TECH NOTES

Measuring Sub-ppb Levels of VOCs in Indoor Air: A Performance Comparison of Diffusive Samplers and Canisters

Introduction
Diffusive (passive) samplers (sometimes referred to as badges) are becoming increasingly popular for sampling indoor air. The New York State Department of Health (NYDOH) and the New York Department of Environmental Conservation (NYDEC) investigated the use of diffusive samplers in a collaborative 10-home study in the state of New York. The SKC ULTRA diffusive samplers and stainless steel canisters were used side-by-side in the study. The compounds investigated were benzene, toluene, perchloroethylene, o-xylene, m-xylene, and p-xylene.

Experimental
Indoor air was sampled at two locations in each of 10 homes, with one location in each home selected for the correlation study of the diffusive samplers and canisters. Additionally, a set of duplicate samples was collected in one of the 10 homes for quality control purposes. The diffusive samplers and canisters were attached to a 5-foot sampling stand. Samples were collected for 24 hours.

The sampling was conducted with 6-liter stainless steel canisters and SKC ULTRA samplers packed with 20/35 Tenax® TA and 60/80 mesh Anasorb® GCB1. The canisters were analyzed by Centek Laboratories using EPA Method TO-15 for a full-scan VOC list. The reporting limit for a 24-hour sample was approximately 1 μg/m^3. The diffusive samplers were analyzed by Columbia Analytical Services using EPA Method TO-17, which included thermal desorption with select ion monitoring. The reporting limits for a 24-hour sample ranged from 0.005 to 0.06 μg/m^3, depending on the analyte.

Results and Discussion
Diffusive samplers are similar to sorbent tubes except that molecular diffusion, instead of a battery-operated pump, is used to collect the sample. The result of a diffusive sampler validation is an "uptake rate," sometimes referred to as a sampling rate. This sampling rate is used in the same fashion as a calibrated pump flow rate for a specific tube and method. Diffusive samplers also exhibit "starvation" effects at lower face velocities, thus affecting the sampling rate. ULTRA samplers perform satisfactorily to 5 cm/sec (10 ft/min). In the New York field study, face velocities were low to negligible, with the highest reading at approximately 1 cm/sec. This was a situation where starvation effects could occur. Additional laboratory work was performed to study sampling rates at face velocities less than 5 cm/sec, which are typically found in homes. The laboratory data indicated that sampling rates were much lower than those generated in the original validation studies at 10 to 200 cm/sec face velocities. Thus, these lower or indoor rates were used in the field comparison study between canisters and diffusive samplers. The sampling rate data is shown in Table 1.

The following six compounds were identified in this study: benzene, perchloroethylene, toluene, o-xylene, m-xylene, and p-xylene. The canister and diffusive sampler comparison data are found in Figures 1 through 5. A test run was conducted in each home. The number of test runs in each chart varies; some of the compounds were not detected during sampling and the data were not reported. The correlation coefficients were very good for both diffusive samplers tested against the canisters and are listed in Table 2. The data indicate that, in general, the sampler containing Anasorb GCB1 gave higher results than the badge with Tenax TA. This is understandable as Tenax TA is a weaker sorbent than GCB1 and could be losing some of the analytes.

Conclusions
The New York study data indicate that the SKC ULTRA diffusive samplers packed with either Anasorb GCB1 or Tenax TA correlate well with canisters. Well-known benefits of diffusive samplers are small size and simple operation. The ULTRA samplers are sensitive enough to detect ppt levels of VOCs for a 24-hour sample. These samplers are a useful alternative to canisters, either as a screening tool or as a sampling device for measuring concentrations inside homes for vapor intrusion studies.

