

# APPLICATION

# Purgeable Volatile Organic Compounds by GC-MS using Zebron™ ZB-624*PLUS*™ GC Columns

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Ramkumar Dhandapani Ph.D. Global Product Manager - GC

He has a PhD in Analytical Chemistry and a total of 14 years experience in chromatographic method development and troubleshooting. Ramkumar loves to write poems, read Shakespeare, and attend Shakespeare plays.

## Introduction

Volatile organic compounds (VOCs), both synthetic and naturally-occurring are a global environmental concern and can be found in a variety of samples including waste water, drinking water, and ground water. The traditional approach to VOC analysis is GC-MS (Gas Chromatography coupled to a Mass Spectrometer) using purge and trap extraction or an alternative extraction technique based on regulatory adherence. These compounds can potentially cause harm to human health as well as the surrounding environment. As a result, regulatory agencies have set standards for monitoring VOCs in all samples regardless of water source.

Due to the varying compositions and range of volatilities of VOCs, a highly selective GC column is required for analysis to provide optimal separation of critical VOCs in a short run time. Additionally, the use of a Mass Spec certified GC column is necessary to reach top performance criteria. An added challenge is method capability to handle various sample matrices as dirtier samples such as wastewater and sludge can greatly decrease column lifetime.

This technical note adheres to EPA Method 8260 for Volatile Organic Compounds by GC-MS, a fast and robust GC-MS method using a Zebron ZB-624PLUS GC column. The highly selective ZB-624PLUS stationary phase allows for identification and quantification of 74 VOCs, while maintaining a rapid analysis time of 15 minutes. The results are excellent performance and peak shapes of critical VOCs after 113 injections of various matrices including groundwater, wastewater, and sludge.

# **GC-MS Method Parameters**

Column: Zebron ZB-624*PLUS*Dimensions: 30 meter x 0.25 mm x 1.40 µm

Part No.: 7HG-G040-27
Recommended Z-Guard™: 7CG-G000-00-GHK

 $\begin{array}{c} \textbf{Injection:} \quad \text{Split 50:1 @ 230 °C, 1 } \mu L \\ \textbf{Recommended Liner:} \quad \text{Zebron PLUS Straight Z-Liner}^{\text{TM}} \\ \end{array}$ 

Liner Part No.: AG2-0A03-05 (for Agilent® & Thermo Scientific® systems)

 $\begin{tabular}{lll} \textbf{Carrier Gas:} & Helium @ 0.7\,mL/min (constant flow) \\ \textbf{Oven Program:} & 40\,^{\circ}\text{C for 2 min, to } 210\,^{\circ}\text{C @ } 17\,^{\circ}\text{C/min for 3 min} \\ \end{tabular}$ 

Detector: MSD @ 250°C

Sample: 74 Volatile Organic Compounds spiked in 25 mL water See **Table 1**. for complete analyte list and retention times)

# **MS Conditions**

Transfer Line Temperature: 250 °C

MS Source: 230 °C

Quad Temp: 150 °C

Emission Energy: 70eV Scan Range: 50-550 m/z Solvent Delay: 1.0 min

Software: MassHunter® Software (Agilent Technologies)

Figure 1. ZB-624PLUS Advantages

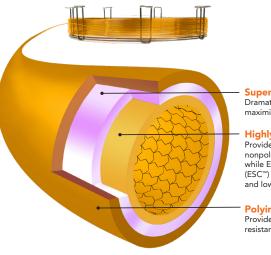
# **Experimental Conditions**

# **Purge and Trap Method Parameters**

Sample Temp: 40 °C Purge Time: 11 min Dry Purge Time: 2 min Crvo Focus Temp: 20 °C Inject Time: 2 min Cryo Inject temp: 180 °C Desorb Preheat: 245 °C Desorb Time: 4 min Desorb Temp: 250 °C Bake Time: 7 min Bake Temp: 260 °C BGB off Delay: 0.5 min MCS Bake Temp: 200 °C Line Temp: 110 °C Valve Temp: 110 °C Purge Temp: 37 °C Sample Volume: 25 mL

Purge and Trap Model: Tekmar® 3100

Trap: Supelco® VOCARB 3000 Trap K (p/n 24920-U)



Superior Deactivated Fused Silica

Dramatically reduces analyte adsorption, maximizing your peak symmetry

# Highly Selective Stationary Phase

Provides excellent separation of polar, nonpolar, low and high boiling solvents, while Engineered Self Cross-linkage (ESC\*\*) results in high-thermal stability and low bleed

# **Polyimide Coating**

Provides flexibility and temperature resistance even at 300/320 °C





# APPLICATION

Figure 2. 5 ppb Organic Volatiles by GC-MS on a Zebron™ ZB-624PLUS™ GC Column

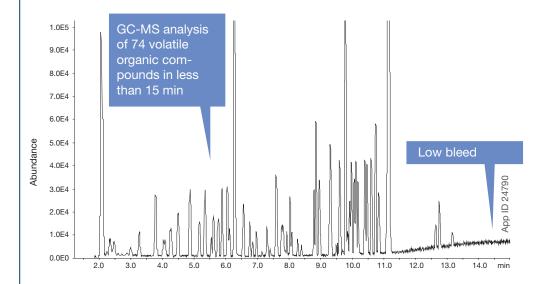
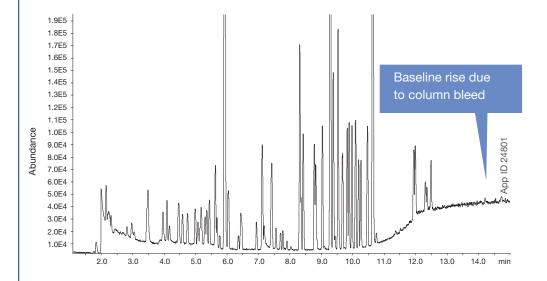


Figure 3. 5 ppb Organic Volatiles by GC-MS on an Agilent® DB®-624 GC Column



# **GC-MS Conditions**

Conditions for both Figure 2 and Figure 3:

Column: Zebron ZB-624PLUS Agilent DB-624

Dimensions: 30 meter x 0.25 mm x 1.40 μm
Part No.: 7HG-G040-27 (Zebron ZB-624 ριως)
122-1334 (Agilent DB-624)
Injection: Split 50:1 @ 230 °C, 1μL

Recommended Liner: Zebron PLUS Straight Z-Liner™

Liner Part No.: AG2-0A03-05 (for Agilent® & Thermo Scientific® systems)

Carrier Gas: Helium @ 0.7 mL/min (constant flow)

Oven Program: 40 °C for 2 min, 210 °C @ 17 °C/min for 3 min

Detector: Mass Spec transfer line @ 250 °C

Comparative separations may not be representative of all applications.

