A study on emission characteristics of VOCs with the lightweight panel finishing material composition

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ABSTRACT

This research sought to make lightweight panels that are commonly used as one of indoor construction materials hazardous-free by measuring, analysing and evaluating VOCs emission volume of lightweight panel indoor finishing materials such as water paints, oil paints and adhesives to determine the emission characteristics of air quality of finishing materials. The three finishing materials were classified into general and vegetable categories, and conditions of temperature, humidity and air change rate were varied in experiments.

As a result, in the case of water paints, the volume of VOCs from vegetarian water paints was found to be smaller than that of VOCs from general water paints. Also, the volume of VOCs emission from general water adhesives and vegetable water adhesives was not much different from each other, suggesting that adhesives do not greatly affect the occurrence of VOCs (BTEX). Thus, of materials of which a lightweight panel is made, adhesives gave the least impact; therefore, it is deemed more economical and good for improving indoor air quality to use vegetable paints as indoor finishing material and water adhesives as adhesives.

INDEX TERMS

Indoor air quality (IAQ); Volatile organic compounds (VOCs); Finishing material

INTRODUCTION

Interior construction materials are manufactured or used for construction, by employing materials producing massive volatile organic compounds (VOCs) such as solvents and paints. VOCs are harmful to the human body, and to reduce these compounds, finishing materials need to be removed of hazardous substances. First and foremost, finishing materials with less emission of VOCs should be used. To this end, nations worldwide are endeavouring hard to classify interior materials aiming at regulating the emission of VOCs.

This research measured the occurrence of VOCs of lightweight panel finishing materials. Likewise, water paints, oil paints and adhesives that are used as lightweight panel finishing

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materials were determined for their respective VOCs occurrence characteristics, and when these materials were combined with each other to form a lightweight panel, the corresponding VOCs occurrence volume was measured to determine which indoor finishing materials would produce less VOCs.

EXPERIMENT CONDITIONS AND METHODS

The process of this research is featured in Figure 1. The research carried two-phase experiments. Likewise, material experiments were conducted to measure the occurrence of VOCs from the materials themselves (water paints, oil paints and adhesives). And, based on this result, specimen experiments were also conducted to measure the occurrence of VOCs from the combination of these materials to be used as finishing materials.

The material experiments selected as materials two general (non-vegetable) products and vegetable products each for water paint, oil paint and adhesive, and measured and analysed the VOCs emission volume with respective materials painted on glass (200 mm × 200 mm), at the interval of 1, 2, 3 and 6 h in accordance with EPA TO-17. The specimen experiments measured the VOCs occurrence volume at the interval of 1, 2, 3, 6, 9, and 12 h with varying temperatures (20°C, 28°C), humidity (40%, 60%), and air change rate (0.5/h, 0.7/h).

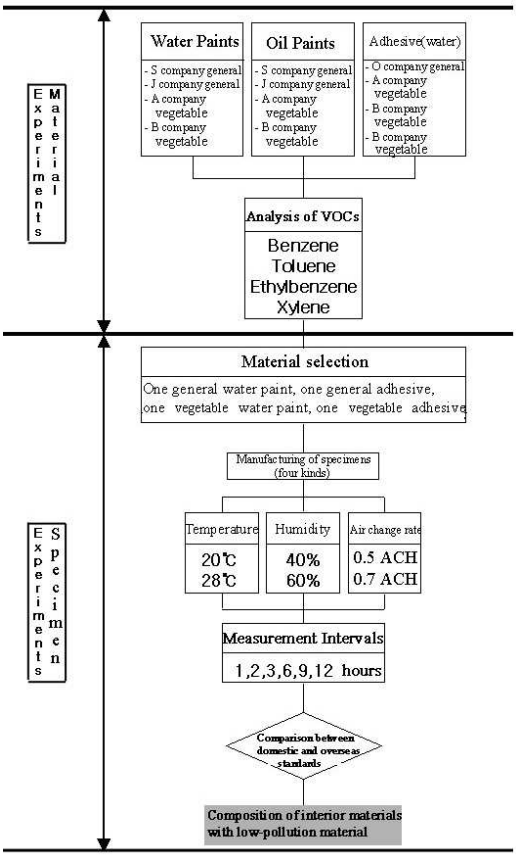


Figure 1 Experiment process.

