Drinking Water Analysis Conditions for USEPA Method 524.3 and the Newly-Proposed Method 524.4

EST analytical

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ABSTRACT

In June 2009, the United States Environmental Protection Agency (USEPA) promulgated a new drinking water method, 524.3. Due to advances in analytical instrumentation, Method 524.3 allows laboratories to modify purge and trap and GCMS conditions. Currently the USEPA is investigating the option of using Nitrogen as the purge gas in a new drinking water method, 524.4. This poster will explore purge and trap conditions for both Helium and Nitrogen purge gases.

DISCUSSION

When the USEPA published Method 524.3, they allowed some method flexibility. However, the method still required Helium as the purge gas. Due to fluctuations in the price and availability of high purity Helium, the USEPA has drafted Method 524.4, which would allow for high purity Nitrogen to be used for the purge gas.

Method 524.4 provides the same flexibility as Method 524.3, thus method parameters can be modified in order to optimize purge and trap cycle times. Although the new method allows for a shorter desorb time, moisture build-up can still be a problem as the new preservation scheme causes effervescing in the sparge vessel. EST has two features that can aid in moisture control and the "foaming" caused by the effervescing. First, EST has a foam sensor to detect any issues with foaming. The foam sensor for the Encon Evolution has a unique placement above the bulb of the sparge vessel, thus allowing the bulb to control the effervescing bubbles and not send a false positive signal to the software, causing the sample sequence to be aborted. Secondly, the Encon Evolution utilizes an 8-port valve instead of a 6-port valve. This unique engineering has the advantage of excluding the Moisture Reduction Trap (MoRT) from the desorb pathway, thus aiding in moisture control for the system. Furthermore, the Centurion WS has the ability of taking samples from the vials without moving the samples. This eliminates opportunities for vial movement errors that would negatively impact productivity.

For this study, Helium and Nitrogen purge gases were compared utilizing two different purge volumes. The results from the different purge gases and volumes were compared for linearity, precision, accuracy and overall compound response.

EXPERIMENTAL

The EST Analytical Encon Evolution purge and trap concentrator and Centurion WS Autosampler were interfaced to a GC/MSD. The purge and trap concentrator was configured with a Vocarb 3000 (K) analytical trap. A chiller unit capable of keeping the sample vials cooled below 10°C was installed on the Centurion WS autosampler. The experimental parameters are listed in **Tables 1 and 2.**

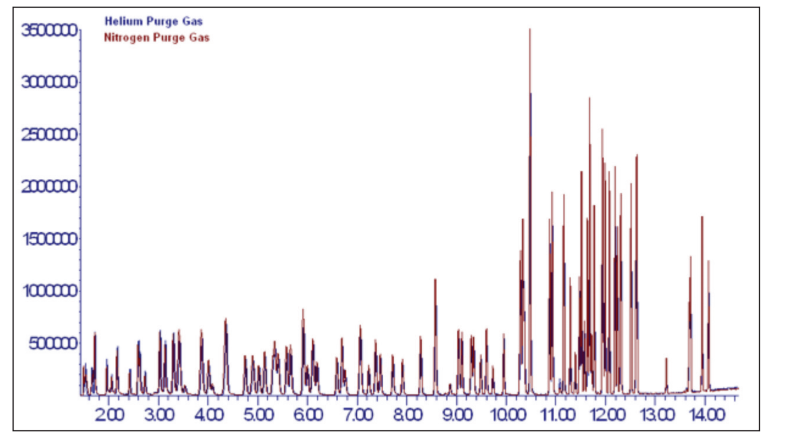

Figure 1. Overlay of 20ppb Standards Purged in Helium and Nitrogen

The GC column and standards were acquired from Restek. The linear range for both purge gases and purge volumes was established with a seven point quadratic regression calibration from 0.5ppb to 40ppb. The internal standard and surrogate concentrations were held constant at 5ppb. **Figure 1** displays an overlay of the 20ppb standard purged in Helium (blue) and in Nitrogen (orange). The quadratic regression and average compound response of the respective purge gases and purge volumes are listed in **Table 3.** Finally, seven 0.5ppb standards and seven 20ppb calibration standards were run in order to establish passing Minimum Reporting Limits (MRLs) for each of the analytes and also the precision and accuracy of the methods at both the low and the mid-range of the curves. These results are listed in **Tables 4 and 5.**

