Laboratory Evaluation of AT525 TraceAir® II Fast Sampling Rate Sampler

Prepared by: MDR Peralta, PhD Revised: 30 November 2018

These tests for evaluation of diffusive air samplers were conducted within the guidelines described in ANSI 104-1998 (R2009).

TraceAir® II Fast Sampling Rate, Organic Vapor Sampler

Assay Technology's 525 TraceAir® II sampler consists of a wafer of activated carbon in a PTFE binder contained in a polypropylene sampler body with a 562-port polypropylene sampling grid. The organic vapor sampler can be used to collect most organic vapors with a low PEL (10 ppm or less), STEL monitoring, or for indoor air quality situations. The most common chemicals used on the AT525 sampler include:

Trichloroethane	Ethyl benzene	N-Butyl Acetate
Butanol	Heptane	Perchloroethylene
4-Phenyl cyclohexane	Hexane	Styrene
Acetone	Isopropyl Alcohol	Tetrahydrofuran
Benzene	Methyl Ethyl Ketone	Toluene
Chloroform	Methyl Isobutyl Ketone	Trichloroethylene
Cyclohexanone	Methyl Methacrylate	Xylenes
Ethyl acetate	Methylene Chloride	
Ethyl alcohol	Naphthalene	

***This is not a complete list of organic vapors (OV's) the TraceAir® Sampler is able to collect. Please refer to Assay Technology's Sampling Guide, online, for a more complete list.**

1. Test Apparatus & Method

Vapor exposures of various organic vapors were created by dynamic dilution from a liquid phase containing the analytes in solution. The liquid analyte mixture was injected into a flowing stream of air at a fixed rate via a syringe pump, and was then dynamically mixed with flow-controlled input air provided by the Miller-Nelson 501 atmosphere conditioner. The controlled mixture was passed through an inert acrylic chamber containing diffusive samplers under test. Flows were verified by calibration, and exposure concentrations were verified by charcoal sampling tubes mounted in the chamber, bracketing the samplers under test. Active and diffusive samplers were analyzed by gas chromatography.

2. Desorption Efficiency (DE)

Analyte recovery from the wafer (desorption efficiency) was determined by analysis (OSHA 7) of charcoal wafers spiked from standard analyte solutions. Samplers were tested at spike levels corresponding to levels of expected exposure in the vicinity of the NIOSH REL. Carbon disulfide was used as the desorption solvent with benzyl alcohol as the co-solvent when necessary. The DE results from the study are presented in Table 1.

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Table 1. Desorption efficiencies (in carbon disulfide and co-solvent benzyl alcohol when necessary) for various OVs on the AT525 sampler

	Methylene Chloride	Benzene	Toluene	o-Xylene
Level 1 Spike (µg)	349.7	5.9	144.2	83.2
Avg % Recovery Trial A	97.8%	103.8%	99.2%	94.4%
Avg % Recovery Trial B	92.3%	97.8%	96.1%	92.2%
Avg % Recovery Trial C	90.0%	93.2%	97.7%	99.9%
Avg % Recovery Trial D	95.1%	95.6%	96.1%	94.0%
Average	93.8%	97.6%	97.3%	95.1%

	Methylene Chloride	Benzene	Toluene	o-Xylene
Level 2 Spike (µg)	703.2	11.8	290.2	167.2
Avg % Recovery Trial A	92.7%	93.2%	94.7%	92.7%
Avg % Recovery Trial B	97.4%	103.2%	97.3%	89.7%
Avg % Recovery Trial C	95.8%	98.6%	94.7%	89.6%
Avg % Recovery Trial D	95.1%	99.3%	95.9%	90.6%
Average	95.2%	98.5%	95.6%	90.7%
Level 3 Spike (µg)	1709.9	28.6	706.6	405.1
Avg % Recovery Trial A	97.6%	101.5%	98.5%	92.9%
Avg % Recovery Trial B	97.2%	101.1%	100.5%	98.1%
Average	97.4%	101.3%	99.5%	95.5%
% Recovery (Grand Avg)	95.5%	99.1%	97.5%	93.8%

3. Verification of Diffusive Sampling Rate

Extensive chamber studies on various organic vapor compounds were initially done on the original TraceAir® design, AT521. Samplers were tested in 2- and 4-hour studies according to the procedure described in Section 1. Then they were analyzed using the OSHA 7 method. Exposures were applied to samplers in the vicinity of the NIOSH REL.

The AT525 sampler is a re-design of the AT521 Sampler designed to improve certain issues with the AT521 Sampler, mainly the difficulty in assembling the product, and some tendency for the product to come apart during use. The new and improved design features a one-piece injection molded sampler body made from polypropylene that opens and closes with a secure snap.

The design goal was to incorporate the exact same number of sampling ports (562) in the AT525 as in the AT521. This goal was accomplished, although the new sampler body (525) was slightly larger than the old (521), because the distance between holes needed to be increased slightly to accommodate molding the 525 with polypropylene rather than the nylon used for the 521.

