Volatile Organic Compounds Analysis in Drinking Water with Headspace GC/MSD Using Hydrogen Carrier Gas and HydroInert Source

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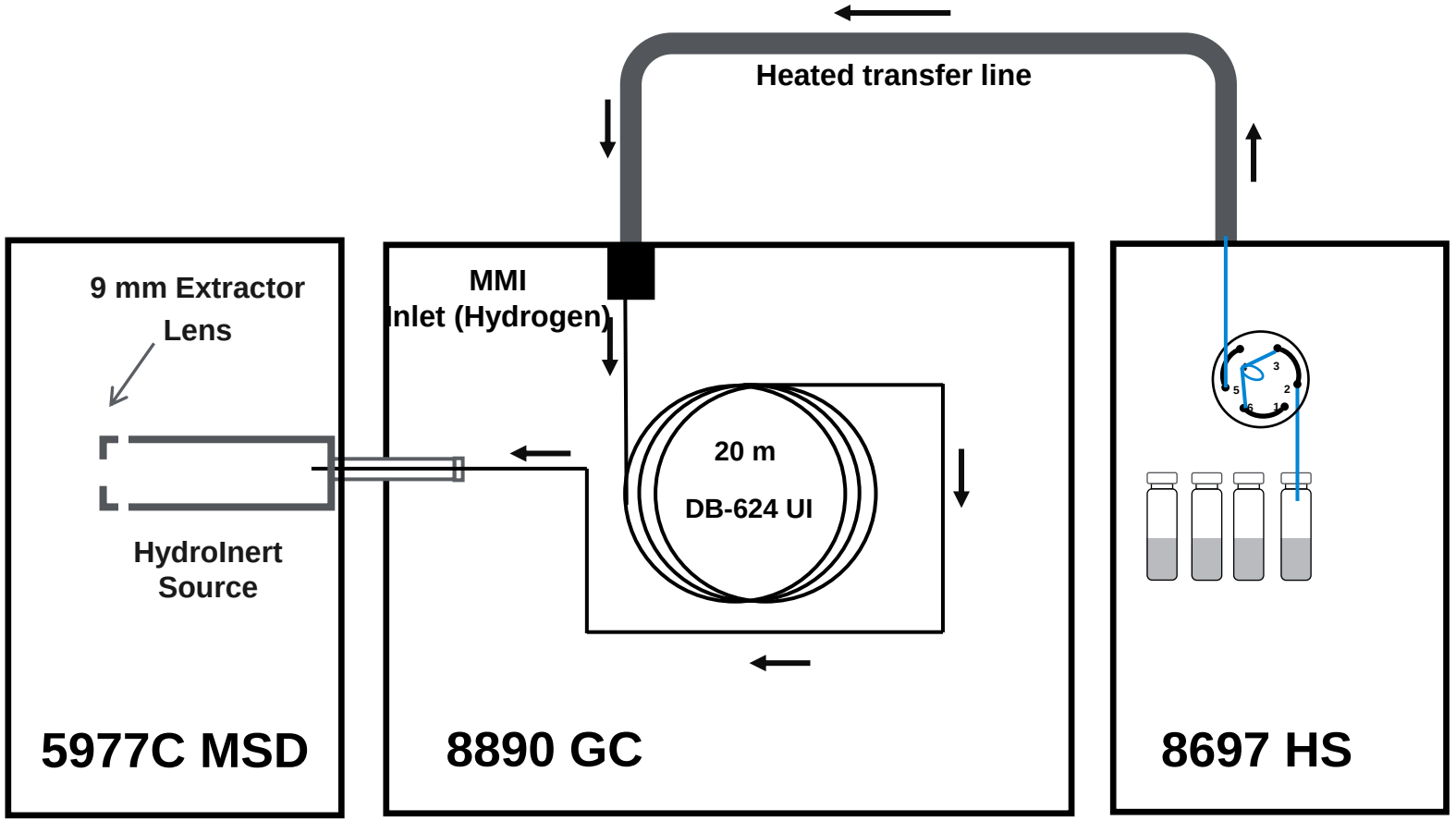
Analysis of Volatile Organic Compounds (VOCs)

- An important part of ensuring water quality.
- VOCs can appear in drinking water by contamination from numerous sources, including industrial and commercial operations.
- Another common source is when VOCs are formed by the addition of chlorine (used to disinfect the water) and react with natural organic matter in the source water.
- Regulations governing the allowable concentration of VOCs in drinking water vary by country and region but are typically in the low µg/L (ppb) range.
- Due to the large number of potential contaminants, and the need to measure them at such low levels, GC/MS systems are commonly used.
- GC/MS offers both the sensitivity and selectivity required to identify and quantify VOCs.
- Purge and trap and static headspace are two commonly used automated sampling techniques that extract the VOC analytes from water samples and inject them into the GC/MS.
- This presentation describes a system configured to perform static headspace/GC/MS analysis of VOCs in drinking water, optimized for using hydrogen as the carrier gas.

Instrument Configuration

Carrier gas is Hydrogen.
Vial pressurization gas is Nitrogen.

HydroInert Source



Key Components and Techniques Employed

- Agilent J&W DB-624 Ultra Inert column, **20 m × 0.18 mm, 1 µm** (part number 121-1324UI)
- Ultra Inert Splitless Inlet Liner, **straight 1 mm id** (part number 5190-4047)
- Pulsed split injection: Used to narrow the injection bandwidth enough to be compatible with small diameter column. Allows a low **21:1 split ratio** used here.
- Agilent **HydroInert source with 9 mm extractor lens**: EI extractor source optimized for use with hydrogen carrier gas that greatly reduces in-source reactions.
- Spectral deconvolution with **Agilent MassHunter Unknowns Analysis software**: Uses spectral deconvolution to extract clean analyte spectra from those of overlapping peaks.
- Addition of salt: **sodium sulfate** is added to increase sensitivity of the analysis.

Agilent 8890 GC Parameters	
Parameters	Setpoints
Inlet Temperature	200 °C
Liner	Agilent Ultra Inert inlet liner, splitless, straight, 1 mm id (p/n 5190-4047)
Carrier Gas	Hydrogen
Column Flow	0.95 mL/min constant flow
Injection Mode	Pulsed split
Split Ratio	21:1
Pulse Pressure	26 psig until 0.3 min
Septum Purge Flow	3 mL/min
Column	Agilent DB-624 Ultra Inert, 20 m × 0.18 mm, 1 µm (p/n 121-1324-UI)
Oven Program	35 °C (0.25 min), ramp 25 °C/min to 240 °C (0.2 min) Run time 8.65 min
Agilent 5977C MSD	
MS Source	HydroInert Extractor with 9 mm Extractor Lens
MS Tune	Etune
MSD Transfer Line Temperature	250 °C
MS Source Temperature	250 °C
MS Quad Temperature	200 °C
Scan Range	35 to 260 Da
Scan Speed	A/D samples 4, TID on
EM Gain Factor (Scan mode)	5
SIM Method Dwell Time	10 to 60 ms, varied by time segment to maintain minimum cycle time of 6.7 Hz
EM Gain Factor (SIM Mode)	2