Table 1. Purge and Trap Parameters

Purge & Trap Concentrator	EST Encon Evolution
Trap Type	Vocarb 3000 (K Trap)
Valve Oven Temp.	150°C
Transfer Line Temp.	150°C
Trap Temp.	35°C
MoRT Temp.	39°C
Purge Time	11 min. and 6.5 min.
Purge Flow	40ml/min and 60ml/min
Dry Purge Temp.	ambient
Dry Purge Flow	50ml/min
Dry Purge Time	1 min.
Desorb Pressure Control	On
Desorb Pressure Control	5psi
Desorb Preheat Delay	5 sec.
Desorb Time	1 min.
Desorb Temp.	260°C
MoRT Bake Temp.	230°C
Bake Temp.	265°C
Sparge Vessel Bake Temp.	120°C
Bake Time	8 min.
Bake Flow	40ml/min
Purge and Trap Autosampler	EST Centurion WS
Sample Size	5ml
Internal Standard Volume	5µl
Surrogate Volume	5µl

Table 2. GC/MS Parameters

GC/MS	Agilent 7890/5975
Inlet	Split/Splitless
Inlet Temp.	220°C
Inlet Head Pressure	11.196 psi
Mode	Split
Split Ratio	30:1
Column	Rtx-VMS 30m x 0.25mm I.D. 1.4µm film thickness
Oven Temp. Program	45°C hold for 4.5 min., ramp 12°C/min to 100°C, ramp 25°C/min to 230°C, hold for 1.3min, 15.58 min run time
Column Flow Rate	0.9ml/min
Gas	Helium
Total Flow	30.9ml/min
Source Temp.	230°C
Quad Temp.	150°C
MS Transfer Line Temp.	180°C
Scan Range	m/z 47-265 (from 1min to 2.9 min): m/z 35-265 (from 2.9 min to end of run)
Scans	3.27 scans/sec (from 1min to 2.9 min): 3.12 scans/sec (from 2.9 min to end of run)
Solvent Delay	1.0 min.

CONCLUSION

The Encon Evolution and Centurion WS performed very well using both the Helium and Nitrogen purge gases and the 440ml and 390ml purge volumes. The Nitrogen and the Helium purge gases met USEPA method 524.3 criteria. Furthermore, the 440ml purge volume and the 390ml purge volume produced comparable results. Overall, the principal difference between the two purge gases was exhibited in the compound response. When examining the overall compound response factors over the curve range, it is evident that the analytes' responses are slightly lower with the Nitrogen purge gas as opposed to the Helium purge gas.

REFERENCES

1. Method 524.3, Measurement of Purgeable Organic Compounds in Water by Capillary Column Gas Chromatography/Mass Spectrometry, Version 1.0, June 2009.
2. Method 524.4 (Draft), Measurement of Purgeable Organic Compounds in Water by Capillary Column Gas Chromatography/Mass Spectrometry (Using Nitrogen Purge Gas), Version 1, September 2011.

