Application Note by Using Nutech Preconcentrator System for PAMS Compounds in Lab Analysis

Abstract

Using a three-stage cryogenic system + GC/MS technology (Full Scan and/or SIM) 57 PAMS target VOC compounds (PAMS Mix by Linde) in air will be analyzed in a single run performance test. The results show that in 0.5-10.0ppb range the calibration, precision, accuracy, blank etc. all meet EPA TO-15 and PAMS requirements. The MDL may reach 0.02ppb or lower. It is within specifications for PAMS target VOCs in ambient air.

Introduction

“Using Summa or silica coated canister to take ambient air samples to the lab and using three stage cryogenic preconcentration system + GC/MS to analyze air VOCs is an approved reliable technology. US EPA published EPA TO-15 method on 1999 and has been continuously used in USA labs from then on. The major target compounds are the listed 65 VOCs. According to USA EPA experience China published HJ759-2015 in 2015 and the technology is similar with US EPA. In USA TO-15 method is also used for Photochemical Air Monitoring System (PAMS) which includes 57 hydrocarbon compounds. This application is focused on the PAMS 57 compounds analyzed in the labs. The application presents the method and conditions for using Nutech preconcentrator with a GC/MS system to achieve the above purpose.

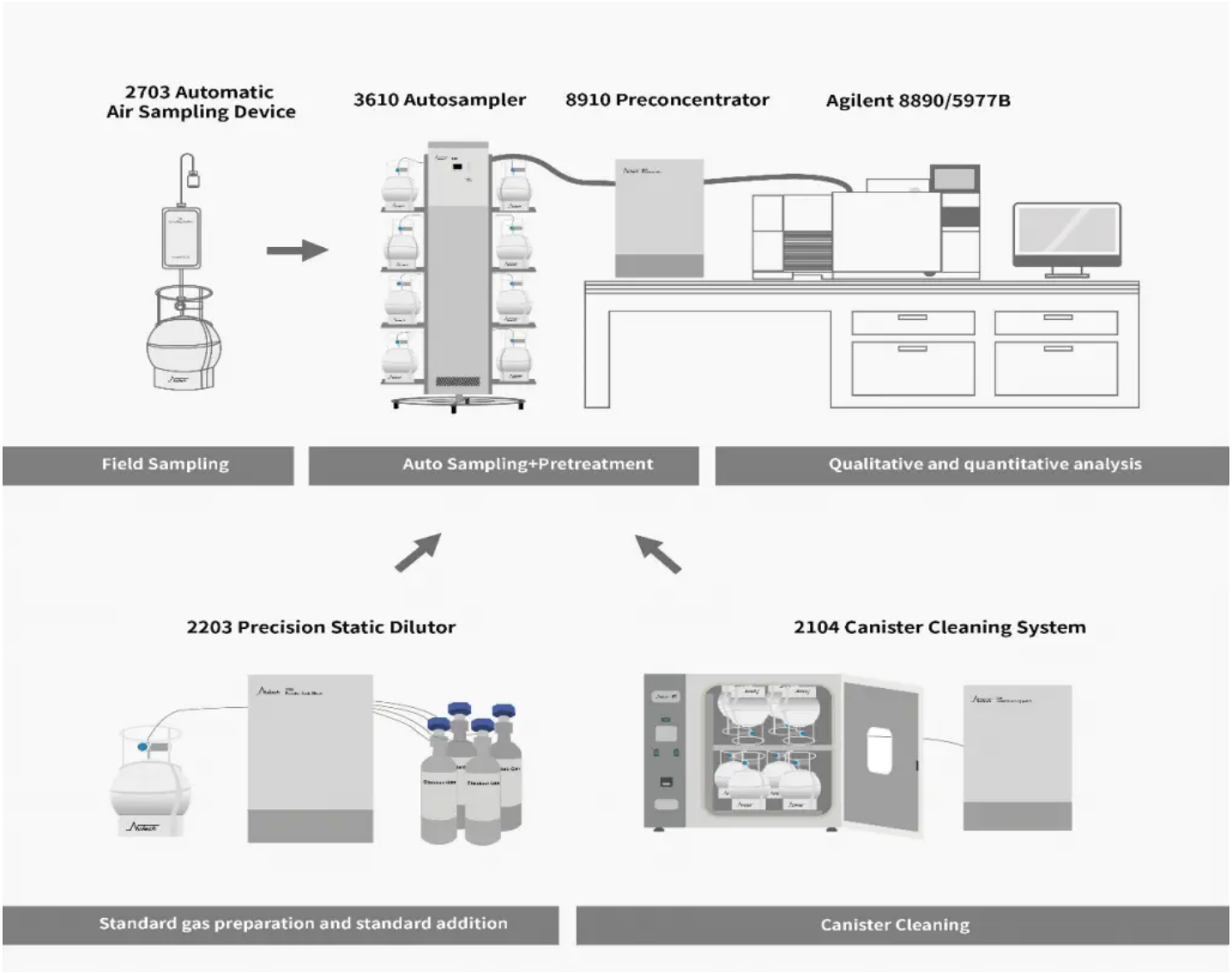
Usually using the preconcentrator with a GC/FID can achieve this PAMS analysis. This is also used the Nutech preconcentrator system. Here we give the lab another approach by using the preconcentrator system with GC/MS. By doing this the lab may combined TO-15 and PAMS together and save their resources and cost for the analysis. Our results show that in a relative wide concentration range (0.5-10.0ppb), the analysis precision, accuracy, blank, initial calibration, continue calibration verifi cation etc. all meet the QA/ QC control requirements in EPA TO-15 and PAMS targets.

1 Experiment

1.1 Configuration of Used Instruments

Preconcentration System Nutech 8910/3610 Preconcentrator/autosampler, Nutech 2203 Static Dilutor, Nutech 2104 Canister Clean System and 6 L Summa or Silica coated Canisters.