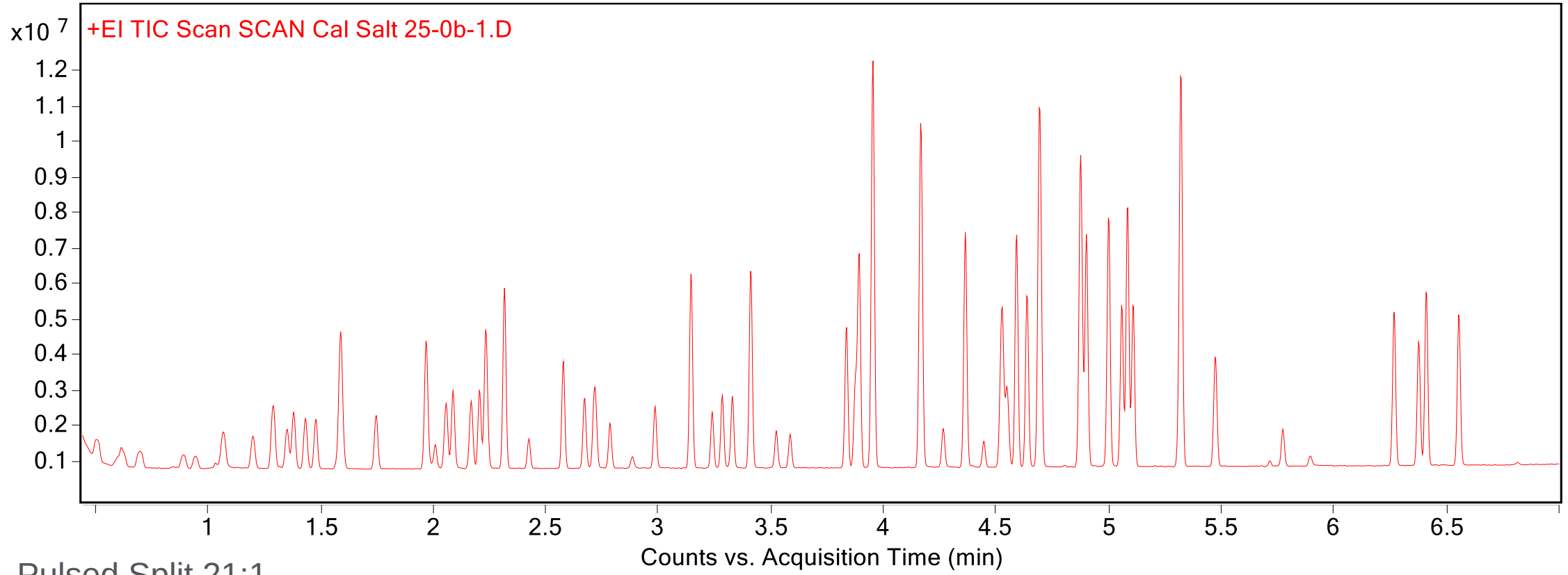
Agilent 8697 Headspace Sampler	
8697 Loop Size	1 mL
Vial Pressurization Gas	Nitrogen
HS Loop Temperature	75 °C
HS Oven Temperature	75 °C
HS Transfer Line Temperature	115 °C
Vial Equilibration	12.00 min
Injection Duration	0.30 min
GC Cycle Time	15.00 min
Vial Size	20 mL
Vial Shaking	Level 9, 250 shakes/min with acceleration of 980 cm/s²
Fill Mode	Default
Fill Flow	50
Fill Pressure	10 psi
Pressure Equilibration Time	0.1 min
Postinjection Purge	100 mL/min for 2 min

Vial Preparation:

20 mL HS vials
10 mL water sample or blank water for STD
5µL MeOH spiking solution with analytes and ISTD
5 grams sodium sulfate
Vortex capped vial vigorously for 20 sec

