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Specialists in Air Sampling Technologies

Advances in Diffusive Sampling

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2010

Diffusive Samplers

- There are many studies now published on the use of badge and tube style diffusive samplers for IH applications
- OSHA has listed several methods which have been validated with the use of diffusive samplers
- The data indicate badges produce consistent and accurate measurements
- Validation studies have documented reliable results under various conditions of use

Diffusive Badges

- They were originally developed and validated for IH monitoring methods
- Both solvent extraction and thermally desorbed version of badges exist
- Considered as a “passive” sampler as they rely on molecular diffusion to collect analytes on media and not on a pump
- When badges are validated, an “uptake rate” or “sampling rate” in mL/min is calculated

Diffusive Samplers

ADVANTAGES

- Low costs for purchase
- Easy operation
- Lightweight and unobtrusive
- Can be placed easily at various heights in the sampling area

DISADVANTAGES

- Possible reverse diffusion effects if sorbents are not selected properly
- Care must be taken to investigate air velocity in area that is being sampled

Multi-Sampling Rate Badge

- We developed a snap-on cap (fewer holes) for our nitrous oxide badge
- This was to lower the sampling rate to avoid saturation of N20 onto molecular Sieve 5A
- What about other caps for other rates??

Multiple Sampling Rates

- We have made 4 other caps which cover the range from 0.5 to 8.0mL/min
- Currently testing is in progress with toluene, benzene, p-xylene, and trichloroethylene
- Data looks good and is predictable
- Toluene rates are: 0.51, 1.06, 2.11, 4.23, and 8.48mL/min
- Uses? Smaller rates for 30 day sampling?

Very Versatile Diffusive Badge

- 5 new snap on caps to cover down to 0.5mL/min
- Solvent extraction and thermal desorption
- Wide selection of sorbents
- ppt to ppm detection limits

Objective

- The **objective** was to develop a **method** for sampling for nitrogen dioxide and sulfur dioxide with a diffusive sampler at concentrations from 0.4 to 8.0ppm under conditions of 20 to 80% relative humidity (RH) at 25oC.

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UMEX Badges

Sulfur Dioxide: 500-200

- Analysis is by ion chromatography for the sulfate ion
- *Studies in progress but same badge can be used for nitrogen dioxide as well.*
- We are investigating whether this badge can be used for ambient air monitoring for both NO2 and SO2 which would require detection of much lower levels than validation study

Sulfur Dioxide: 500-200

- Triethanolamine-treated tape contained in the UMEX badge housing
- Sampling rate is 15.1mL/min, RSD of 16.7%
- Validated from 0.4 to 8.0ppm for 8h exposure
- Short-term (15 min) sampling at 2ppm and above
- Samples can store for 3 weeks at ambient or temperatures below 4oC
- Unused badges store for 18 months at temps below 4oC.

Uptake

- The uptake rate for SO2 was 15.1ml/min with an RSD of 16.7%.
- A study of reverse diffusion indicated no losses for either compound.
- Storage studies showed that samplers could be stored for up to three weeks at both freezer and ambient temperatures with less than 10% loss in recovery.

Sampling Rate

- Samples were solvent extracted and analyzed by IC. The **results** showed that the sampling rate for NO2 was 12.83 ml/min with an RSD of 13.4%.

Conclusion

- In **conclusion**, a diffusive has been validated that will monitor for nitrogen dioxide and sulfur dioxide for 15-minutes to 8-hour exposure. A field study with 24-hour sampling is in progress.

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Vapor Intrusion Sampling Options: Performance Data for Canisters, Badges, and Sorbent Tubes for VOCs

Air sampling devices must allow for extended sampling times of 24 hours or longer, for ppb level detection.

Canisters have been widely used for sampling in vapor intrusion studies.

The **objective** of this study was to investigate the use of diffusive samplers for conducting long-term, low level sampling of organic compounds.

Background

- Canisters are commonly used to monitor VOCs at sub-ppm levels
- Referenced in detail in EPA Methods TO-14A and TO-15
- Analysis is accurate and sensitive; good storage properties
- Canisters can be expensive due to high shipping costs and recertification
- Require extensive training and cannot do semi-volatiles

Purpose

- Conduct side-by-side comparisons between tubes/badges and canisters
  - Vapor Intrusion study in homes with diffusive badges and canisters
  - Soil gas sampling with thermal desorption tubes and canisters

Vapor Intrusion Study in Homes

- New York State Department of Health and Department of Environmental Conservation approached us to conduct a field study comparing badges against canisters
- The test sites were being investigated for vapor intrusion by VOCs in ground water from a dry cleaning establishment and gas station
- They were interested in badges because they were simple to use, lightweight, and unobtrusive.