Table 3. Quadratic Regression and Average Response Factors

Compound	440ml Purge Vol. He		390ml Purge Vol. He		440ml Purge Vol. N2		390ml Purge Vol. N2	
	Curve Quadratic Regress	Curve RF	Curve Quadratic Regress	Curve RF	Curve Quadratic Regress	Curve RF	Curve Quadratic Regress	Curve RF
dichlorodifluoromethane	0.998	0.287	0.996	0.369	0.999	0.292	0.999	0.304
chlorodifluoromethane	0.995	0.555	1.000	0.564	0.999	0.441	0.999	0.478
chloromethane	1.000	0.490	1.000	0.569	0.997	0.452	0.998	0.470
vinyl chloride	1.000	0.412	1.000	0.454	0.997	0.326	0.999	0.351
1,3-butadiene	1.000	0.340	1.000	0.360	0.977	0.223	1.000	0.243
bromomethane	0.999	0.226	0.999	0.248	0.997	0.155	1.000	0.165
chloroethane	0.999	0.286	0.998	0.304	0.998	0.203	0.999	0.216
trichlorofluoromethane	0.999	0.621	1.000	0.623	0.998	0.457	0.998	0.502
diethyl ether	1.000	0.341	1.000	0.338	1.000	0.225	0.999	0.224
1,1-dichloroethene	1.000	0.321	1.000	0.306	0.997	0.206	1.000	0.223
carbon disulfide	1.000	0.970	1.000	1.025	0.998	0.652	1.000	0.706
methyl iodide	0.999	0.360	0.999	0.353	0.998	0.221	0.999	0.215
allyl chloride	0.999	0.206	1.000	0.217	0.998	0.141	0.999	0.153
methylene chloride	1.000	0.383	1.000	0.387	0.999	0.244	1.000	0.253
trans-1,2-dichloroethene	1.000	0.330	1.000	0.304	0.998	0.265	1.000	0.280
methyl acetate	1.000	0.348	0.999	0.305	0.999	0.276	1.000	0.255
methyl-t-butyl ether (MtBE)	1.000	1.067	1.000	1.063	1.000	0.768	1.000	0.734
t-butyl alcohol (TBA)	1.000	0.026	1.000	0.028	0.999	0.020	0.999	0.020
diisopropyl ether (DIPE)	1.000	1.211	1.000	1.244	1.000	0.915	0.999	0.889
1,1-dichloroethane	1.000	0.634	1.000	0.661	0.998	0.536	0.999	0.574
t-butyl ethyl ether (ETBE)	1.000	1.060	0.999	1.070	0.999	0.764	0.999	0.742
cis-1,2-dichloroethene	1.000	0.318	0.999	0.338	0.997	0.258	0.999	0.259
bromochloromethane	0.999	0.157	0.999	0.159	0.998	0.131	0.999	0.140
chloroform	1.000	0.691	1.000	0.672	1.000	0.526	1.000	0.551
carbon tetrachloride	1.000	0.453	1.000	0.478	0.998	0.351	0.999	0.395
tetrahydrofuran	0.999	0.069	0.998	0.063	0.999	0.046	1.000	0.043
1,1,1-trichloroethane	1.000	0.533	0.999	0.562	0.999	0.419	0.999	0.469
1,1-dichloropropene	0.999	0.331	1.000	0.339	0.998	0.251	0.999	0.273
1-chlorobutane	1.000	0.723	1.000	0.717	0.999	0.546	1.000	0.567
benzene	1.000	1.386	1.000	1.389	0.999	1.055	0.999	1.064
t-amyl methyl ether (TAME)	1.000	0.921	0.999	0.876	0.999	0.605	0.999	0.605
1,2-dichloroethane	1.000	0.520	1.000	0.542	1.000	0.378	1.000	0.420
trichloroethene	1.000	0.322	1.000	0.322	0.999	0.243	0.999	0.257
t-amyl ethyl ether (TAEE)	1.000	0.790	1.000	0.763	1.000	0.512	0.999	0.532
dibromomethane	1.000	0.206	1.000	0.208	1.000	0.163	0.999	0.166
1,2-dichloropropane	1.000	0.352	1.000	0.356	0.999	0.283	0.999	0.281