8697 HS/8890/5977C VOCs With H_2 Carrier and HydroInert

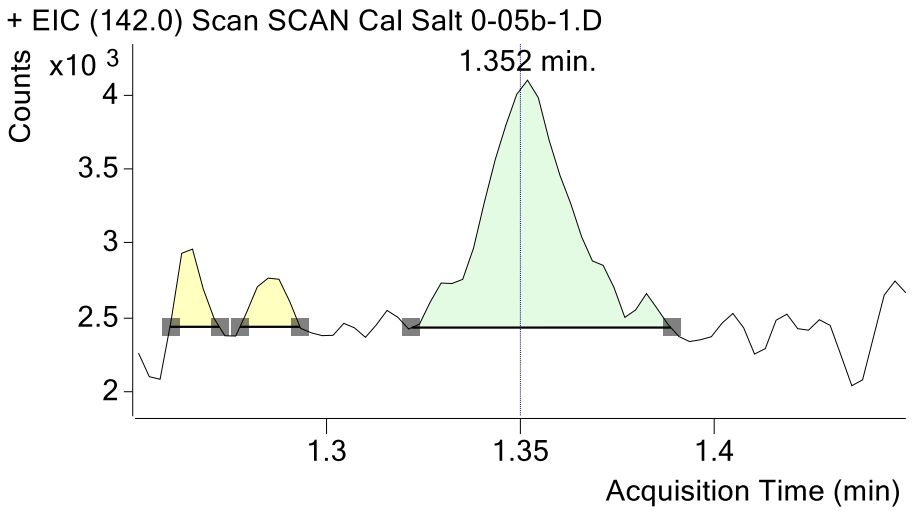
80 Compounds in 7 minutes



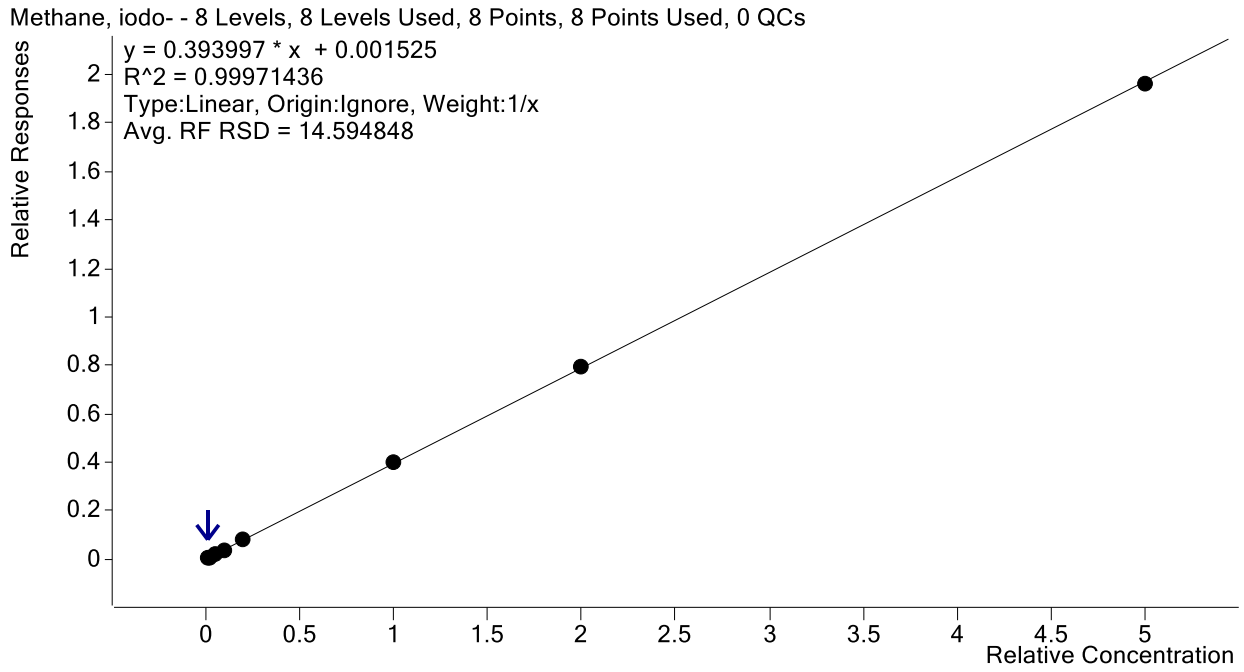
Pulsed Split 21:1
DB-624 UI 20 m x 0.18 mm x 1.0um
0.95 mL/min H_2 carrier
5 g Na_2SO_4 added to each vial

Cal from 0.05 ppb to 25 ppb in Scan and SIM modes

Iodomethane: Scan Mode Calibration from 0.05 ppb to 25 ppb



0.05 ppb Iodomethane



Average RF RSD = 14.6%
Relative Standard Error =7.4%

Partial Scan Mode Results Table from 0.05 ppb to 25 ppb

Table 2. Peak identifications, calibration results, and deconvoluted library match scores against NIST20 for the scan analysis.

Peak No.	Compound	RT (min)	Tgt *m/z*	Q1	Avg. RF RSD	CF Limit Low (µg/L)	CF Limit High (µg/L)	CF R^2	CF	CF Weight	Rel. Std. Error	LMS NIST20	
	Fluorobenzene [ISTD]	2.425	96	77								97	
1	Dichlorodifluoromethane	0.508	85	87	12.5	0.1	25	0.9989	Linear	1/x	17.3	92	
2	Chloromethane	0.615	50	52	14.4	0.25	25	0.9977	Linear	1/x	16.2	97	
3	Chloroethene	0.698	62	64	18.4	0.05	25	0.9995	Linear	1/x	9	91	
4	Bromomethane	0.891	94	96	21.7	1	25	0.9995	Linear	1/x	4.2	96	
5	Ethyl Chloride	0.945	64	66	13.6	0.25	25	0.9995	Linear	1/x	6.5	92	
6	Trichloromonofluoromethane	1.067	101	103	9.6	0.05	25	0.9994	Linear	1/x	9.6	96	
7	Ethyl ether	1.198	74	59	12.8	0.25	25	0.9992	Linear	1/x	11.4	97	
8	1,1-Dichloroethene	1.288	61	96	6.7	0.05	25	0.9993	Linear	1/x	7.3	98	
9	Acetone	1.317	58	43	112.5	1	25	0.9770	Linear	1/x	22.9	87	*
10	Iodomethane	1.350	142	127	14.6	0.05	25	0.9997	Linear	1/x	7.4	99	
11	Carbon disulfide	1.379	76		16.4	0.05	25	0.9997	Linear	1/x	5.7	95	
12	Allyl chloride	1.432	76	41	13.9	0.1	25	0.9982	Linear	1/x	17.2	97	
13	Methylene chloride	1.478	84	49	5.0	0.1	25	0.9996	Linear	1/x	5.1	97	
14	Acrylonitrile	1.572	52	53	16.1	0.5	25	0.9940	Linear	1/x	16.3	90	
15	*trans*-1,2-Dichloroethylene	1.586	61	96	15.9	0.05	25	0.9991	Linear	1/x	17.5	99	
16	Methyl tert-butyl ether	1.592	73	57	8.3	0.05	25	0.9991	Linear	1/x	9.6	98	
17	1,1-Dichloroethane	1.745	63	65	9.4	0.05	25	0.9998	Linear	1/x	5.2	97	
18	*cis*-1,2-Dichloroethylene	1.966	61	96	7.9	0.05	25	0.9998	Linear	1/x	6.1	95	
19	2,2-Dichloropropane	1.969	77	79	3.1	0.5	25	0.9994	Linear	1/x	3.7	80	**
20	Propanenitrile	1.993	54	52	14.5	0.5	25	0.9943	Linear	1/x	16.4	67	*
21	2-Propenoic acid, methyl ester	2.008	55	85	12.2	0.1	25	0.9991	Linear	1/x	8.5	97	

