

Application Note

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Abstract

US EPA Method 524.3 is used primarily by environmental labs for the analysis of volatile organic compounds (VOCs) in drinking water. While this method is effective at concentrating the trace levels of VOCs sometimes found in finished drinking water, it also tends to transfer significant quantities of water vapor to the gas chromatography-mass spectrometry (GC-MS) instruments.

Teledyne Tekmar's Lumin purge and trap (P&T) concentrator incorporates a moisture control system (MCS) specifically designed to reduce the amount of water transferred during desorb, in comparison to current purge and trap technologies. This application note will demonstrate the ability of the Lumin to reduce the amount of water transferred to the Agilent GC-MSD system when using this method.

Introduction

Gas chromatography (GC) inlets, columns and mass spectrometers (MS) are sensitive to water. However, to detect toxic VOC compounds, the VOCs must be purged and trapped from water. This places water vapor on the GC-MS system, which contributes to column and inlet issues and frequent MS cleaning to remove the oxidation from the MS source.

US EPA method 524.3 places a large amount of water vapor on the GC-MS system. This method allows flexibility in the dry purge and desorb time of the analytical trap to reduce the large volume of water that inundates the GC-MS system and leads to poor chromatography for early eluting gases.

Traditionally, purge and trap instruments reduced the amount of water transferred to the GC-MS instrument through numerous water management techniques. The Teledyne Tekmar Lumin significantly reduces the amount of water transferred to GC-MS system over current P&T instrumentation through the design of its MCS. Additionally, improvements in analytical trap cooling have further reduced sample cycle times, permitting more samples to be processed within a 12-hour period.

Sample Preparation

Calibration standards were prepared from Restek® 524.3 VOA MegaMix® and 524.3 Gas Calibration Mix standards in deionized water containing the required amount of maleic acid and ascorbic acid. A calibration curve was prepared from 0.2 ppb to 50 ppb for all of the compounds.

The relative response factor (RF) was calculated for each VOC using either 1,4-difluorobenzene, chlorobenzene-d5 or 1,4-dichlorobenzene-d4 as an internal standard. Surrogate standards consisted of: methyl-t-butyl ether-d3, 4-bromofluorobenzene and 1,2-dichlorobenzene-d4. A linear calibration curve with 1/X weighting was used for all compounds.

Seven 0.5 ppb and seven 5 ppb standards were prepared to calculate the method detection limit (MDL), accuracy and precision data. All calibration and MDL samples were analyzed with the Lumin and AQUATEk 100 conditions in [Table I](#) and the GC-MSD conditions in [Table II](#).

The correlation coefficient of the calibration curve (r^2), MDL, accuracy and precision data are shown in [Table III](#). A 0.2 ppb standard was analyzed and indicated the lowest detectable peak for the initial seven gases was unencumbered by excessive water ([Figure 1](#)). [Figure 2](#) displays a 5 ppb standard, indicating excellent peak resolution for all of the VOCs.



Experimental Instrument Conditions

Table I Lumin and AQUATek 100 Conditions			
Standby	Variable	Bake	Variable
Valve Oven Temp	150 °C	Bake Time	2.00 min
Transfer Line Temp	150 °C	Bake Temp	260 °C
Sample Mount Temp	90 °C	MCS Bake Temp	180 °C
Purge Ready Temp	35 °C	Bake Flow	200 mL/min
MCS Purge Temp	20 °C	AQUATek 100	Variable
Standby Flow	20 mL/min	Sample Loop Time	0.35 min
Purge	Variable	Sample Transfer Time	0.35 min
Purge Time	11.00 min	Rinse Loop Time	0.30 min
Purge Flow	40 mL/min	Sweep Needle Time	0.30 min
Dry Purge Temp	20 °C	Presweep Time	0.25 min
Dry Purge Time	0 min	Water Temp	90 °C
Dry Purge Flow	0 mL/min	Bake Rinse Drain Cycles	3
Desorb	Variable	Bake Rinse Drain Time	0.35 min
Desorb Preheat Temp	245 °C		
Desorb Time	1.00 min	Trap	9
Desorb Temp	250 °C	Chiller Tray	On
Drain Flow	300 mL/min	Purge Gas	Helium