bromodichloromethane	1.000	0.471	0.999	0.483	0.999	0.361	0.999	0.376
cis-1,3-dichloropropene	1.000	0.535	1.000	0.519	1.000	0.389	0.999	0.399
toluene	1.000	0.799	1.000	0.732	1.000	0.601	0.999	0.614
tetrachloroethene	0.999	0.335	0.999	0.317	1.000	0.254	0.999	0.269
trans-1,3-dichloropropene	1.000	0.500	1.000	0.479	1.000	0.392	0.999	0.369
ethyl methacrylate	1.000	0.418	1.000	0.359	0.999	0.302	0.998	0.273
1,1,2-trichloroethane	0.999	0.259	0.999	0.236	1.000	0.208	1.000	0.202
dibromochloromethane	1.000	0.325	0.999	0.305	0.999	0.256	1.000	0.258
1,3-dichloropropane	1.000	0.521	1.000	0.497	0.999	0.418	1.000	0.417
1,2-dibromomethane	1.000	0.290	1.000	0.266	0.999	0.228	0.998	0.217
chlorobenzene	1.000	0.874	1.000	0.832	0.999	0.702	1.000	0.727
ethylbenzene	1.000	1.548	1.000	1.481	1.000	1.226	0.999	1.280
1,1,1,2-tetrachloroethane	1.000	0.317	1.000	0.319	0.999	0.252	0.999	0.258
xylene (m+p)	1.000	0.588	0.999	0.539	1.000	0.458	0.999	0.476
xylene (o)	0.999	0.541	0.999	0.502	0.999	0.435	0.998	0.465
styrene	1.000	0.894	1.000	0.848	0.999	0.694	0.999	0.718
bromoform	1.000	0.220	0.998	0.195	1.000	0.168	0.998	0.163
isopropylbenzene	1.000	1.536	1.000	1.429	1.000	1.172	0.999	1.249
bromobenzene	0.999	0.584	1.000	0.565	0.999	0.484	0.999	0.468
n-propylbenzene	1.000	2.993	0.999	2.835	1.000	2.458	0.999	2.523
1,1,2,2-tetrachloroethane	1.000	0.668	0.999	0.616	1.000	0.592	0.999	0.510
2-chlorotoluene	1.000	0.554	0.999	0.529	1.000	0.460	0.998	0.469
1,3,5-trimethylbenzene	1.000	2.034	0.999	1.895	1.000	1.660	0.998	1.665
1,2,3-trichloropropane	1.000	0.214	0.998	0.185	0.999	0.175	0.998	0.163
4-chlorotoluene	1.000	0.613	1.000	0.559	1.000	0.477	1.000	0.500
t-butylbenzene	1.000	0.478	1.000	0.440	1.000	0.379	0.998	0.386
pentachloroethane	1.000	0.396	0.999	0.390	0.998	0.326	0.998	0.302
1,2,4-trimethylbenzene	1.000	2.142	1.000	1.994	1.000	1.716	0.998	1.712
sec-butylbenzene	1.000	2.612	0.999	2.382	0.999	2.065	0.999	2.152
4-isopropyltoluene	1.000	2.160	1.000	1.966	1.000	1.701	0.998	1.723
1,3-dichlorobenzene	1.000	1.165	0.999	1.129	0.999	0.954	0.998	0.996
1,4-dichlorobenzene	1.000	1.169	1.000	1.125	0.999	0.986	0.999	0.991
n-butylbenzene	1.000	0.556	0.999	0.514	1.000	0.450	0.998	0.441
hexachloroethane	1.000	0.326	0.999	0.324	0.998	0.259	0.999	0.262
1,2-dichlorobenzene	1.000	1.113	1.000	1.092	1.000	0.939	0.999	0.951
1,2-dibromo-3-chloropropane	1.000	0.139	0.999	0.129	0.999	0.129	0.997	0.111
hexachlorobutadiene	0.999	0.310	1.000	0.289	0.996	0.238	0.999	0.256
1,2,4-trichlorobenzene	1.000	0.687	1.000	0.684	0.999	0.581	0.998	0.575
napthalene	1.000	2.000	0.999	1.684	0.999	1.708	0.999	1.552
1,2,3-trichlorobenzene	1.000	0.631	0.999	0.598	1.000	0.539	0.998	0.543
Average	**1.000**	**0.704**	**1.000**	**0.681**	**0.999**	**0.560**	**0.999**	**0.568**