VOCs: Library Match Scores vs NIST20

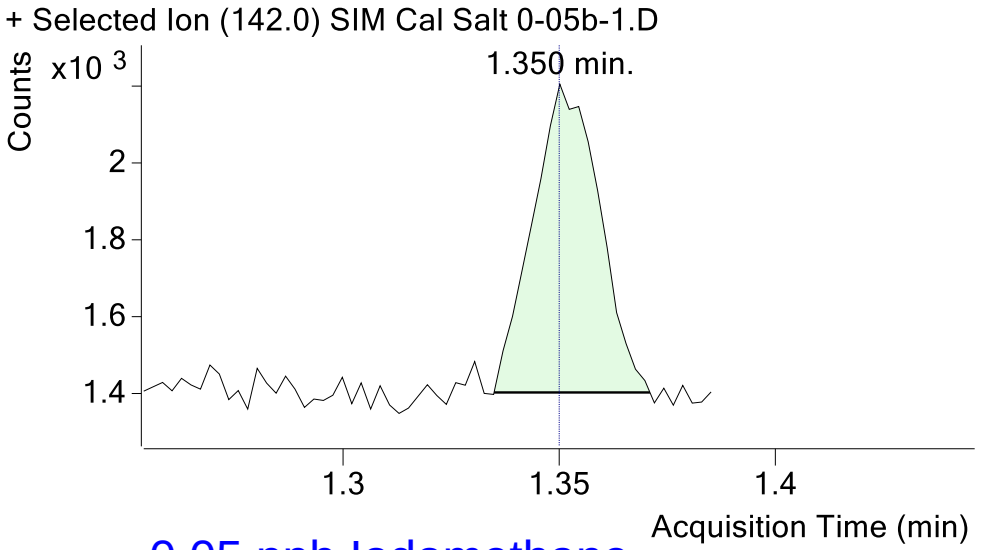
	RT (min)	LMS NIST20	
Dichlorodifluoromethane	0.507	92	
Chloromethane	0.616	97	
Ethene, chloro-	0.698	91	
Methane, bromo-	0.891	96	
Ethyl Chloride	0.945	92	
Trichloromonofluoromethane	1.068	96	
Ethyl ether	1.199	97	
Ethene, 1,1-dichloro-	1.289	98	
Acetone	1.316	87	*
Methane, iodo-	1.351	99	
Carbon disulfide	1.380	95	
Allyl chloride	1.433	97	
Methylene chloride	1.479	97	
2-Propenenitrile	1.574	90	
Ethylene, 1,2-dichloro-, (E)-	1.587	99	
Propane, 2-methoxy-2-methyl-	1.592	98	
Ethane, 1,1-dichloro-	1.747	97	
Ethylene, 1,2-dichloro-, (Z)-	1.968	95	
Propane, 2,2-dichloro-	1.970	80	**
2-Butanone	1.975	72	*
Propanenitrile	1.994	67	*
2-Propenoic acid, methyl ester	2.010	97	
Methylacrylonitrile	2.053	95	
Methane, bromochloro-	2.060	97	
Trichloromethane	2.088	98	
Tetrahydrofuran	2.091	96	
Ethane, 1,1,1-trichloro-	2.169	98	
Butane, 1-chloro-	2.206	97	
1-Propene, 1,1-dichloro-	2.233	96	
Carbon Tetrachloride	2.237	96	
Benzene	2.317	94	
Benzene, fluoro-	2.425	98	
Trichloroethylene	2.578	99	
Propane, 1,2-dichloro-	2.673	98	
Methyl methacrylate	2.714	98	
Methane, dibromo-	2.723	98	
Methane, bromodichloro-	2.786	98	
Propane, 2-nitro-	2.884	93	
Chloromethyl cyanide	2.888	63	*
1-Propene, 1,3-dichloro-, (Z)-	2.986	98	
Toluene	3.146	99	
1-Propene, 1,3-dichloro-, (E)-	3.240	98	
Methacrylic acid, ethyl ester	3.284	98	
Ethane, 1,1,2-trichloro-	3.329	98	
Tetrachloroethylene	3.411	91	
Propane, 1,3-dichloro-	3.412	90	
Methane, dibromochloro-	3.524	98	
Ethane, 1,2-dibromo-	3.586	99	
Benzene, chloro-	3.836	99	
Ethane, 1,1,1,2-tetrachloro-	3.876	96	
Ethylbenzene	3.892	98	
Benzene, 1,3-dimethyl-	3.953	99	
o-Xylene	4.165	89	
Styrene	4.169	96	
Methane, tribromo-	4.266	99	
Benzene, (1-methylethyl)-	4.364	98	
p-Bromofluorobenzene	4.446	97	
Ethane, 1,1,2,2-tetrachloro-	4.521	97	
Benzene, bromo-	4.529	97	
Propane, 1,2,3-trichloro-	4.547	84	
2-Butene, 1,4-dichloro-, (E)-	4.554	65	**
Benzene, propyl-	4.592	98	
Benzene, 1-chloro-2-methyl-	4.638	98	
Mesitylene	4.691	91	
Benzene, 1-chloro-4-methyl-	4.698	95	
Benzene, tert-butyl-	4.875	97	
Ethane, pentachloro-	4.881	86	
Benzene, 1,2,4-trimethyl-	4.902	98	
Benzene, (1-methylpropyl)-	5.001	98	
Benzene, 1,3-dichloro-	5.059	99	
p-Cymene	5.085	97	
Benzene, 1,4-dichloro-	5.110	99	
1,2-Dichlorobenzene-D4	5.314	78	**
Benzene, n-butyl-	5.321	96	
Benzene, 1,2-dichloro-	5.324	92	
Ethane, hexachloro-	5.475	97	
Propane, 1,2-dibromo-3-chloro-	5.775	98	
Benzene, nitro-	5.896	94	
Benzene, 1,2,4-trichloro-	6.269	99	
1,3-Butadiene, 1,1,2,3,4,4-hexachloro-	6.379	91	
Naphthalene	6.412	99	
Benzene, 1,2,3-trichloro-	6.557	99	

Average LMS = 94

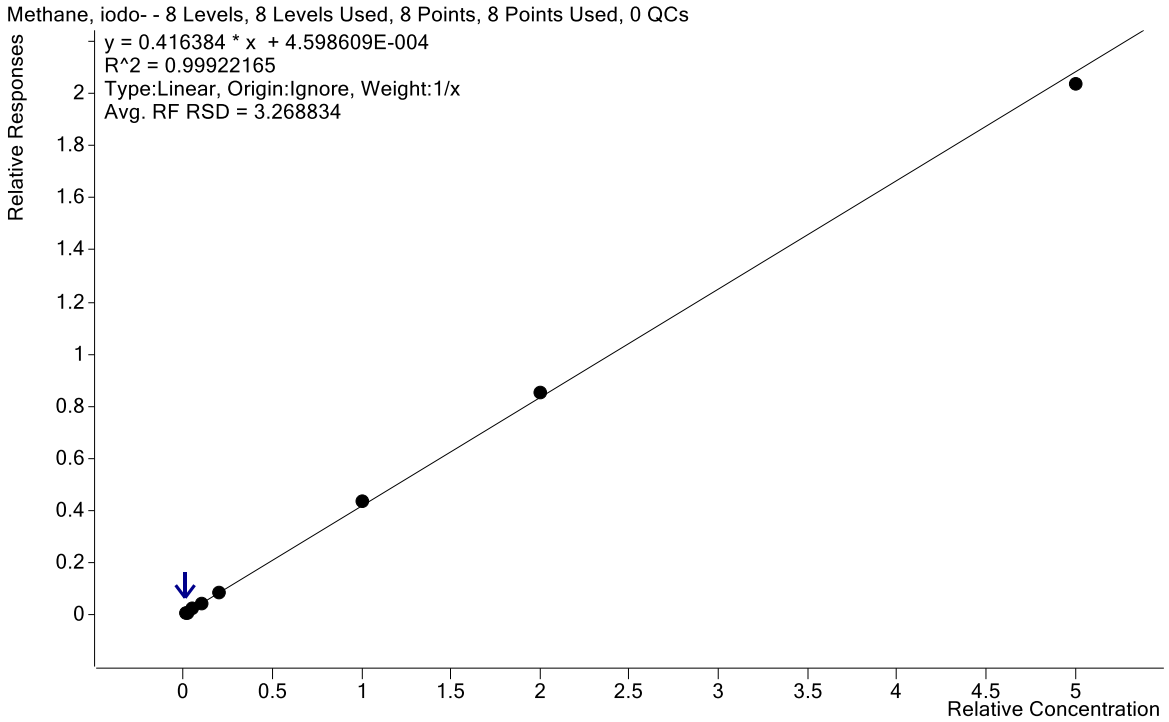
* low responding compound

** spectral interference from overlapping peaks

Iodomethane: SIM Mode Calibration from 0.05 ppb to 25 ppb



0.05 ppb Iodomethane



Average RF RSD = 3.3%
Relative Standard Error =4.8%

Partial SIM Mode Results Table from 0.05 ppb to 25 ppb

Table 3. Calibration results, and method detection limits (MDL) using SIM acquisition.