# Table 1. Analyte List

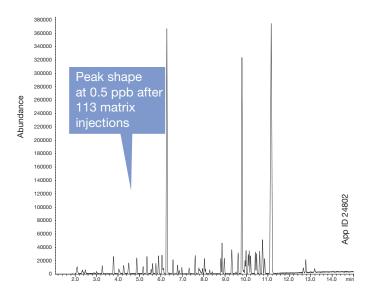
Analytes         RT (min           1. Dichlorodifluoromethane         2.097           2. Fluorobenzene (Istd)         6.281           3. Chloromethane         2.329           4. Vinyl chloride         2.456           5. Bromomethane         2.966           6. Chloroethane         3.266           8. 1,1-Dichloroethene         3.783           9. Carbon disulfide         4.039           10. Trichlorotifluoroethane         3.786           11. Methylene chloride         4.261           12. Acetone         3.823           13. trans-1,2-Dichloroethene         4.503           14. Methyl-t-butyl ether         4.484           15. Tert-butyl alcohol(TBA)         4.319           16. Diisopropyl ether         4.875           17. 1,1,Dichloroethane         4.880           18. Ethyl-t-butyl ether         5.377           19. cis-1,2-Dichloroethane         5.351           20. 2,2-Dichloropropane         5.359           21. Bromochloromethane         5.553           22. Chloroform         5.615           32. Carbon tetrachloride         5.901           24. 1,1,1-Trichloroethane         5.769           25. 2-butanone (MEK)         5.322           26	List		
2. Fluorobenzene (Istd)         6.281           3. Chloromethane         2.329           4. Vinyl chloride         2.456           5. Bromomethane         2.865           6. Chloroethane         2.990           7. Trichlorofluoromethane         3.266           8. 1,1-Dichloroethene         3.793           9. Carbon disulfide         4.039           10. Trichlorotrifluoroethane         3.786           11. Methylene chloride         4.261           12. Acetone         3.823           13. trans-1,2-Dichloroethene         4.503           14. Methyl-t-butyl ether         4.444           15. Tert-butyl alcohol(TBA)         4.319           16. Diisopropyl ether         4.875           17. 1,1-Dichloroethane         4.880           18. Ethyl-t-butyl ether         5.177           19. cis-1,2-Dichloroethene         5.351           20. 2,2-Dichloropropane         5.352           21. Bromochloromethane         5.553           22. Chloroform         5.615           23. Carbon tetrachloride         5.901           24. 1,1-Trichloroethane         5.769           25. 2-butanone (MEK)         5.322           26. 1,1-Dichloropropane         6.782		Analytes	RT (min)
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11.         Methylene chloride         4.261           12.         Acetone         3.823           13.         trans-1,2-Dichloroethene         4.503           14.         Methyl-t-butyl ether         4.841           15.         Tert-butyl alcohol(TBA)         4.319           16.         Diisopropyl ether         4.875           17.         1,1,-Dichloroethane         4.880           18.         Ethyl-t-butyl ether         5.777           19.         cis-1,2-Dichloroethene         5.351           20.         2,2-Dichloropropane         5.359           21.         Bromochloromethane         5.553           22.         Chloroform         5.615           23.         Carbon tetrachloride         5.901           24.         1,1,1-Trichloroethane         5.769           25.         2-butanore (MEK)         5.322           26.         1,1-Dichloropropene         5.890           27.         Benzene         6.056           28.         1,2-Dichloropthane         6.91           30.         Trichloroethane         6.991           31.         Dibromoethane         6.862           32.         1,2-Dichloroptopane         7	9.	Carbon disulfide	4.039
12. Acetone         3.823           13. trans-1,2-Dichloroethene         4.503           14. Methyl-t-butyl ether         4.484           15. Tert-butyl alcohol(TBA)         4.319           16. Diisopropyl ether         4.875           17. 1,1-Dichloroethane         4.880           18. Ethyl-t-butyl ether         5.177           19. cis-1,2-Dichloroethene         5.351           20. 2,2-Dichloropropane         5.359           21. Bromochloromethane         5.553           22. Chloroform         5.615           23. Carbon tetrachloride         5.901           24. 1,1,1-Trichloroethane         5.769           25. 2-butanone (MEK)         5.322           26. 1,1-Dichloropropene         5.800           27. Benzene         6.056           28. t-Amyl methyl ether         6.126           29. 1,2-Dichloropethane         6.091           30. Trichloroethane         6.982           31. Dibromomethane         6.862           32. 1,2-Dichloropropane         6.782           33. Bromodichloromethane         6.823           34. cis-1,3-Dichloropropane         7.607           35. 2-chloroethyl vinyl ethane         7.644           36. MiBK         7.410      <	10.	Trichlorotrifluoroethane	3.786
12. Acetone         3.823           13. trans-1,2-Dichloroethene         4.503           14. Methyl-t-butyl ether         4.484           15. Tert-butyl alcohol(TBA)         4.319           16. Diisopropyl ether         4.875           17. 1,1,-Dichloroethane         4.880           18. Ethyl-t-butyl ether         5.177           19. cis-1,2-Dichloroethene         5.351           20. 2,2-Dichloropropane         5.359           21. Bromochloromethane         5.553           22. Chloroform         5.615           23. Carbon tetrachloride         5.901           24. 1,1,1-Trichloroethane         5.769           25. 2-butanone (MEK)         5.322           26. 1,1-Dichloropropene         5.890           27. Benzene         6.056           28. t-Amyl methyl ether         6.126           29. 1,2-Dichloroptopene         6.852           31. Dibromoethane         6.862           32. 1,2-Dichloroptopane         6.782           33. Bromodichloromethane         6.862           34. cis-1,3-Dichloroptopene         7.323           35. 2-chloroethyl vinyl ethane         7.164           36. MiBK         7.410           37. trans-1,3-Dichloroptopane         8.089     <	11.	Methylene chloride	4.261
13.         trans-1,2-Dichloroethene         4.503           14.         Methyl-t-butyl ether         4.844           15.         Tert-butyl alcohol(TBA)         4.319           16.         Diisopropyl ether         4.875           17.         1,1,-Dichloroethane         4.880           18.         Ethyl-t-butyl ether         5.177           19.         cis-1,2-Dichloroethene         5.351           20.         2,2-Dichloropropane         5.359           21.         Bromochloromethane         5.553           22.         Chloroform         5.615           23.         Carbon tetrachloride         5.901           24.         1,1,1-Trichloroethane         5.769           25.         2-butanone (MEK)         5.322           26.         1,1-Dichloropropene         5.890           27.         Benzene         6.056           28.         t-Amyl methyl ether         6.126           29.         1,2-Dichloropropene         6.823           31.         1,2-Dichloropropane         6.862           32.         1,2-Dichloropropane         7.323           35.         2-chloroethyl vinyl ethane         7.164           36.         Misk </td <td>12.</td> <td>•</td> <td>3.823</td>	12.	•	3.823
14. Methyl-t-butyl ether         4.484           15. Tert-butyl alcohol(TBA)         4.319           16. Diisopropyl ether         4.875           17. 1,1-Dichloroethane         4.880           18. Ethyl-t-butyl ether         5.177           19. cis-1,2-Dichloroethene         5.351           20. 2,2-Dichloropropane         5.359           21. Bromochloromethane         5.553           22. Chloroform         5.615           23. Carbon tetrachloride         5.901           24. 1,1,1-Trichloroethane         5.769           25. 2-butanone (MEK)         5.322           26. 1,1-Dichloropropene         5.890           27. Benzene         6.056           28. t-Amyl methyl ether         6.126           29. 1,2-Dichloroethane         6.091           30. Trichloroethene         6.570           31. Dibromomethane         6.862           32. 1,2-Dichloropropane         7.323           33. Bromodichloromethane         6.982           34. cis-1,3-Dichloropropene         7.323           35. 2-chloroethyl vinyl ethane         7.164           36. MiBK         7.410           37. trans-1,3-Dichloropropane         7.073           38. 1,1,2-Tirchloroethane         7.948			
15. Tert-butyl alcohol(TBA)         4.319           16. Diisopropyl ether         4.875           17. 1,1,-Dichloroethane         4.880           18. Ethyl-t-butyl ether         5.177           19. cis-1,2-Dichloroethene         5.351           20. 2,2-Dichloropropane         5.359           21. Bromochloromethane         5.553           22. Chloroform         5.615           23. Carbon tetrachloride         5.901           24. 1,1,1-Trichloroethane         5.769           25. 2-butanone (MEK)         5.322           26. 1,1-Dichloropropene         5.890           27. Benzene         6.056           28. t-Amyl methyl ether         6.126           29. 1,2-Dichloroptopene         6.570           30. Trichloroethane         6.991           31. Dibromomethane         6.862           32. 1,2-Dichloropropane         6.782           33. Bromodichloromethane         6.982           34. cis-1,3-Dichloropropene         7.732           35. 2-chloroethyl vinyl ethane         7.164           36. MiBK         7.410           37. trans-1,3-Dichloropropane         7.097           40. 1,3-Dichloropropane         8.089           41. Dibromoethane         8.284 <td></td> <td></td> <td></td>			
16. Diisopropyl ether         4.875           17. 1,1,-Dichloroethane         4.880           18. Ethyl-t-butyl ether         5.177           19. cis-1,2-Dichloroethene         5.351           20. 2,2-Dichloropropane         5.359           21. Bromochloromethane         5.553           22. Chloroform         5.615           23. Carbon tetrachloride         5.901           24. 1,1,1-Trichloroethane         5.769           25. 2-butanone (MEK)         5.322           26. 1,1-Dichloropropene         5.890           27. Benzene         6.056           28. t-Amyl methyl ether         6.126           29. 1,2-Dichloroethane         6.091           30. Trichloroethene         6.570           31. Dibromomethane         6.862           32. 1,2-Dichloropropane         6.782           33. Bromodichloromethane         6.982           34. cis-1,3-Dichloropropene         7.323           35. 2-chloroethyl vinyl ethane         7.164           36. MiBK         7.410           37. trans-1,3-Dichloropropane         7.073           38. 1,1,2-Trichloroethane         7.948           39. Toluene         7.607           40. 1,3-Dichloropropane         8.089 <tr< td=""><td></td><td></td><td></td></tr<>			