GC/FID/MS：Agilent 8890/5977B（Optional Deans Switch with FID, but not used in this application) As shown in the following flow path.：



1.2 Standard Gases

The standard gases are all from Linde. :

1.2.1 VOC Standards

57 Compounds PAMS Standard Concentration: 1.00ppm； 65 Compounds TO-15 Standard

Concentration: 1.00ppm (as additional) 13 Compounds TO-11A Aldehyde Standard

Concentration: 1.00 ppm (as additional)

1.2.2 Internal Standard/Surrogate Standard

Bromochloromethane, 1,4-Difluorobenzene, Deuterichlorobenzene, 4-Bromofluorobenzene

1.3 Making Working Standard

Connect 3 high concentration standard and certified clean 6-liter Summa canister to Nutech 2203 and set up 5 ppb as working standard to make the working standard. Do same as internal/Surrogate standard but concentration as 30ppb. The canisters were humidified with 50% humidity.

1.4 Instruments Parameters

1.4.1 8910 Method Set:

Trap 1: -160℃，Trap 2: -40℃，Transfer from Trap 1 to Trap to 20°C, Trap 2 desorption: 230℃. Focuser: -160°C，Focuser Injection impulse: 80℃， Transfer line: 40℃。

1.4.2 8890GC Set

Injection：250℃

Split Split/Splitless

Column Restek Rtx-1，60m×0.32mm×3.0μm Buffer Column for Dean Switch：
2.5m×0.18mm×0μm （May not use it if no Dean Switch not apply）
Temperature program：-40℃（ 5 min）- 10℃/min – 220℃（18min） Carrier Gas Constant flow at: 1.8 ml/m

1.4.3 5977B MS
Ion Source：320 ℃

Scan Full Scan/SIM
Scan range Full Scan: 25-300 amu SIM: 26,27,29,30,31,39,40,41,42,43,95,128,130,114,117 amu

1.5 Initial Calibration

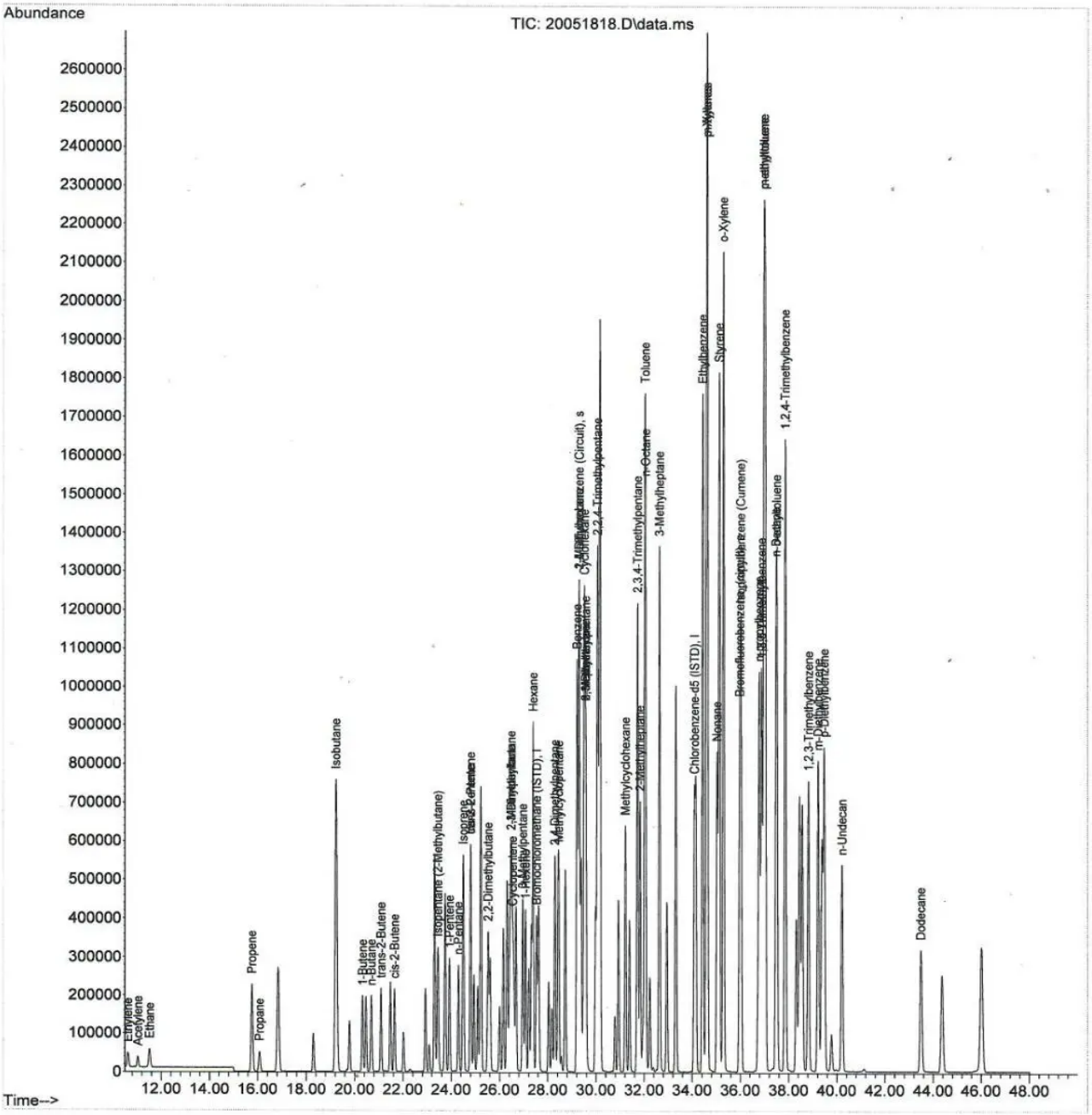
“8910/3610 loading 30ml, 60 ml, 120 ml, 240 ml, 300 ml, 600 ml Basic volume is 300 ml.

Using 5 ppb working standard gas the related concentration will be: 0.5 ppb, 1.0 ppb, 2.0 ppb, 4.0 ppb, 5.0 ppb, 10.0ppb.， The curve will be concentration ppb vs. Responses (Peak area). The internal/surrogate standard is loaded 20ml and the concentration is 6.67 ppb.