Peak No.	Compound Name	RT (min)	Tgt *m/z*	Q1	Avg. RF RSD	CF Limit Low (µg/L)	CF Limit High (µg/L)	CF R^2	CF	CF Weight	Rel. Std. Error	Conc. for MDL	MDL (µg/L)
	Fluorobenzene [ISTD]	2.425	96	77									
1	Dichlorodifluoromethane	0.508	85	87	15.3	0.05	25	0.9994	Linear	1/x	11.6	0.10	0.011
2	Chloromethane	0.615	50	52	7.3	0.1	25	0.9997	Linear	1/x	8.4	0.10	0.022
3	Chloroethene	0.698	62	64	4.1	0.05	25	0.9998	Linear	1/x	4.7	0.05	0.008
4	Bromomethane	0.891	94	96	4.1	0.05	25	0.9999	Linear	1/x	4.4	0.10	0.029
5	Ethyl Chloride	0.945	64	66	4.5	0.05	25	0.9998	Linear	1/x	4.7	0.05	0.010
6	Trichloromonofluoromethane	1.067	101	103	4.1	0.05	25	0.9997	Linear	1/x	4.3	0.05	0.008
7	Ethyl ether	1.198	74	59	6.4	0.05	25	0.9994	Linear	1/x	11	0.05	0.017
8	1,1-Dichloroethene	1.288	61	96	5.9	0.05	25	0.9996	Linear	1/x	5.3	0.05	0.006
9	Acetone	1.317	58	43	102.2	1	10	0.9994	Linear	1/x	3.5	[cont]	
10	Iodomethane	1.350	142	127	3.3	0.05	25	0.9992	Linear	1/x	4.8	0.05	0.006
11	Carbon disulfide	1.379	76		12.6	0.1	25	0.9994	Linear	1/x	4.6	0.05	0.003
12	Allyl chloride	1.432	76	41	4.9	0.05	25	0.9997	Linear	1/x	6.4	0.05	0.014
13	Methylene chloride	1.478	84	49	12.2	0.1	25	0.9999	Linear	1/x	5.2	0.05	0.007
14	Acrylonitrile	1.572	52	53	8.3	0.1	25	0.9999	Linear	1/x	5.4	[0.25]	
15	*trans*-1,2-Dichloroethylene	1.586	61	96	7.1	0.05	25	0.9997	Linear	1/x	5	0.05	0.007
16	Methyl tert-butyl ether	1.592	73	57	4.2	0.05	25	0.9995	Linear	1/x	7.5	0.05	0.003
17	1,1-Dichloroethane	1.745	63	65	3.7	0.05	25	0.9998	Linear	1/x	4.6	0.05	0.003
18	*cis*-1,2-Dichloroethylene	1.966	61	96	10.1	0.05	25	0.9996	Linear	1/x	7.3	0.05	0.007
19	2,2-Dichloropropane	1.969	77	79	3.6	0.05	25	0.9999	Linear	1/x	4.2	0.10	0.017
20	Propanenitrile	1.993	54	52	5.0	0.25	25	0.9996	Linear	1/x	4.3	[0.25]	
21	2-Propenoic acid, methyl ester	2.008	55	85	11.0	0.05	25	0.9996	Linear	1/x	14.8	0.10	0.029

MDL Calculations for SIM Method

$$MDL = s \cdot t(n - 1, 1 - alpha = 99)$$
$$= s \cdot 2.998$$

Where:

t(n – 1, 1 – alpha) = t value for the 99% confidence level with n – 1 degrees of freedom

n = number of trials (8)

s = standard deviation of the eight trials

MDLs: SIM HS/GC/MSD VOAs With H_2 Carrier and HydroInert

Name	RT Min min	Conc for MDL	MDL µg/L
Dichlorodifluoromethane	0.508	0.10	0.011
Chloromethane	0.615	0.10	0.022
Ethene, chloro-	0.698	0.05	0.008
Methane, bromo-	0.891	0.10	0.029
Ethyl Chloride	0.945	0.05	0.010
Trichloromonofluoromethane	1.067	0.05	0.008
Ethyl ether	1.198	0.05	0.017
Ethene, 1,1-dichloro-	1.288	0.05	0.006
Acetone	1.317	[cont]	
Methane, iodo-	1.350	0.05	0.006
Carbon disulfide	1.379	0.05	0.003
Allyl chloride	1.432	0.05	0.014
Methylene chloride	1.478	0.05	0.007
Acrylonitrile	1.572	[0.25]	
Ethylene, 1,2-dichloro-, trans-	1.586	0.05	0.007
Methyl tert-butyl ether	1.592	0.05	0.003
Ethane, 1,1-dichloro-	1.745	0.05	0.003
Ethylene, 1,2-dichloro-, cis-	1.966	0.05	0.007
Propane, 2,2-dichloro-	1.969	0.10	0.017
Propanenitrile	1.993	[0.25]	
2-Propenoic acid, methyl ester	2.008	0.10	0.029
Methylacrylonitrile	2.052	0.10	0.032
Methane, bromochloro-	2.059	0.10	0.019
Trichloromethane	2.086	0.05	0.011
Tetrahydrofuran	2.090	0.05	0.030
Ethane, 1,1,1-trichloro-	2.168	0.05	0.007
Butane, 1-chloro-	2.205	0.05	0.007
1-Propene, 1,1-dichloro-	2.231	0.05	0.007
Carbon Tetrachloride	2.235	0.05	0.015
Benzene	2.315	0.05	0.004
Ethane, 1,2-dichloro-	2.316	0.05	0.005
Trichloroethylene	2.577	0.05	0.006
Propane, 1,2-dichloro-	2.671	0.05	0.011
Methyl methacrylate	2.713	0.05	0.033
Methane, dibromo-	2.722	0.05	0.009
Methane, bromodichloro-	2.785	0.05	0.011
Propane, 2-nitro-	2.883	0.10	0.041
Chloromethyl cyanide	2.887	[0.25]	
1-Propene, 1,3-dichloro-, cis-	2.985	0.05	0.003
Toluene	3.145	0.05	0.003
1-Propene, 1,3-dichloro-, trans-	3.239	0.05	0.005
Methacrylic acid, ethyl ester	3.283	0.05	0.008
Ethane, 1,1,2-trichloro-	3.328	0.05	0.034
Tetrachloroethylene	3.410	0.05	0.005
Propane, 1,3-dichloro-	3.412	0.05	0.007
Methane, dibromochloro-	3.524	0.05	0.008
Ethane, 1,2-dibromo-	3.585	0.05	0.005
Benzene, chloro-	3.835	0.05	0.002
Ethane, 1,1,1,2-tetrachloro-	3.875	0.05	0.007
Ethylbenzene	3.892	0.05	0.005
m-Xylene	3.953	0.05	0.001
o-Xylene	4.164	0.05	0.004
Styrene	4.169	0.05	0.005
Methane, tribromo-	4.266	0.05	0.003
Benzene, (1-methylethyl)-	4.364	0.05	0.004
p-Bromofluorobenzene	4.446	ISTD	
Ethane, 1,1,2,2-tetrachloro-	4.521	0.05	0.006
Benzene, bromo-	4.530	0.05	0.003
Propane, 1,2,3-trichloro-	4.548	0.05	0.024
2-Butene, 1,4-dichloro-, trans-	4.555	[0.25]	
Benzene, propyl-	4.592	0.05	0.008
Benzene, 1-chloro-2-methyl-	4.638	0.05	0.006
Mesitylene	4.692	0.05	0.008
Benzene, tert-butyl-	4.876	0.05	0.004
Ethane, pentachloro-	4.881	0.05	0.009
Benzene, 1,2,4-trimethyl-	4.903	0.05	0.007
Benzene, (1-methylpropyl)-	5.001	0.05	0.004
Benzene, 1,3-dichloro-	5.060	0.05	0.003
p-Cymene	5.086	0.05	0.009
Benzene, 1,4-dichloro-	5.110	0.05	0.004
1,2-Dichlorobenzene-D4	5.313	Surr	
Benzene, n-butyl-	5.322	0.05	0.012
Benzene, 1,2-dichloro-	5.325	0.05	0.003
Ethane, hexachloro-	5.476	0.05	0.008
Propane, 1,2-dibromo-3-chloro-	5.775	0.05	0.017
Benzene, nitro-	5.896	[0.25]	
Benzene, 1,2,4-trichloro-	6.270	0.05	0.007
1,3-Butadiene, 1,1,2,3,4,4-hexachloro-	6.380	0.05	0.006
Naphthalene	6.413	0.05	0.003
Benzene, 1,2,3-trichloro-	6.558	0.05	0.006