17.         1,1,-Dichloroethane         4.880           18.         Ethyl-t-butyl ether         5.177           19.         cis-1,2-Dichloroethene         5.351           20.         2,2-Dichloropropane         5.359           21.         Bromochloromethane         5.553           22.         Chloroform         5.615           23.         Carbon tetrachloride         5.901           24.         1,1,1-Trichloroethane         5.769           25.         2-butanone (MEK)         5.322           26.         1,1-Dichloropropene         5.890           27.         Benzene         6.056           28.         t-Amyl methyl ether         6.126           29.         1,2-Dichloropropene         6.982           21.         1,2-Dichloropropane         6.70           30.         Trichloroethane         6.982           31.         Dibromoethloromethane         6.982           32.         1,2-Dichloropropane         7.323           35.         2-chloroethyl vinyl ethane         7.164           36.         MiBK         7.410           37.         trans-1,3-Dichloropropane         8.089           41.         1,3-Dirichloropropane			
18. Ethyl-t-butyl ether         5.177           19. cis-1,2-Dichlororethene         5.351           20. 2,2-Dichloropropane         5.359           21. Bromochloromethane         5.553           22. Chloroform         5.615           23. Carbon tetrachloride         5.901           24. 1,1,1-Trichloroethane         5.769           25. 2-butanone (MEK)         5.322           26. 1,1-Dichloropropene         5.890           27. Benzene         6.056           28. t-Amyl methyl ether         6.126           29. 1,2-Dichloroethane         6.091           30. Trichloroethene         6.570           31. Dibromomethane         6.862           32. 1,2-Dichloropropane         6.782           33. Bromodichloromethane         6.982           34. cis-1,3-Dichloropropene         7.323           35. 2-chloroethyl vinyl ethane         7.164           36. MiBK         7.410           37. trans-1,3-Dichloropropene         7.773           38. 1,1,2-Trichloroethane         7.948           39. Toluene         7.607           40. 1,3-Dichloropropane         8.089           41. Dibromochloromethane         8.040           42. Pexanone         8.089			
19.         cis-1,2-Dichloroethene         5.351           20.         2,2-Dichloropropane         5.359           21.         Bromochloromethane         5.553           22.         Chloroform         5.615           23.         Carbon tetrachloride         5.901           24.         1,1,1-Trichloroethane         5.769           25.         2-butanone (MEK)         5.322           26.         1,1-Dichloropropene         6.056           28.         1-Amyl methyl ether         6.126           29.         1,2-Dichloropthane         6.091           30.         Trichloroethane         6.981           31.         Dibromomethane         6.862           32.         1,2-Dichloropropane         6.782           33.         Bromodichloromethane         6.982           34.         cis-1,3-Dichloropropene         7.642           35.         2-chloroethyl vinyl ethane         7.164           36.         MiBK         7.410           37.         trans-1,3-Dichloropropene         7.773           38.         1,1,2-Trichloroethane         7.948           39.         Toluene         7.607           40.         1,3-Dichloropenome		• •	
20.         2,2-Dichloropropane         5.359           21.         Bromochloromethane         5.553           22.         Chloroform         5.615           23.         Carbon tetrachloride         5.901           24.         1,1,1-Trichloroethane         5.769           25.         2-butanone (MEK)         5.322           26.         1,1-Dichloropropene         5.890           27.         Benzene         6.056           28.         t-Amyl methyl ether         6.126           29.         1,2-Dichloropropene         6.570           31.         Dibromomethane         6.862           32.         1,2-Dichloropropane         6.782           33.         Bromodichloromethane         6.982           34.         cis-1,3-Dichloropropene         7.323           35.         2-chloroethyl vinyl ethane         7.164           36.         MiBK         7.410           37.         trans-1,3-Dichloropropene         7.773           38.         1,1,2-Trichloroethane         7.948           39.         Toluene         7.607           40.         1,3-Dichloropropane         8.089           41.         Dibromochloromethane <t< td=""><td></td><td></td><td></td></t<>			
21.         Bromochloromethane         5.553           22.         Chloroform         5.615           23.         Carbon tetrachloride         5.901           24.         1,1,1-Trichloroethane         5.769           25.         2-butanone (MEK)         5.322           26.         1,1-Dichloropropene         5.890           27.         Benzene         6.056           28.         t-Amyl methyl ether         6.126           29.         1,2-Dichloropropene         6.991           30.         Trichloroethane         6.991           31.         Dibromomethane         6.982           22.         1,2-Dichloropropane         6.782           33.         Bromodichloromethane         6.982           34.         cis-1,3-Dichloropropene         7.323           35.         2-chloroethyl vinyl ethane         7.164           36.         MiBK         7.410           37.         trans-1,3-Dichloropropene         7.773           38.         1,1,2-Trichloroethane         7.948           39.         Toluene         7.607           40.         1,3-Dichloropropane         8.089           41.         2,1-Dibromoethane         8.089	19.		5.351
22.         Chloroform         5.615           23.         Carbon tetrachloride         5.901           24.         1,1,1-Trichloroethane         5.769           25.         2-butanone (MEK)         5.322           26.         1,1-Dichloropropene         5.890           27.         Benzene         6.056           28.         t-Amyl methyl ether         6.126           29.         1,2-Dichloroethane         6.091           30.         Trichloroethane         6.862           31.         Dibromomethane         6.862           32.         1,2-Dichloropropane         6.782           33.         Bromodichloromethane         6.982           34.         cis-1,3-Dichloropropene         7.323           35.         2-chloroethyl vinyl ethane         7.164           36.         MiBK         7.410           37.         trans-1,3-Dichloropropene         7.733           38.         1,1,2-Tirchloroethane         7.948           39.         Toluene         7.607           40.         1,3-Dichloropropane         8.089           41.         2-Dibromoethane         8.049           42.         1,2-Diernoethane         8.040	20.	2,2-Dichloropropane	5.359
23.         Carbon tetrachloride         5.901           24.         1,1,1-Trichloroethane         5.769           25.         2-butanone (MEK)         5.322           26.         1,1-Dichloropropene         5.890           27.         Benzene         6.056           28.         t-Amyl methyl ether         6.126           29.         1,2-Dichloroethane         6.091           30.         Trichloroethane         6.862           31.         Dibromomethane         6.862           32.         1,2-Dichloropropane         6.782           33.         Bromodichloromethane         6.982           34.         cis-1,3-Dichloropropene         7.323           35.         2-chloroethyl vinyl ethane         7.164           36.         MiBK         7.410           37.         trans-1,3-Dichloropropene         7.773           38.         1,1,2-Tichloroethane         7.948           39.         Toluene         7.607           40.         1,3-Dichloropropane         8.089           41.         Dibromochloromethane         8.284           42.         1,2-Dibromoethane         8.041           43.         2-texanone         8.04<	21.	Bromochloromethane	5.553
24.         1,1,1-Trichloroethane         5.769           25.         2-butanone (MEK)         5.322           26.         1,1-Dichloropropene         5.890           27.         Benzene         6.056           28.         t-Amyl methyl ether         6.126           29.         1,2-Dichloroethane         6.091           30.         Trichloroethene         6.570           31.         Dibromomethane         6.862           32.         1,2-Dichloropropane         6.782           33.         Bromodichloromethane         6.982           34.         cis-1,3-Dichloropropene         7.323           35.         2-chloroethyl vinyl ethane         7.164           36.         MiBK         7.410           37.         trans-1,3-Dichloropropene         7.773           38.         1,1,2-Trichloroethane         7.948           39.         Toluene         7.607           40.         1,3-Dichloropropane         8.089           41.         Dibromochloromethane         8.284           42.         1,2-Dibromoethane         8.04           43.         Tetrachloroethene (PCE)         8.041           44.         2-hexanone         8.	22.	Chloroform	5.615
24.         1,1,1-Trichloroethane         5.769           25.         2-butanone (MEK)         5.322           26.         1,1-Dichloropropene         5.890           27.         Benzene         6.056           28.         t-Amyl methyl ether         6.126           29.         1,2-Dichloroethane         6.091           30.         Trichloroethene         6.570           31.         Dibromomethane         6.862           32.         1,2-Dichloropropane         6.782           33.         Bromodichloromethane         6.982           34.         cis-1,3-Dichloropropene         7.323           35.         2-chloroethyl vinyl ethane         7.164           36.         MiBK         7.410           37.         trans-1,3-Dichloropropene         7.773           38.         1,1,2-Trichloroethane         7.948           39.         Toluene         7.607           40.         1,3-Dichloropropane         8.089           41.         Dibromochloromethane         8.284           42.         1,2-Dibromoethane         8.04           43.         Tetrachloroethene (PCE)         8.041           44.         2-hexanone         8.	23.	Carbon tetrachloride	5.901