2 The Results

2.1 57 Compounds (with mixed 65 TO-15 compound and 13 aldehydes)

```
File       :D:\MassHunter\GCMS\1\data\200518\20051818.D
Operator   : SL
Acquired   : 19 May 2020  10:17 am using AcqMethod TO-15-AECOM-AL.M
Instrument :   Nutech Deans Switch
Sample Name: 5.0ppb ICal 600mL-Run18
Misc Info  : TO15+PAMS+Aldehydes
Vial Number: 44
```



Using 0.5 ppb, 1.0 ppb, 2.0 ppb, 4.0 ppb, 5.0 ppb, 10.0ppbto set up an initial calibration the linear range is 1:20. By using Bromochloromethane and Duterochlorobenzene as internal standard (IS), Difluorobenzene and bromofluorobenzene as surrogate standard (SS), The calibration data shown as follows:

Response Factor Report Nutech Deans Switch

Method Path : D:\MassHunter\GCMS\1\
Method File : PAMS_200516_6LV.M
Title : TO-15+PAMS+Aldehydes
Last Update : Thu May 28 17:21:49 2020
Response Via : Initial Calibration

Calibration Files
1 =20051602-PAMS.D 2 =20051603-PAMS.D 3 =20051604-PAMS.D 4 =20051605-PAMS.D 5
6 =20051818-PAMS.D

		Compound	1	2	3	4	5	6	Avg	%RSD
1)	I	Bromochloromethane...	----------ISTD----------							
2)		Ethylene	0.169	0.147	0.175	0.144	0.113	0.122	0.145	16.97
3)		Acetylene	0.128	0.153	0.149	0.154	0.136	0.143	0.144	7.08
4)		Ethane	0.326	0.263	0.229	0.232	0.184	0.193	0.238	21.80
5)		Propene	0.252	0.289	0.271	0.286	0.257	0.273	0.271	5.49
6)		Propane	0.092	0.088	0.075	0.075	0.066	0.075	0.078	12.20
7)		Isobutane	0.954	0.886	0.755	0.751	0.649	0.704	0.783	14.67
8)		1-Butene	0.376	0.404	0.401	0.411	0.367	0.401	0.393	4.48
9)		n-Butane	0.456	0.488	0.472	0.504	0.453	0.529	0.484	6.08
10)		trans-2-Butene	0.313	0.334	0.327	0.359	0.320	0.352	0.334	5.41
11)		cis-2-Butene	0.321	0.351	0.354	0.373	0.329	0.365	0.349	5.84
12)		Isopentane (2-...	0.162	0.162	0.150	0.166	0.147	0.159	0.158	4.77
13)		1-Pentene	0.296	0.330	0.304	0.348	0.308	0.335	0.320	6.38
14)		n-Pentane	0.456	0.477	0.566	0.498	0.424	0.478	0.483	9.84
15)		Isoprene	0.411	0.502	0.523	0.492	0.427	0.463	0.470	9.37
16)		trans-2-Pentene	0.484	0.639	0.604	0.572	0.494	0.538	0.555	11.03
17)		cis-2-Pentene	0.484	0.639	0.604	0.572	0.494	0.538	0.555	11.03
18)		2,2-Dimethylbu...	0.469	0.592	0.582	0.530	0.556	0.504	0.539	8.77
19)		2,3-Dimethylbu...	0.535	0.653	0.648	0.600	0.592	0.570	0.600	7.56
20)		2-Methylpentane	0.856	0.964	0.966	0.864	0.880	0.872	0.900	5.65
21)		Cyclopentene	0.041	0.048	0.042	0.040	0.035	0.038	0.040	11.17
22)		3-Methylpentane	0.622	0.733	0.749	0.678	0.690	0.720	0.699	6.58
23)		1-Hexene	0.174	0.204	0.206	0.191	0.188	0.203	0.195	6.38
24)		Hexane	0.532	0.616	0.612	0.550	0.569	0.588	0.578	5.78
25)		2,4-Dimethylpe...	0.588	0.726	0.707	0.765	0.663	0.689	0.690	8.75
26)		Methylcyclopen...	0.670	0.798	0.800	0.843	0.742	0.764	0.769	7.76
27)		Benzene	1.356	1.551	1.500	1.574	1.375	1.442	1.466	6.16
28)		2-Methylhexane	0.676	0.795	0.758	0.803	0.705	0.727	0.744	6.79
29)	s	1,4-Difluorobe...	3.644	3.580	3.608	3.906	3.593	3.579	3.652	3.48
30)		Cyclohexane	0.554	0.654	0.651	0.675	0.603	0.620	0.626	7.01
31)		2,3-Dimethylpe...	0.629	0.726	0.726	0.785	0.693	0.673	0.705	7.56
32)		3-Methylhexane	0.629	0.726	0.726	0.785	0.693	0.673	0.705	7.56
33)		n-Heptane	0.208	0.266	0.264	0.255	0.228	0.243	0.244	9.35
34)		2,2,4-Trimethy...	1.975	2.318	2.288	2.422	2.131	2.195	2.222	7.07
35)		Methylcyclohexane	0.752	0.880	0.862	0.922	0.819	0.857	0.849	6.82
36)		2,3,4-Trimethy...	0.840	0.969	0.997	1.068	0.916	0.974	0.961	8.01
37)		2-Methylheptane	0.741	0.872	0.867	0.928	0.833	0.881	0.854	7.39
38)		Toluene	1.465	1.817	1.837	1.959	1.745	1.809	1.772	9.37
39)		n-Octane	0.597	0.713	0.703	0.741	0.656	0.670	0.680	7.45
40)		3-Methylheptane	0.327	0.375	0.393	0.427	0.371	0.388	0.380	8.60
41)	I	Chlorobenzene-d5 (...	----------ISTD----------							
42)		Ethylbenzene	1.214	1.553	1.610	1.609	1.566	1.557	1.518	9.94
43)		m-Xylenes	0.930	1.201	1.242	1.241	1.203	1.192	1.168	10.16
44)		p-Xylenes	0.497	0.631	0.664	0.666	0.646	0.636	0.623	10.23
45)		Nonane	0.227	0.298	0.313	0.313	0.303	0.301	0.293	11.17
46)		Styrene	0.349	0.439	0.467	0.471	0.453	0.452	0.438	10.31
47)		o-Xylene	0.469	0.613	0.638	0.641	0.617	0.614	0.599	10.83
48)	s	Bromofluoroben...	0.570	0.566	0.563	0.567	0.568	0.585	0.570	1.34
49)		isopropylbenze...	0.721	0.910	0.948	0.952	0.927	0.929	0.898	9.82
50)		n-propylbenzene	0.879	1.156	1.191	1.201	1.169	1.163	1.126	10.87
51)		1,3,5-Trimethy...	0.336	0.449	0.482	0.498	0.486	0.461	0.452	13.16
52)		m-ethyltoluene	2.487	3.212	3.351	3.370	3.236	3.133	3.131	10.47