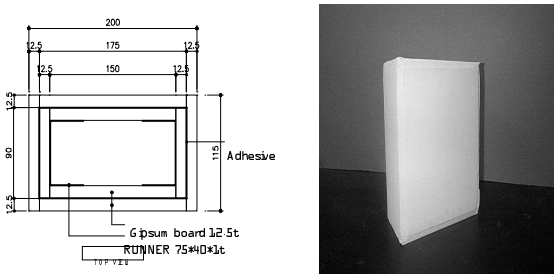


Figure 2 Material composition of specimen.

The composition and exterior of the specimen are featured in Figure 2. The specimen was fabricated to measure 120 × 240 × 290 mm^3.

The VOCs occurrence volume from the materials and specimens was measured by analysing air samples collected through the university-manufactured Hanyang Air Quality Test (HAQT) system using gas chromatography (GC). Figure 3 features the HAQT system configuration. The HAQT system consists of three chambers such as constant temperature and constant humidity chamber, constant temperature chamber and measurement chamber, as well as air control units. The constant temperature and constant humidity chamber is designed to keep the air and humidity constant inside it to be supplied to the measurement chamber, and the constant

temperature chamber is designed to keep constant the temperature of the measurement chamber inside it. The measurement chamber is designed to put the specimen into it and measure it. Photo 1 features the exterior and section of the measurement chamber.

ANALYSIS AND REVIEW OF EXPERIMENT RESULTS

Material Selection and Experiment

Featured in Figures 4 and 5 are the material experiment results of two general (non-vegetable) water paints and two vegetable water paints. The emission volume of VOCs (BTEX: benzene, toluene, ethylbenezene, xylene) per unit area (m^2) for both general water paints and vegetable water paints was found to be largely below 10 $\mu/m^2/h$. These volumes were very minimal, suggesting that the VOCs emission volume from general and vegetable water paints was insignificant. Figure 6 features BTEX emission volume of general oil paint. It is much bigger compared to water paint. In particular, *m*,*p*-xylene peaked at 16 000 $\mu g/m^2$ 3 h after measurement.

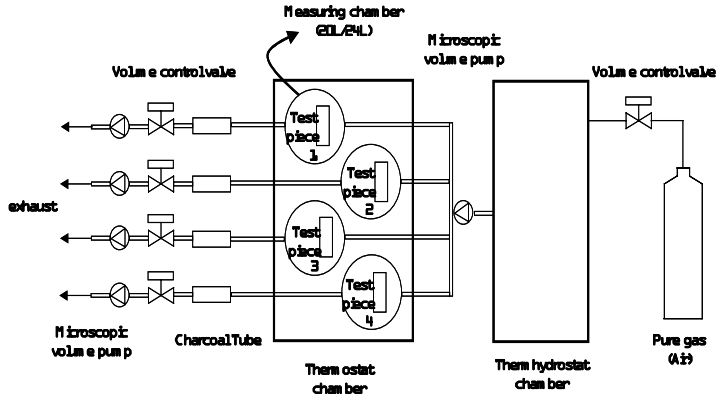


Figure 3 Configuration of HAQT system.

Photo 1 Exterior and section of measurement chamber.

Figure 7 features the measurement result of BTEX emission volume of vegetable water paint. The vegetable oil paint C shows a nearly zero emission volume. Vegetable oil paint D generally shows an emission volume of below 50 $\mu g/m^2/h$ except for *o*-*x*ylene. *o*-Xylene emission shows 260 $\mu g/m^2/h$ 1 h after measurement, but afterwards, it gradually declines to 100 $\mu g/m^2/h$ 6 h after measurement.

Figures 8 and 9 feature BTEX emission measurement volume of three vegetable water adhesives and one general (non-vegetable) water adhesive, respectively. Adhesives are materials used for manufacturing lightweight panels in this research, and lightweight panels were manufactured by attaching two gypsum boards using an adhesive. Regarding the result of measurement, the BTEX emission volume was all insignificantly low at below 15 $\mu g/m^2/h$, while the emission difference between general water adhesives and vegetable adhesives was almost none.