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Table 1. Sampling Rates for ULTRA Diffusive Samplers

Compound	Sampling Rate (ml/min) 5-200 cm/sec	Sampling Rate (ml/min) < 5 cm/sec*
Benzene	16.0	10.70
o-Xylene	11.9	8.11
m-Xylene	12.5	7.78
p-Xylene	12.8	8.42
Toluene	14.5	8.90
Perchloroethylene	13.1	10.00

* *Low air velocities, typically found in indoor air, result in lower uptake rates in diffusive samplers.*

Figure 1. *(See Appendix A, Table 1 for individual data points)*

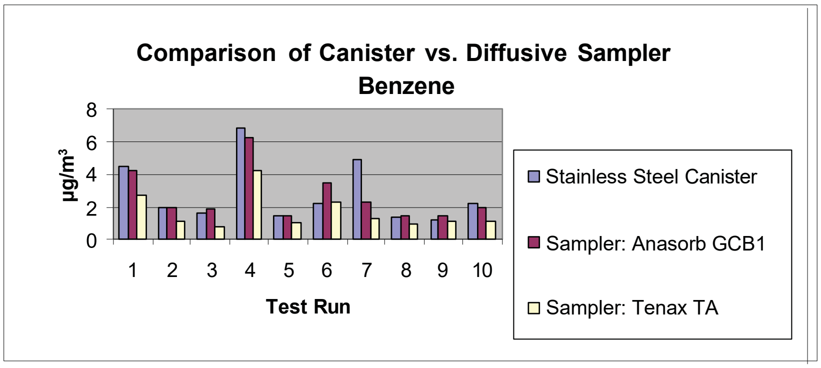

Figure 2. *(See Appendix A, Table 2 for individual data points)*

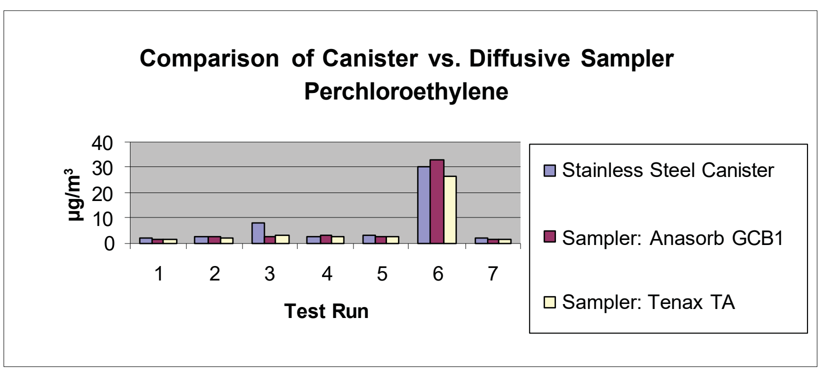

Figure 3. *(See Appendix A, Table 3 for individual data points)*

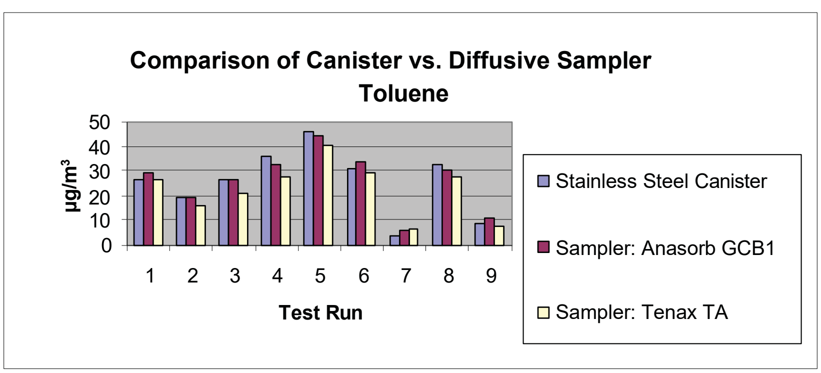

Figure 4. *(See Appendix A, Table 4 for individual data points)*

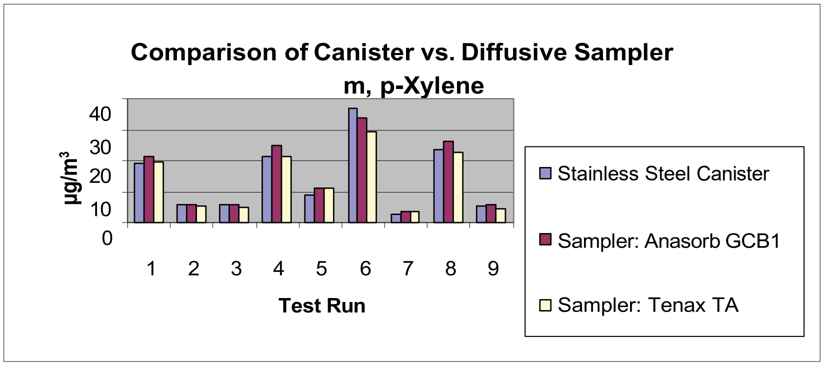

Figure 5. *(See Appendix A, Table 5 for individual data points)*

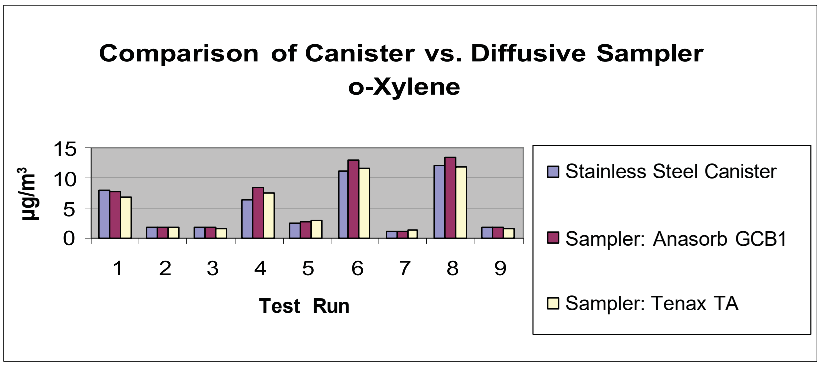

Table 2. Correlation Coefficients Between Diffusive Samplers and Canisters

Compound	Anasorb GCB1 Sampler	Tenax TA Sampler
Benzene	0.954	0.942
Toluene	0.986	0.980
m, p-Xylene	0.985	0.982
o-Xylene	0.999	0.999
Perchloroethylene	0.981	0.984

Appendix A

Table 1 Collection of Benzene with Canisters and Diffusive Samplers (μg/m^3) — 24 hour Samples