New York Study:
Canister vs. SKC Ultra II Badge

- Field study performed at 10 homes that were part of a vapor intrusion evaluation; a set of duplicate samples at one location

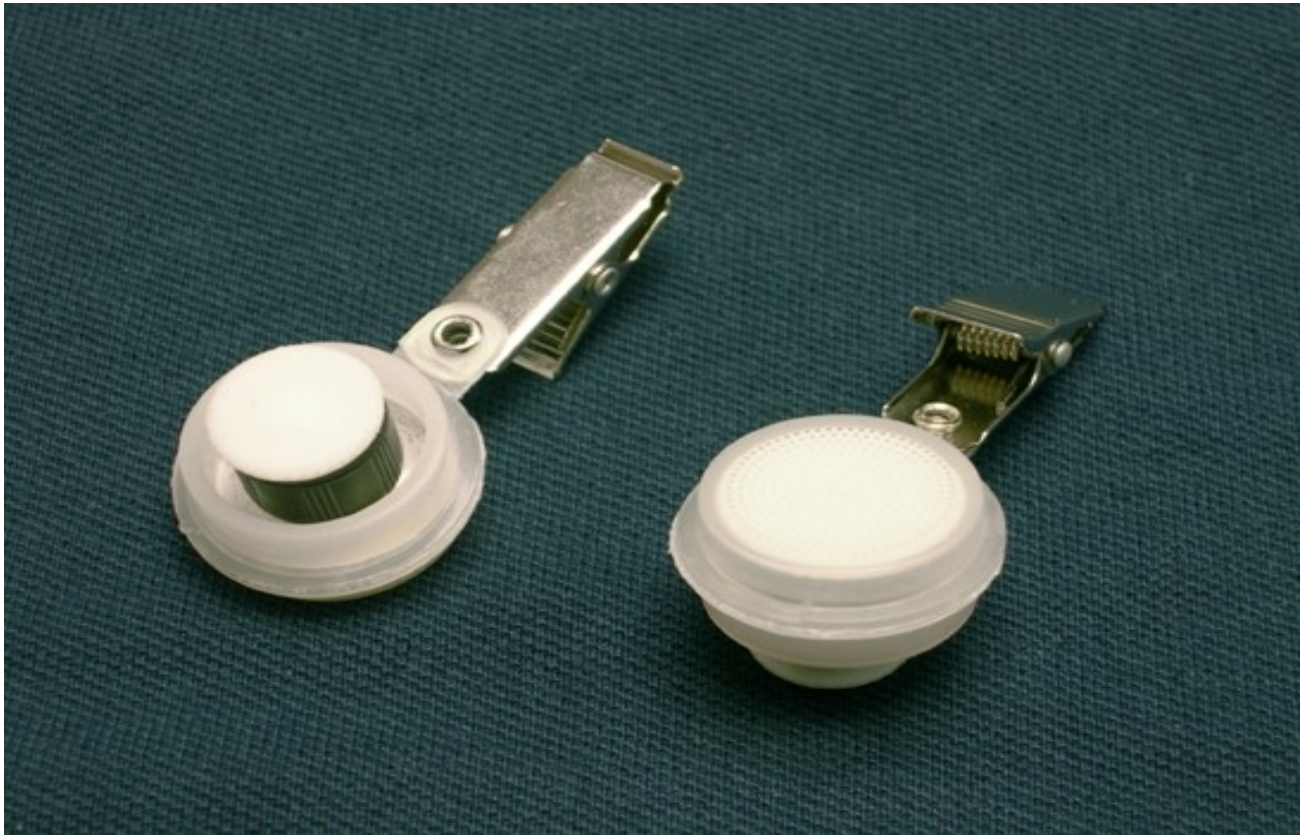
- Main contaminants were those from gasoline and dry cleaning establishments

- Stainless–steel canisters (1 litre) with TO-15 Full Scan; SIM if necessary

New York Study: Canister vs. SKC Ultra II Badge

- Ultra II Badges with Tenax TA/TO-17 SIM
- Ultra II Badges with Anasorb GCB1/TO-17 SIM
- Samples were collected for 24 hours
- Charcoal badges for PCE only/NYSDOH 311-9