Table 4. 0.5ppb Precision and Accuracy

Compound	440ml Purge Vol. He		390ml Purge Vol. He		440ml Purge Vol. N2		390ml Purge Vol. N2	
	0.5ppb Precision	0.5ppb Accuracy	0.5ppb Precision	0.5ppb Accuracy	0.5ppb Precision	0.5ppb Accuracy	0.5ppb Precision	0.5ppb Accuracy
dichlorodifluoromethane	2.294	129.429	4.251	124.286	5.735	106.857	6.533	94.000
chlorodifluoromethane	6.837	69.429	7.900	78.571	5.286	117.429	8.040	75.714
chloromethane	4.527	126.857	7.744	72.857	11.008	90.286	7.344	90.571
vinyl chloride	5.262	112.857	8.520	98.571	7.448	87.143	7.832	76.000
1,3-butadiene	5.323	116.857	7.345	80.286	7.517	71.714	4.877	62.000
bromomethane	6.484	118.571	6.974	71.429	8.956	106.571	9.926	90.571
chloroethane	5.788	115.143	9.413	88.286	11.458	100.857	6.298	73.429
trichlorofluoromethane	2.691	134.286	8.852	82.286	4.337	124.286	6.783	76.286
diethyl ether	5.255	114.571	10.164	88.000	6.168	82.857	7.582	85.429
1,1-dichloroethene	7.523	113.429	5.865	109.143	7.674	72.000	11.237	96.286
carbon disulfide	3.909	127.429	6.181	99.143	8.989	93.429	5.752	88.857
methyl iodide	5.595	112.571	7.570	100.286	9.143	105.143	2.951	118.571
allyl chloride	5.463	118.571	11.474	92.571	8.549	82.000	6.532	90.286
methylene chloride	7.334	115.429	8.553	85.429	10.256	97.143	7.190	99.429
trans-1,2-dichloroethene	8.680	108.571	2.533	136.286	9.161	106.857	6.733	110.000
methyl acetate	8.034	104.286	10.149	101.429	9.660	103.143	8.948	86.857
methyl-t-butyl ether (MtBE)	6.693	97.714	7.881	92.857	3.538	87.714	4.277	115.714
t-butyl alcohol (TBA)	7.539	112.743	11.709	97.429	8.646	81.657	4.094	90.000
diisopropyl ether (DIPE)	3.905	114.286	4.628	98.000	4.930	92.000	3.686	106.286
1,1-dichloroethane	5.982	115.429	4.583	120.571	6.003	85.143	6.141	100.000
t-butyl ethyl ether (ETBE)	3.938	117.429	2.618	113.429	4.395	96.857	6.966	102.286
cis-1,2-dichloroethene	8.288	110.857	5.013	113.714	5.000	80.000	8.142	100.000
bromochloromethane	8.283	100.571	8.778	110.857	8.522	75.714	7.628	82.571
chloroform	7.553	96.000	9.841	100.571	5.011	64.000	8.304	110.000
carbon tetrachloride	6.072	107.714	10.333	89.429	9.525	95.143	4.356	80.857
tetrahydrofuran	6.686	115.143	9.336	80.857	7.122	115.714	12.278	98.286
1,1,1-trichloroethane	6.881	117.143	8.269	112.286	6.894	92.857	9.956	87.143
1,1-dichloropropene	5.837	115.429	11.119	103.429	11.139	96.857	8.793	87.429
1-chlorobutane	4.732	114.571	8.472	110.000	9.701	101.429	7.337	102.000
benzene	6.725	98.000	8.009	109.143	6.266	87.714	4.966	105.143
t-amyl methyl ether (TAME)	6.331	112.000	4.494	122.286	5.358	110.571	5.774	102.857
1,2-dichloroethane	9.797	97.429	8.361	80.286	5.488	94.286	7.621	90.286
trichloroethene	7.629	112.857	2.071	135.143	7.636	96.857	8.972	107.143
t-amyl ethyl ether (TAEE)	2.989	123.143	7.448	114.571	3.673	120.000	6.354	108.857
dibromomethane	11.135	90.286	7.575	76.000	6.579	107.429	7.752	106.571
1,2-dichloropropane	3.218	98.857	8.747	110.286	8.437	95.429	8.211	104.857
bromodichloromethane	7.179	105.143	5.485	86.857	10.334	102.857	6.848	106.857