Most MDLs are in ppt range

Overview of Method Performance

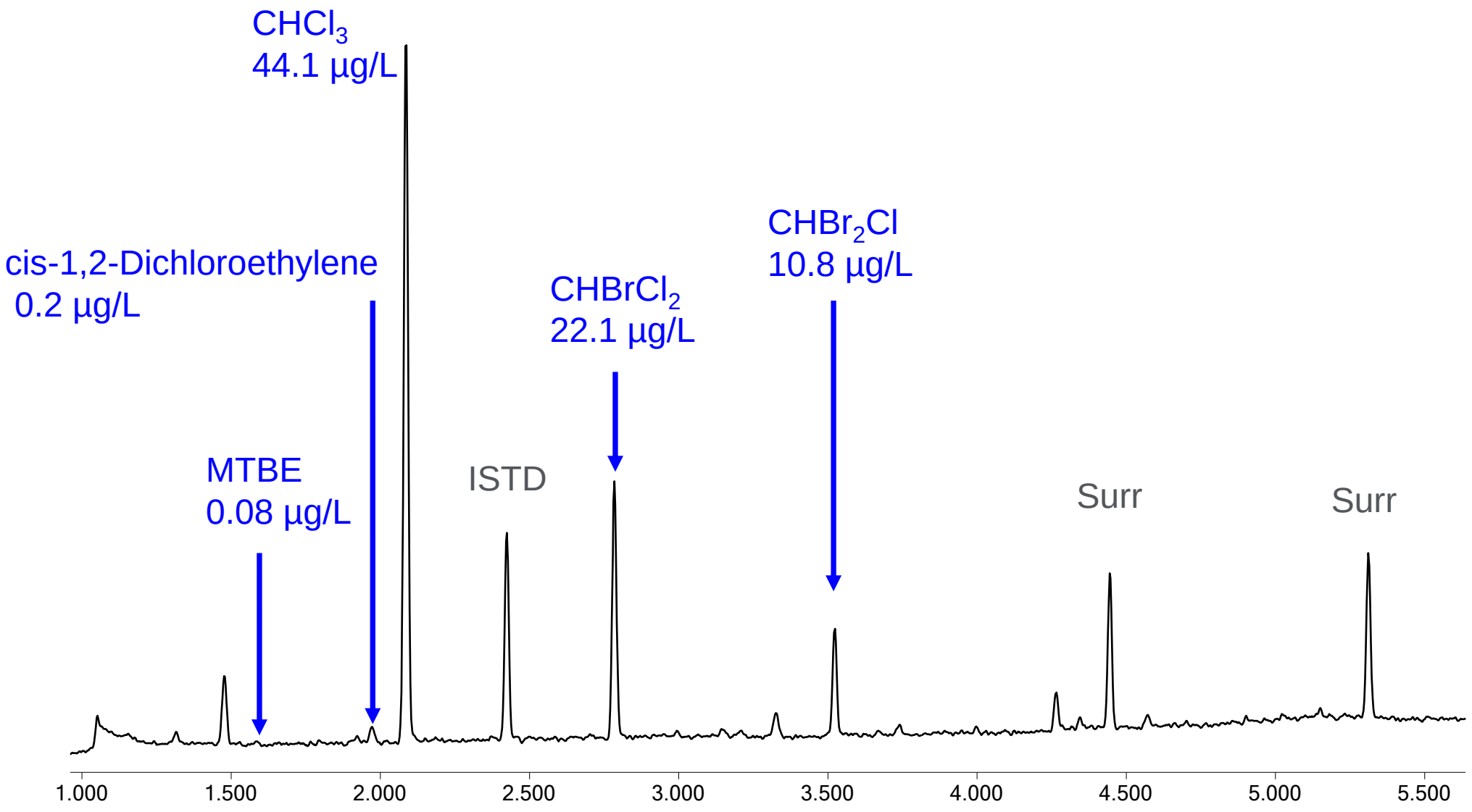
Results of the Scan mode evaluation demonstrated excellent:

- Spectral matching against the NIST20 library. The average library match score for the 80 compounds was **94**.
- Calibration linearity with an **average range of 0.16 µg/L to 25 µg/L** and **average R^2 of 0.9978.**

The results of the SIM mode evaluation demonstrated excellent:

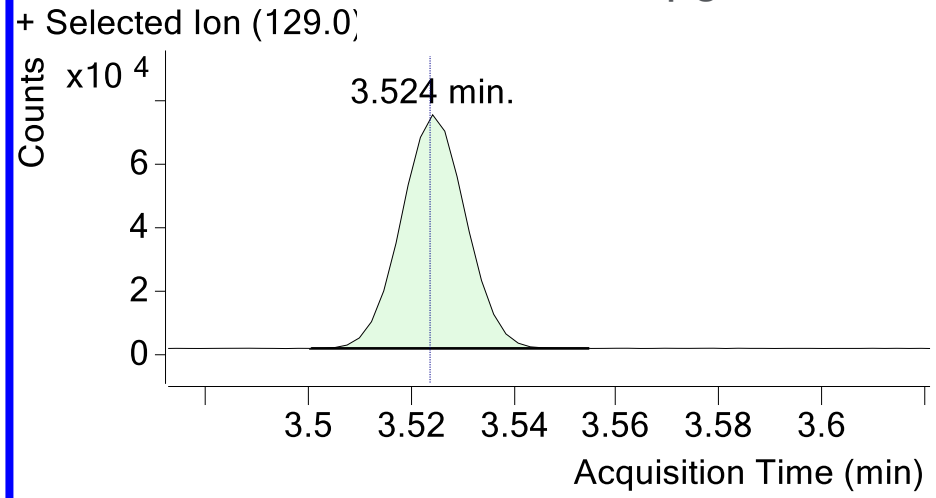
- Calibration linearity with an average range of **0.07 µg/L to 25 µg/L** and average **R^2 of 0.9990**.
- Method detection limits (MDL) as calculated using the standard deviation of 8 replicates of the lowest calibration standard multiplied by 2.998. The **average MDL for the 80 compounds was 0.026 µg/L.**