Front and Back of Sampler



Filling the Sampler

Emptying the Sampler

Transfer of Media to Tube

Sampling Rates for Diffusive Badges

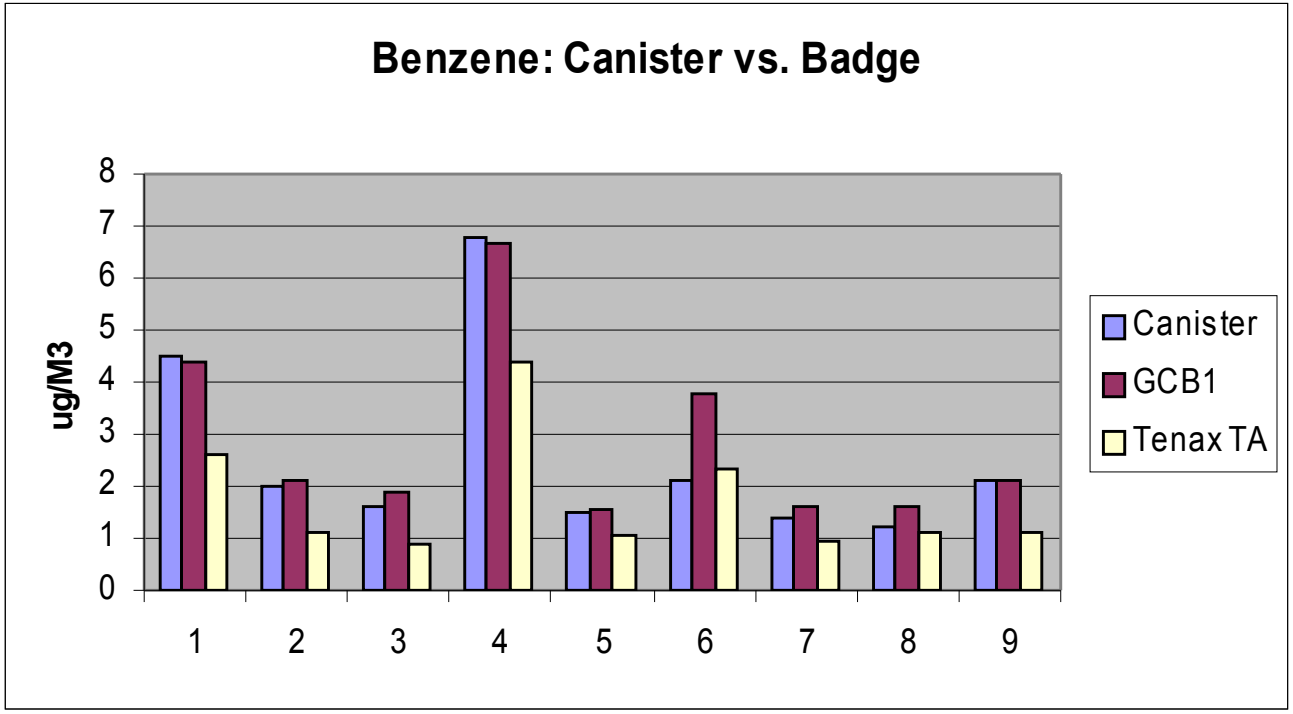
- Sampling rates are used in the same way as a calibrated pump flow rate
- Different at low velocities
- Velocities in homes/buildings must be documented so that a proper rate is selected