Table II Agilent 7890B GC and 5977A MSD System Conditions	
Agilent 7890B GC Conditions	
Column	DB-624 UI, 20 m x 0.18 mm ID, 1 µm Film; Helium – 0.8 mL/min
Oven Profile	35 °C, 2 min, 10 °C/min to 100 °C, 25 °C/min to 225 °C, 2 min hold; Run Time 15.5 min
Inlet	150 °C; 65:1 Split; Gas Saver Flow - 20 mL/min after 1 min
Agilent 5977A MSD Conditions	
Temp	Transfer Line 225 °C; Source 230 °C; Quad 150 °C
Scan	Range 35 amu to 260 amu; Threshold 10; Scan Speed n=3; Delay 0.8 min
Current	Gain Factor 14; Trace Ion Detection - On; Tune File – BFB Atune

Results

Table III Method 524.3 Calibration, Accuracy and Precision Data							
Compound	Calibration		MRL Confirmation (0.5 ppb)		Accuracy and Precision (n=7, 0.5 ppb) ³		
	Linearity (r ²)	MDL (ppb)	LPIR (> 50%)	UPIR (<150%)	Avg. Conc. (ppb)	Accuracy (± 20%)	Precision (≤ 20%)
1,4-Difluorobenzene (IS 1)	3.1 ¹						1.3 ²
Dichlorodifluoromethane	0.999	0.14	61.1	130.9	0.48	96	9.2
Chlorodifluoromethane	0.999	0.05	70.1	93.3	0.41	82	3.6
Chloromethane	1.000	0.15	51.2	127.1	0.45	89	10.7
Vinyl Chloride	1.000	0.14	64.1	136.4	0.50	100	9.1
1,3-Butadiene	0.999	0.08	78.1	117.9	0.49	98	5.1
Bromomethane	0.998	0.17	54.0	139.2	0.48	97	11.1
Trichlorofluoromethane	0.999	0.07	71.1	108.9	0.45	90	5.3
Diethyl Ether	1.000	0.16	62.1	144.8	0.52	103	10.1
1,1-Dichloroethene	1.000	0.05	88.7	114.1	0.51	101	3.2
Carbon Disulfide	1.000	0.09	74.3	122.3	0.49	98	6.2
Iodomethane	0.998	0.11	73.0	127.5	0.50	100	6.9
Allyl Chloride	1.000	0.15	70.8	145.2	0.54	108	8.7
Methylene Chloride (DCM)	1.000	0.11	70.1	127.0	0.49	99	7.3
trans-1,2-Dichloroethene	1.000	0.15	63.3	140.1	0.51	102	9.5
Methyl Acetate	0.999	0.12	71.6	132.4	0.51	102	7.5
MtBE-d3 (Surr)	1.4 ¹				12.48	100	0.8 ²
Methyl-t-Butyl Ether (MtBE)	1.000	0.08	77.3	117.0	0.49	97	5.2
Diisopropyl Ether (DIPE)	1.000	0.11	70.3	127.4	0.49	99	7.3
t-Butyl Alcohol (TBA) ³	0.998	10.06	68.6	122.2	4.8	95	7.1
1,1-Dichloroethane	1.000	0.14	54.0	123.7	0.44	89	9.9
t-Butyl Ethyl Ether (ETBE)	1.000	0.10	71.7	122.6	0.49	97	6.6
cis-1,2-Dichloroethene	1.000	0.09	77.7	125.7	0.51	102	5.9
Bromochloromethane	1.000	0.14	69.8	140.0	0.52	105	8.4
Chloroform	1.000	0.11	69.5	124.3	0.48	97	7.1
Carbon Tetrachloride	0.999	0.06	81.8	113.1	0.49	97	4.1
Tetrahydrofuran	0.998	0.14	72.3	142.0	0.54	107	8.2
1,1,1-Trichloroethane	1.000	0.13	64.6	128.5	0.48	97	8.3
1,1-Dichloropropene	0.999	0.17	63.4	148.0	0.53	106	10.1
1-Chlorobutane	1.000	0.09	70.1	113.9	0.46	92	6.0
Benzene	1.000	0.09	74.8	119.5	0.49	97	5.8
t-Amyl Methyl Ether (TAME)	1.000	0.10	72.6	121.7	0.49	97	6.4
1,2-Dichloroethane	1.000	0.10	67.3	120.2	0.47	94	7.1
Trichloroethene	1.000	0.08	80.5	121.2	0.50	101	5.1