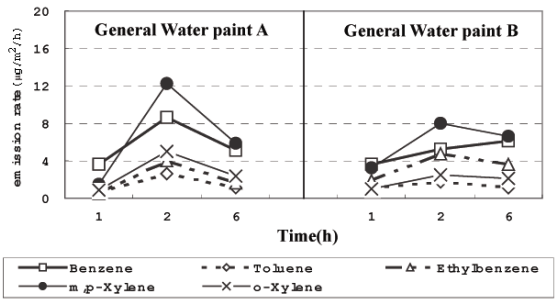


Figure 4 General water paint emission rate (μg/m²/h).

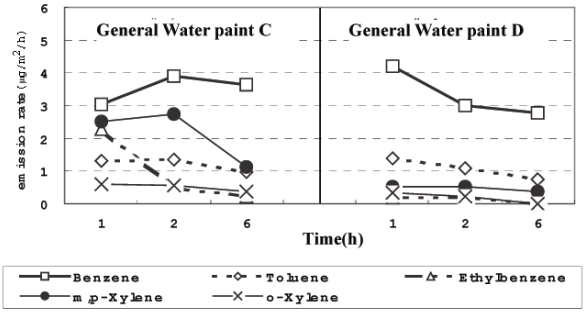


Figure 5 General water paint emission rate (μg/m²/h)

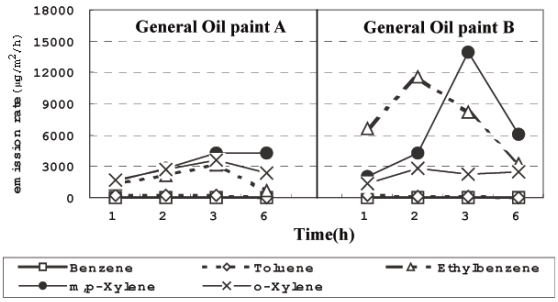


Figure 6 General oil paint emission rate (μg/m²/h)

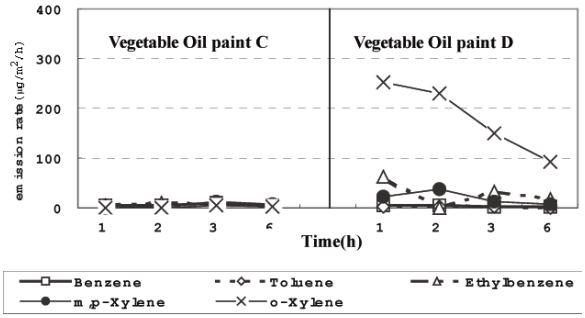
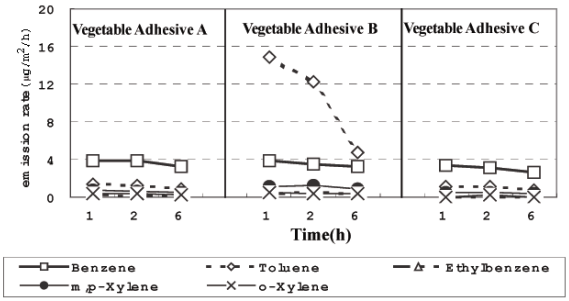


Figure 7 Vegetable oil paint emission rate (μg/m²/h)



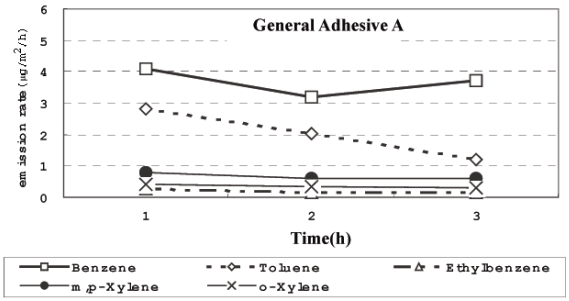


Figure 10 features the measurement of VOCs emission from gypsum boards of which lightweight panels are made. The VOCs emission is insignificantly low.