Sampling Rates at Zero Velocity for Test Compounds

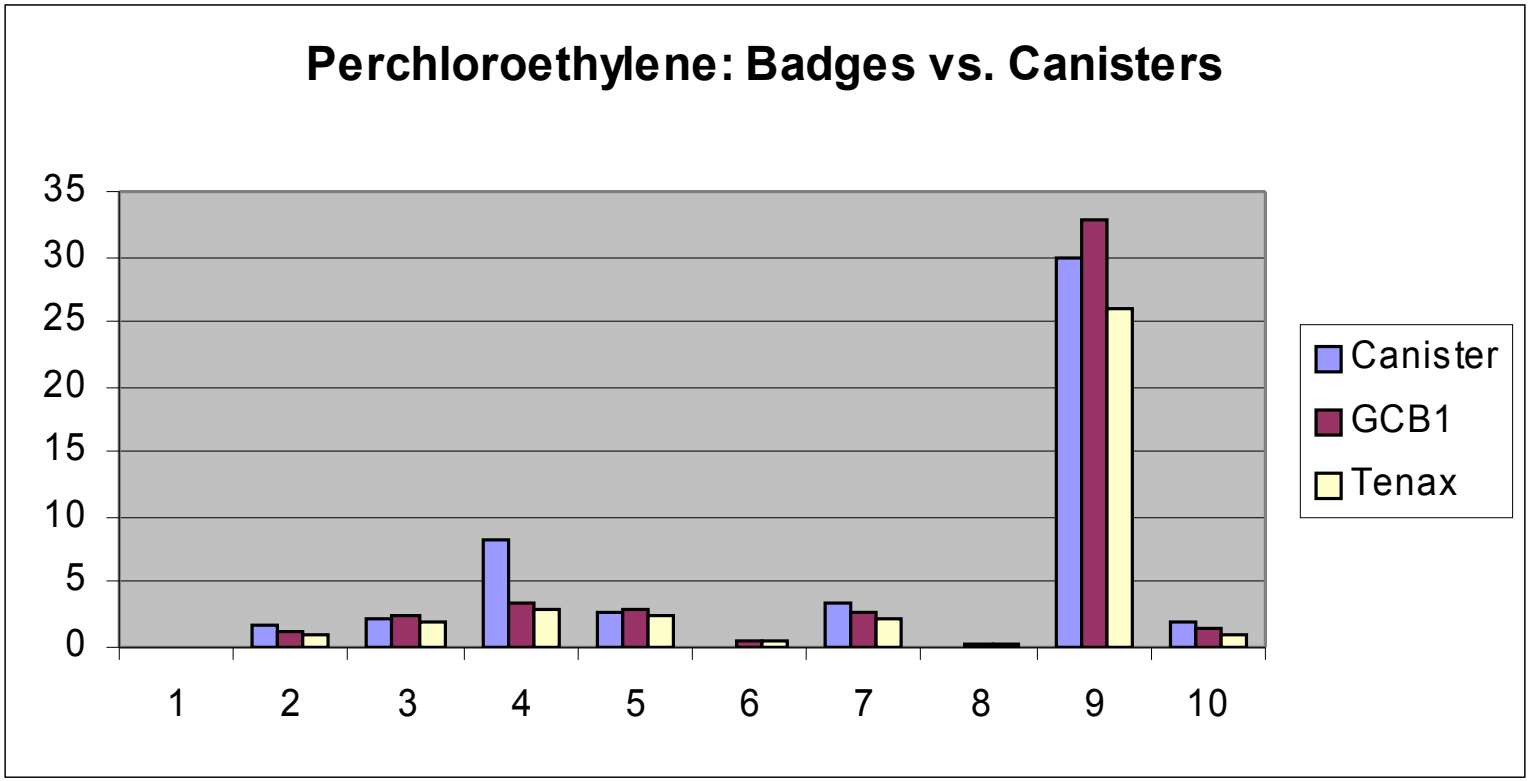
Compound	Sampling rate Zero velocity (mL/min)	Sampling Rate 5 to 200 cm/sec (mL/min)
Toluene	8.58	14.5
m-Xylene	8.02	12.5
o-Xylene	7.87	11.9
p-Xylene	7.57	12.8
Perchloroethylene	9.40	12.9
Trichloroethylene	10.2	14.9
Benzene	10.1	16.0

