DEVELOPMENT OF A PASSIVE FLUX SAMPLER (PFS)

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ABSTRACT

The mitigation to reduce indoor pollutant concentration are increasing ventilation rate or to reduce the emission of the pollutant which is also common in VOCs. Households, furnitures, building materials and so are well known as the source of indoor VOCs. There are several devices to measure emission of VOCs, such as an emission chamber or FLEC, which are adopted in ISO 16000. However these 2 methods has each disadvantages e.g. the chamber is suitable only in a fixed condition such as a laboratory, or the necessity of a pump and humidifer. The device introduced in this study is portable (D x H = 41 x 16(mm)) and samples VOCs only by diffusion so there is no necessity of pump. The size of the sampler, adsorbent, detection limit, the sampling period, reproductivity, and the possibility of practice will be discussed in this study.

KEYWORDS

Passive Flux Sampler (PFS), VOC, Emission Rate, Adsorbent, Thermal Desorption

INTRODUCTION

The increasing numbers of occupants who suffer from health symptoms i.e. eye irritation, headache and fatigue, which is similar to sick building syndrome has been reported recently. The cause of this symptom is commonly said to be VOCs emitting from building materials and household and etc. As mitigation to this problem, reducing VOCs emission to indoors or ventilation to dilute the pollutant is essential. Especially in indoor environment after completion, specification and exchanging the source will be a one of the most

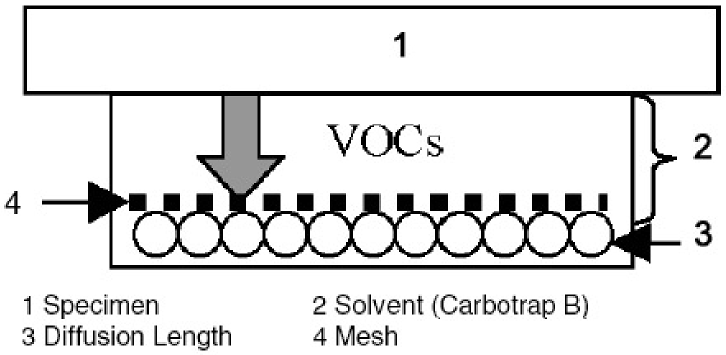

Fig.1 Diagram of The Passive Flux Sampler

effective way to decrease indoor VOCs concentration.

There are several methods to measure VOCs emission rate building materials such as an emission chamber or FLEC (Field and Laboratory Emission Cell). Especially FLEC is used in both field and laboratory, however the system itself is large and heavy and is not easy to carry when needed in field measurement. Furthermore because of its complexity and price, it is not realistic to use FLEC when there are numbers of sampling points. There are several PFSs reported by Akustu, Matsumoto, Satake or Tsukahara. However in both samplers the diffusion length is not confirmed so the emission rate mentioned in it is not reliable.

PURPOSE

The purpose of this study is to develop a passive flux sampler (PFS), which is small, light and inexpensive and reliable for practice. The size of the sampler, adsorbent, detection limit, the sampling period, reproductivity, and the possibility in practical use was determined.

Table 1: Conditions of TD-GC/MS

Thermal Desorption	Perkin Elmer ATD-400
Primary Desorption Temp.	280°C
Primary Desorption Time	7 min.
Flow rate	75 mL/min.
Secondary Desorption Temp.	300°C
Trap Temp.	-30°C
Secondary Desorption time	10 min.
Transfer Line Temp.	225°C
GC/MS	Agilent Technologies GC:6890, MS:5973
Mode	SIM, SCAN
Column	HB5 30m x 0,25mm x 0,25um
Column Temp.	40°C(4min) → 10°C/min.→ 280°C
Solvent Delay	1.2min.
Injector Temp.	250°C
Injection	Pulse split
Interface Temp.	220°C
Carrier	He
Ion Souce Temp.	230°C

METHOD

The PFS is made of glass and its diameter x depth = 41mm x 16mm as shown in figure 1. The targeted compound is to emit from the source and adsorb directly to the adsorbent by molecular diffusion. A Teflon disk is place inside the glass plate when the diffusion length is changed. The target compound emitting from building materials were VOCs such as toluene, xylene ethylbenzene and etc.. Carbotrap B which the mesh size is 20/40 was selected as adsorbent. A stainless mesh was placed inside the plate to cover the adsorbent so to prevent the adsorbent drop when the PFS is set to place such as walls or ceilings. The adsorbent was placed into a Perkin Elmer ATD tube after sampling and analyzed with ATD-GC-MS by the condition described in Table 1.

RESULTS AND DISCUSSION

DETECTION LIMIT

Detection limit was set to 10 time of the standard deviation of the blank. A typical sized Japanese room sized 32.5m^3 (=area 13m^2 x height 2.5m) and the ventilation rate set to 0.5 ACH was assumed to calculate the concentration of indoor by the emission rate of the sampler. The concentration of this room was calculated as VOCs emitting from 1 side by the detection limit of each compounds. The calculated results were compared with the Japanese indoor guideline and the results by the Ministry of Health, Labor and Welfare, Japan. From the comparison shown in table 1 this flux sampler sufficient for practice from the point of detection limit.

Table 2 Concentration Detection Limit, MHLW Guideline and Mean Concentration of MHLW's Survey (unit: ug/m^{-3})

Compound	Detection Limit by Thermal Desorption (6hr. Sampling)	Detection Limit by Solvent Extraction (6hr. Sampling)	Guideline (MHLW, Japan)	Mean (2)
Toluene	4.8	312	260	98.3
Ethylbenzene	1.7	312	3800	22.5
m-Xylene	1.9	312	870	24.3
Styrene	1.9	312	220	4.9

REPRODUCTIVITY

The reproductivety of the PFS was tested with 5 PFS in parallel on a material. The RSD of this test was 15%, and from this we can say that this PFS accurate for practical use.