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	Linearity (r ²)	MDL (ppb)	LPIR (> 50%)	UPIR (<150%)	Avg. Conc. (ppb)	Accuracy (± 20%)	Precision (≤ 20%)
t-Amyl Ethyl Ether (TAEE)	1.000	0.05	87.6	111.3	0.50	99	3.0
Dibromomethane	1.000	0.11	61.4	118.6	0.45	90	8.0
1,2-Dichloropropane	1.000	0.14	65.8	137.6	0.51	102	8.9
Bromodichloromethane	1.000	0.11	68.6	126.3	0.49	97	7.5
cis-1,3-Dichloropropene	0.999	0.10	76.5	127.0	0.51	102	6.3
Chlorobenzene-d5 (IS 2)	4.8 ¹						4.8 ²
Toluene	0.998	0.10	72.6	125.1	0.49	99	6.7
Tetrachloroethene	0.995	0.17	50.8	137.2	0.47	94	11.6
trans-1,3-Dichloropropene	0.999	0.14	67.4	138.8	0.52	103	8.7
Ethyl Methacrylate	0.998	0.17	57.4	142.0	0.50	100	10.7
1,1,2-Trichloroethane	0.998	0.13	55.2	123.0	0.45	89	9.6
Dibromochloromethane	0.999	0.09	72.8	117.5	0.48	95	5.9
1,3-Dichloropropane	0.998	0.13	64.2	132.4	0.49	98	8.7
1,2-Dibromoethane (EDB)	0.998	0.09	75.4	122.9	0.50	99	6.0
Chlorobenzene	0.999	0.04	90.8	113.2	0.51	102	2.8
Ethylbenzene	0.999	0.08	79.3	117.8	0.49	99	4.9
1,1,1,2-Tetrachloroethane	1.000	0.06	84.4	114.4	0.50	99	3.8
m-, p-Xylene	0.999	0.11	78.1	107.0	0.93	185	3.9
o-Xylene	0.998	0.14	59.5	129.6	0.47	95	9.4
Styrene	0.999	0.10	64.5	115.0	0.45	90	7.1
Bromoform	0.999	0.14	67.6	139.9	0.52	104	8.8
Isopropylbenzene	0.999	0.08	71.6	111.2	0.46	91	5.5
1,4-Dichlorobenzene-d4 (IS 3)	5.2 ¹						5.2 ²
4-Bromofluorobenzene (Surr)	4.2 ¹				12.44	100	1.1 ²
Bromobenzene	1.000	0.05	84.1	107.3	0.48	96	3.1
n-Propylbenzene	1.000	0.04	83.1	103.2	0.47	93	2.7
1,1,2,2-Tetrachloroethane	0.999	0.08	78.6	120.3	0.50	99	5.3
2-Chlorotoluene	1.000	0.13	67.5	131.4	0.50	99	8.1
1,3,5-Trimethylbenzene	1.000	0.06	81.5	110.5	0.48	96	3.8
1,2,3-Trichloropropane	0.999	0.16	67.0	146.7	0.53	107	9.4
4-Chlorotoluene	1.000	0.05	80.1	103.3	0.46	92	3.2
t-Butylbenzene	0.999	0.10	69.8	122.7	0.48	96	6.9
Pentachloroethane	0.995	0.16	63.3	141.9	0.51	103	9.7
1,2,4-Trimethylbenzene	1.000	0.06	83.5	112.5	0.49	98	3.7
sec-Butylbenzene	0.999	0.08	70.6	112.3	0.46	91	5.7
4-Isopropyltoluene	1.000	0.05	84.9	108.8	0.48	97	3.1