53)	p-ethyltoluene	1.244	1.606	1.676	1.685	1.618	1.566	1.566	10.47
54)	n-Decane	0.225	0.304	0.309	0.310	0.298	0.265	0.285	11.98
55)	o-ethyltoluene	0.678	0.879	0.918	0.927	0.898	0.861	0.860	10.73
56)	1,2,4-Trimethy...	0.531	0.709	0.744	0.761	0.732	0.672	0.691	12.20
57)	1,2,3-Trimethy...	0.543	0.742	0.774	0.784	0.760	0.672	0.713	12.94
58)	m-Diethylbenzene	0.403	0.533	0.548	0.563	0.545	0.435	0.505	13.41
59)	p-Diethylbenzene	0.413	0.566	0.587	0.583	0.567	0.451	0.528	14.30
60)	n-Undecan	0.269	0.403	0.371	0.352	0.346	0.276	0.336	15.90
61)	Dodecane	0.142	0.249	0.200	0.199	0.213	0.193	0.199	17.32

(#) = Out of Range

PAMS_200516_6LV.M Thu May 28 17:21:52 2020

2.3 CCV

Using 5ppb working standard loading 120 ml concentration is 2.0pp. The CCV results are shown in the flowing table:

Evaluate Continuing Calibration Report

Data Path : D:\MassHunter\GCMS\1\data\200519\
Data File : 20051901.D
Acq On : 19 May 2020 02:29 pm
Operator : SL
Sample : 5.0ppb CCV 120mL-Run1
Misc : TO15+PAMS+Aldehydes
ALS Vial : 44 Sample Multiplier: 1

Quant Time: May 28 17:23:16 2020
Quant Method : D:\MassHunter\GCMS\1\PAMS_200516_6LV.M
Quant Title : TO-15+PAMS+Aldehydes
QLast Update : Thu May 28 17:21:50 2020
Response via : Initial Calibration

Min. RRF : 0.000 Min. Rel. Area : 50% Max. R.T. Dev 0.50min
Max. RRF Dev : 25% Max. Rel. Area : 150%

		Compound	AvgRF	CCRF	%Dev	Area%	Dev(min)
1	I	Bromochloromethane (ISTD)	1.000	1.000	0.0	86	0.01
2		Ethylene	0.145	0.132	9.0	65	0.03
3		Acetylene	0.144	0.141	2.1	81	0.04
4		Ethane	0.238	0.204	14.3	77	0.07
5		Propene	0.271	0.268	1.1	85	0.03
6		Propane	0.078	0.080	-2.6	92	0.00
7		Isobutane	0.783	0.766	2.2	87	0.02
8		1-Butene	0.393	0.404	-2.8	87	0.01
9		n-Butane	0.484	0.504	-4.1	92	0.01
10		trans-2-Butene	0.334	0.351	-5.1	93	0.01
11		cis-2-Butene	0.349	0.359	-2.9	87	0.01
12		Isopentane (2-Methylbutane)	0.158	0.168	-6.3	96	0.01
13		1-Pentene	0.320	0.333	-4.1	95	0.01
14		n-Pentane	0.483	0.513	-6.2	78	0.02
15		Isoprene	0.470	0.464	1.3	77	0.03
16		trans-2-Pentene	0.555	0.559	-0.7	80	0.00
17		cis-2-Pentene	0.555	0.559	-0.7	80	0.00
18		2,2-Dimethylbutane	0.539	0.510	5.4	76	0.02
19		2,3-Dimethylbutane	0.600	0.612	-2.0	81	0.00
20		2-Methylpentane	0.900	0.862	4.2	77	0.02
21		Cyclopentene	0.040	0.044	-10.0	92	0.00
22		3-Methylpentane	0.699	0.709	-1.4	82	0.02
23		1-Hexene	0.195	0.201	-3.1	84	0.01
24		Hexane	0.578	0.589	-1.9	83	0.01
25		2,4-Dimethylpentane	0.690	0.699	-1.3	85	0.01
26		Methylcyclopentane	0.769	0.767	0.3	83	0.01
27		Benzene	1.466	1.441	1.7	83	0.01
28		2-Methylhexane	0.744	0.730	1.9	83	0.01
29	s	1,4-Difluorobenzene (Circui	3.652	3.609	1.2	86	0.01
30		Cyclohexane	0.626	0.623	0.5	83	0.01
31		2,3-Dimethylpentane	0.705	0.688	2.4	82	0.01
32		3-Methylhexane	0.705	0.688	2.4	82	0.01
33		n-Heptane	0.244	0.247	-1.2	81	0.01
34		2,2,4-Trimethylpentane	2.222	2.214	0.4	83	0.01
35		Methylcyclohexane	0.849	0.832	2.0	83	0.01
36		2,3,4-Trimethylpentane	0.961	0.972	-1.1	84	0.00
37		2-Methylheptane	0.854	0.851	0.4	85	0.01
38		Toluene	1.778	1.818	-2.2	85	0.00