Battery-Operated Rotating Badge Stand

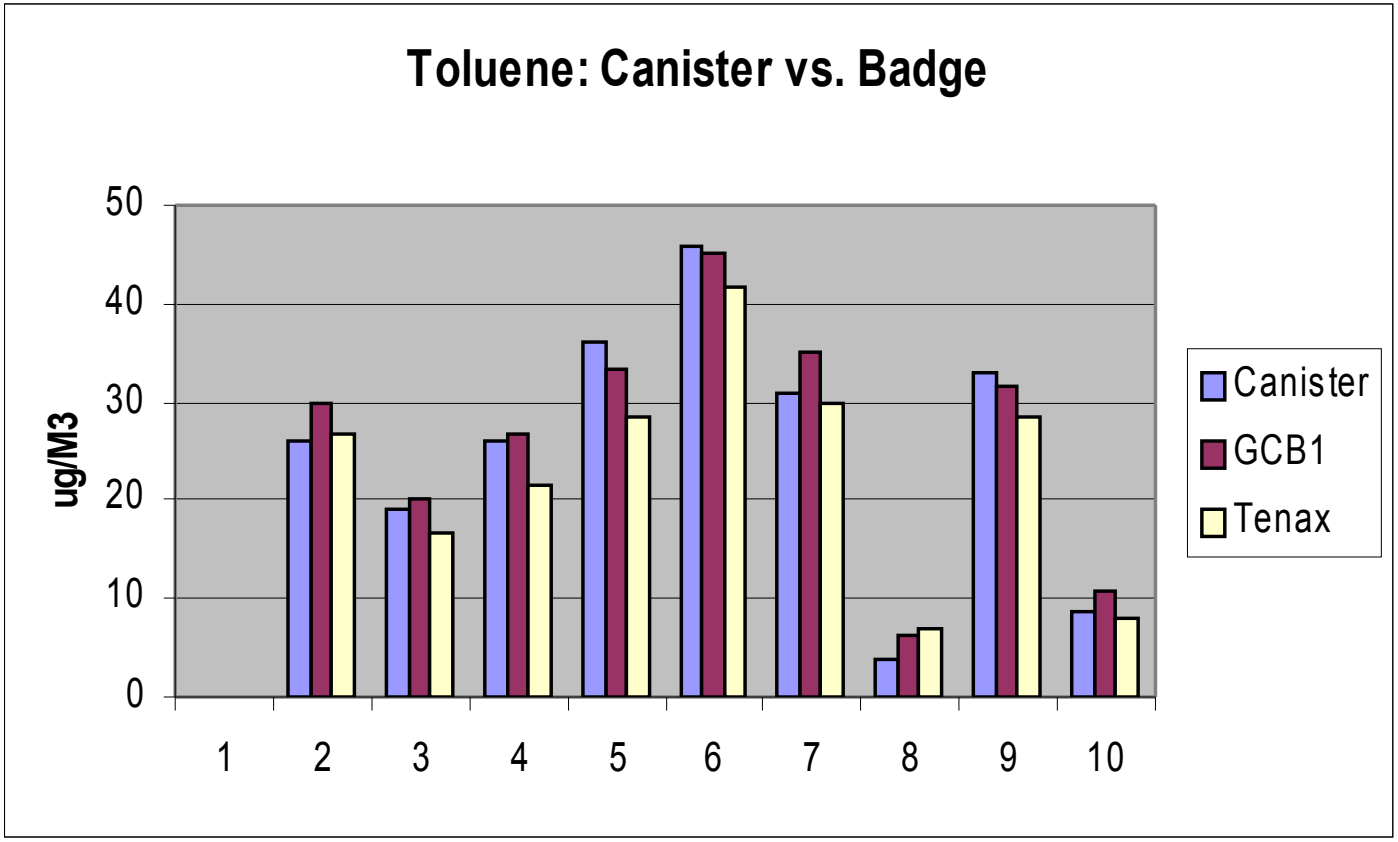
Benzene: Canister vs. Badge



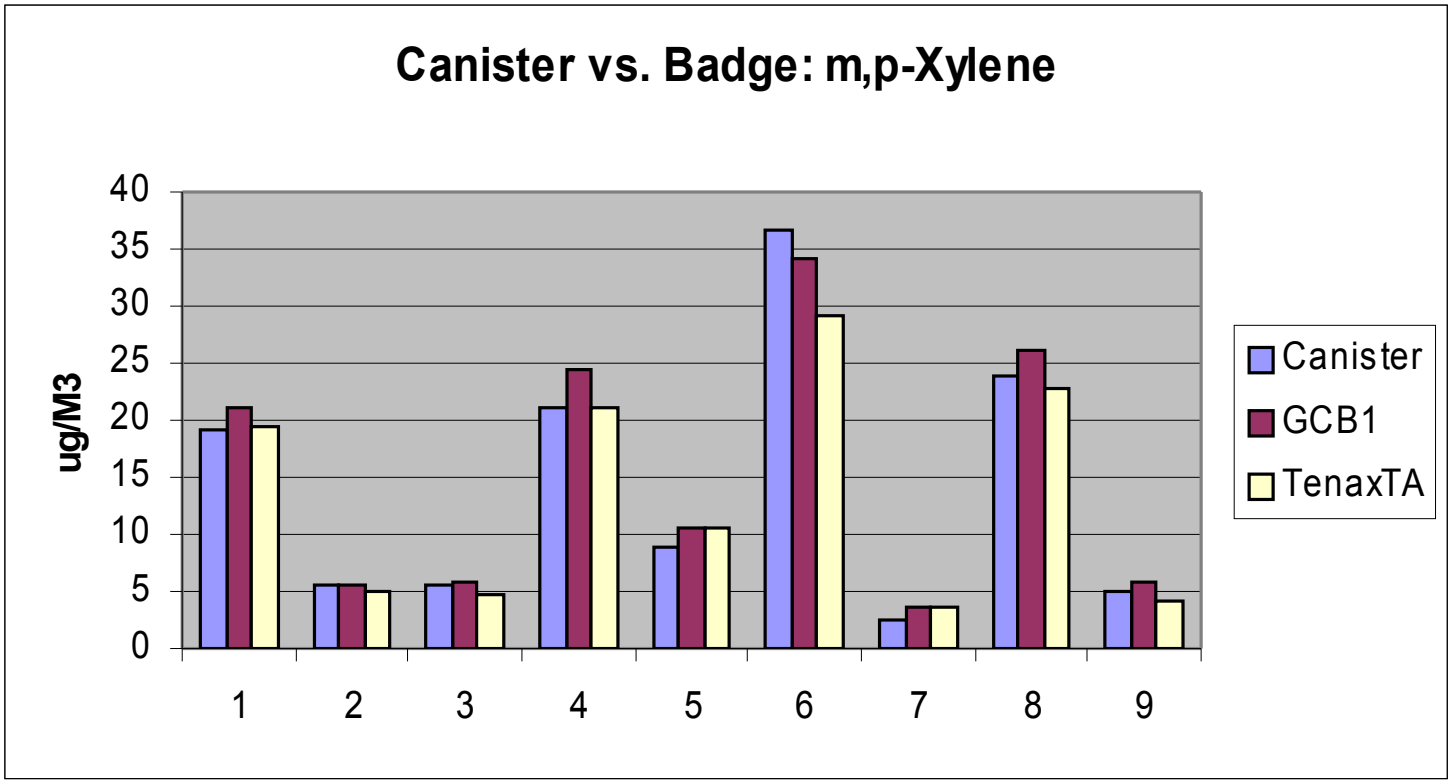
Perchloroethylene: Canister vs. Badge



Toluene: Canister vs. Badge



m,p-Xylene: Canister vs. Badge



Conclusions from Badge Study

- Badges correlated well with canisters
- They were lightweight and simple to use in the field
- They can be used as a screening tool and potential predictor of concentration

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The Effects of Sorbent Selection and Sample Volume on Long-Term Sampling (1 to 30 day) of 6 VOCs using Diffusive Samplers

There is a growing concern among environmental health professionals about the migration of chemicals from contaminated groundwater into overlying buildings.

Traditional 8-hour air measurements for occupational environments are not suitable for measuring contaminants involved in vapor intrusion.

Diffusive samplers were studied for sample periods of 1, 3, 7, and 30 days using a variety of sorbents including Anasorb GCB1, activated charcoal, and Carbopack X.

The compounds studied were benzene, toluene, o-xylene, methylene chloride, trichloroethylene and perchloroethylene.

The **method** involved exposing the badges to concentrations of 30 to 120 ppb and analysis by gas chromatography using both solvent extraction and thermal desorption techniques.

The study revealed that one of the critical factors in using passive samplers for long-term sampling is **reverse diffusion**.