25.         2-butanone (MEK)         5.322           26.         1,1-Dichloropropene         5.890           27.         Benzene         6.056           28.         t-Amyl methyl ether         6.126           29.         1,2-Dichloroprothane         6.091           30.         Trichloroethene         6.570           31.         Dibromomethane         6.862           32.         1,2-Dichloropropane         6.782           33.         Bromodichloromethane         6.982           34.         cis-1,3-Dichloropropene         7.323           35.         2-chloroethyl vinyl ethane         7.164           36.         MiBK         7.410           37.         trans-1,3-Dichloropropene         7.773           38.         1,1,2-Trichloroethane         7.948           39.         Toluene         7.607           40.         1,3-Dichloropropane         8.089           41.         Dibromochloromethane         8.402           42.         1,2-Dibromoethane         8.402           43.         Tetrachloroethane (PCE)         8.041           44.         2-hexanone         8.804           45.         1,1,1,2-Tetrachloroethane			
26.         1,1-Dichloropropene         5.890           27.         Benzene         6.056           28.         t-Amyl methyl ether         6.126           29.         1,2-Dichloroethane         6.091           30.         Trichloroethene         6.570           31.         Dibromomethane         6.862           32.         1,2-Dichloropropane         6.782           33.         Bromodichloromethane         6.982           34.         cis-1,3-Dichloropropene         7.323           35.         2-chloroethyl vinyl ethane         7.164           36.         MiBK         7.410           37.         trans-1,3-Dichloropropene         7.948           39.         Toluene         7.607           40.         1,3-Dichloropropane         8.089           41.         Dibromochloromethane         8.284           42.         1,2-Dibromoethane         8.402           43.         Tetrachloroethane (PCE)         8.041           44.         2-hexanone         8.089           45.         1,1,1,2-Tetrachloroethane         8.864           46.         Chlorobenzene         8.801           47.         Ethylbenzene         9.512 <td></td> <td>, ,</td> <td></td>		, ,	
27.         Benzene         6.056           28.         t-Amyl methyl ether         6.126           29.         1,2-Dichloroethane         6.091           30.         Tirchloroethene         6.570           31.         Dibromomethane         6.862           32.         1,2-Dichloropropane         6.782           33.         Bromodichloromethane         6.982           34.         cis-1,3-Dichloropropene         7.323           35.         2-chloroethyl vinyl ethane         7.164           36.         MiBK         7.410           37.         trans-1,3-Dichloropropene         7.773           38.         1,1,2-Tirchloroethane         7.607           40.         1,3-Dichloropropane         8.089           41.         Dibromochloromethane         8.284           42.         1,2-Dibromoethane         8.042           43.         Tetrachloroethane         8.049           45.         1,1,1,2-Tetrachloroethane         8.864           46.         Chlorobenzene         8.859           48.         m,p-Xylene         8.966           49.         Bromoform         9.512           50.         Styrene         9.305     <		, ,	
28.         t-Amyl methyl ether         6.126           29.         1,2-Dichloroethane         6.091           30.         Trichloroethane         6.570           31.         Dibromomethane         6.862           32.         1,2-Dichloropropane         6.782           33.         Bromodichloromethane         6.982           34.         cis-1,3-Dichloropropene         7.323           35.         2-chloroethyl vinyl ethane         7.164           36.         MiBK         7.410           37.         trans-1,3-Dichloropropene         7.773           38.         1,1,2-Trichloroethane         7.948           39.         Toluene         7.607           40.         1,3-Dichloropropane         8.089           41.         Dibromochloromethane         8.284           42.         1,2-Dibromoethane         8.049           43.         Tetrachloroethene (PCE)         8.041           44.         2-hexanone         8.089           45.         1,1,1,2-Tetrachloroethane         8.864           46.         Chlorobenzene         8.801           47.         Ethylbenzene         8.966           49.         Bromoform         9.512			
29.         1,2-Dichloroethane         6.091           30.         Trichloroethene         6.570           31.         Dibromomethane         6.862           32.         1,2-Dichloropropane         6.782           33.         Bromodichloromethane         6.982           34.         cis-1,3-Dichloropropene         7.323           35.         2-chloroethyl vinyl ethane         7.164           36.         MiBK         7.410           37.         trans-1,3-Dichloropropene         7.773           38.         1,1,2-Trichloroethane         7.607           40.         1,3-Dichloropropane         8.089           41.         Dibromochloromethane         8.284           42.         1,2-Dibromoethane         8.402           43.         Tetrachloroethane (PCE)         8.041           44.         2-hexanone         8.089           45.         1,1,1,2-Tetrachloroethane         8.864           46.         Chlorobenzene         8.801           47.         Ethylbenzene         8.966           48.         m,p-Xylene         8.966           49.         Bromoform         9.512           50.         Styrene         9.320			
30.         Trichloroethene         6.570           31.         Dibromomethane         6.862           32.         1,2-Dichloropropane         6.782           33.         Bromodichloromethane         6.982           34.         cis-1,3-Dichloropropene         7.323           35.         2-chloroethyl vinyl ethane         7.164           36.         MiBK         7.410           37.         trans-1,3-Dichloropropene         7.948           39.         Toluene         7.607           40.         1,3-Dichloropropane         8.089           41.         Dibromochloromethane         8.284           42.         1,2-Dibromoethane         8.402           43.         Tetrachloroethane         8.049           44.         2-hexanone         8.089           45.         1,1,1,2-Tetrachloroethane         8.864           46.         Chlorobenzene         8.801           47.         Ethylbenzene         8.859           48.         m,p-Xylene         8.966           49.         Bromoform         9.512           50.         Styrene         9.320           51.         0-Xylene         9.305           52			6.126
31.         Dibromomethane         6.862           32.         1,2-Dichloropropane         6.782           33.         Bromodichloromethane         6.982           34.         cis-1,3-Dichloropropene         7.323           35.         2-chloroethyl vinyl ethane         7.164           36.         MiBK         7.410           37.         trans-1,3-Dichloropropene         7.773           38.         1,1,2-Trichloroethane         7.607           40.         1,3-Dichloropropane         8.089           41.         Dibromochloromethane         8.284           42.         1,2-Dibromoethane         8.09           43.         Tetrachloroethane         8.042           43.         Tetrachloroethane         8.044           44.         2-hexanone         8.089           45.         1,1,1,2-Tetrachloroethane         8.864           46.         Chlorobenzene         8.859           48.         m,p-Xylene         8.966           49.         Bromoform         9.512           50.         Styrene         9.305           51.         0-Xylene         9.305           52.         1,1,2,2-Tetrachloroethane         9.611     <	29.	1,2-Dichloroethane	6.091
32.         1,2-Dichloropropane         6.782           33.         Bromodichloromethane         6.982           34.         cis-1,3-Dichloropropene         7.323           35.         2-chloroethyl vinyl ethane         7.164           36.         MiBK         7.410           37.         trans-1,3-Dichloropropene         7.773           38.         1,1,2-Trichloroethane         7.607           40.         1,3-Dichloropropane         8.089           41.         Dibromochloromethane         8.284           42.         1,2-Dibromoethane         8.402           43.         Tetrachloroethene (PCE)         8.041           44.         2-hexanone         8.089           45.         1,1,1,2-Tetrachloroethane         8.864           46.         Chlorobenzene         8.804           47.         Ethylbenzene         8.869           48.         m,p-Xylene         8.966           49.         Bromoform         9.512           50.         Styrene         9.320           51.         o-Xylene         9.305           52.         1,1,2,2-Tetrachloroethane         9.876           53.         1,2,3 Trichlopropane         9.943 <td>30.</td> <td>Trichloroethene</td> <td>6.570</td>	30.	Trichloroethene	6.570
33.         Bromodichloromethane         6.982           34.         cis-1,3-Dichloropropene         7.323           35.         2-chloroethyl vinyl ethane         7.164           36.         MiBK         7.410           37.         trans-1,3-Dichloropropene         7.773           38.         1,1,2-Trichloroethane         7.948           39.         Toluene         7.607           40.         1,3-Dichloropropane         8.089           41.         Dibromochloromethane         8.284           42.         1,2-Dibromoethane         8.402           43.         Tetrachloroethane         8.041           44.         2-hexanone         8.089           45.         1,1,1,2-Tetrachloroethane         8.864           46.         Chlorobenzene         8.801           47.         Ethylbenzene         8.966           49.         Bromoform         9.512           50.         Styrene         9.320           51.         o-Xylene         9.35           52.         1,1,2,2-Tetrachloroethane         9.876           53.         1,2,3 Trichlopropane         9.876           53.         1,2,3 Trichlopropane         9.978 </td <td>31.</td> <td>Dibromomethane</td> <td>6.862</td>	31.	Dibromomethane	6.862