36	2,3,4-Trimethylpentane	0.961	0.972	-1.1	84	0.00
37	2-Methylheptane	0.854	0.851	0.4	85	0.01
38	Toluene	1.772	1.818	-2.6	85	0.02
39	n-Octane	0.680	0.676	0.6	83	0.01
40	3-Methylheptane	0.380	0.390	-2.6	86	0.00
41 I	Chlorobenzene-d5 (ISTD)	1.000	1.000	0.0	87	0.00
42	Ethylbenzene	1.518	1.577	-3.9	86	0.01
43	m-Xylenes	1.168	1.226	-5.0	86	0.02
44	p-Xylenes	0.623	0.655	-5.1	86	0.01
45	Nonane	0.293	0.303	-3.4	84	0.01
46	Styrene	0.438	0.456	-4.1	85	0.00
47	o-Xylene	0.599	0.630	-5.2	86	0.02
48 s	Bromofluorobenzene_(circuit	0.570	0.600	-5.3	93	0.01
49	isopropylbenzene (Cumene)	0.898	0.934	-4.0	86	0.01
50	n-propylbenzene	1.126	1.180	-4.8	87	0.01
51	1,3,5-Trimethylbenzene	0.452	0.458	-1.3	83	0.01
52	m-ethyltoluene	3.131	3.350	-7.0	87	0.01
53	p-ethyltoluene	1.566	1.675	-7.0	87	0.01
54	n-Decane	0.285	0.305	-7.0	86	0.00
55	o-ethyltoluene	0.860	0.911	-5.9	87	0.01
56	1,2,4-Trimethylbenzene	0.691	0.734	-6.2	86	0.01
57	1,2,3-Trimethylbenzene	0.713	0.774	-8.6	87	0.01
58	m-Diethylbenzene	0.505	0.553	-9.5	88	0.01
59	p-Diethylbenzene	0.528	0.573	-8.5	85	0.01
60	n-Undecan	0.336	0.360	-7.1	85	0.01
61	Dodecane	0.199	0.189	5.0	82	0.00

(#) = Out of Range SPCC's out = 0 CCC's out = 0

PAMS_200516_6LV.M Thu May 28 18:47:43 2020

2.4 Blank Spike Recovery % Accuracy %

Spike 5.0 ppb into a canister as blank spike evaluation standard to Performed by the instrument the recovery as shown as follows: (10ppb is due to some compounds are replicate in standard.）

Quantitation Report (QT Reviewed)

Data Path : D:\MassHunter\GCMS\1\data\200516\
Data File : 20051610.D
Acq On : 16 May 2020 07:14 pm
Operator : SL
Sample : 5.0ppb ICal 300mL-Run10
Misc : no FID
ALS Vial : 44 Sample Multiplier: 1

Quant Time: May 28 18:49:45 2020
Quant Method : D:\MassHunter\GCMS\1\PAMS_200516_6LV.M
Quant Title : TO-15+PAMS+Aldehydes
QLast Update : Thu May 28 17:21:50 2020
Response via : Initial Calibration

Compound	R.T.	QIon	Response	Conc	Units	Dev(Min)
Internal Standards						
1) Bromochloromethane (ISTD)	27.540	130	381347	5.00	ppbv	0.00
41) Chlorobenzene-d5 (ISTD)	34.084	117	1093535	5.00	ppbv	0.00
System Monitoring Compounds						
29) 1,4-Difluorobenzene (C...	29.290	114	1378834	4.95	ppbv	0.00
48) Bromofluorobenzene_(ci...	35.959	95	628771	5.04	ppbv	0.00
Target Compounds						Qvalue
2) Ethylene	10.613	28	46176	4.17	ppbv #	37
3) Acetylene	11.024	26	56049	5.10	ppbv #	69
4) Ethane	11.506	28	71754	3.96	ppbv #	65
5) Propene	15.755	41	207507	10.02	ppbv	100
6) Propane	16.061	39	27192	4.54	ppbv	98
7) Isobutane	19.207	43	265312	4.44	ppbv	96
8) 1-Butene	20.316	41	150141	5.00	ppbv	98

9)	n-Butane	20.680	43	183686	4.98 ppbv	99
10)	trans-2-Butene	21.082	41	128112	5.03 ppbv	98
11)	cis-2-Butene	21.646	41	133127	5.00 ppbv	98
12)	Isopentane (2-Methylbu...	23.435	57	118756	9.88 ppbv	97
13)	1-Pentene	23.914	55	124454	5.10 ppbv	94
14)	n-Pentane	24.296	43	172221	4.68 ppbv	98
15)	Isoprene	24.468	67	171276	4.78 ppbv	96
16)	trans-2-Pentene	24.784	55	196612	4.64 ppbv	99
17)	cis-2-Pentene	24.784	55	196612	4.64 ppbv	98
18)	2,2-Dimethylbutane	25.521	71	221677	5.40 ppbv	96
19)	2,3-Dimethylbutane	26.487	71	237230	5.19 ppbv	97
20)	2-Methylpentane	26.468	42	354022	5.16 ppbv #	90
21)	Cyclopentene	26.545	67	14589	4.73 ppbv #	79
22)	3-Methylpentane	26.956	57	276783	5.19 ppbv	99
23)	1-Hexene	27.061	56	154848	10.44 ppbv	95
24)	Hexane	27.387	57	454584	10.31 ppbv	100
25)	2,4-Dimethylpentane	28.286	43	269606	5.13 ppbv	98
26)	Methylcyclopentane	28.448	56	292381	4.98 ppbv	99
27)	Benzene	29.204	78	1106138	9.89 ppbv	98
28)	2-Methylhexane	29.290	43	282444	4.98 ppbv	99
30)	Cyclohexane	29.510	84	476584	9.98 ppbv #	36
31)	2,3-Dimethylpentane	29.558	43	277811	5.17 ppbv #	63
32)	3-Methylhexane	29.558	43	277811	5.17 ppbv #	91
33)	n-Heptane	29.568	57	182411	9.81 ppbv	92
34)	2,2,4-Trimethylpentane	30.056	57	1712886	10.11 ppbv	95
35)	Methylcyclohexane	31.213	83	326846	5.05 ppbv	96
36)	2,3,4-Trimethylpentane	31.720	43	371625	5.07 ppbv	98
37)	2-Methylheptane	31.835	57	333204	5.12 ppbv	99
38)	Toluene	32.027	91	1398300	10.35 ppbv	100
39)	n-Octane	32.065	43	260411	5.02 ppbv	97
40)	3-Methylheptane	32.629	57	150950	5.20 ppbv	95
42)	Ethylbenzene	34.428	91	1756492	5.29 ppbv	99
43)	m-Xylenes	34.600	91	2707374	10.60 ppbv	99
44)	p-Xylenes	34.600	106	1435744	10.53 ppbv	98
45)	Nonane	35.021	57	342765	5.35 ppbv	98
46)	Styrene	35.117	104	1027545	10.72 ppbv	99
47)	o-Xylene	35.289	91	1378965	10.53 ppbv	99
49)	isopropylbenzene (Cumene)	36.007	105	1038636	5.29 ppbv	99
50)	n-propylbenzene	36.782	91	1319760	5.36 ppbv	97
51)	1,3,5-Trimethylbenzene	36.868	105	998439	10.10 ppbv	98
52)	m-ethyltoluene	36.973	105	3718309	5.43 ppbv	100
53)	p-ethyltoluene	36.973	105	3718309	10.86 ppbv	93
54)	n-Decane	37.470	43	336824	5.40 ppbv	97
55)	o-ethyltoluene	37.509	105	1003701	5.33 ppbv	99
56)	1,2,4-Trimethylbenzene	37.853	105	1628629	10.77 ppbv	99
57)	1,2,3-Trimethylbenzene	38.810	105	835785	5.36 ppbv	100
58)	m-Diethylbenzene	39.212	105	596671	5.41 ppbv	99
59)	p-Diethylbenzene	39.470	119	626653	5.43 ppbv	99
60)	n-Undecan	40.197	57	362708	4.93 ppbv	98
61)	Dodecane	43.488	57	211322	4.85 ppbv	96

