BEACON ENVIRONMENTAL

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TECHNICAL MEMORANDUM

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ChloroSorber™ – The Passive Sampler to Target Chlorinated Compounds in Air – Vinyl Chloride to Tetrachloroethene

Background

Beacon provides passive sorbent samplers internationally to accurately and reliably target volatile organic compounds (VOCs) in the indoor and ambient air. Beacon can analyze sorbent samplers with various adsorbents depending on which compounds are of concern; however, the performance of a sorbent tube with a select adsorbent preferred by Beacon was evaluated in a robust study completed by the Health and Safety Laboratory (HSL) in the United Kingdom and the validated uptake rates from that study are used to target a range of chlorinated compounds from vinyl chloride to tetrachloroethene (PCE).

Other passive samplers are known to use inexpensive and inferior adsorbents that are not appropriate for vinyl chloride and possibly the other more volatile compounds, resulting in false positives and at a minimum biased low results.[1] The ChloroSorber™ provided by Beacon overcomes these challenges and concerns.

Sampling Method

The passive sorbent tube sampler consists of a 6mm o.d. stainless steel tube packed with adsorbent with a demonstrated affinity for the target compounds. The tubes are shipped to the project site with Swagelok storage caps on both ends of the tubes. To sample air, the storage cap is removed from the sampling end of the tube and replaced with a diffusion cap that allows air to enter the tube and the VOCs present to be adsorbed onto the sorbent bed following the principles of diffusion. The sampler is suspended in the air by wire or string typically within the breathing zone. Following the sampling period, the diffusion cap is removed and replaced with the storage cap, which is tightened to be gas-tight for storage and transport. The sampler is returned to Beacon for analysis following analytical procedures described in U.S. EPA Method TO-17 and TO-15. The holding time from sample collection until analysis is 30 days.

Sampler Uptake Rates

In 2016, Beacon commissioned two consecutive studies at the Health and Safety Laboratory (HSL) in the United Kingdom. The studies set out to experimentally determine and validate the quantitative uptake rates of multiple passive samplers based on 7-, 14-, and 26-day exposure periods. Beacon Passive Samplers and sorbent tube samplers with various adsorbents were included in the studies.

The experiments were carried out in the HSL standard atmosphere generator based upon procedures described in ISO 6145-4:2004[2]. HSL is a renowned center of excellence for VOC sampling, and their methods for the determination of hazardous substances (MDHS) are the source of most of the published uptake rates in the relevant international standard methods (e.g., ISO 16017-2)[3].

Quantitative uptake rates for 13 key chlorinated and aromatic VOCs were determined and verified for the passive samplers. In this six-replicate study, the devices showed excellent performance with great linearity and reproducibility. The uptake rates determined for the ChloroSorber to target chlorinated compounds from vinyl chloride to tetrachloroethene (PCE) are provided in **Table 1**.

Table 1: Validated Uptake Rates

COMPOUND	Uptake Rate (ml/min)
Vinyl Chloride	0.56
1,1-Dichloroethene	0.45
trans-1,2-Dichloroethene	0.70
1,1-Dichloroethane	0.74
cis-1,2-Dichloroethene	0.70
1,2-Dichloroethane	0.44
Trichloroethene	0.65
Tetrachloroethene	0.55

Analytical Method

The sorbent tube is analyzed using thermal desorption-gas chromatography/mass spectrometry (TD-GC/MS) instrumentation in accordance with the requirements of EPA Method TO-17 and TO-15. The masses measured of individual target compounds (in nanograms) are converted to a concentration (ug/m3) following the procedures and equations detailed in ISO 16017-2.

The equation below describes how the mass measured (nanograms) of individual compounds is multiplied by the dilution factor (if required), which is divided by the uptake rate (ml/min) and time of sample exposure (minutes) to calculate the time-weighted average concentration (ug/m3). Further, to provide the most accurate results, the uptake rates are corrected for the average temperature during the sampling period as compared to the average temperature when the uptake rates were verified during the HSL study.