33.         Bromodichloromethane         6.982           34.         cis-1,3-Dichloropropene         7.323           35.         2-chloroethyl vinyl ethane         7.164           36.         MiBK         7.410           37.         trans-1,3-Dichloropropene         7.773           38.         1,1,2-Trichloroethane         7.948           39.         Toluene         7.607           40.         1,3-Dichloropropane         8.089           41.         Dibromochloromethane         8.284           42.         1,2-Dibromoethane         8.402           43.         Tetrachloroethane         8.049           44.         2-hexanone         8.089           45.         1,1,1,2-Tetrachloroethane         8.864           46.         Chlorobenzene         8.801           47.         Ethylbenzene         8.966           49.         Bromoform         9.512           50.         Styrene         9.320           51.         o-Xylene         9.305           52.         1,1,2,2-Tetrachloroethane         9.876           53.         1,2,3 Trichlopropane         9.876           53.         1,2,3 Trichlopropane         9.978     <	32.	1.2-Dichloropropane	6.782
34.         cis-1,3-Dichloropropene         7.323           35.         2-chloroethyl vinyl ethane         7.164           36.         MiBK         7.410           37.         trans-1,3-Dichloropropene         7.948           38.         1,1,2-Trichloroethane         7.607           40.         1,3-Dichloropropane         8.089           41.         Dibromochloromethane         8.284           42.         1,2-Dibromoethane         8.402           43.         Tetrachloroethane         8.049           44.         2-hexanone         8.089           45.         1,1,1,2-Tetrachloroethane         8.864           46.         Chlorobenzene         8.801           47.         Ethylbenzene         8.859           48.         m,p-Xylene         8.966           49.         Bromoform         9.512           50.         Styrene         9.305           51.         0-Xylene         9.305           52.         1,1,2,2-Tetrachloroethane         9.876           53.         1,2,3 Trichlopropane         9.876           53.         1,2,3 Trichlopropane         9.943           54. Bromofluorobenzene         \$9.11			
35.         2-chloroethyl vinyl ethane         7.164           36.         MiBK         7.410           37.         trans-1,3-Dichloropropene         7.773           38.         1,1,2-Trichloroethane         7.948           39.         Toluene         7.607           40.         1,3-Dichloropropane         8.089           41.         Dibromochloromethane         8.284           42.         1,2-Dibromoethane         8.041           43.         Tetrachloroethane         8.089           45.         1,1,1,2-Tetrachloroethane         8.864           46.         Chlorobenzene         8.801           47.         Ethylbenzene         8.859           48.         m,p-Xylene         8.966           49.         Bromoform         9.512           50.         Styrene         9.320           51.         0-Xylene         9.305           52.         1,1,2,2-Tetrachloroethane         9.876           53.         1,2,3 Trichlopropane         9.943           54.         Isopropylbenzene         9.611           55.         1,1,2,2-Tetrachloroethane         9.789           56.         Bromobenzene         9.611      <			
36. MiBK         7.410           37. trans-1,3-Dichloropropene         7.773           38. 1,1,2-Trichloroethane         7.948           39. Toluene         7.607           40. 1,3-Dichloropropane         8.089           41. Dibromochloromethane         8.284           42. 1,2-Dibromoethane         8.402           43. Tetrachloroethene (PCE)         8.041           44. 2-hexanone         8.089           45. 1,1,1,2-Tetrachloroethane         8.864           46. Chlorobenzene         8.801           47. Ethylbenzene         8.859           48. m,p-Xylene         8.966           49. Bromoform         9.512           50. Styrene         9.320           51. o-Xylene         9.305           52. 1,1,2,2-Tetrachloroethane         9.876           53. 1,2,3 Trichlopropane         9.876           54. Isopropylbenzene         9.611           55. 4-Bromofluorobenzene S1         9.789           56. Bromobenzene         9.934           57. n-Propylbenzene         9.978           58. 2-Chlorotoluene         10.084           59. 4-Chlorotoluene         10.185           60. 1,3,5-Trimethylbenzene         10.110           61. tert-Butylbenzene			
37.         trans-1,3-Dichloropropene         7.773           38.         1,1,2-Trichloroethane         7.948           39.         Toluene         7.607           40.         1,3-Dichloropropane         8.089           41.         Dibromochloromethane         8.284           42.         1,2-Dibromoethane         8.402           43.         Tetrachloroethene (PCE)         8.041           44.         2-hexanone         8.089           45.         1,1,1,2-Tetrachloroethane         8.864           46.         Chlorobenzene         8.851           47.         Ethylbenzene         8.859           48.         m,p-Xylene         8.966           49.         Bromoform         9.512           50.         Styrene         9.320           51.         o-Xylene         9.305           52.         1,1,2,2-Tetrachloroethane         9.876           53.         1,2,3 Trichlopropane         9.876           54.         Isopropylbenzene         9.611           55.         4-Bromofluorobenzene         9.611           56.         Bromobenzene         9.978           57.         n-Propylbenzene         9.978			
38.         1,1,2-Trichloroethane         7.948           39.         Toluene         7.607           40.         1,3-Dichloropropane         8.089           41.         Dibromochloromethane         8.284           42.         1,2-Dibromoethane         8.402           43.         Tetrachloroethane (PCE)         8.041           44.         2-hexanone         8.089           45.         1,1,1,2-Tetrachloroethane         8.864           46.         Chlorobenzene         8.801           47.         Ethylbenzene         8.966           48.         m,p-Xylene         8.966           49.         Bromoform         9.512           50.         Styrene         9.320           51.         o-Xylene         9.305           52.         1,1,2,2-Tetrachloroethane         9.876           53.         1,2,3 Trichlopropane         9.976           54.         Isopropylbenzene         9.611           55.         4-Bromofluorobenzene         \$9.789           56.         Bromobenzene         9.978           57.         n-Propylbenzene         9.978           58.         2-Chlorotoluene         10.084			
39. Toluene         7.607           40. 1,3-Dichloropropane         8.089           41. Dibromochloromethane         8.284           42. 1,2-Dibromoethane         8.402           43. Tetrachloroethane (PCE)         8.041           44. 2-hexanone         8.089           45. 1,1,1,2-Tetrachloroethane         8.864           46. Chlorobenzene         8.859           48. m,p-Xylene         8.966           49. Bromoform         9.512           50. Styrene         9.320           51. o-Xylene         9.305           52. 1,1,2,2-Tetrachloroethane         9.876           53. 1,2,3 Trichlopropane         9.943           54. Isopropylbenzene         9.611           55. 4-Bromofluorobenzene S1         9.789           56. Bromobenzene         9.934           57. n-Propylbenzene         9.978           58. 2-Chlorotoluene         10.185           59. 4-Chlorotoluene         10.185           60. 1,3,5-Trimethylbenzene         10.127           61. tert-Butylbenzene         10.416           62. 1,2,4-Trimethylbenzene         10.613           64. 1,3-Dichlorobenzene         10.755           65. 4-Isopropyltoluene         10.755           65. 4-Iso			
40.         1,3-Dichloropropane         8.089           41.         Dibromochloromethane         8.284           42.         1,2-Dibromoethane         8.402           43.         Tetrachloroethene (PCE)         8.041           44.         2-hexanone         8.089           45.         1,1,1,2-Tetrachloroethane         8.864           46.         Chlorobenzene         8.861           47.         Ethylbenzene         8.966           48.         m,p-Xylene         8.966           49.         Bromoform         9.512           50.         Styrene         9.320           51.         o-Xylene         9.305           52.         1,1,2,2-Tetrachloroethane         9.876           53.         1,2,3 Trichlopropane         9.876           53.         1,2,3 Trichlopropane         9.943           54.         Isopropylbenzene         9.611           55.         4-Bromofluorobenzene         9.978           56.         Bromobenzene         9.978           57.         n-Propylbenzene         9.978           58.         2-Chlorotoluene         10.084           59.         4-Chlorotoluene         10.127			
41. Dibromochloromethane         8.284           42. 1,2-Dibromoethane         8.402           43. Tetrachloroethene (PCE)         8.041           44. 2-hexanone         8.089           45. 1,1,1,2-Tetrachloroethane         8.864           46. Chlorobenzene         8.851           47. Ethylbenzene         8.859           48. m,p-Xylene         8.966           49. Bromoform         9.512           50. Styrene         9.320           51. o-Xylene         9.305           52. 1,1,2,2-Tetrachloroethane         9.876           53. 1,2,3 Trichlopropane         9.943           54. Isopropylbenzene         9.611           55. 4-Bromofluorobenzene S1         9.789           56. Bromobenzene         9.934           57. n-Propylbenzene         9.978           58. 2-Chlorotoluene         10.084           59. 4-Chlorotoluene         10.185           60. 1,3,5-Trimethylbenzene         10.416           61. tetr-Butylbenzene         10.416           62. 1,2,4-Trimethylbenzene         10.613           64. 1,3-Dichlorobenzene         10.740           65. 4-Isopropyltoluene         10.740           66. 1,4-Dichlorobenzene         11.171           68.	39.	Toluene	7.607