Another design goal was to have, as nearly a possible, the same sampling rates for AT525 vs AT521. Due to the increase in space between sampling holes and other mold details arising from using polypropylene rather than nylon, it was recognized that there could likely be a systematic difference

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between the two samplers. A study to evaluate the difference in sampling rates between AT521 and AT525 badges was undertaken, with results shown in table 2B. The data for sampling rate verification on the AT525 badge can be found in table 2A.

Table 2A. Verification of sampling rates in a 2-hour test; using published sampling rates to determine concentration on AT525 samplers, values should be in line with the concentrations found on tubes.

Sample Description	Chemical Analyte	Qty (µg)	Volume (L)	Time (min)	Concn (ppm)
2 hr Exposure - Sampler A	Methylene Chloride	315	8.7	120	10.4
	Benzene	298	9.2	120	10.1
	Toluene	1250	8.3	120	39.8
	Xylene	926	7.6	120	28.2
2 hr Exposure - Sampler B	Methylene Chloride	297	8.7	120	9.8
	Benzene	283	9.2	120	9.6
	Toluene	1200	8.3	120	38.2
	Xylene	901	7.6	120	27.4
2 hr Exposure - Sampler C	Methylene Chloride	310	8.7	120	10.2
	Benzene	294	9.2	120	10.0
	Toluene	1240	8.3	120	39.5
	Xylene	922	7.6	120	28.1
2 hr Exposure - Sampler D	Methylene Chloride	340	8.7	120	11.2
	Benzene	307	9.2	120	10.4
	Toluene	1270	8.3	120	40.4
	Xylene	936	7.6	120	28.5
2 hr Exposure - Average of Charcoal Tubes	Methylene Chloride	81.8	2.3	120	10.2
	Benzene	60	2.3	120	9.9
	Toluene	345	2.3	120	39.7
	Xylene	281.7	2.3	120	28.1

Sample Description	Chemical Analyte	Qty (ug)	Time (min)	Concn ppm	% of Reference
2 hr Exposure – Average Personal Monitoring Badges	Methylene Chloride	315.5	120	10.4	101%
	Benzene	295.5	120	10.0	101%
	Toluene	1240	120	39.5	99.5%
	Xylene	921.3	120	28.1	100%

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Table 2B. Verification of sampling rates for the new TraceAir® design, AT525, compared to published AT521 sampling rates.

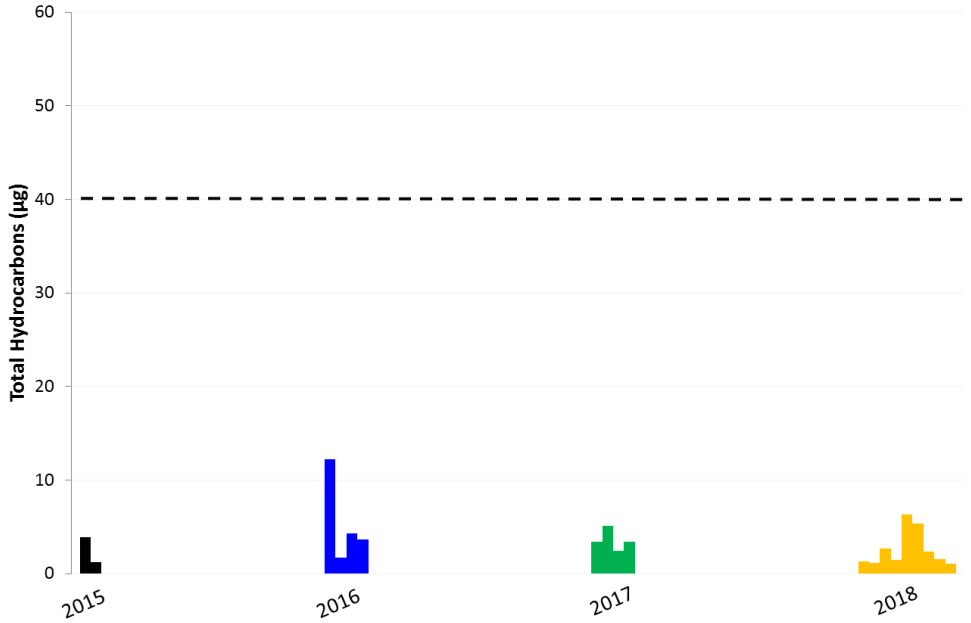
Analyte	Target Concn (ppm)	Ref Concn (ppm)	521 Sampler Published Sampling Rate (mL/hr)	525 Sampler Amount Found (µg)	525 Sampler Co-Eff Variation (%)	525 Sampler Sampling Rate (mL/min)	Sampling Rate Ratio (%)
Methylene Chloride	9	10	69.2	316	3%	72	105%
Benzene	10	10	73	296	3%	77	105%
Toluene	42	40	66.2	1240	2%	69	104%
Xylenes	29	28	57.6	921	2%	63	109%

Sampling rates on the AT525 are slightly faster compared to AT521 rates. Published rates have reflected this increase as an applied systemic amount.