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	Linearity (r ²)	MDL (ppb)	LPIR (> 50%)	UPIR (<150%)	Avg. Conc. (ppb)	Accuracy (± 20%)	Precision (≤ 20%)
1,3-Dichlorobenzene	1.000	0.06	82.5	111.2	0.48	97	3.7
1,4-Dichlorobenzene	1.000	0.08	77.8	116.5	0.49	97	5.0
n-Butylbenzene	0.999	0.09	78.2	125.8	0.51	102	5.9
Hexachloroethane	1.000	0.14	63.3	133.3	0.49	98	9.0
1,2-Dichlorobenzene	1.000	0.09	70.8	115.5	0.47	93	6.1
1,2-Dichlorobenzene-d4 (Surr)	3.5 ¹				12.65	101	1.5 ²
1,2-Dibromo-3-chloropropane	0.998	0.11	71.2	125.9	0.49	99	7.0
Hexachlorobutadiene	1.000	0.18	54.7	144.2	0.50	99	11.4
1,2,4-Trichlorobenzene	0.999	0.06	89.2	117.7	0.52	103	3.5
Naphthalene	0.999	0.07	89.7	126.8	0.54	108	4.3
1,2,3-Trichlorobenzene	0.999	0.04	93.1	114.4	0.52	104	2.6

1. %RSD of the peak areas for the internal standard or the calculated amount for the surrogate standards from the calibration curve samples.
2. %RSD of the peak areas for the internal standard or the calculated amount for the surrogate standards from the seven MDL samples.
3. Data from seven 5 ppb samples.

Figure 1 Primary Characteristic Ions for the First Seven Gases of a 0.2 ppb Standard Indicating Excellent Detection Limits with Minimal Interference from Water.