42.         1,2-Dibromoethane         8.402           43.         Tetrachloroethene (PCE)         8.041           44.         2-hexanone         8.089           45.         1,1,1,2-Tetrachloroethane         8.864           46.         Chlorobenzene         8.801           47.         Ethylbenzene         8.966           48.         m,p-Xylene         8.966           49.         Bromoform         9.512           50.         Styrene         9.320           51.         o-Xylene         9.305           52.         1,1,2,2-Tetrachloroethane         9.876           53.         1,2,3 Trichlopropane         9.943           54.         Isopropylbenzene         9.611           55.         4-Bromofluorobenzene         9.789           56.         Bromobenzene         9.978           58.         2-Chlorotoluene         9.978           58.         2-Chlorotoluene         10.084           59.         4-Chlorotoluene         10.185           60.         1,3,5-Trimethylbenzene         10.416           61.         tetr-Butylbenzene         10.416           62.         1,2,4-Trimethylbenzene         10.613      <	40.	1,3-Dichloropropane	8.089
43. Tetrachloroethene (PCE)         8.041           44. 2-hexanone         8.089           45. 1,1,1,2-Tetrachloroethane         8.864           46. Chlorobenzene         8.859           47. Ethylbenzene         8.859           48. m,p-Xylene         8.966           49. Bromoform         9.512           50. Styrene         9.320           51. o-Xylene         9.305           52. 1,1,2,2-Tetrachloroethane         9.876           53. 1,2,3 Trichlopropane         9.943           54. Isopropylbenzene         9.611           55. 4-Bromofluorobenzene S1         9.789           56. Bromobenzene         9.978           57. n-Propylbenzene         9.978           58. 2-Chlorotoluene         10.084           59. 4-Chlorotoluene         10.185           60. 1,3,5-Trimethylbenzene         10.127           61. tert-Butylbenzene         10.416           62. 1,2,4-Trimethylbenzene         10.416           63. sec-Butylbenzene         10.613           64. 1,3-Dichlorobenzene         10.755           65. 4-Isopropyltoluene         10.755           65. 4-Isopropyltoluene         10.740           66. 1,4-Dichlorobenzene         11.171           68.	41.	Dibromochloromethane	8.284
43. Tetrachloroethene (PCE)         8.041           44. 2-hexanone         8.089           45. 1,1,1,2-Tetrachloroethane         8.864           46. Chlorobenzene         8.859           47. Ethylbenzene         8.859           48. m,p-Xylene         8.966           49. Bromoform         9.512           50. Styrene         9.320           51. o-Xylene         9.305           52. 1,1,2,2-Tetrachloroethane         9.876           53. 1,2,3 Trichlopropane         9.943           54. Isopropylbenzene         9.611           55. 4-Bromofluorobenzene S1         9.789           56. Bromobenzene         9.978           57. n-Propylbenzene         9.978           58. 2-Chlorotoluene         10.084           59. 4-Chlorotoluene         10.185           60. 1,3,5-Trimethylbenzene         10.127           61. tert-Butylbenzene         10.416           62. 1,2,4-Trimethylbenzene         10.416           63. sec-Butylbenzene         10.613           64. 1,3-Dichlorobenzene         10.755           65. 4-Isopropyltoluene         10.755           65. 4-Isopropyltoluene         10.740           66. 1,4-Dichlorobenzene         11.171           68.	42.	1.2-Dibromoethane	8.402
44.         2-hexanone         8.089           45.         1,1,1,2-Tetrachloroethane         8.864           46.         Chlorobenzene         8.801           47.         Ethylbenzene         8.966           48.         m,p-Xylene         8.966           49.         Bromoform         9.512           50.         Styrene         9.320           51.         o-Xylene         9.305           52.         1,1,2,2-Tetrachloroethane         9.876           53.         1,2,3 Trichlopropane         9.943           54.         Isopropylbenzene         9.611           55.         4-Bromofluorobenzene S1         9.789           56.         Bromobenzene         9.934           57.         n-Propylbenzene         9.978           58.         2-Chlorotoluene         10.084           59.         4-Chlorotoluene         10.185           60.         1,3,5-Trimethylbenzene         10.127           61.         tert-Butylbenzene         10.416           62.         1,2,4-Trimethylbenzene         10.416           63.         sec-Butylbenzene         10.613           64.         1,3-Dichlorobenzene         10.755      <		•	
45.         1,1,1,2-Tetrachloroethane         8.864           46.         Chlorobenzene         8.801           47.         Ethylbenzene         8.859           48.         m,p-Xylene         8.966           49.         Bromoform         9.512           50.         Styrene         9.320           51.         o-Xylene         9.305           52.         1,1,2,2-Tetrachloroethane         9.876           53.         1,2,3 Trichlopropane         9.943           54.         Isopropylbenzene         9.611           55.         4-Bromofluorobenzene S1         9.789           56.         Bromobenzene         9.934           57.         n-Propylbenzene         9.978           58.         2-Chlorotoluene         10.084           59.         4-Chlorotoluene         10.185           60.         1,3,5-Trimethylbenzene         10.127           61.         tetr-Butylbenzene         10.416           62.         1,2,4-Trimethylbenzene         10.613           64.         1,3-Dichlorobenzene         10.740           65.         4-Isopropyltoluene         10.740           66.         1,4-Dichlorobenzene         11.171			
46. Chlorobenzene         8.801           47. Ethylbenzene         8.859           48. m,p-Xylene         8.966           49. Bromoform         9.512           50. Styrene         9.320           51. o-Xylene         9.305           52. 1,1,2,2-Tetrachloroethane         9.876           53. 1,2,3 Trichlopropane         9.943           54. Isopropylbenzene         9.611           55. 4-Bromofluorobenzene S1         9.789           56. Bromobenzene         9.934           57. n-Propylbenzene         9.978           58. 2-Chlorotoluene         10.084           59. 4-Chlorotoluene         10.185           60. 1,3,5-Trimethylbenzene         10.416           61. tetr-Butylbenzene         10.416           62. 1,2,4-Trimethylbenzene         10.416           63. sec-Butylbenzene         10.613           64. 1,3-Dichlorobenzene         10.740           65. 4-Isopropyltoluene         10.740           66. 1,4-Dichlorobenzene         11.171           67. 1,2-Dichlorobenzene         11.171           68. 1,2-Dichlorobenzene         11.171           69. n-Butylbenzene         11.170           70. 1,2-Dibromo-3-chloropropane         11.877 <t< td=""><td></td><td></td><td></td></t<>			
47. Ethylbenzene         8.859           48. m,p-Xylene         8.966           49. Bromoform         9.512           50. Styrene         9.305           51. o-Xylene         9.305           52. 1,1,2,2-Tetrachloroethane         9.876           53. 1,2,3 Trichlopropane         9.943           54. Isopropylbenzene         9.611           55. 4-Bromofluorobenzene S1         9.789           56. Bromobenzene         9.934           57. n-Propylbenzene         9.978           58. 2-Chlorotoluene         10.084           59. 4-Chlorotoluene         10.185           60. 1,3,5-Trimethylbenzene         10.416           61. tert-Butylbenzene         10.416           62. 1,2,4-Trimethylbenzene         10.416           63. sec-Butylbenzene         10.613           64. 1,3-Dichlorobenzene         10.755           65. 4-Isopropyltoluene         10.740           66. 1,4-Dichlorobenzene         11.771           68. 1,2-Dichlorobenzene         11.171           70. 1,2-Dibromo-3-chloropropane         11.173           71. 1,2,4-Trichlorobenzene         12.650           72. Naphthalene         12.939           73. Hexachlorobutadiene         12.768			
48.         m,p-Xylene         8.966           49.         Bromoform         9.512           50.         Styrene         9.305           51.         o-Xylene         9.305           52.         1,1,2,2-Tetrachloroethane         9.876           53.         1,2,3 Trichlopropane         9.943           54.         Isopropylbenzene         9.611           55.         4-Bromofluorobenzene S1         9.789           56.         Bromobenzene         9.934           57.         n-Propylbenzene         9.978           58.         2-Chlorotoluene         10.084           59.         4-Chlorotoluene         10.185           60.         1,3,5-Trimethylbenzene         10.127           61.         tert-Butylbenzene         10.416           62.         1,2,4-Trimethylbenzene         10.468           63.         sec-Butylbenzene         10.613           64.         1,3-Dichlorobenzene         10.755           65.         4-Isopropyltoluene         10.740           66.         1,4-Dichlorobenzene         10.845           67.         1,2-Dichlorobenzene         11.171           68.         1,2-Dichlorobenzene         11.171 </td <td></td> <td></td> <td></td>			
49. Bromoform         9.512           50. Styrene         9.320           51. o-Xylene         9.305           52. 1,1,2,2-Tetrachloroethane         9.876           53. 1,2,3 Trichlopropane         9.943           54. Isopropylbenzene         9.611           55. 4-Bromofluorobenzene S1         9.789           56. Bromobenzene         9.934           57. n-Propylbenzene         9.978           58. 2-Chlorotoluene         10.084           59. 4-Chlorotoluene         10.185           60. 1,3,5-Trimethylbenzene         10.416           62. 1,2,4-Trimethylbenzene         10.468           63. sec-Butylbenzene         10.613           64. 1,3-Dichlorobenzene         10.755           65. 4-Isopropyltoluene         10.740           66. 1,4-Dichlorobenzene         11.771           68. 1,2-Dichlorobenzene         11.171           68. 1,2-Dichlorobenzene         11.171           68. 1,2-Dichlorobenzene         11.171           69. n-Butylbenzene         11.170           70. 1,2-Dibromo-3-chloropropane         11.877           71. 1,2,4-Trichlorobenzene         12.650           72. Naphthalene         12.939           73. Hexachlorobutadiene         12.768 <td></td> <td></td> <td></td>			
