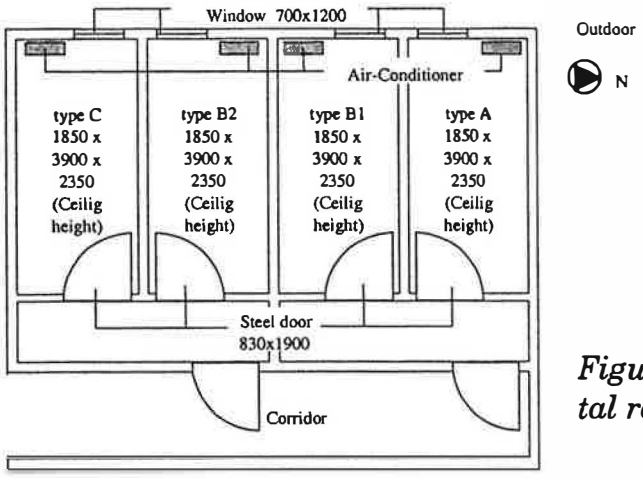

Figure 1. Plan of the experimental rooms unit: mm

vided, which have different specifications from each other in kind of finishing material and adhesive, and for each of the rooms, the concentration in the indoor air and decreasing rate of TVOC (total VOCs) and HCHO were quantified.

Table 1. Concept of the three types of rooms

Type	Concept
A	Typical specification before the adverse effects of VOCs and HCHO called people's attention
B	Improved specification in terms of HCHO emission than Type A, but with a slightly higher cost of construction
C	Optimized specification in terms of HCHO

This paper reports the results of concentration of TVOC and HCHO in each of the rooms and their decrease profile over one year, and we examined a method for predicting the concentration of HCHO in the air by the use of the measured emission rate of HCHO from each of the different kinds of materials.

Conditions and Methods for Measurement

Temperature and Relative Humidity

An air-conditioner was used to maintain the temperature of each room at the same level (see Figure 2).

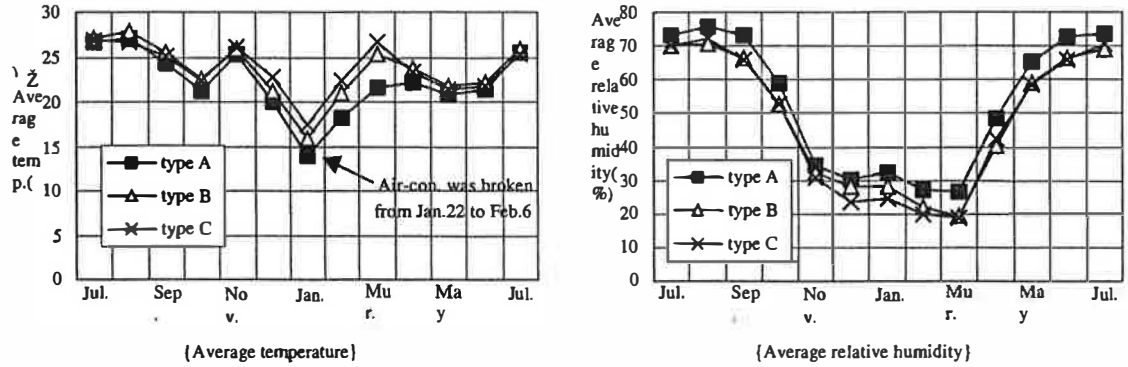

Figure 2. Change of the average temperature and relative humidity

Measurement of Concentration

After adequate ventilation, all the openings were closed. After the closing the concentrations were measure at the time point of four hours, eight hours and 24 hours from the closing. The outline of the air-sampling apparatus is shown in Figure3.

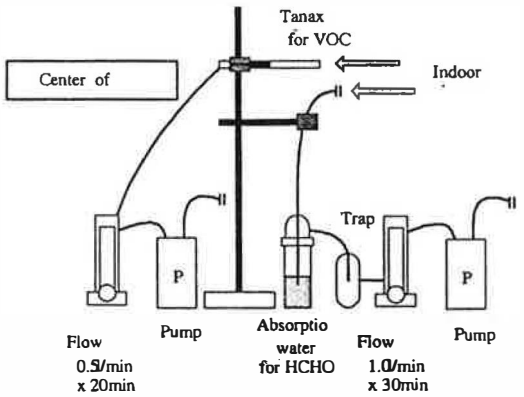

Figure 3. Outline of the air-sampling apparatus

Decrease Trend of the Concentration over One Year

Decrease trend of the concentration is illustrated by the concentrations at the time of 24 hours from the closing of the room measured just after their completion, and at the time points of one month, three months, five months, eight months and twelve months from the completion.

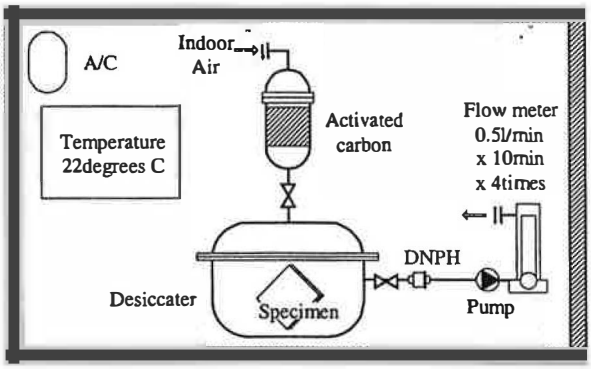

Figure 4. Outline of the apparatus for qualifying the emission rate of HCHO from each specimen

Emission Rates of HCHO

The emission rates from the finishing materials of type B room were measured using its 100 x 100mm specimens (see Figure 4).