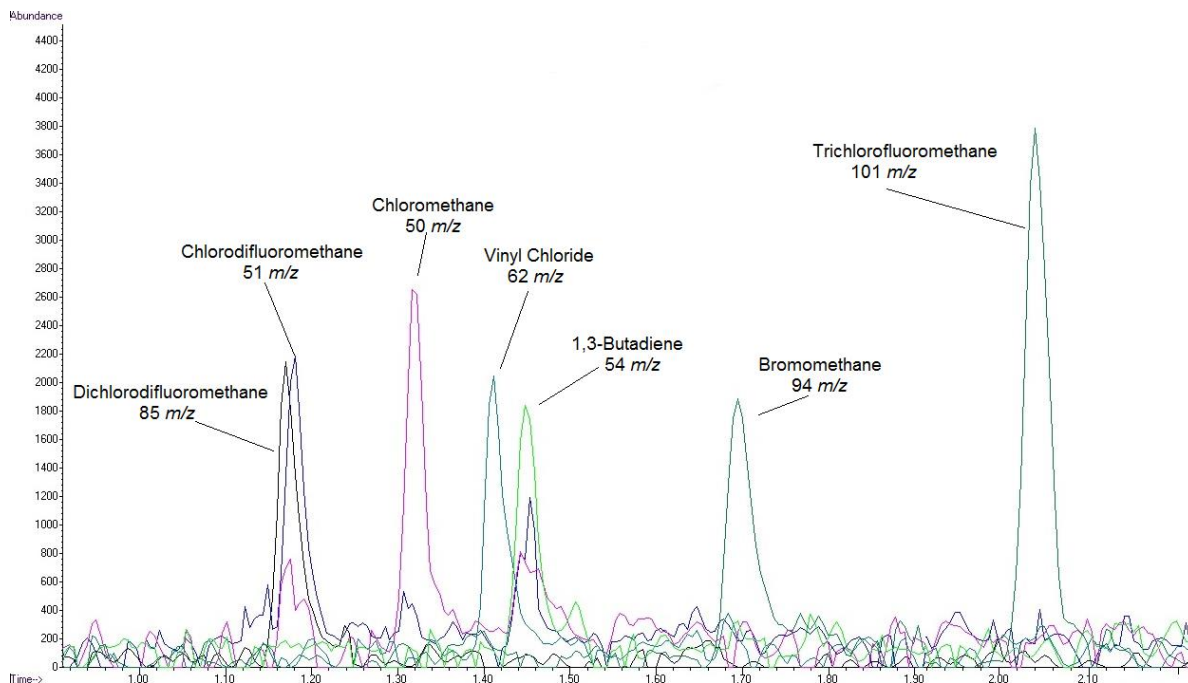
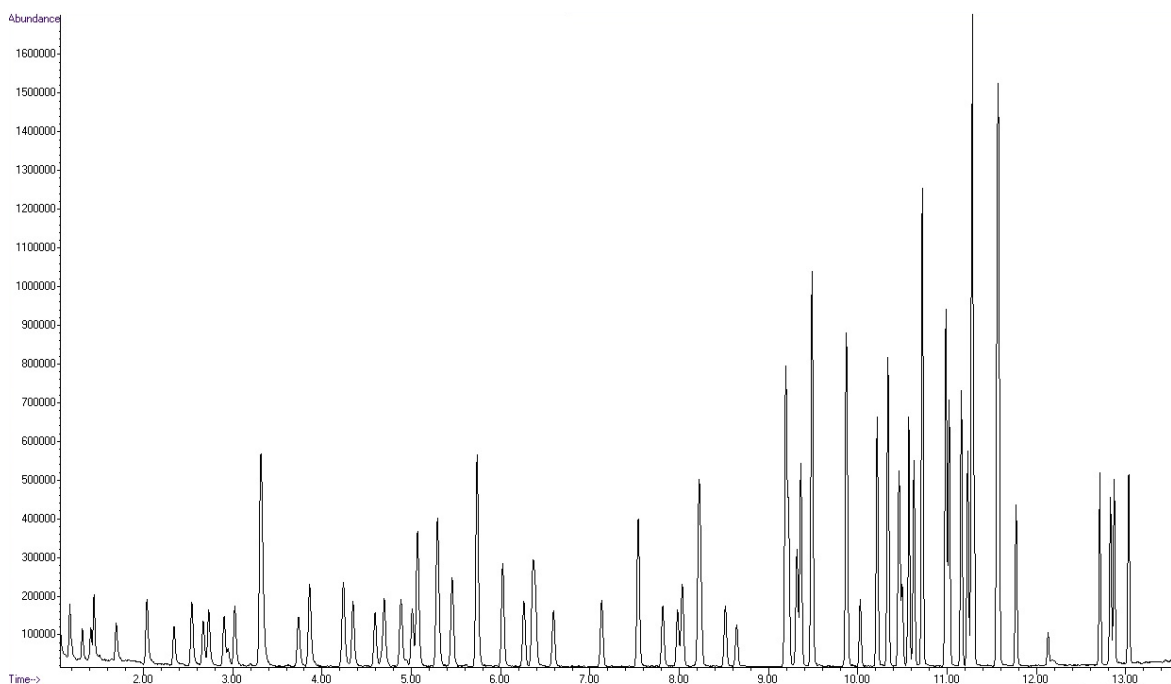


Figure 2 Total Ion Chromatogram of a 5 ppb VOC Standard Indicating Consistent Peak Shapes for all Compounds with No Water Interference.



Conclusion

The Teledyne Tekmar Lumin purge and trap concentrator and AQUATek 100 were used to process water samples containing VOCs following US EPA Method 524.3 with detection by an Agilent 7890B GC and 5977A MSD system. The linearity of the calibration curve from 0.2 ppb to 50 ppb passed all method requirements with no interference from excessive water. The MDL, precision and accuracy for seven 0.5 ppb standards also indicated no interference from excessive water.

References

1. Munch, J.W.; *Measurement of Purgeable Organic Compounds in Water by Capillary Column Gas Chromatography/Mass Spectrometry*; US EPA Method 524.3 - Revision 1.0, June 2009.