50.         Styrene         9.320           51.         o-Xylene         9.305           52.         1,1,2,2-Tetrachloroethane         9.876           53.         1,2,3 Trichlopropane         9.943           54.         Isopropylbenzene         9.611           55.         4-Bromofluorobenzene S1         9.789           56.         Bromobenzene         9.934           57.         n-Propylbenzene         9.978           58.         2-Chlorotoluene         10.084           59.         4-Chlorotoluene         10.185           60.         1,3,5-Trimethylbenzene         10.416           61.         tetr-Butylbenzene         10.416           62.         1,2,4-Trimethylbenzene         10.613           63.         sec-Butylbenzene         10.613           64.         1,3-Dichlorobenzene         10.740           65.         4-Isopropyltoluene         10.740           66.         1,4-Dichlorobenzene         11.171           68.         1,2-Dichlorobenzene         11.171           68.         1,2-Dichlorobenzene         11.172           69.         n-Butylbenzene         11.171           70.         1,2-Dibloromo-3-chloropropane			
51.         o-Xylene         9.305           52.         1,1,2,2-Tetrachloroethane         9.876           53.         1,2,3 Trichlopropane         9.943           54.         Isopropylbenzene         9.611           55.         4-Bromofluorobenzene S1         9.789           56.         Bromobenzene         9.934           57.         n-Propylbenzene         9.978           58.         2-Chlorotoluene         10.084           59.         4-Chlorotoluene         10.185           60.         1,3,5-Trimethylbenzene         10.416           61.         tetr-Butylbenzene         10.416           62.         1,2,4-Trimethylbenzene         10.416           63.         sec-Butylbenzene         10.613           64.         1,3-Dichlorobenzene         10.755           65.         4-Isopropyltoluene         10.740           66.         1,4-Dichlorobenzene         11.71           67.         1,2-Dichlorobenzene         11.171           68.         1,2-Dichlorobenzene         11.153           69.         n-Butylbenzene         11.171           70.         1,2-Dibromo-3-chloropropane         11.877           71.         1,2,4-Tri		Bromoform	
52.         1,1,2,2-Tetrachloroethane         9.876           53.         1,2,3 Trichlopropane         9.943           54.         Isopropylbenzene         9.611           55.         4-Bromofluorobenzene S1         9.789           56.         Bromobenzene         9.934           57.         n-Propylbenzene         9.978           58.         2-Chlorotoluene         10.084           59.         4-Chlorotoluene         10.185           60.         1,3,5-Trimethylbenzene         10.127           61.         tert-Butylbenzene         10.416           62.         1,2,4-Trimethylbenzene         10.468           63.         sec-Butylbenzene         10.613           64.         1,3-Dichlorobenzene         10.755           65.         4-Isopropyltoluene         10.740           66.         1,4-Dichlorobenzene         11.774           68.         1,2-Dichlorobenzene         11.171           69.         n-Butylbenzene         11.171           70.         1,2-Dichlorobenzene         11.171           71.         1,2,4-Trichlorobenzene         12.650           72.         Naphthalene         12.939           73.         Hexachlor	50.	Styrene	9.320
53.         1,2,3 Trichlopropane         9.943           54.         Isopropylbenzene         9.611           55.         4-Bromofluorobenzene S1         9.789           56.         Bromobenzene         9.934           57.         n-Propylbenzene         9.978           58.         2-Chlorotoluene         10.084           59.         4-Chlorotoluene         10.185           60.         1,3,5-Trimethylbenzene         10.416           61.         tert-Butylbenzene         10.416           62.         1,2,4-Trimethylbenzene         10.468           63.         sec-Butylbenzene         10.613           64.         1,3-Dichlorobenzene         10.755           65.         4-Isopropyltoluene         10.740           66.         1,4-Dichlorobenzene         11.771           68.         1,2-Dichlorobenzene         11.171           68.         1,2-Dichlorobenzene         11.153           69.         n-Butylbenzene         11.110           70.         1,2-Dibromo-3-chloropropane         11.877           71.         1,2,4-Trichlorobenzene         12.650           72.         Naphthalene         12.939           73.         Hexach	51.	o-Xylene	9.305
54.         Isopropylbenzene         9.611           55.         4-Bromofluorobenzene S1         9.789           56.         Bromobenzene         9.934           57.         n-Propylbenzene         9.978           58.         2-Chlorotoluene         10.084           59.         4-Chlorotoluene         10.185           60.         1,3,5-Trimethylbenzene         10.416           62.         1,2,4-Trimethylbenzene         10.468           63.         sec-Butylbenzene         10.613           64.         1,3-Dichlorobenzene         10.755           65.         4-Isopropyltoluene         10.740           66.         1,4-Dichlorobenzene         10.845           67.         1,2-Dichlorobenzene         11.171           68.         1,2-Dichlorobenzene         11.153           69.         n-Butylbenzene         11.110           70.         1,2-Dibromo-3-chloropropane         11.877           71.         1,2,4-Trichlorobenzene         12.650           72.         Naphthalene         12.939           73.         Hexachlorobutadiene         12.768	52.	1,1,2,2-Tetrachloroethane	9.876
54.         Isopropylbenzene         9.611           55.         4-Bromofluorobenzene S1         9.789           56.         Bromobenzene         9.934           57.         n-Propylbenzene         9.978           58.         2-Chlorotoluene         10.084           59.         4-Chlorotoluene         10.185           60.         1,3,5-Trimethylbenzene         10.416           62.         1,2,4-Trimethylbenzene         10.468           63.         sec-Butylbenzene         10.613           64.         1,3-Dichlorobenzene         10.755           65.         4-Isopropyltoluene         10.740           66.         1,4-Dichlorobenzene         11.771           68.         1,2-Dichlorobenzene         11.171           68.         1,2-Dichlorobenzene         11.153           69.         n-Butylbenzene         11.110           70.         1,2-Dibromo-3-chloropropane         11.877           71.         1,2,4-Trichlorobenzene         12.650           72.         Naphthalene         12.939           73.         Hexachlorobutadiene         12.768	53.	1,2,3 Trichlopropane	9.943
55.         4-Bromofluorobenzene S1         9.789           56.         Bromobenzene         9.934           57.         n-Propylbenzene         9.978           58.         2-Chlorotoluene         10.185           59.         4-Chlorotoluene         10.127           61.         tetr-Butylbenzene         10.416           62.         1,2,4-Trimethylbenzene         10.468           63.         sec-Butylbenzene         10.613           64.         1,3-Dichlorobenzene         10.755           65.         4-Isopropyltoluene         10.740           66.         1,4-Dichlorobenzene         10.845           67.         1,2-Dichlorobenzene         11.171           68.         1,2-Dichlorobenzene         11.153           69.         n-Butylbenzene         11.110           70.         1,2-Dibromo-3-chloropropane         11.877           71.         1,2,4-Trichlorobenzene         12.650           72.         Naphthalene         12.939           73.         Hexachlorobutadiene         12.768	54		9 611
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59.         4-Chlorotoluene         10.185           60.         1,3,5-Trimethylbenzene         10.127           61.         tert-Butylbenzene         10.416           62.         1,2,4-Trimethylbenzene         10.663           63.         sec-Butylbenzene         10.613           64.         1,3-Dichlorobenzene         10.740           65.         4-Isopropyltoluene         10.740           66.         1,4-Dichlorobenzene         10.845           67.         1,2-Dichlorobenzene         11.171           68.         1,2-Dichlorobenzene-d4 S2         11.153           69.         n-Butylbenzene         11.110           70.         1,2-Dibromo-3-chloropropane         11.877           71.         1,2,4-Trichlorobenzene         12.650           72.         Naphthalene         12.939           73.         Hexachlorobutadiene         12.768			
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65.       4-Isopropyltoluene       10.740         66.       1,4-Dichlorobenzene       10.845         67.       1,2-Dichlorobenzene       11.171         68.       1,2-Dichlorobenzene-d4 S2       11.153         69.       n-Butylbenzene       11.110         70.       1,2-Dibromo-3-chloropropane       11.877         71.       1,2,4-Trichlorobenzene       12.650         72.       Naphthalene       12.939         73.       Hexachlorobutadiene       12.768			
66.       1,4-Dichlorobenzene       10.845         67.       1,2-Dichlorobenzene       11.171         68.       1,2-Dichlorobenzene-d4 S2       11.153         69.       n-Butylbenzene       11.110         70.       1,2-Dibromo-3-chloropropane       11.877         71.       1,2,4-Trichlorobenzene       12.650         72.       Naphthalene       12.939         73.       Hexachlorobutadiene       12.768			
67.       1,2-Dichlorobenzene       11.171         68.       1,2-Dichlorobenzene-d4 S2       11.153         69.       n-Butylbenzene       11.110         70.       1,2-Dibromo-3-chloropropane       11.877         71.       1,2,4-Trichlorobenzene       12.650         72.       Naphthalene       12.939         73.       Hexachlorobutadiene       12.768			
68.       1,2-Dichlorobenzene-d4 S2       11.153         69.       n-Butylbenzene       11.110         70.       1,2-Dibromo-3-chloropropane       11.877         71.       1,2,4-Trichlorobenzene       12.650         72.       Naphthalene       12.939         73.       Hexachlorobutadiene       12.768			
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70.       1,2-Dibromo-3-chloropropane       11.877         71.       1,2,4-Trichlorobenzene       12.650         72.       Naphthalene       12.939         73.       Hexachlorobutadiene       12.768			
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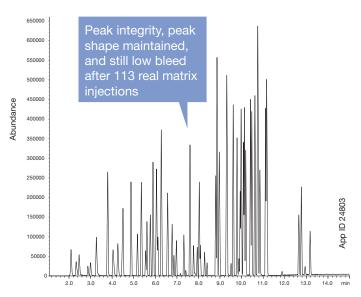
# APPLICATION

