Monitoring Volatile Organic Compounds Found in Indoor Air Using Diffusive Samplers

Cynthia A. Kuhlman
Bruce D. Pacolay
Linda S. Coyne
SKC Inc.
863 Valley View Road
Eighty Four, Pa. 15330 U.S.A.

Abstract

Most people spend more time indoors than outdoors during the course of a 24-hour day. Therefore, it is important to know what contaminants exist in an indoor environment and their concentration. The U.S. EPA has conducted studies, which indicate that toluene, acetone, hexane, and p-xylene are among the most frequently quantified volatile organic compounds (VOCs).

Typical VOC sampling involves battery-operated pumps with sorbent tubes and desorption either with solvents and/or heat. Although this procedure is accurate and reproducible, this equipment can be noisy in an indoor environment. It may also require some training to use it correctly. In recent years, passive or diffusive monitors have been tested for this application. These monitors are small, quiet, lightweight, and simple to use. Challenges with indoor air have been low concentrations and face velocities observed relative to occupational exposures in the workplace.

This study will discuss diffusive samplers and their ability to monitor for VOCs at the ppb level and for periods of 24 hours. The VOCs studied were hexane, toluene, acetone, and p-xylene. Atmospheres of these compounds were generated and factors such as sampling rate, desorption efficiencies at sub-microgram levels, and reverse diffusion were studied.

The sampling rates for acetone, hexane, toluene, and p-xylene were 21.1, 17.3, 14.2, and 16.0 mL/min, respectively, and were within $\pm$ 25% of rates previously validated for 8-hour exposures at ppm levels. The desorption efficiencies at sub-microgram levels range from 91 to 111%. All compounds were acceptable after a 1- and 5-day reverse diffusion study except for acetone, which showed 63% recovery after 5 days.

The data indicates that passive monitors can be used to monitor ppb levels of VOCs for 24-hour periods in homes and office buildings.

Material and Methods

Sampling rates were determined by generating ppb levels of acetone, hexane, toluene, and p-xylene in air. This was accomplished by using a syringe pump, which can meter known volumes of a liquid into an airstream of known flow rate and relative humidity. This airstream is then connected to a test chamber where the badges can be placed for evaluation. Atmospheres were generated at a wind velocity of 20 cm/sec and were confirmed by using battery-operated pumps and sorbent tubes.

Desorption efficiencies were determined by spiking known quantities of each compound onto the diffusive sampler. The samplers were allowed to equilibrate overnight and were then solvent extracted and analyzed.

Reverse diffusion experiments were conducted by spiking a known quantity of the test analyte onto the badge and then letting the badges set open for 1 and 5 days. This technique was chosen, because it can be difficult to conduct a vapor generation experiment to simulate this for 5 days.

The 575-001 charcoal-based badges were desorbed with 2 mL of carbon disulfide, shaken for 30 minutes, and analyzed by gas chromatography (GC) with flame ionization detection (FID). The 575-002 badges were used for acetone and were desorbed with 10% 2-butanol in carbon disulfide. Analytical limits of detection were in the range of 200-500 ng per badge, depending on the compound.

Diffusive Samplers Tested in This Study

575-001

- **Contains 350 mg of Anasorb® CSC (activated charcoal)**
- **In-situ desorption with carbon disulfide**
- **Analysis by GC/FID or GC/MS**
- **Detection limits: 200-500 ng/badge, depending on compound**

575-002

- **Contains 500 mg of Anasorb 747**
- **In-situ desorption with carbon disulfide**
- **Analysis by GC/FID or GC/MS**
- **Detection limits: 200-500 ng/badge, depending on compound**

Sampling Rate (SR) Data for 24-hour Sampling of Acetone, Hexane, Toluene, and p-Xylene on the 575 Series Diffusive Samplers

10-100 ppb, 80% RH, 25 C

Test Compound	24-h SR (mL/min)	8-h SR (mL/min)[a]
Acetone	21.1[b]	20.3
Hexane	17.3	14.3
Toluene	14.2	14.9
p-Xylene	16.0	13.9

[a] Validated by either SKC Inc. or OSHA Salt Lake City Technical Center for 8-hour sampling of compounds in air.

[b] All compounds were collected on the 575-001 samplers except for acetone, which was collected on the 575-002 sampler.

Desorption Efficiency Data on the 575 Series Diffusive Sampler for Acetone, Hexane, Toluene, and p-Xylene

Compound	Range(μg)	Mean DE(%)	RSD(%)
Acetone	1.5-10	92.6[a]	8.3
Hexane	0.9-10	91.1	13.9
Toluene	1.5-10	111.0	13.0
p-Xylene	0.3-20	98.6	13.1

[a] Acetone was desorbed in 10% 2-butanol in carbon disulfide

5-day Reverse Diffusion Data for Acetone, Hexane, Toluene, and p-Xylene on the 575 Series Diffusive Samplers

	Recovery (%)	
Compound	**Day 0 ± RSD**	**Day 5 ± RSD**
Acetone	**92.6 ± 8.2**	**63.3 ± 13.7**
Hexane	**91.1 ± 13.8**	**93.0 ± 5.8**
Toluene	**111 ± 13.0**	**96.4 ± 10.0**
p-Xylene	**98.6 ± 13.0**	**97.6 ± 4.7**

Conclusions

1. **Desorption efficiency data for low levels remained high and ranged from 91 to 111 % on the 575-001 and 575-002 diffusive samplers.**

2. **Sampling rates for 24 hours at ppb concentrations remained consistent with previously validated sampling rates that were generated at ppm levels and for 8 hour periods. The extended sampling rates were within ± 25% of the 8 hour sampling rates.**

3. **Reverse diffusion data was within acceptable limits, except for acetone. This is believed to be due to the poor storage stability acetone shows at ambient temperatures.**

4. **When sampling at ppb levels, the variability will be greater as was demonstrated with higher relative standard deviations for both desorption efficiency and reverse diffusion data.**

5. **These diffusive monitors can detect easily 10 ppb for a 24-hour sample for the compounds studied.**

Sample Chromatogram
Hexane, Acetone, and p-Xylene in Carbon Disulfide

GC CONDITIONS

Column: 30 m x 0.32 mm, 1.0 micron Restek Stabilwax® capillary column

Temperatures:

Injector: 250 c

FID: 250 c

Column: Initial temperature at 35 c
Hold for 3 minutes and ramp at 10 c/min up to 100 c
Hold for 0.1 minute

Injection: 1 microliter, split/splitless