(#) = qualifier out of range (m) = manual integration (+) = signals summed

PAMS_200516_6LV.M Thu May 28 18:50:35 2020

The duplicated samples are selected 0.5ppb and 2.0ppb with 7 points the data shows that the RSD% of most compounds are less than 10%.

2.5.1 Replicate Data, 0.5 ppb Level

Response Factor Report Nutech Deans Switch

Method Path : D:\MassHunter\GCMS\1\
Method File : PAMS_200516_Replicate.M
Title : TO-15+PAMS+Aldehydes
Last Update : Thu May 28 19:03:14 2020
Response Via : Initial Calibration

Calibration Files
1 =20051903.D 2 =20051904.D 3 =20051905.D 4 =20051906.D 5 =20051907.D 6 =20

		Compound	1	2	3	4	5	6	7	Avg	%RSD
1)	I	Bromochloromethane...	----------ISTD----------								
2)		Ethylene	0.135	0.141	0.132	0.151	0.149	0.145	0.134	0.141	5.30
3)		Acetylene	0.146	0.152	0.144	0.151	0.154	0.178	0.134	0.151	8.80
4)		Ethane	0.241	0.206	0.252	0.203	0.218	0.242	0.229	0.227	8.35
5)		Propene	0.523	0.573	0.549	0.570	0.562	0.626	0.494	0.557	7.49
6)		Propane	0.075	0.083	0.079	0.087	0.081	0.094	0.080	0.083	7.42
7)		Isobutane	0.739	0.800	0.778	0.787	0.782	0.895	0.722	0.786	7.06
8)		1-Butene	0.379	0.415	0.389	0.400	0.410	0.456	0.368	0.403	7.16
9)		n-Butane	0.466	0.511	0.493	0.497	0.493	0.561	0.464	0.498	6.56
10)		trans-2-Butene	0.331	0.350	0.341	0.357	0.346	0.392	0.323	0.349	6.34
11)		cis-2-Butene	0.342	0.370	0.351	0.367	0.357	0.404	0.329	0.360	6.70
12)		Isopentane (2-...	0.306	0.325	0.309	0.323	0.323	0.364	0.309	0.323	6.18
13)		1-Pentene	0.333	0.344	0.352	0.337	0.325	0.364	0.317	0.339	4.73
14)		n-Pentane	0.507	0.533	0.511	0.483	0.519	0.550	0.457	0.509	6.07
15)		Isoprene	0.460	0.516	0.480	0.480	0.497	0.501	0.428	0.480	6.06
16)		trans-2-Pentene	0.551	0.595	0.564	0.641	0.616	0.599	0.510	0.582	7.54
17)		cis-2-Pentene	0.551	0.595	0.564	0.641	0.616	0.599	0.510	0.582	7.54
18)		2,2-Dimethylbu...	0.526	0.569	0.541	0.621	0.617	0.643	0.470	0.570	10.86
19)		2,3-Dimethylbu...	0.622	0.672	0.641	0.674	0.671	0.708	0.557	0.649	7.53
20)		2-Methylpentane	0.984	0.958	0.910	1.012	1.072	1.181	0.844	0.994	11.04
21)		Cyclopentene	0.037	0.048	0.044	0.044	0.034	0.053	0.051	0.045	15.73
22)		3-Methylpentane	0.737	0.795	0.752	0.793	0.781	0.806	0.658	0.760	6.76
23)		1-Hexene	0.406	0.441	0.417	0.434	0.432	0.462	0.369	0.423	7.03
24)		Hexane	1.202	1.309	1.238	1.268	1.266	1.369	1.100	1.250	6.80
25)		2,4-Dimethylpe...	0.707	0.759	0.738	0.738	0.738	0.813	0.650	0.735	6.73
26)		Methylcyclopen...	0.778	0.845	0.790	0.830	0.824	0.892	0.701	0.809	7.45
27)		Benzene	2.973	3.202	3.031	3.104	3.097	3.350	2.704	3.066	6.55
28)		2-Methylhexane	0.753	0.827	0.778	0.802	0.808	0.890	0.704	0.795	7.36
29)	s	1,4-Difluorobe...	3.605	3.588	3.577	3.590	3.624	3.604	3.584	3.596	0.45
30)		Cyclohexane	1.287	1.394	1.308	1.349	1.341	1.457	1.151	1.327	7.21
31)		2,3-Dimethylpe...	0.711	0.754	0.760	0.746	0.753	0.842	0.658	0.746	7.43
32)		3-Methylhexane	0.711	0.754	0.760	0.746	0.753	0.842	0.658	0.746	7.43
33)		n-Heptane	0.515	0.554	0.512	0.549	0.538	0.547	0.438	0.522	7.77
34)		2,2,4-Trimethy...	4.546	4.888	4.651	4.788	4.753	5.188	4.132	4.707	6.90
35)		Methylcyclohexane	0.870	0.927	0.867	0.901	0.918	0.979	0.764	0.889	7.53
36)		2,3,4-Trimethy...	0.985	1.077	1.001	1.020	1.032	1.123	0.887	1.018	7.31
37)		2-Methylheptane	0.825	0.885	0.852	0.903	0.920	0.961	0.768	0.873	7.35
38)		Toluene	3.653	3.977	3.742	3.865	3.844	4.127	3.353	3.795	6.54
39)		n-Octane	0.694	0.739	0.702	0.728	0.721	0.796	0.647	0.718	6.35
40)		3-Methylheptane	0.388	0.415	0.403	0.413	0.397	0.446	0.353	0.402	7.04
41)	I	Chlorobenzene-d5 (...	----------ISTD----------								
42)		Ethylbenzene	1.543	1.746	1.598	1.629	1.609	1.735	1.325	1.598	8.83
43)		m-Xylenes	2.389	2.681	2.476	2.508	2.456	2.678	2.056	2.463	8.56
44)		p-Xylenes	1.265	1.422	1.311	1.345	1.317	1.433	1.078	1.310	9.07
45)		Nonane	0.293	0.337	0.309	0.313	0.307	0.336	0.254	0.307	9.20
46)		Styrene	0.898	1.005	0.918	0.943	0.922	1.005	0.762	0.922	8.92
47)		o-Xylene	1.216	1.375	1.276	1.293	1.263	1.369	1.058	1.264	8.47
48)	s	Bromofluoroben...	0.591	0.600	0.598	0.597	0.595	0.617	0.633	0.604	2.51
49)		isopropylbenze...	0.910	1.036	0.947	0.974	0.940	1.025	0.789	0.946	8.76
50)		n-propylbenzene	1.140	1.303	1.198	1.220	1.192	1.305	0.993	1.193	8.93
51)		1,3,5-Trimethy...	0.909	1.024	0.968	0.972	0.946	1.078	0.739	0.948	11.30
52)		m-ethyltoluene	3.252	3.673	3.333	3.417	3.313	3.612	2.820	3.346	8.37
53)		p-ethyltoluene	3.252	3.673	3.333	3.417	3.313	3.612	2.820	3.346	8.37
54)		n-Decane	0.302	0.346	0.313	0.319	0.313	0.351	0.261	0.315	9.47
55)		o-ethyltoluene	0.890	1.008	0.931	0.939	0.927	1.012	0.769	0.925	8.85
56)		1,2,4-Trimethy...	1.444	1.644	1.516	1.539	1.483	1.631	1.233	1.499	9.22
57)		1,2,3-Trimethy...	0.755	0.868	0.788	0.794	0.781	0.840	0.645	0.781	9.13
58)		m-Diethylbenzene	0.549	0.628	0.573	0.577	0.554	0.607	0.462	0.565	9.42
59)		p-Diethylbenzene	0.581	0.671	0.612	0.605	0.591	0.640	0.485	0.598	9.76
60)		n-Undecan	0.395	0.452	0.411	0.391	0.374	0.403	0.313	0.391	10.76
61)		Dodecane	0.259	0.291	0.250	0.216	0.202	0.207	0.160	0.227	19.14