4. Background (Blank) Determination

Unexposed samplers were analyzed using the OSHA 7 method to determine background analyte levels (if any) on the sampler prior to sampling. No interfering background peaks above the reporting limit were found. Average background was found to be well below the reporting limit of 40 µg across all AT521 and AT525 batches manufactured since 2015, see graph 1.

Graph 1. Historical data of total hydrocarbon background (µg) across various batches of AT521 and AT525 manufactured from 2015 to 2018.



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5. Atmospheric Effects

Air Velocity & Orientation – Previous studies demonstrated that there is no significant effect of air velocity and orientation on sampling rate

Temperature and Humidity – Previous studies demonstrated the absence of an effect of temperature and humidity on sampling rate in the range 0 – 50°C and 10 – 80% RH.

6. Reverse Diffusion

Reverse diffusion studies were performed on the activated carbon used in the media for AT525. Three experiments were conducted to analyze for any reverse diffusion of the analyte after absorbing to the media. Recoveries of analyte from samplers subject to a Zero Exposure Period (ZEP) were compared with recoveries of analyte from samplers analyzed immediately. Any difference between these two recoveries is taken as the extent reverse diffusion.

The three experiments were:

- Samplers exposed to challenge analytes at a level equivalent to 1.0 PEL, then held in the chamber with air flow only for 2 hours (a zero exposure period (ZEP))
- Samplers exposed to challenge analytes at a level equivalent to 1.0 PEL, then held in the chamber with air flow only for an additional 4 hours (ZEP)
- Samplers exposed to challenge analytes at a level equivalent to 1.0 PEL, then held in the chamber with air flow only for an additional 8 hours (ZEP)

For samplers subject to a ZEP, recoveries were within 10% compared to samplers analyzed immediately after exposure. Thus, no significant bias due to reverse diffusion was observed. Results are shown in table 3.

Table 3. Reverse diffusion data on activated carbon used in AT525 media for 2, 4 and 8-hour zero exposure periods. Recoveries are expressed as "% of Initial Recovery."

		% Initial Recovery		
Sample Description	Chemical Analyte	2-h ZEP	4-h ZEP	8-h ZEP
Samplers exposed to 1.0 PEL of analyte followed by zero exposure period	Methylene Chloride	95%	93%	90%
	Benzene	98%	95%	96%
	Toluene	97%	96%	97%
	Xylene	98%	96%	99%

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7. Analyte Stability (storage post-sampling)

A challenge test to assess the stability of the collected analyte on the media after sampling was conducted by exposing a set of samplers to the challenge concentration (as described in Section 1). Samples were divided into three different groups with various storage times:

- Initial samples collected immediately following the exposure to OVs
- Samples stored at room temperature for 1 week
- Samples stored at room temperature for 2 weeks

The samples were found to be stable at room temperature (i.e. no special storage precautions after sampling) for up to two weeks (recommended maximum holding time). For more volatile compounds, samplers may be returned for analysis within one week or as soon as possible. Table 4 summarizes the results.

Table 4. Verification of analyte stability on the AT525 sampler after a 2-hr exposure test.

Sample Description	Chemical Analyte	Qty (μg)	Concentration (ppm)	% of Initial
2-hr exposure-immediate collection	Methylene Chloride	315.5	10.4	
	Benzene	295.5	10.1	
	Toluene	1240	39.5	
	Xylene	921.25	28.1	
2-hr exposure-1 week storage at RT	Methylene Chloride	298	9.8	94%
	Benzene	291.25	9.9	98%
	Toluene	1227.5	39.1	99%
	Xylene	918.25	28	99.6%
2-hr exposure-2 week storage at RT	Methylene Chloride	262.5	8.7	84%
	Benzene	269	9.1	90.1%
	Toluene	1147.5	36.5	92.4%
	Xylene	867.25	26.4	94%

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8. Summary Comments

Four chemicals have been highlighted and detailed in this report: methylene chloride, benzene, toluene and xylene. The AT525 sampler has been historically and internally shown to collect hundreds of other VOC's as well; this report is meant to highlight a few of those chemicals in detail and not meant to be an exhaustive list. The overall system accuracy expressed as Maximum Total Error (95% confidence) is estimated at $\leq$ 25 %.

Concentration Range	Analyte dependent
Sampling Time	0.25 – 8 hour
Air Velocity	15 – 150 cm/sec
Temperature	0 – 50°C
Humidity	10 – 80% RH

The recommended maximum holding time after sampling is 14 days at room temperature, for more volatile chemicals, it is advised to return them within one week or as soon as possible.

It is recommended that AT525 samplers be used within the envelope of conditions specified above and elaborated on in the technical insert, available at assaytech.com. In general, minor excursions outside these limits would be expected to have only minor effects. Longer or shorter sampling times are possible but have not been evaluated.