cis-1,3-dichloropropene	2.964	123.429	8.421	106.857	8.458	76.286	7.866	98.000
toluene	7.923	111.143	5.135	121.143	5.327	87.143	6.156	106.857
tetrachloroethene	5.576	77.714	7.170	86.571	7.440	71.429	9.272	92.857
trans-1,3-dichloropropene	8.464	103.714	6.223	111.143	7.575	103.429	6.657	108.571
ethyl methacrylate	5.781	114.000	6.248	119.429	2.571	134.286	12.033	100.286
1,1,2-trichloroethane	10.127	92.286	10.228	98.286	6.848	106.857	5.441	103.429
dibromochloromethane	8.738	99.714	10.289	95.143	3.499	104.571	4.639	114.571
1,3-dichloropropane	9.643	104.000	4.689	94.000	6.336	119.143	4.791	110.286
1,2-dibromomethane	8.039	111.143	7.606	88.571	6.959	116.857	6.970	95.429
chlorobenzene	7.252	111.714	7.667	114.857	7.974	102.857	7.879	94.000
ethylbenzene	5.176	123.429	7.601	93.143	6.151	94.286	2.658	93.714
1,1,1,2-tetrachloroethane	6.027	109.143	10.127	93.143	7.949	98.571	6.690	99.429
xylene (m+p)	6.537	110.143	4.945	99.571	4.785	103.857	4.533	105.286
xylene (o)	7.897	110.571	6.168	104.000	5.151	98.286	10.000	89.714
styrene	2.562	118.000	4.916	98.286	4.315	108.000	4.156	99.143
bromoform	9.944	94.857	9.737	100.286	11.441	103.143	11.740	98.857
isopropylbenzene	6.104	105.714	4.878	98.000	6.728	80.571	6.185	92.857
bromobenzene	6.192	107.429	10.502	88.571	7.998	81.143	11.377	101.143
n-propylbenzene	5.251	117.714	3.725	129.714	7.848	97.143	4.653	104.571
1,1,2,2-tetrachloroethane	9.315	89.429	9.930	93.143	9.171	102.857	7.913	99.143
2-chlorotoluene	6.625	106.857	9.096	97.429	9.909	99.714	7.402	98.857
1,3,5-trimethylbenzene	4.139	109.143	5.720	96.857	8.515	99.429	3.616	105.429
1,2,3-trichloropropane	9.641	90.571	10.206	96.000	9.629	104.571	7.120	75.714
4-chlorotoluene	8.515	99.429	5.773	116.286	7.461	105.714	7.603	88.286
t-butylbenzene	8.379	103.429	5.909	120.000	9.246	97.714	4.569	106.857
pentachloroethane	8.047	112.286	9.031	85.714	10.022	93.429	4.647	113.714
1,2,4-trimethylbenzene	5.745	101.429	4.846	99.714	9.373	99.714	1.335	109.143
sec-butylbenzene	5.749	118.857	2.124	98.857	6.926	101.714	5.208	93.429
4-isopropyltoluene	6.564	114.000	5.718	94.286	5.868	90.571	2.090	98.571
1,3-dichlorobenzene	3.442	100.286	5.754	112.571	4.086	100.857	7.773	93.714
1,4-dichlorobenzene	3.569	116.000	8.832	92.857	7.416	108.286	9.311	105.143
n-butylbenzene	8.005	100.571	10.082	99.714	7.389	88.000	8.458	107.143
hexachloroethane	4.710	101.143	7.806	80.857	7.213	94.571	11.235	100.571
1,2-dichlorobenzene	7.071	106.286	5.976	100.286	8.409	88.857	3.273	98.000
1,2-dibromo-3-chloropropane	10.443	94.857	4.097	63.143	10.034	85.143	10.968	94.000
hexachlorobutadiene	7.986	112.571	9.860	104.000	10.954	98.286	9.528	87.429
1,2,4-trichlorobenzene	4.510	106.000	10.467	85.714	6.298	106.000	5.285	102.571
napthalene	3.857	97.714	7.731	91.429	6.335	116.571	4.016	98.571
1,2,3-trichlorobenzene	6.082	93.714	9.059	109.714	6.836	104.571	9.233	94.571
Average	**6.360**	**108.120**	**7.210**	**99.650**	**7.170**	**97.670**	**6.800**	**97.510**