Canister	ULTRA sampler (Anasorb GCB1)	ULTRA sampler (Tenax TA)
4.5	4.2	2.6
2.0	2.1	1.1
1.6	1.9	0.88
6.8	6.67	4.4
1.5	1.58	1.04
2.1	3.8	2.25
1.4	1.5	0.94
1.2	1.5	1.13
2.1	1.9	1.1

Table 2 Collection of Perchloroethylene with Canisters and Diffusive Samplers (μg/m^3) — 24 hour Samples

Canister	ULTRA sampler (Anasorb GCB1)	ULTRA sampler (Tenax TA)
1.6	1.1	0.96
2.2	2.3	1.92
8.3	2.5	2.88
2.6	2.85	2.47
3.4	2.71	2.2
30	32.9	26
2.0	1.37	1.0

Table 3 Collection of Toluene with Canisters and Diffusive Samplers (μg/m^3) — 24 hour Samples

Canister	ULTRA sampler (Anasorb GCB1)	ULTRA sampler (Tenax TA)
26	30	26.7
19	20.3	16.7
26	26.7	21.7
36	33.3	28.3
46	44	41
31	34	29
3.8	6.1	6.8
33	30.1	28.3
8.8	10.8	8

Table 4 Collection of m,p-xylene with Canisters and Diffusive Samplers (μg/m^3) — 24 hour Samples

Canister	ULTRA sampler (Anasorb GCB1)	ULTRA sampler (Tenax TA)
19.2	21.2	19.5
5.6	5.52	5.04
5.5	5.85	4.71
21.1	24.2	21.1
8.9	10.6	10.6
36.7	34.1	29.1
2.51	3.7	3.58
23.8	26	22.8
5.1	5.7	4.06

Table 5 Collection of o-xylene with Canisters and Diffusive Samplers (μg/m^3) — 24 hour Samples

Canister	ULTRA sampler (Anasorb GCB1)	ULTRA sampler (Tenax TA)
7.9	7.55	6.8
1.9	1.96	1.96
1.9	1.8	1.5
6.2	8.3	7.4
2.3	2.6	2.9
11	13.3	11.8
0.93	1.16	1.28
12	13.3	11.8
1.9	1.96	1.51

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