The equations used to calculate the time-weighted average concentrations are provided below.

$$C = \frac{1000 \times M \times DF}{Uc \times t}$$

$$Uc = U \times \left(\frac{Ts+273.15}{Tu+273.15} \right)^{1/2}$$

Where:
- C = concentration (ug/m^3)
- M = mass (ng)
- DF = dilution factor
- Uc = uptake rate (ml/min), corrected
- t = sampling time (minutes)
- U = compound specific uptake rate
- Ts = temperature – sampling period
- Tu = temperature – uptake rate study

Table 2 provides the limits of quantitation (LOQs) for each of the chlorinated compounds with validated uptake rates based on sampling periods from days to more than 3 weeks. The LOQ is at or above the low point of the initial calibration curve. In addition, results less than the LOQ but greater than the demonstrated limit of detection (LOD) may be reported as estimates and qualified with a “J” to achieve lower reporting limits. **Table 3** provides the limits of detection (LODs) for each of the chlorinated compounds. ■

Table 2: Limits of Quantitation (LOQs) based on Exposure Periods and Third Party Validated Uptake Rates

COMPOUND	CAS	Uptake Rate (ml/min)	3 Days LOQ (ug/m3)	7 Days LOQ (ug/m3)	10 Days LOQ (ug/m3)	14 Days LOQ (ug/m3)	26 Days LOQ (ug/m3)
Vinyl Chloride	75-01-4	0.56	0.41	0.18	0.12	0.09	0.05
1,1-Dichloroethene	75-35-4	0.45	0.51	0.22	0.15	0.11	0.06
trans-1,2-Dichloroethene	156-60-5	0.70	0.33	0.14	0.10	0.07	0.04
1,1-Dichloroethane	75-34-3	0.74	0.31	0.13	0.09	0.07	0.04
cis-1,2-Dichloroethene	156-59-2	0.70	0.33	0.14	0.10	0.07	0.04
1,2-Dichloroethane	107-06-2	0.44	0.53	0.23	0.16	0.11	0.06
Trichloroethene	79-01-6	0.65	0.36	0.15	0.11	0.08	0.04
Tetrachloroethene	127-18-4	0.55	0.42	0.18	0.13	0.09	0.05

Table 3: Limits of Detection (LODs) based on Exposure Periods and Third Party Validated Uptake Rates

COMPOUND	CAS	Uptake Rate (ml/min)	3 Days LOD (ug/m3)	7 Days LOD (ug/m3)	10 Days LOD (ug/m3)	14 Days LOD (ug/m3)	26 Days LOD (ug/m3)
Vinyl Chloride	75-01-4	0.56	0.21	0.09	0.06	0.04	0.02
1,1-Dichloroethene	75-35-4	0.45	0.26	0.11	0.08	0.06	0.03
trans-1,2-Dichloroethene	156-60-5	0.70	0.17	0.07	0.05	0.04	0.02
1,1-Dichloroethane	75-34-3	0.74	0.16	0.07	0.05	0.03	0.02
cis-1,2-Dichloroethene	156-59-2	0.70	0.17	0.07	0.05	0.04	0.02
1,2-Dichloroethane	107-06-2	0.44	0.26	0.11	0.08	0.06	0.03
Trichloroethene	79-01-6	0.65	0.18	0.08	0.05	0.04	0.02
Tetrachloroethene	127-18-4	0.55	0.21	0.09	0.06	0.05	0.02

[1] Karstoft, J., Mortensen, P. Measurement for Vinyl Chloride in Indoor Climate. NIRAS/Region Midtjylland, Denmark. November 13, 2018.
[2] ISO 6145-4:2004 Gas analysis — Preparation of calibration gas mixtures using dynamic volumetric methods — Part 4: Continuous syringe injection method
[3] ISO 16017-2, Indoor, ambient and workplace air – Sampling and analysis of volatile organic compounds by sorbent tube/thermal desorption/capillary gas chromatography – Part 2: Diffusive Sampling, 2003.