Table 5. 20ppb Precision and Accuracy

Compound	440ml Purge Vol. He		390ml Purge Vol. He		440ml Purge Vol. N2		390ml Purge Vol. N2	
	20ppb Precision	20ppb Accuracy	20ppb Precision	20ppb Accuracy	20ppb Precision	20ppb Accuracy	20ppb Precision	20ppb Accuracy
dichlorodifluoromethane	6.323	82.600	6.523	99.350	7.739	103.678	3.680	84.250
chlorodifluoromethane	4.607	93.729	6.873	99.189	7.044	105.556	4.340	90.214
chloromethane	4.396	93.557	5.476	101.772	6.966	97.278	4.200	89.421
vinyl chloride	4.777	94.050	7.029	95.850	7.579	99.339	4.534	85.450
1,3-butadiene	6.956	92.093	7.536	93.806	7.748	100.372	4.130	83.300
bromomethane	5.354	98.850	5.796	97.400	9.130	96.600	4.547	97.793
chloroethane	4.770	98.493	6.573	93.106	6.413	96.394	4.719	90.343
trichlorofluoromethane	6.238	92.829	7.102	92.133	7.453	99.944	4.023	82.457
diethyl ether	2.462	104.171	3.209	103.844	1.917	100.083	2.075	95.736
1,1-dichloroethene	5.992	94.593	5.506	96.400	6.658	100.411	3.488	87.743
carbon disulfide	5.910	96.829	5.366	96.294	6.380	98.667	3.946	89.729
methyl iodide	4.126	99.364	4.260	99.839	6.045	98.283	4.108	91.479
allyl chloride	3.745	100.164	5.154	96.022	6.052	96.467	3.534	91.821
methylene chloride	3.544	100.529	3.694	99.122	8.206	103.200	2.615	93.686
trans-1,2-dichloroethene	2.732	95.450	3.589	101.517	4.844	99.022	1.325	92.321
methyl acetate	4.546	115.493	5.540	102.183	4.003	108.672	2.780	94.514
methyl-t-butyl ether (MtBE)	2.036	100.843	2.888	107.283	2.949	103.544	1.540	95.386
t-butyl alcohol (TBA)	2.611	94.927	3.115	106.089	3.840	100.743	2.737	92.769
diisopropyl ether (DIPE)	2.457	98.836	3.060	106.633	2.927	102.656	1.746	96.079
1,1-dichloroethane	3.616	96.007	4.058	101.944	4.638	100.089	2.440	92.100
t-butyl ethyl ether (ETBE)	2.162	99.557	2.841	106.333	2.666	103.089	1.507	96.693
cis-1,2-dichloroethene	6.058	106.757	4.052	94.683	7.300	105.128	3.487	90.121
bromochloromethane	1.428	98.057	3.078	104.267	3.070	99.317	3.340	94.671
chloroform	3.300	97.171	3.637	103.328	4.195	100.767	2.085	93.729
carbon tetrachloride	4.804	93.093	7.196	100.233	7.188	101.628	3.603	92.029
tetrahydrofuran	3.018	97.521	4.576	105.006	6.405	109.483	3.366	100.114
1,1,1-trichloroethane	5.014	94.921	5.953	99.283	5.922	101.789	4.209	90.893
1,1-dichloropropene	4.078	92.936	5.521	99.239	6.646	102.672	3.873	92.479
1-chlorobutane	4.718	93.414	6.252	101.883	6.218	101.061	3.346	93.557
benzene	3.476	94.457	4.061	102.500	4.758	101.172	2.843	94.357
t-amyl methyl ether (TAME)	2.316	98.300	2.813	106.800	2.378	104.211	1.312	97.914
1,2-dichloroethane	2.471	99.657	3.128	104.533	1.970	101.011	2.369	95.843
trichloroethene	3.570	93.814	5.359	100.306	5.193	101.433	3.102	96.043
t-amyl ethyl ether (TAEE)	2.278	96.007	3.279	105.533	3.369	102.672	2.145	97.836
dibromomethane	2.235	101.636	2.982	108.150	1.934	101.200	1.568	94.436
1,2-dichloropropane	3.035	96.571	3.486	104.994	3.766	100.417	2.191	97.214
bromodichloromethane	3.140	97.629	2.696	105.561	3.700	100.167	1.276	96.321