FLUX BY DIFUSSION LENGTH

The sampling rate of the target compound is affected by the flux of material and the diffusion inside the sampler. Changing the diffusion length can control the effect of diffusion and the flux can be determined in both phases. From this test, the maximum flux and the maximum surface concentration can be observed.

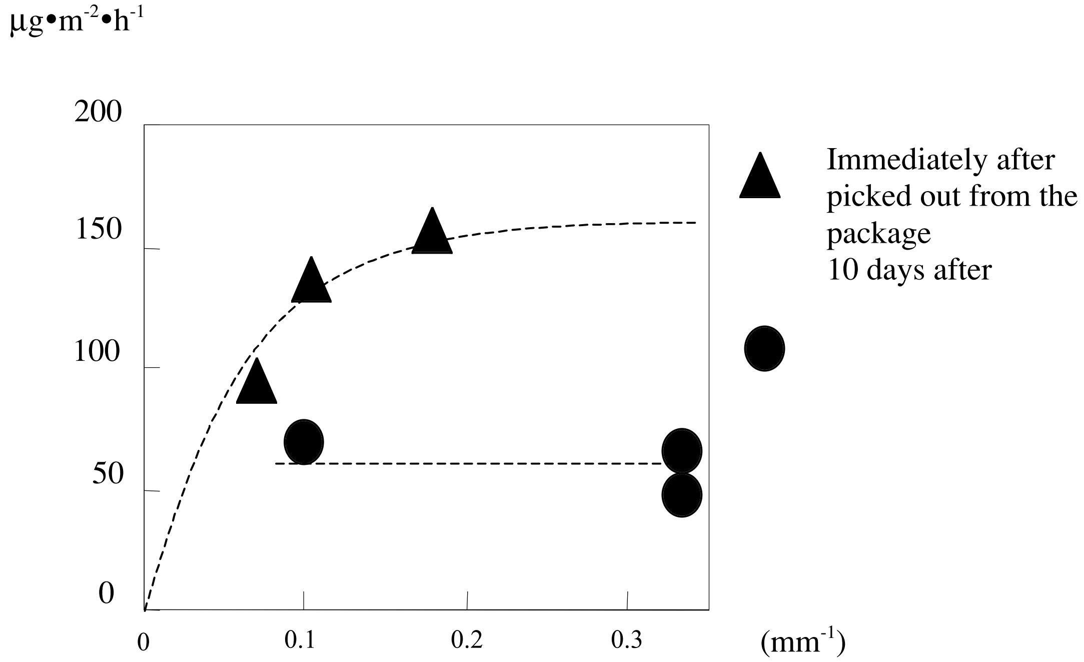

Fig. 2 Reciprocal Diffusion Length (mm^{-1}) by Flux ($ug•m^{-2}•h^{-1}$) on m-Xylene

The flux of plywood was sampled immediately after it was open from the package and 10 days later, by changing the diffusion length. The condition was set to 20_ and sampled period for 6 hours. For example the result of m-xylene will be shown in figure 2. The emission has decreased after the plywood has been exposed in the controlled condition.

MEASUREMENT IN A NEW HOUSE

A measurement using this PFS was taken place in new built house. The schedule of the measurement was as shown in figure 3. The doors and windows of the house were opened for 30 minutes, and then they were kept closed for 8 hours. During the sampling period the doors and windows kept were closed and the PFS was place on the positions of the room shown in table 3.

A part of the result will be shown in table 3. As a result the flux of the ceiling and wall of the living room

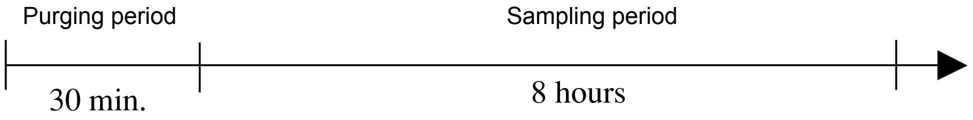

Fig. 3 Time Table of Measurement

Table 3 VOCs Emission Rate (ug•m^{-2}•h^{-1}) in a New House

Position	Living Room	Living Room	Japanese Room	Japanese Room	Kitchen	Cupboard
	Ceiling	Wall	Tatami	Wall	Floor	
Material	Vinyl Wallcovering	Wall Cloth	Chemical Tatami	Woodchip & Soil	Wood	Vinyl-chloride Covering
Ethylbenzene	3	4.5	N.D.	N.D.	N.D.	4.2
m-Xylene	3.2	4.9	N.D.	N.D.	N.D.	6
Styrene	34.1	35.9	8	N.D.	4.3	3.9
1,2,4-Trimethylbenzene	6.3	6.1	N.D.	N.D.	5.2	6

were large which means the effect of the ceiling and the wall covering turned out to be large to indoor VOCs concentration because the flooring material were the same in the living room and kitchen. The styrene emission rate was high in tatami, i.e. Japanese styled flooring material, which includes a heat insulator.

CONCLUSION

The conclusion of this study will be shown as bellow.

1. A passive type VOCs flux sampler was developed.
2. Carbotrap B was selected as a suitable adsorbent to sample the target compounds.
3. The RSD in the reproductivity was under 15%.
4. The detection limit was low enough using the thermal desorption system, which lead to shortening the sampling period.
5. The surface concentration of VOCs can be calculated by changing the diffusion length.
6. This PFS could be used in determining the source of high emission, which will lead to simulating indoor VOCs concentration.

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