

# Multi-residue Analysis for PAHs, PCBs and OCPs on Agilent J&W FactorFour VF-200ms

# **Application Note**

#### Author

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#### Introduction

With multi-residue analysis, different groups of compounds are analyzed in a single run. Enhanced productivity is one of the most important advantages of this type of analysis. This application note describes a multi-residue method for polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and organochlorine pesticides (OCPs).

PAHs, PCBs and OCPs have different origins and structures. PAHs contain two or more aromatic rings. They are formed during incomplete combustion or pyrolysis of organic matter. Characteristically, PCBs contain two phenyl groups, with varying number of chlorine atoms. Due to their non-flammability, chemical stability, high boiling point and electrical insulating properties, PCBs were used in hundreds of industrial and commercial applications, for example, in electrical, heat transfer and hydraulic equipment, as plasticizers in paints, plastics and rubber products, and in pigments, dyes and carbonless copy paper. OCPs are pesticides that primarily consist of carbon, hydrogen and chlorine. Most of them break down slowly and can remain in the environment long after application, and in organisms long after exposure. These compounds are typically very persistent in the environment, and are known for accumulating in sediments, plants and animals.

16 PAHs, 17 PCBs and 24 OCPs were analyzed in a single run at different concentration levels. The concentration of the PAHs was ten times higher than the concentration of PCBs and OCPs. This concentration difference can be found in real environmental samples.



#### **Materials and Methods**

Technique: GC/MS

Column: VF-200ms,  $30m \times 0.25mm$ ,  $df = 0.25\mu m$ 

(part number CP8858)

Sample Conc: OCPs and PCBs 0.1 µg/mL, PAHs 1 µg/mL

Injection Volume: 1 µL

Temperature: 70 °C (1 min), 20 °C/min, 190 °C,

10 °C/min, 250 °C, 5 °C/min, 260 °C,

2 °C/min, 280 °C

Carrier Gas: Helium, constant flow, 1 mL/min

Injection: 100 °C (0.4 min), 600 °C/min, 300 °C

(15 min), 50 °C/min, 120 °C, splitless

Detection: Quadrupole MS, EI in SIM, source 230 °C,

transfer line 280 °C

### **Results and Discussion**

The VF-200ms column provided a multi-residue analysis of PAHs, PCBs and OCPs in 24 minutes (Figure 1). Analyzing 57 compounds in a single run is normally quite challenging because every group of compounds presents its own difficulties in separation.

In the PAH group, two pairs of isomers are difficult to resolve. The first pair is benzo[b]fluoranthene and benzo[k]-fluoranthene. These two compounds have the same mass and therefore cannot be separated by MS alone. Another PAH pair comprises indeno[1,2,3-c,d]pyrene and dibenz[a,h] anthracene. These compounds have different masses (278 and 276 respectively) but again are difficult to resolve with just MS.

In the PCB and OCP group, PCB 28/PCB 31 and p,p'-DDD/o,p'-DDT have the same mass spectra and cannot be resolved by MS. The OCP group has another pair that is difficult to resolve. Cis-heptachlor epoxide/trans-heptachlor epoxide both have m/z 353 in their mass spectra. For SIM analysis, an extra m/z should be analyzed to confirm the presence of cisor trans-heptachlor epoxide.

Figures 2 to 6 show the peak pairs that are difficult to resolve, although the VF-200ms is very capable of providing adequate separation.