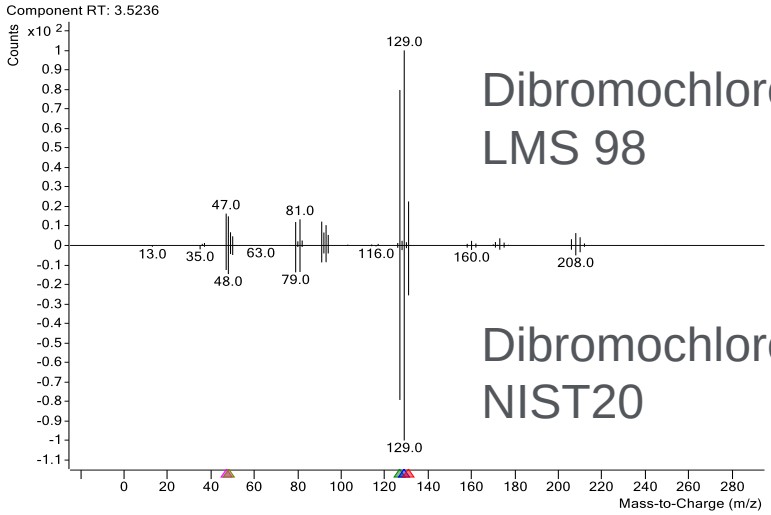
Tap Water Sample, Eastern Pennsylvania



Examples From Eastern PA Sample

Dibromochloromethane, 10.8 µg/L

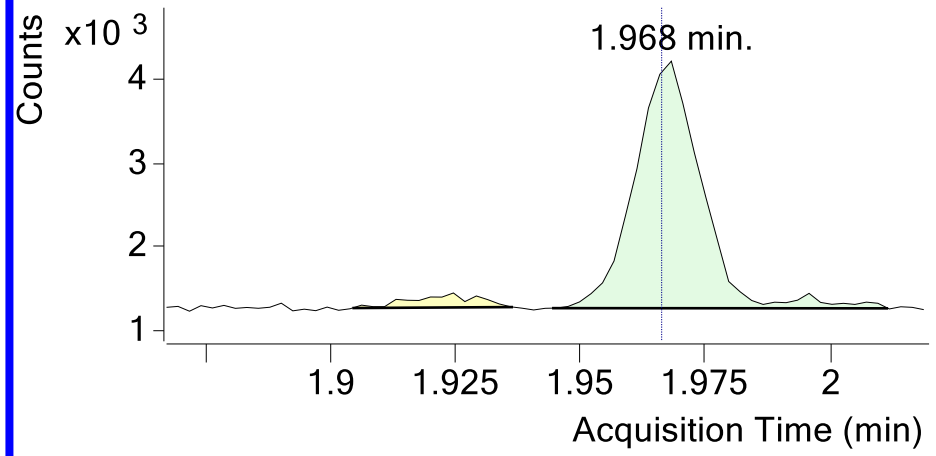


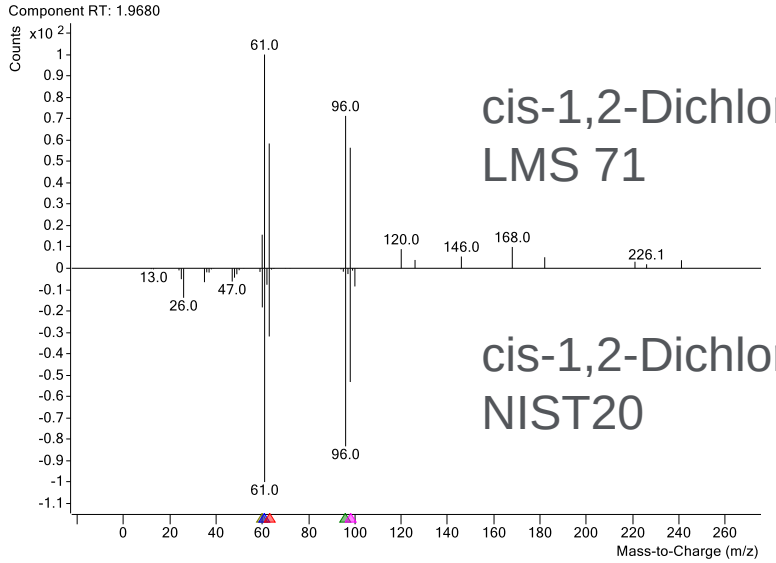


Dibromochloromethane
LMS 98

Dibromochloromethane
NIST20

cis-1,2-Dichloroethylene, 0.2 µg/L



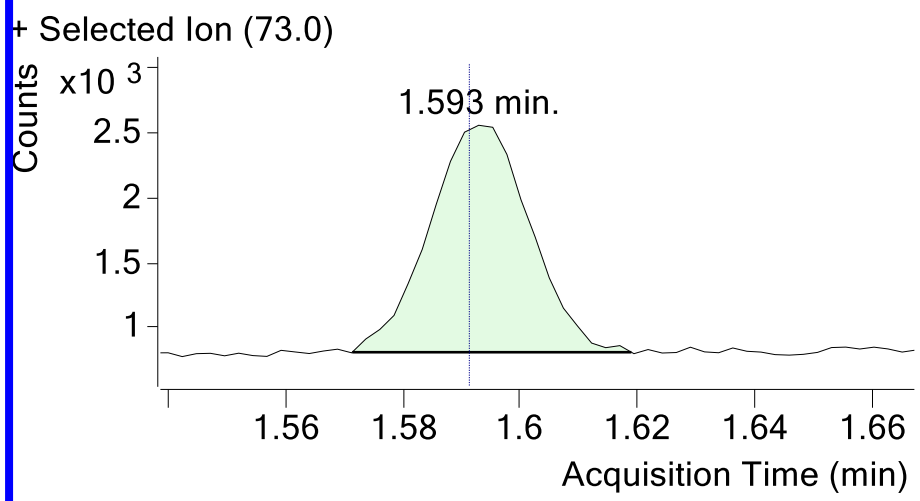


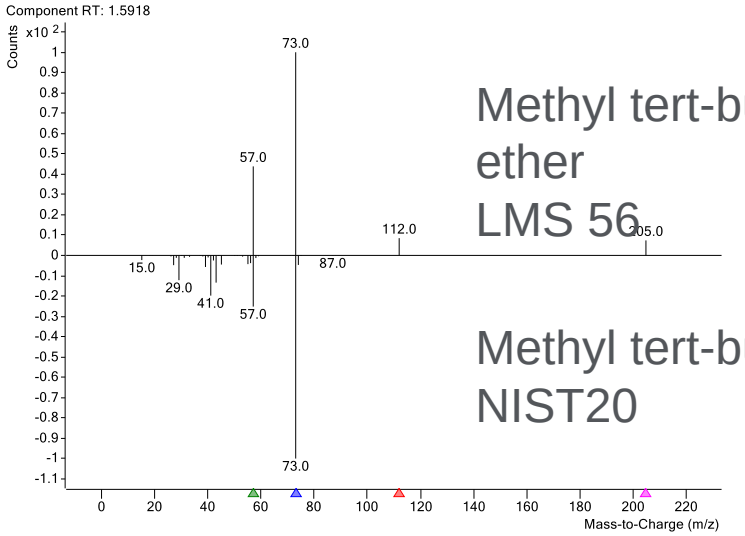
cis-1,2-Dichloroethylene
LMS 71

cis-1,2-Dichloroethylene
NIST20

Examples From Eastern PA Sample

Methyl tert-butyl ether, 0.08 µg/L

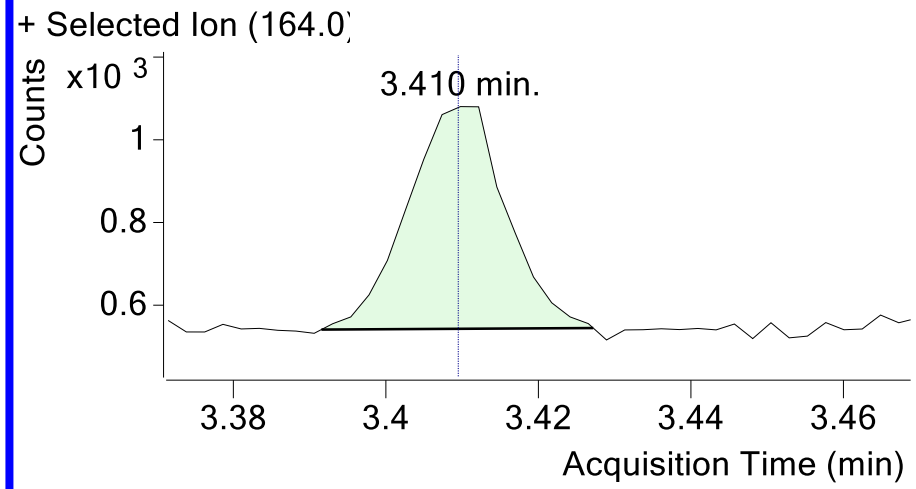


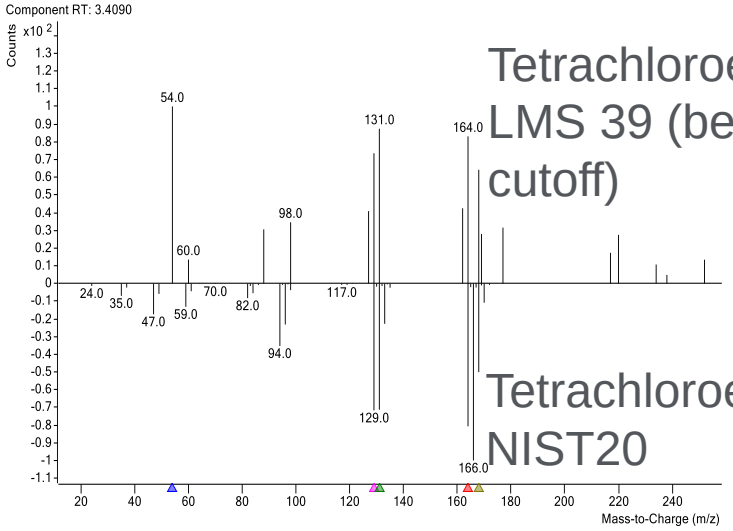


Methyl tert-butyl ether
LMS 56

Methyl tert-butyl ether
NIST20

Tetrachloroethylene, 0.05 µg/L





Tetrachloroethylene
LMS 39 (below cutoff)

Tetrachloroethylene
NIST20

Results from analysis of tap water samples

Name	RT (min)	Eastern PA			Southeastern PA		
		Scan	Scan	SIM	Scan	Scan	SIM
		LMS NIST20	Conc. (µg/L)	Conc. (µg/L)	LMS NIST20	Conc. (µg/L)	Conc. (µg/L)
Methyl *tert*-butyl ether	1.592	56	0.08	0.08			
cis-1,2-Dichloroethylene	1.968	71	0.19	0.20			
Trichloromethane	2.087	98	43.47	44.08	97	21.03	20.90
Bromodichloromethane	2.785	98	21.81	22.07	92	4.82	4.85
Tetrachloroethylene	3.410			0.05			
Dibromochloromethane	3.524	98	11.34	10.80	68	0.69	0.69
Tribromomethane	4.266	97	3.97	3.71			0.02

Summary

The configuration used here with hydrogen carrier and the new HydroInert EI source provided excellent results for the analysis of VOCs.