(#) = Out of Range

The data shows that the MDL of all 27 compounds are ~0.2 ppb, and some

2.5.1 Replicate Data, 0.5 ppb Level

compounds may go as low as ＜0.05 ppb,MDL is based on 600mL Loading Volume with 7 replicate Run

Number	Compound	Spike Conc. (ppbv)	Avg. Conc. (ppbv)	% RSD	MDL
1	Bromochloromethane (ISTD)	5	5.00		
2	Ethylene	0.5	0.41	14.67	0.09
3	Acetylene	0.5	0.53	11.46	0.10
4	Ethane	0.5	0.55	16.44	0.14
5	Propene	0.5	0.51	7.20	0.06
6	Propane	0.5	0.53	6.20	0.05
7	Isobutane	0.5	0.50	5.82	0.05
8	1-Butene	0.5	0.52	8.62	0.07
9	n-Butane	0.5	0.52	8.32	0.07
10	trans-2-Butene	0.5	0.53	8.51	0.07
11	cis-2-Butene	0.5	0.52	10.11	0.08
12	Isopentane (2-Methylbutane)	0.5	0.53	7.44	0.06
13	1-Pentene	0.5	0.52	8.50	0.07
14	n-Pentane	0.5	0.52	4.97	0.04
15	Isoprene	0.5	0.52	6.87	0.06
16	trans-2-Pentene	0.5	0.49	5.43	0.04
17	cis-2-Pentene	0.5	0.49	5.43	0.04
18	2,2-Dimethylbutane	0.5	0.50	7.70	0.06
19	2,3-Dimethylbutane	0.5	0.50	8.04	0.06
20	2-Methylpentane	0.5	0.52	10.20	0.08
21	Cyclopentene	0.5	0.58	17.41	0.16