Specimen Experiment

Experiment conditions of specimens are featured in Table 1. Based on VOCs measurement results of various water paints, oil paints and adhesives through materials selection and experiments, specimens were each organized to consist of one adhesive with the least VOCs emission volume, one general water paint and one vegetable water paint. Oil paints were excluded from experiments since they produced too much VOCs emission, compared to water paints.

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Specimen experiments were conducted about 1 week after specimens were manufactured. This is because the dwellers generally enter apartments over 1 week after the interior finishing work and the massive emission of VOCs right after finishing work is eliminated. Specimen experiments measured VOCs emission volume with varying temperature (20°C, 28°C), humidity (40%, 60%) and air change rate (0.5/h, 0.7/h), at the time of 1, 2, 3, 6, 9 and 12 h. Figure 11 features VOCs emission volume according to respective specimen types at 20°C in temperature, 40% in relative humidity, and 0.7/h in air change rate of measurement conditions in Table 1.

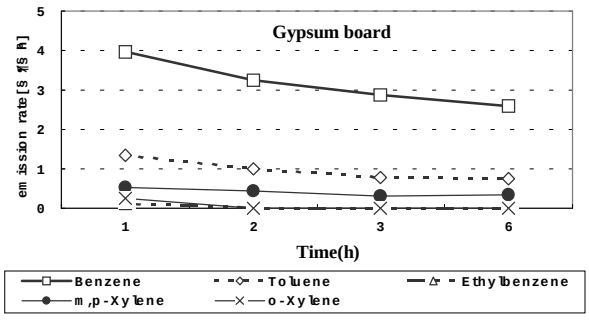

Figure 10 Gypsum board emission rate (μg/m²/h).

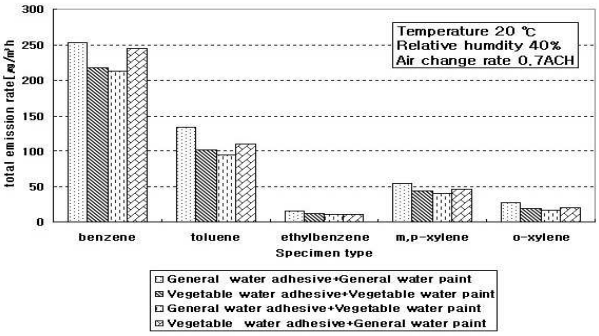

Figure 11 VOCs emission volume (μg/m²/h).

	Specimen composition	Temp. (°C)	Humid. (%)	Air change rate (ᐩh)	No. of specimens	Measurement interval (h)
Type 1	General water adhesive, General water paint	20° 28°	40% 60%	0.5/h 0.7/h	32	1 h 2 h 3 h 6 h 9 h 12 h
Type 2	Vegetable water adhesive, Vegetable water paint					
Type 3	General water adhesive, Vegetable water paint					
Type 4	Vegetable Water adhesive, General water paint					

Table 1 Composition and experiment conditions of specimens

If the VOCs emission volume is compared in identical experiment conditions, type 2 of the combination of vegetable water adhesive and vegetable water paint, and type 3 of the combination

of general water adhesive and vegetable water paint were found to produce less emission than types 1 and 4 containing water paint. As reviewed from material selection and experiments, likewise, vegetable water paints produce less—albeit minimal—VOCs than general water paints, and VOCs emission vary little according to adhesives.

CONCLUSION

This research measured, compared and analysed the VOCs emission volume according to lightweight panel interior finishing materials (general adhesives, vegetable adhesives, general paints and vegetable paints). This is summarized as follows:

- In the case of water paint, vegetable water paints were found to produce less VOCs emission volume than general water paints.
- General oil paints were found to produce VOCs (BTEX) more than six times that of vegetable oil paints, suggesting that the use of the former in indoor finishing materials will greatly worsen the indoor air quality.
- There is almost no difference in VOCs emission volume from general water adhesives and vegetable water adhesives.
- The experiments with specimens using a combination of adhesives and water paints found that regardless of adhesives, the occasion of using vegetable water paints produced less VOCs emission volume than the occasion of using general water paints.

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