The **results** indicate that **reverse diffusion** depends little on the sorbent capacity, but largely on air sample volume and the physical properties of the target chemical.

In a study with methylene chloride at 55 ppb, the passive samplers containing activated charcoal showed no signs of reverse diffusion after 3 days of sampling.

However, after 7 days of sampling, the samplers showed significant loss of methylene chloride even though the overall loading was only 20 micrograms. Similar results were found for other chemicals.

In **conclusion**, the data indicated that the primary concern for long-term, low-level sampling of organic vapors using diffusive samplers is reverse diffusion.

The effects of reverse diffusion can be minimized through proper sorbent selection for the target compounds and lower sampling rates.

POTENTIAL NEW MARKETS

- CANCER DETECTION
- FORENSICS
- ARSON
- DIRECT READING PERSONAL MONITOR
- SOIL SAMPLING
- MULTI-SAMPLING RATE BADGE

FORENSICS

- Forensics—trace evidence which includes gunshot residue, explosives, and VOCs.
- VOCs evolved from human decomposition
- 11 core compounds–ethanol, 2-propanone, dimethyl disulfide, methyl benzene, octane, MEK, methyl ethyl disulfide, dimethyl trisulfide, o-xylene, m-xylene, and p-xylene.
- Thermal desorption tubes and/or Ultra II badges
- Work with some forensic labs to see how our products could serve them better

Arson

- Falls in line with forensics to a certain degree
- Using charcoal strips to collect VOC