cis-1,3-dichloropropene	3.241	96.071	3.239	104.767	2.625	103.483	1.826	96.593
toluene	4.563	94.593	4.701	99.322	4.907	105.678	3.105	99.371
tetrachloroethene	5.014	95.679	5.575	95.050	5.813	101.594	4.698	94.721
trans-1,3-dichloropropene	2.522	100.957	1.987	98.772	3.194	104.583	2.148	99.114
ethyl methacrylate	2.490	100.736	2.538	103.550	3.474	108.417	2.144	102.286
1,1,2-trichloroethane	3.468	97.721	3.346	100.472	2.442	105.250	3.378	99.450
dibromochloromethane	3.637	99.443	2.156	101.667	1.947	103.544	3.276	95.586
1,3-dichloropropane	2.542	99.179	2.490	100.072	2.145	102.828	2.486	97.771
1,2-dibromomethane	3.642	99.150	2.912	102.511	2.622	103.672	2.759	99.221
chlorobenzene	3.949	95.714	3.566	97.833	3.409	102.439	3.549	98.214
ethylbenzene	4.497	94.993	4.923	98.544	4.802	104.561	3.937	98.907
1,1,1,2-tetrachloroethane	4.225	98.543	2.910	100.083	2.580	103.994	3.306	98.586
xylene (m+p)	4.457	95.725	4.007	99.161	4.629	103.392	3.566	99.261
xylene (o)	3.358	96.786	3.210	100.250	4.374	103.833	3.770	99.229
styrene	3.581	98.157	2.960	100.244	3.602	103.511	2.726	100.579
bromoform	2.894	100.050	2.259	100.139	2.080	106.261	3.022	98.464
isopropylbenzene	4.401	94.829	4.901	98.106	4.848	104.650	4.006	98.514
bromobenzene	3.545	95.300	2.343	98.022	2.430	105.750	3.486	99.757
n-propylbenzene	5.360	94.164	5.227	94.794	4.849	106.067	4.187	100.071
1,1,2,2-tetrachloroethane	2.573	99.093	2.265	99.711	2.998	109.161	3.336	102.364
2-chlorotoluene	4.790	95.464	3.481	98.172	4.428	106.611	4.036	100.321
1,3,5-trimethylbenzene	4.790	96.086	3.847	98.367	4.244	105.350	3.739	100.436
1,2,3-trichloropropane	4.426	102.343	2.816	101.694	3.368	108.561	2.535	102.693
4-chlorotoluene	4.635	94.893	3.687	97.228	3.300	105.361	3.224	100.779
t-butylbenzene	5.537	94.879	4.737	97.050	4.999	105.017	4.254	97.614
pentachloroethane	3.829	95.686	2.496	100.150	2.657	103.217	4.040	101.129
1,2,4-trimethylbenzene	4.426	96.171	3.603	99.250	4.015	105.133	3.735	100.100
sec-butylbenzene	5.395	93.800	5.179	98.156	4.996	105.267	4.803	98.971
4-isopropyltoluene	5.165	93.793	4.777	98.222	4.764	105.872	4.726	99.679
1,3-dichlorobenzene	4.458	96.929	2.449	97.272	2.758	104.278	3.417	99.729
1,4-dichlorobenzene	3.696	96.014	2.778	99.200	2.834	103.839	3.409	100.529
n-butylbenzene	5.771	94.214	5.242	96.117	4.945	105.411	4.368	100.800
hexachloroethane	4.626	94.386	5.248	99.250	5.409	107.761	4.409	100.550
1,2-dichlorobenzene	3.628	98.114	2.301	98.828	2.277	105.917	3.136	99.871
1,2-dibromo-3-chloropropane	1.668	100.421	3.213	103.678	4.869	111.172	3.300	102.679
hexachlorobutadiene	5.243	97.164	4.018	95.539	4.687	106.644	5.493	99.871
1,2,4-trichlorobenzene	3.547	98.193	1.639	101.072	2.680	103.983	3.052	100.207
napthalene	2.376	99.864	2.031	101.522	2.621	108.839	3.118	101.550
1,2,3-trichlorobenzene	3.010	98.307	1.876	98.911	1.944	105.389	3.416	101.400
Average	**3.890**	**97.210**	**3.980**	**100.040**	**4.323**	**103.237**	**3.223**	**96.450**