Changing gas concentration in a display case using low emission materials

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1. Introduction

In this study, gas concentrations in a full-scale display case for test were measured to confirm the actual environmental conditions within the case. Also gas concentrations in the case were estimated based on initial gas concentrations.

2. Experiment

【Display case for test】

The free standing display for test contained measurement holes. A sampling tube was mounted in upper part of a glass case to be penetrated through the holes to allow gas sampling without opening the glass case (Fig.1).

The interior table was exchanged every test. Two interior tables made by different materials were tested (Table 2).

【Method】

Multiple gas sampling events focusing on acetic acid and formic acid were performed within a specific time cycle to measure gas concentration in the case. Sampling method was as below.

1. *Fan was operated during the gas sampling.*
2. *The air in the case was sucked by a pump (1.0 L/min) for 3 hours. The air was caught by pure water in an impinger outside the case through the sampling tube (Fig.1).*
3. *Components in the pure water were identified by using ion chromatograph (DIONEX ICS-5000).*
4. *The air was returned through the pump to the case as clean air to prevent reduced pressure in the case by the gas sampling.*
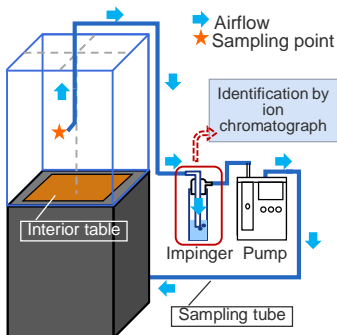
Airflow
Sampling point

Identification by ion chromatograph

Interior table

Impinger Pump

Sampling tube

Fig. 1. Image of gas sampling.

Table 1. Display case detail

Size (m)	W 0.75, D 0.75, H 1.92
	【glass case】0.55m³ W 0.73, D 0.73, H 0.97
Air exchange rate (changes/day)	0.12 (fan operation: 4.64)
Ventilation volume (m³/h)	0.0028 (fan operation: 0.107)
Function	fan, chemical filter, damper for ventilation, moisture adsorbent box

Table 2. materials of the interior table

Test	Plywood (veneer /adhesive)	Adhesive	Cloth (cloth /flame retardant /adhesive)
1	Lauan / phenol resin	starch	cellulose fiber /organophosphorus compound /vinyl acetate resin
2	Lauan + Japanese red pine /urea resin		regenerated cellulose fiber /nitrogen compound /vinyl acetate resin

【Predicted concentration】

Predicted concentration was calculated by the prediction formula[1] based on the <u>initial gas concentration</u>.
Corrected concentration was calculated from the measured gas concentration by each gas sampling.

As for these concentrations, influence of the air exchange in the case by the gas sampling was removed.

[1] *Strategies to prevent sick house syndrome -Design principles for healthy life-, ed. Architectural Institute of Japan (2005)*

Prediction formula :

$$C = C_1 e^{-(\frac{Q}{R}+\frac{Q_{eq}}{R})t} + \frac{(M + QC_0)}{(Q + Q_{eq})}\,(1 - e^{-(\frac{Q}{R}+\frac{Q_{eq}}{R})t})$$

C : gas concentration of display case(μ g/m³) , C_1 : initial gas concentration of display case(μg/m³), C_0 : gas concentration of indoor air(μg/m³), M : gas emission(μg/h), Q : ventilation volume(m³/h), Q_{eq} : equivalent ventilation volume (m³/h), R : display case volume(m³), t : time(h)
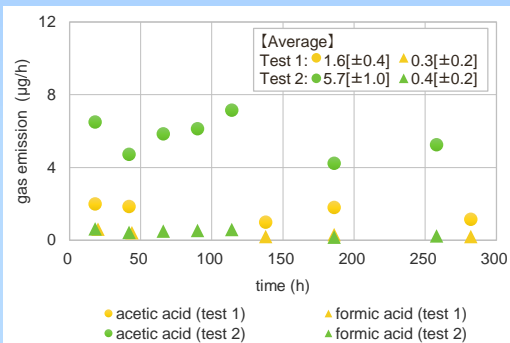
3. Results and Discussion

Fig. 2. Gas emission from interior table.

【Average】
Test 1: 1.6[±0.4] 0.3[±0.2]
Test 2: 5.7[±1.0] 0.4[±0.2]

acetic acid (test 1) formic acid (test 1)
acetic acid (test 2) formic acid (test 2)

Gas emissions were estimated by the prediction formula from the measured gas concentrations in the case by each gas sampling.
- Slight variations were observed in both gas emissions throughout the test (Fig.2).

- In acetic acid concentration with test 1 and test 2, the predicted concentrations were almost consistent with the corrected concentrations (Fig.3).
- In formic acid, concentrations in later part of the tests were not consistent (Fig.3).
Small ventilation causes variation in corrected concentration, even though slight variations were observed in the gas emissions.

Fig. 3. Predicted concentration and corrected concentration.
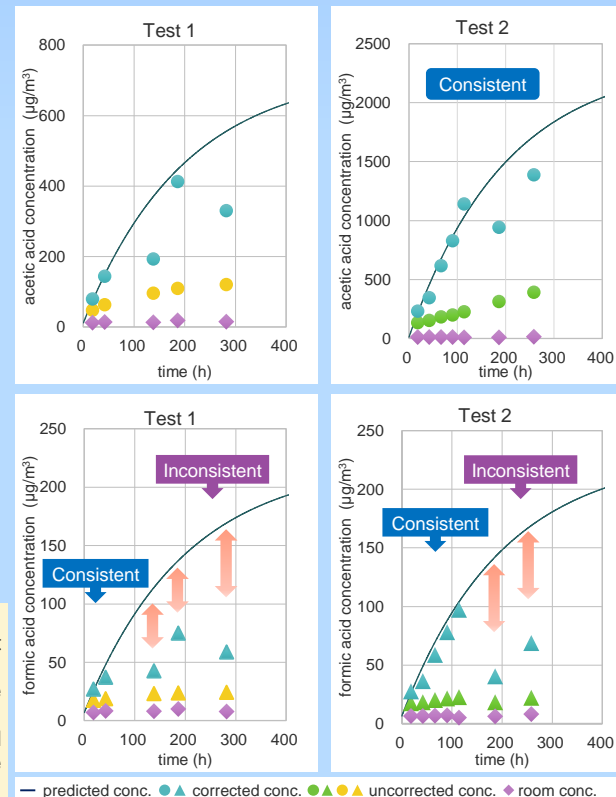
— predicted conc. corrected conc. uncorrected conc. room conc.

4. Conclusion

> **It is possible to predict changes in the gas concentration in display cases using the initial gas concentration.**
> **The reason for the slight variation in gas emissions needs to be discussed.**