Scan mode:

- Spectral matching against the NIST20 library. The average library match score for the 80 compounds was 94.
- Calibration linearity with an average range of 0.16 µg/L to 25 µg/L and average R^2 of 0.9978.

SIM mode:

- Calibration linearity with an average range of 0.07 µg/L to 25 µg/L and average R^2 of 0.9990.
- Method detection limits (MDL). The average MDL for the 80 compounds was 0.026 µg/L.

Complete details are available in application note: 5994-4963EN

https://www.agilent.com/cs/library/applications/an-voc-headspace-hydroinert-gc-msd-5994-4963en-agilent.pdf

Thank You For Your Attention!

More information from Agilent.com:

Agilent Inert Plus HydroInert GC-MS System: Applying H_2 Carrier Gas to Real World GC-MS Analyses. Agilent Technologies technical overview, publication number 5994-4889EN, 2022.

- https://www.agilent.com/cs/library/technicaloverviews/public/te-hydroinert-source-5994-4889en-agilent.pdf

Analysis of Semivolatile Organic Compounds Using Hydrogen Carrier Gas and the Agilent HydroInert Source by Gas Chromatography/Mass Spectrometry

https://www.agilent.com/cs/library/applications/an-svoc-hydrogen-carrier-gas-hydroinert-gcms-5994-4890en-agilent.pdf

Analysis of Semivolatile Organic Compounds with Hydrogen Carrier Gas and HydroInert Source by Gas Chromatography/Triple Quadrupole Mass Spectrometry (GC/MS/MS)

https://www.agilent.com/cs/library/applications/an-svoc-hydrogen-carrier-gas-hydroinert-7000e-gcms-5994-4891en-agilent.pdf