Figure 4.

0.5 ppb Organic Volatiles by GC-MS on a Zebron ZB-624PLUS After 113
Sample Injections



# **Figure 5.** 5 ppb Organic Volatiles by GC-MS on a Zebron ZB-624*PLUS* After 113 Sample Injections



# **Results and Discussion**

Organic volatile compounds in water is a very critical analysis. It requires a high efficiency GC column dimension for optimal separation of 74 analytes (Table 1.). Since this method is run on a GC-MS, the transfer line which serves as the interface between GC and MS is kept at higher temperature, in order to prevent condensation of analytes. The traditional 624 phase has 260°C as column maximum temperature and will start to bleed if transfer line is maintained at 250 °C. Zebron ZB-624PLUS GC column is a low bleed MS certified column that has a maximum temperature limit of 300 °C/320 °C GC. This reduces baseline disturbance at high temperature and helps with accurate detections of higher boiling analyte. For this study, a Zebron ZB-624PLUS GC column 30 m x 0.25 mm x 1.40 um was considered for analysis. As shown in Figure 1, ZB-624PLUS provides optimal separation of 74 VOCs with high efficiency and resolution. Compared to traditional 624 phase GC columns with a maximum temperature of 260°C, the ZB-624PLUS, due to its extensive Engineered Self Cross Linkage (ESC™), Mass Spec compatibility and maximum temperature of 300/320 °C, gives the flexibility to elute out high boiling solvents without causing column bleed (Figure 1.).

Illustrated in **Figure 3**, an Agilent DB®-624 GC column was run under the same method parameters using the same 74 VOCs. Due to the temperature limit of the traditional 624 column at 260 °C, the chromatogram shows the baseline rising indicating stationary phase bleed. This not only affects the quantitation of higher boiling analytes, but also results in mass spec source contamination. **Figures 4** and **5** shows the separation of 74 VOCs at 0.5 ppb and 5 ppb levels after 113 injections on ZB-624*PLUs*. These injections included samples from wastewater, sludge, and groundwater. The retention, peak symmetry, and efficiency of all the analytes were maintained even after 113 injections of real sample matrix at both at 5 ppb and 0.5 ppb levels. Additionally, with the Zebron ZB-624*PLUs* upper temperature limit of 300/320°C, it gave the flexibility to bake out analytes and regenerate the GC column when needed. The low bleed column provided steady baseline even at higher

temperatures and helped in repeatable quantitation of the 74 compounds. The highly selective ZB-624PLUS stationary phase allowed for identification and quantification of 74 VOCs, while maintaining a rapid analysis time of 15 minutes, and resulted in excellent performance and peak shapes of 74 VOCs after 113 injections of various matrices including groundwater, wastewater, and sludge.

# Conclusion

Volatile organic compound analysis via GC-MS and purge and trap is routine analysis for environmental testing and requires a high efficiency, low bleed, Mass Spec certified GC Column for optimal separation of critical VOCs. The Zebron ZB-624PLUS GC column is a low bleed and high efficiency column which has produced a shorter run time of 15 minutes for 74 VOCs with an added flexibility to bake out contaminants at 300/320°C. The Zebron ZB-624PLUS is suitable for VOC analysis by EPA methods 524, 624, and 8260 and provides reproducible quantitation of volatile analytes.

# Acknowledgement

We would like to provide special thanks to Weck Laboratories for contributing this application.

WECK LABORATORIES. INC





# **Ordering Information** Zebron<sup>™</sup> PLUS GC Inlet Liners

			Dimensions			
Description	Application	Inlet Style	ID x L (mm)	Deactivation	Part No.	Unit
For 5890, 6890 and 7890 Models						
Straight Z-Liner™	Dirty samples, Volatiles,				AG2-0A03-01	ea
Zebron Plus	High initial oven temperatures	S/SL	4 x 78.5	PLUS Inert	AG2-0A03-05 AG2-0A03-25	5/pk 25/pk

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- USA t: +1 (310) 212-0555
- f: +1 (310) 328-7768 info@phenomenex.com







# **Ordering Information**

<b>Zebron ZB-624</b> PI ID(mm)	df(µm)	Temp. Limits °C	Part No.
20-Meter	(		
0.18	1.00	-20 to 300/320	7FD-G040-22
30-Meter			
0.25	1.40	-20 to 300/320	7HG-G040-27
0.32	1.80	-20 to 300/320	7HM-G040-31
0.53	3.00	-20 to 300/320	7HK-G040-36
60-Meter			
0.25	1.40	-20 to 300/320	7KG-G040-27
0.32	1.80	-20 to 300/320	7KM-G040-31
0.53	3.00	-20 to 300/320	7KK-G040-36

Note: If you need a 5 in. cage, simply add a (-B) after the part number, e.g., 7HG-G040-27-B. Some exceptions may apply. Agilent 6850 and some SRI and process GC systems use only



If Phenomenex products in this technical note do not provide at least an equivalent separation as compared to other products of the same phase and dimensions, return the product with comparative data within 45 days for a FULL REFUND.

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