The Application of Manual Sampling Device Using Human Exposure Assessment Technology for Household Chemical Products

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The main purpose of this study is to develop a passive sampler for volatile and reactive hazardous chemicals derived from household chemical products, and to verify its applicability through an intervention study targeting primary users of the passive sampler. The study was conducted collaboratively by research teams from Korea University, Ewha Womans University, and Chungbuk National University over three years (2021-2023). Passive samplers were developed for more than 15 types of volatile organic compounds and more than four groups of reactive hazardous chemicals originating from household chemical products. The passive samplers were validated through chamber experiments and human exposure modeling results. Additionally, the applicability of the passive sampler was verified through an intervention study, leading to the production of passive sampler prototypes, user manuals, and SOPs (Standard Operating Procedures). The verified passive samplers are expected to help vulnerable groups effectively use the passive samplers, enabling them to live and work in a safe environment.
Key words: household chemical product, passive sampler, intervention study, human exposure modeling, consumer safety

I. Introduction

Consumers commonly use household chemical products in their daily or professional lives. The neologism 'Homo Chemicus' exemplifies how deeply household chemical products are integrated into modern daily life. In South Korea, particularly since the humidifier disinfectant incident, there has been significant awareness regarding respiratory exposure to chemicals from household products. Recently, with the widespread use of disinfectants due to the COVID-19 pandemic, there is an increased risk of exposure to reactive hazardous chemicals such as chlorine compounds and ozone/radicals both professionally and in daily life. Household chemical products contain hazardous chemicals and can expose individuals to these substances through the skin or respiratory system. Excessive exposure can pose health risks, highlighting the need for meticulous management of human exposure to household chemicals.

Especially, various household products containing volatile organic compounds (VOCs)—such as disinfectant cleaners, removers, copier toners, adhesives, air fresheners, and preservatives can expose consumers directly when the product is used and indirectly through prolonged indoor air contamination. VOCs are known for causing mild and gradually appearing irritations and symptoms in the human body. Depending on the exposure level, VOCs can irritate the respiratory system, cause headaches, and lead to neurological and physiological impairments (Son & Yoon, 1995).

Therefore, there is a need to develop a passive sampler to understand human exposure levels to volatile organic compounds and reactive hazardous chemicals from household products. To achieve this, it is necessary to validate the effectiveness of the passive sampler through an intervention study measuring human exposure at the time of product use and cessation of use.

Until now, hazardous chemicals inhaled through the respiratory system have been primarily measured using active samplers. However, active samplers have the disadvantage of not being able to account for the impact of individual user activities, and they are also limited in terms of cost and efficiency. Conversely, in the field of occupational environment measurement, passive samplers have been researched and developed for various substances, with their applicability being consistently studied in both laboratory and field settings.

However, passive samplers for hazardous chemicals derived from household products have not yet been validated. Therefore, this study aims to develop a passive sampler targeting volatile and reactive hazardous chemicals from household chemical products. An intervention study will be conducted with primary users of the passive sampler to validate its applicability. Furthermore, through the validation of the passive sampler's applicability, it is expected that vulnerable groups will be able to use the passive sampler effectively, allowing them to live and work in a safe environment.

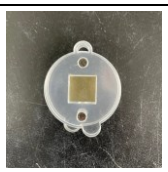
II. Research Method

This study was conducted collaboratively by research teams from Korea University, Ewha Womans University, and Chungbuk National University over three years (2021-2023). A passive sampler was developed for more than 15 types of volatile organic compounds and more than four groups of reactive hazardous chemicals derived from household chemical products. The passive sampler was validated through chamber experiments and human exposure modeling results. Additionally, the applicability of the passive sampler was verified through an intervention study, leading to the production of passive sampler prototypes, user manuals, and SOPs (Standard Operating Procedures).

III. Result

The performance of the main passive samplers developed through this study is summarized in Table 1.

Table 1. The performance of the main passive samplers

Substance Type		Sampling Rate	Detection Limit	Error Rate	Precision (RSD)
Ozone substances		3.5 L/h	1.8 ppbv	4%	6.6% (5 repetitions)
Available chlorine substances		2.5 L/h	28 ppb (5 hours)	30%	Within 30%

Electrophilic substances		0.11 L/h			
Volatile organic compounds (VOCs)		8.3-25 L/h	0.1-0.5 μg/m³ (9 hours)	15%	Within 10% (7 repetitions)
Quaternary ammonium substances		1.2 x 10^{-3} min	0.48 μg	Not specified	22% (500 ppmv chamber experiment)

IV. Conclusions

Based on these results, prototypes of the passive samplers were produced. It is expected that these samplers will be useful in ensuring that individuals and workers vulnerable to the use of household chemical products can live and work in safe environments.

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