한국대기환경학회 1999 추계학술대회 논문집
Proceedings of 29th Meeting of KOSAE (1999) pp. 399~400
Proceedings of Korean Society for Atmospheric Environment

PS22(MA33) 비작업장 환경에서의 ETS와 VOC에 대한 개인피폭량 측정방법의 성능평가

Performance Evaluation of Methodology for Personal Exposure Monitoring of ETS and VOCs in Non-occupational Environments

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INTRODUCTION

From the scientific point of view, any regulation of the emissions of toxic air pollutants in general, and ETS or VOCs in particular, will inevitably be based on exposure levels and consequential health effects, data of this nature is still lacking for most of ETS and VOCs. In this context, the importance of personal monitoring measurements of ETS and VOCs in relation to risk assessment has been emphasized previously. This study was carried out to develop and demonstrate a methodology for the determination of human exposure to a variety of indoor air contaminants, including RSP, ETS components, and VOCs.

EXPERIMENTAL DESIGN AND METHODS

Protocol of Study Design: A total of 60 non-smoking, non-occupational residents at homes were recruited in Taegu city, Korea in both summer and winter conditions. Although each subject was recruited on the basis of their self-reported non-smoking status, saliva samples were also collected to assess actual smoking status. Air samples were collected for each subject in two phases over a 24 hour period, i.e. awake time and sleeping time separately. Each subject was asked to wear a personal monitoring system during the approximate hours in which she is awake (ca. 15-16 hours), while an identical area monitoring system was placed alongside her sleeping area when she is asleep (ca 7-8 hours). In any case, the sampling system was able to be continuously operated without changing batteries during the sampling period.

Sampling System: In order to simultaneously collect three different classes of target analytes, i.e. RSP, vapor phase ETS markers, and VOCs, a personal sampler should have three channels with multiple pumps at different flow rates. We modified and assembled the samplers with commercially available ones from different manufacturers. The dual pump sampling system consists of the SKC Double Take Sampler drawing air through an XAD-4 sorbent collection channel and through the particulate collection channel. A third sampling pump was attached to a flow splitter on top of the sampling head, to which two VOC sorbent cartridges for duplicate sampling are attached.

Measurement of RSP: RSP sampling was undertaken by drawing air at 2.2 L/min through a cyclone inlet with a cut-off of 4 m in diameter and a Fluoropore filter (37 mm, 1.0 m pore) held in a black filter holder. Gravimetric measurement of RSP were carried out using an electronic microbalance.

Determination of ETS Markers: For the determination of ultraviolet absorbing particulate matter (UVPM) and fluorescing particulate matter (FPM), the particle laden filter was extracted ultrasonically in 2 ml of methanol, and then analyzed by a columnless HPLC system. 2,2',4,4'-THBP and scopoletin were used as a surrogate standard for UVPM and FPM, respectively. The solanesol content of the methanol extract was determined by a reverse phase HPLC system and UV detection

at 205 nm. A Hypersil BDS C18 column was used as an analytical column. Nicotine and 3-EP were collected by drawing air at a flow rate of about 1 L/min through a glass tube containing XAD-4 resin, and then analyzed using a GC system equipped with a NPD and an autosampler.

Sampling and Analysis of VOCs: VOCs were collected by drawing air through a stainless steel sampling tube (1/4" x 9 cm) containing ca. 400mg of Carbotrap (20/40 mesh) at a flow rate of 30 ml/min. Analysis of VOCs was performed by automatic thermal desorption coupled with GC/MS, using a Perkin-Elmer ATD400 and a Hewlett-Packard 6890 GC fitted with 5973 MSD. A total of 35 target VOCs were determined. Quantitation of VOC concentrations was conducted by the internal standard method. Each of the adsorbent tube used either for standard spiking or field sampling was spiked with a liquid mixture of four deuterated internal standards, including d6-benzene, d8-toluene, d10-ethylbenzene, and d5-bromobenzene.

RESULTS AND DISCUSSION

Sampling and analytical methods applied to this study for the determination of RSP and ETS components are fundamentally similar to the methods used for the US 16 cities study, while the methodology used for the determination of VOCs was based on the USEPA Method TO-17. The factors used in this study to convert the concentrations of surrogate standards and solanesol into an equivalent concentration of ETS particles were 7.0, 38.2, and 35.5 for UVPM, FPM, and SolPM, respectively. These factors were obtained for Korean cigarettes specifically by a recent study. The detection limits for UVPM and FPM were also estimated in the same manner as the RSP, and no data appeared to be lower than the limits. However, instead of using the field blank samples, samples spiked with a very low concentration standard solution were used to estimate method detection limits for SolPM, 3-EP, and nicotine, since these analytes were detected in no or only few field blank samples.

Similarly to the ETS components, performance evaluation of the sampling and analytical method used for the determination of VOCs were evaluated with respect to repeatability, linearity, MDLs, and duplicate precision. As an example, the repeatability of response factors for six replicate analyses were found to be in the range of 7.7-16.6 % for benzene and 3.3-17.7 % for toluene, while the estimated MDLs for the two compounds were 0.05 and 0.04 μg/m3. Although a total of 35 target compounds were determined in this study, a number of VOCs, mainly halogenated compounds, appeared to be present at extremely low levels in the air. Thus, only selected VOCs are reported in this paper. Evaluation of duplicate precision for VOC samples analyzed by adsorption and thermal desorption method is essential since replicate analysis is practically impossible for such samples. A criteria of 30% for duplicate precision was recommended for the sorbent based sampling of VOCs in USEPA Method TO-17. In this study, the mean duplicate precision was within 30% for majority of target VOCs. It is interesting to note that non-halogenated compounds appeared to be generally more precise than halogenated ones. Relatively poorer precision found for the halogenated compounds might be attributed to that fact that these compounds are generally present at very low concentrations in the air, and hence uncertainty tends to be greater than the more abundant compounds such as BTEX.

ACKNOWLEDGMENT

This study was sponsored by the Center for Indoor Air Research (MD) under Contract No. 98-12 with Yeungnam University, Korea.