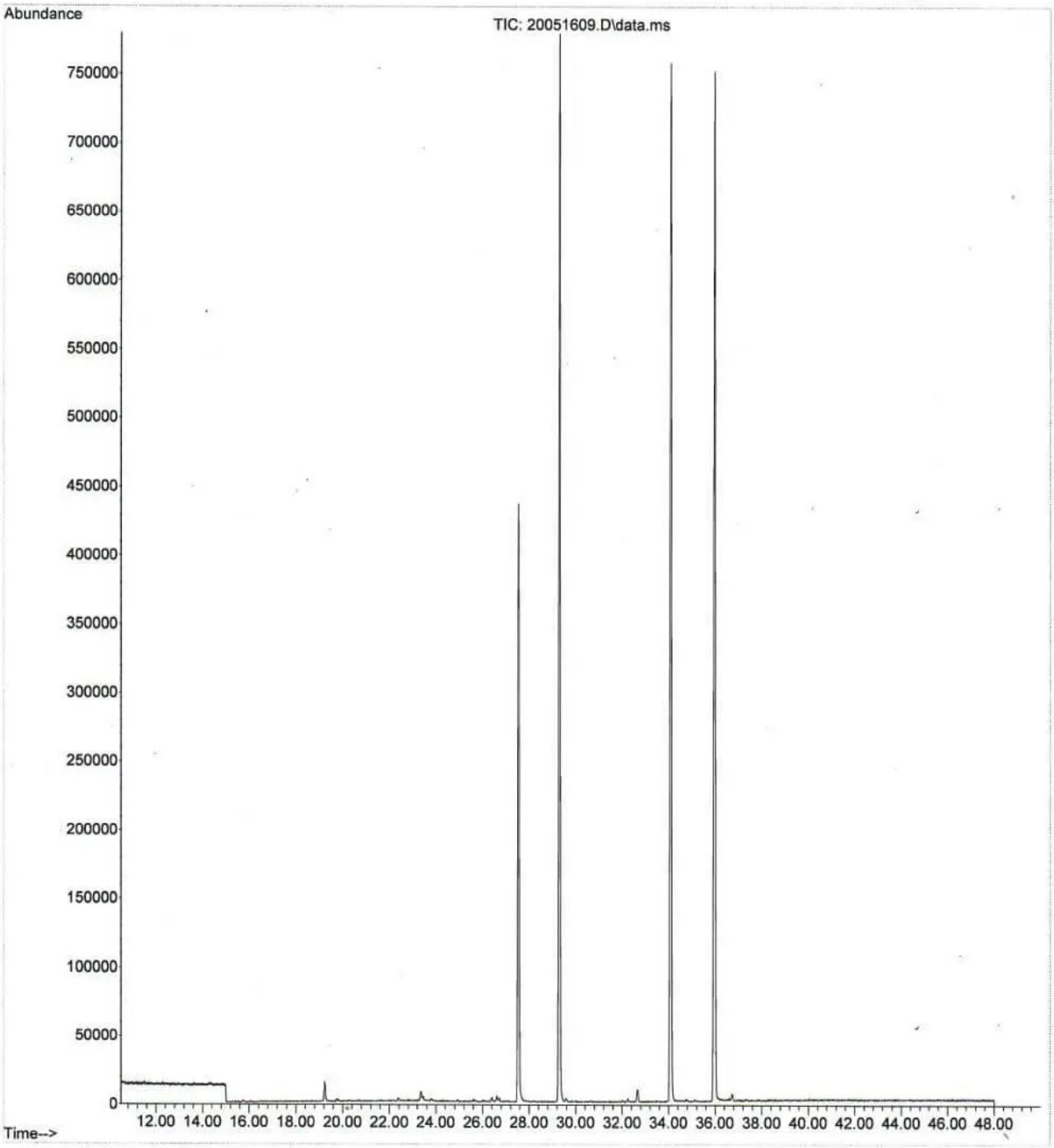
22	3-Methylpentane	0.5	0.50	9.55	0.07
23	1-Hexene	0.5	0.53	7.24	0.06
24	Hexane	0.5	0.51	8.05	0.06
25	2,4-Dimethylpentane	0.5	0.52	8.01	0.07
26	Methylcyclopentane	0.5	0.52	8.28	0.07
27	Benzene	0.5	0.52	7.89	0.06
28	2-Methylhexane	0.5	0.51	7.46	0.06
29	1,4-Difluorobenzene (Circuit)	5	5.01	0.87	0.07
30	Cyclohexane	0.5	0.52	9.06	0.07
31	2,3-Dimethylpentane	0.5	0.54	9.86	0.08
32	3-Methylhexane	0.5	0.54	9.86	0.08
33	n-Heptane	0.5	0.50	8.51	0.07
34	2,2,4-Trimethylpentane	0.5	0.51	8.25	0.07
35	Methylcyclohexane	0.5	0.51	8.17	0.07
36	2,3,4-Trimethylpentane	0.5	0.05	8.84	0.01
37	2-Methylheptane	0.5	0.51	6.29	0.05
38	Toluene	0.5	0.51	7.74	0.06
39	n-Octane	0.5	0.50	8.73	0.07
40	3-Methylheptane	0.5	0.51	8.23	0.07
41	Chlorobenzene-d5 (ISTD)	5	5.00		
42	Ethylbenzene	0.5	0.51	7.67	0.06
43	m-Xylenes	0.5	0.52	8.04	0.07
44	p-Xylenes	0.5	0.52	7.44	0.06
45	Nonane	0.5	0.52	8.86	0.07
46	Styrene	0.5	0.52	8.02	0.07
47	o-Xylene	0.5	0.51	7.64	0.06
48	Bromofluorobenzene (circuit)	5	5.04	0.49	0.04
49	isopropylbenzene (Cumene)	0.5	0.52	8.41	0.07

50		0.5	0.52	8.08	0.07
51	1,3,5-Trimethylbenzene	0.5	0.52	7.15	0.06
52	m-ethyltoluene	0.5	0.52	8.97	0.07
53	p-ethyltoluene	0.5	0.52	8.97	0.07
54	n-Decane	0.5	0.52	8.14	0.07
55	o-ethyltoluene	0.5	0.52	7.80	0.06
56	1,2,4-Trimethylbenzene	0.5	0.53	8.21	0.07
57	1,2,3-Trimethylbenzene	0.5	0.52	8.15	0.07
58	m-Diethylbenzene	0.5	0.54	9.34	0.08
59	p-Diethylbenzene	0.5	0.52	8.44	0.07
60	n-Undecan	0.5	0.56	10.56	0.09
61	Dodecane	0.5	0.66	15.70	0.16

2.7 The Blank

After analyzed 600ml 10 ppb standard gas immediately load 300ml nitrogen blank and there is no compound tested above MDL. The blank chromatography shows the following.

File :D:\MassHunter\GCMS\1\data\200516\20051609.D
Operator : SL
Acquired : 16 May 2020 06:16 pm using AcqMethod TO-15-AECOM-AL.M
Instrument : Nutech Deans Switch
Sample Name: Blank 300mL N2 -Run9
Misc Info : no FID
Vial Number: 11



3 Conclusion

3.1 Using Nutech 8910 pre-concentrator system with GC/MS full scan and/or SIM the 57 PAMS target compounds can be tested at one time performance. All QA/QC meets EPA PAMS requirements.

3.2 The method and instrument configuration needs is just GC/MS and no Deans Switch with FID is necessary. That give the lab to using existing instruments a good example of a successful application. The analysis cost can be saved by combined PAMS and TO-15 target compounds together.

3.3 The results also show that the linear range can be from 0.5ppb to 10ppb and is better than similar application (1.25-10ppb). The performance is stable and no carry over is another advantage.

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