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Project Summary

Evaluation of a Passive Monitor for Volatile Organics

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A laboratory investigation was conducted to determine the potential utility of a commercially available passive dosimeter for monitoring toxic volatile organic compounds at ambient levels. Test compounds included: chloroform, methylchloroform, carbon tetrachloride, trichloroethylene, tetrachloroethylene, benzene, and chlorobenzene.

Feasibility for reduction in device blanks was demonstrated and improvements were made in the analytical procedures. Chamber tests of device performance showed generally good performance at ambient levels, but indicated a severe limitation in sampling ability at relative humidities greater than about 80 percent. Also, generally low results were obtained with carbon tetrachloride. The cause of the observed effect of air velocity on sampling rates was examined on a theoretical basis, and it is recommended that these devices not be employed without adequate ventilation.

It is concluded that at least one currently available passive dosimeter could be useful for monitoring of ambient levels of toxic organic chemicals, and appropriate precautions are indicated.

This Project Summary was developed by EPA's Environmental Monitoring Systems Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

In recent years an increased awareness of the need for monitoring of individual or personal exposures to pollutants and toxic chemicals of various types has evolved. This awareness has prompted the development of a variety of personal sampling devices including battery driven pump systems (active systems), passive systems having high specificity for individual compounds, and generalized passive systems intended for collection of volatile organic compounds. Initial applications of these various devices have been concerned with the relatively high concentrations of contaminants found in industrial workplaces. In an earlier program conducted for the Environmental Monitoring Systems Laboratory, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina (RTP), Battelle's Columbus Laboratories (BCL) explored the problems and limitations associated with the potential use of passive devices for monitoring ambient level toxic organic chemicals (1). This current Work Assignment was concerned with the alleviation of some of the problems associated with this application of passive monitors and with a laboratory level evaluation of the performance of passive monitors at ambient concentrations.

The objective of this task was to evaluate the utility of selected passive monitors for their applicability to 24-hour monitoring of volatile organic compounds at typical ambient concentration levels. Seven target compounds that are representative of volatile toxic chemicals relevant to EPA monitoring requirements were considered. These included chloroform, 1,1,1-trichloroethane, carbon tetrachloride, trichloroethylene, tetrachloroethylene, benzene, and chlorobenzene.

Procedures

Analytical Methodology

Analyses of exposed badges were performed by solvent extraction of the collectors followed by gas chromatographic

quantitation of sample aliquots. The use of fused-silica capillary column techniques was compared with previously employed packed-column procedures. An in-series combination of electron capture and photoionization detectors was used for quantitation. Reference levels of chemicals used in the exposures were determined by direct gas sampling, using the same chromatographic system.

Device Blanks

Discussions were held with representatives of manufacturers of passive organic samplers for the purpose of determining potential solutions to the problem of high blank levels associated with these devices. One manufacturer, DuPont, supplied several series of devices that were prepared under a variety of conditions. These were then analyzed to determine the most effective means for minimization of blank levels.

Chamber Tests

Triplicate sets of DuPont badges were exposed to the test chemicals at concentrations of 10^{-1} to 10^{2} ppbv under well-controlled conditions in a 200 L chamber. Test variables included concentration, relative humidity, and exposure time.

Comparison Basis

The rate of collection of a volatile substance by a passive sampler is determined by the product of the intrinsic sampling rate, a function of the physical characteristics of the device and the diffusion coefficient for each substance, and the exposure concentration. Inasmuch as the effects of these two variables cannot be separated in any given experiment, it must be assumed that one or the other is known. In the current work, it was assumed that the intrinsic sampling rates specified by the manufacturer were correct, and performance comparisons were made relative to the apparent concentrations indicated by the analyses.

Results

Analytical Methodology

Fused-silica capillary column techniques have been used to improve the overall quality of the analytical procedures for passive device analysis. Thermal desorption was shown not to be a viable approach for analysis of the carbon-based collectors used in these devices.

Device Blanks

The problem of high and variable blanks for these devices was discussed with manufacturers, and one manufacturer, DuPont, was able to demonstrate capability for production of devices having satisfactorily low blank levels, without adding undue cost to the production of the devices. Blanks for the "clean" DuPont badges were close to or below detection limits for the test chemicals.

Chamber Tests

Examples of the DuPont badge were exposed in triplicate sets to concentrations of 10^{-1} to 10^{2} ppbv of the test chemicals under controlled chamber conditions. No effect of concentration in this range was discernible. The apparent responses to all of the chemicals were, however, diminished at relative humidities of 80 percent and higher. Relative responses (observed apparent concentration/actual concentration) for a given chemical were strongly correlated to responses for other chemicals with the same badge, i.e., when the response for one chemical was high, responses for all other chemicals on the same badge also tended to be high. This observation suggests that differences from one badge to the next were due largely to variations in physical parameters of the individual badges. In some cases, this was believed to have been caused by faulty seals between the diffusor plates and the collector chambers. One approach to illustrate the potential magnitude of the variability due to badge construction problems is to normalize the responses for each badge with respect to the mean response for that badge. The standard deviations in response for a given chemical can be compared for the raw data and normalized data to yield a measure of the effect. A summary of average responses obtained for each chemical studied and the standard deviations before and after normalization is shown in Table 1. These data suggest that approximately one-half of the variation observed in the raw data may be due to physical differences between the individual devices. The remaining variation is consistent with the total analytical uncertainty associated with the procedures that were used.

Conclusions and Recommendations

It is concluded that the blank and analytical problems previously identified for the use of passive monitors at ambient levels of toxic volatile organic compounds can be minimized satisfactorily. The use of thermal desorption for the analysis of carbon-based collectors used in these devices is not recommended. Chamber tests of the performance of the DuPont badge indicate that reasonably accurate sampling can be achieved at concentrations of 10^{-1} to 10^{2} ppbv as long as the relative humidity is below approximately 80 percent. However, at relative humidities higher than about 80 percent the apparent sampling rates are reduced by about 50 percent. The available list of sampling rates needs to be extended and validated, but this aspect is being pursued independently by the manufacturer. Sources of occasionally high apparent sampling rates are believed to be related to variations in manufacturing quality control and this too is being investigated by DuPont.

It is recommended that further consideration be given to the performance of passive devices under field conditions. In these tests, passive monitors should be compared with currently used active devices and with direct sampling and analysis methodology where possible.

References

1. Coutant, R. W., and D. R. Scott, "Applicability of Passive Dosimeters for Ambient Air Monitoring of Toxic Organic Compounds," Environ. Sci. Technol., *16* 410-413 (1982).

Table 1. *Average Response Ratios*

	Raw Data		Normalized Data	
Chemical	*R*	*SDev*	*R*	*SDev*
Chloroform	*0.94*	*0.29*	*0.96*	*0.12*
Methylchloroform	*1.19*	*0.31*	*1.19*	*0.18*
Carbon tetrachloride	*0.73*	*0.26*	*0.71*	*0.11*
Trichloroethylene	*1.07*	*0.32*	*1.05*	*0.13*
Tetrachloroethylene	*0.98*	*0.33*	*0.96*	*0.11*
Benzene[a]	*(0.97)*	*(0.45)*	*(0.94)*	*(0.17)*
Chlorobenzene[a]	*(0.96)*	*(0.34)*	*(1.07)*	*(0.28)*

[a] *Limited data (indicated by parentheses).*