Results

Concentration and Decrease Trend of TVOC

Figure 5 illustrates the changes in concentration of TVOC over the year. As a result, we could obtain the following findings.

1) At each of the room types, the concentration continuously decreased by 90% or more, up to the time point of five months from the completion. And then the concentration remained at the same level.

2) Since after the completion of the rooms, they all demonstrated almost the same level of concentration except for Type A immediately after the completion. As far as judged from the results of the experiment, that the difference in interior finishing specifications makes no contribution to the improvement of the concentration of TVOC.

Concentration and Decrease Trend of HCHO

Figure 6 illustrates the changes in concentration of HCHO over the year. As a result, we obtained the following findings.

1) The concentration of HCHO in all the types of rooms continued decreasing up to the time point of five months from the completion, then turned to increasing and continued its trend to the time point of twelve months from the completion. Decreasing to the time point of five months from the completion is probably due to lowered temperatures of the materials in the winter.

2) The difference in interior specification contributed to the lowering of HCHO concentration.

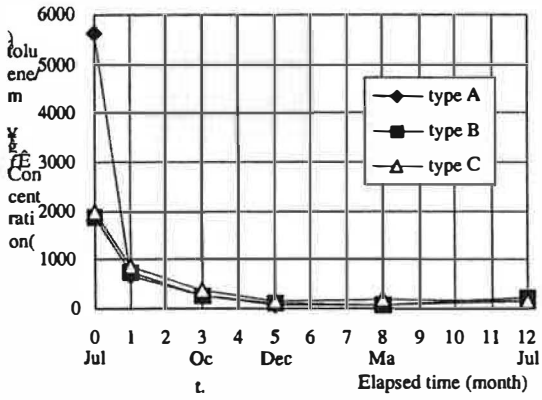

Figure 5. Change of concentration of TVOC over one year after the complition

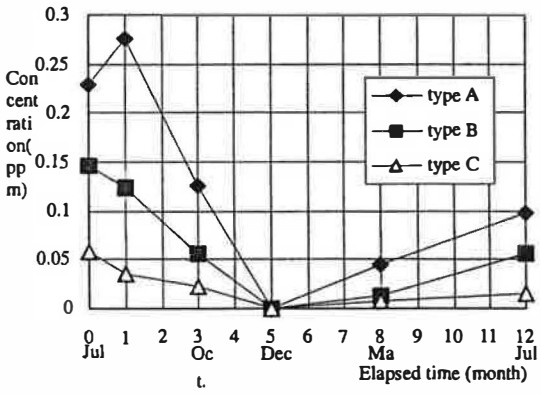

Figure 6. Change of concentration of HCHO over one year after the complition

Examination of a Method for Predicting the Concentration of HCHO

The room of Type B was finished with polyvinyl-chloride cloth for the walls and ceiling (RAL standard) and with woody board for the floor (the rank of "F 2" of JAS). In this room, the emission rate of HCHO from the walls and ceiling was 5 $\mu g/h/m^2$ and that from the floor was 15 $\mu g/h/m^2$. These values were multiplied by its area in actual room and summed up to determine the total emission rate in the room, that is, 231$\mu g/h$.

Assuming that the air-change rate is 0.3 times per hour, the saturated concentration was calculated to be 0.07 ppm from Equation (1). By using Equation (2) for the conversion with temperature which is proposed by Sakuramachi et al. (3), we calculated the concentration at the measured temperature to be 0.14 ppm. This value is an approximation

to the measured concentration, 0.15 ppm, at the time of the completion.

$$C = M/Q + C_0 \quad \text{.....(1)}$$

$$C_T = C_t * EXP\,(0.135(T-t)) \quad \text{.....(2)}$$

where **C** = predicted concentration ($\mu g/m^3$), **M** = total emission rate of a room ($\mu g/h$), **Q** = quantity of natural ventilation (m^3/h), $\mathbf{C_0}$ = concentration of outdoor air ($\mu g/m^3$), $\mathbf{C_T}$ = converted concentration at a given temperature, T (degrees C), $\mathbf{C_t}$ = measured concentration in measured temperature, t (degrees C)

Discussion

In this study, it seems that the concentration of TVOC from indoor finishing material decreases faster than HCHO. But, the furniture which is carried in by occupants emits VOCs and HCHO to increase the concentration of TVOC and HCHO in the room. Taking into consideration these factors, it is necessary to develop an adequate reduction method or adsorption method, in an effort to control or reduce the concentration of such adverse substances.

Predicted concentrations obtained in this study were approximation to measured concentration, but there is only one case of examination. We can know that the method used is effective in predicting the general trend of concentrations. To improve the accuracy of prediction, there remain many tasks to achieve, including influence of temperatures, relative humidity, aging of materials and error of examination as quantification items.

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