Table 1. Peak Identification and SIM ions

Naphthalene	lable 1. Feak Identification and Silvi Ions			
2         Acenaphthene         152           3         Acenaphthylene         154           4         Fluorene         166           5         Hexachlorobenzene         284, 149           6         PCB 18         186, 256           7         G-HCH         183, 219           8         6-HCH         181, 219           9         Phenanthrene         178           10         Anthracene         178           11         PCB 31         186, 256           12         PCB 28         186, 256           13         B-HCH         219, 183           14         PCB 20         186, 256           15         Heptachlor         272, 100           16         Y-HCH         183, 219           17         PCB 52         292, 220           18         Aldrin         66, 263           19         PCB 44         220, 292           20         PCB 155         360, 290           21         o.p'-DDE         246, 318           22         cis-Heptachlor epoxide         183, 353           23         PCB 101         326, 256           24         trans-Heptachlor epoxi	Peak	Compound	lons	
3 Acenaphthylene 154 4 Fluorene 166 5 Hexachlorobenzene 284, 149 6 PCB 18 186, 256 7 α-HCH 181, 219 8 δ-HCH 181, 219 9 Phenanthrene 178 10 Anthracene 178 11 PCB 31 186, 256 12 PCB 28 186, 256 13 β-HCH 2119, 183 14 PCB 20 186, 256 15 Heptachlor 272, 100 16 γ-HCH 183, 219 17 PCB 52 292, 220 18 Aldrin 66, 263 19 PCB 44 220, 292 20 PCB 185 360, 290 21 ο,ρ'-DDE 246, 318 22 cis-Heptachlor epoxide 18, 353 23 PCB 101 326, 256 24 trans-Heptachlor epoxide 81, 353 25 trans-Chlordane 373, 237 26 cis-Chlordane 373, 237 27 Fluoranthene 202 28 p.p'-DDE 246, 318 29 Endosulfan 1 37, 77 30 ο,ρ'-DDD 235, 165 31 Pyrene 202 22 PCB 183 360, 290 32 PCB 183 360, 290 33 ο,ρ'-DDT 235, 165 31 Pyrene 202 32 PCB 183 360, 290 33 ο,ρ'-DDT 235, 165 31 Pyrene 202 32 PCB 183 360, 290 34 PCB 18 326, 254 35 Dieldrin 79, 137 36 PCB 18 360, 290 37 PCB 18 360, 290 38 Endrin 137, 77 39 p.ρ'-DDD 235, 165 31 Pyrene 202 32 PCB 180 360, 290 34 PCB 18 360, 290 37 PCB 18 360, 290 38 Endrin 137, 77 39 p.ρ'-DDD 235, 165 31 PCB 18 360, 290 41 PCB 18 360, 290 44 PCB 18 360, 290 45 PCB 18 360, 290 46 Endrinaldehyde 67, 345 47 PCB 180 394, 324 48 Benz[a]anthracene 228 49 Chrysene 228 50 Endosulfan 1 137, 77 51 PCB 194 430, 388 56 Dibenz[a,h]anthracene 276		•		
44         Fluorene         166           5         Hexachlorobenzene         284, 149           6         PCB 18         186, 256           7         o-HCH         183, 219           8         δ-HCH         181, 219           9         Phenanthrene         178           10         Anthracene         178           11         PCB 31         186, 256           12         PCB 28         186, 256           12         PCB 28         186, 256           13         B-HCH         219, 183           14         PCB 20         186, 256           15         Heptachlor         272, 100           16         Y-HCH         183, 219           17         PCB 52         292, 220           16         Y-HCH         183, 219           17         PCB 52         292, 220           18         Aldrin         66, 263           19         PCB 44         220, 292           20         PCB 155         360, 290           21         o.p'-DDE         246, 318           22         cis-Heptachlor epoxide         183, 353           23         PCB 101		•		
5         Hexachlorobenzene         284, 149           6         PCB 18         186, 256           7         α-HCH         183, 219           8         δ-HCH         181, 219           9         Phenanthrene         178           10         Anthracene         178           11         PCB 31         186, 256           12         PCB 28         186, 256           13         β-HCH         219, 183           14         PCB 20         186, 256           15         Heptachlor         272, 100           16         V-HCH         183, 219           17         PCB 52         292, 220           18         Aldrin         66, 263           19         PCB 44         220, 292           20         PCB 155         360, 290           21         o.p'-DDE         246, 318           22         cis-Heptachlor epoxide         183, 353           23         PCB 101         326, 256           24         trans-Chlordane         373, 237           25         trans-Chlordane         373, 237           26         cis-Chlordane         373, 237           27			-	
6 PCB 18				
7	5			
8 6-HCH 178   181, 219   9   Phenanthrene 178   10   Anthracene 178   11   PCB 31   186, 256   12   PCB 28   186, 256   13   β-HCH 219, 183   14   PCB 20   186, 256   15   Heptachlor 272, 100   16   γ-HCH 183, 219   17   PCB 52   292, 220   18   Aldrin 66, 263   19   PCB 44   220, 292   20   20   20   20   20   20   20		PCB 18		
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10 Anthracene 178 11 PCB 31 186, 256 12 PCB 28 186, 256 13 β-HCH 219, 183 14 PCB 20 186, 256 15 Heptachlor 272, 100 16 γ-HCH 183, 219 17 PCB 52 292, 220 18 Aldrin 66, 263 19 PCB 44 220, 292 20 PCB 155 360, 290 21 ο,p'-DDE 246, 318 22 cis-Heptachlor epoxide 183, 353 23 PCB 101 326, 256 24 trans-Heptachlor epoxide 81, 353 25 trans-Chlordane 373, 237 26 cis-Chlordane 373, 237 27 Fluoranthene 202 28 p.p'-DDE 246, 318 29 Endosulfan I 137, 77 30 ο,p'-DDD 235, 165 31 Pyrene 202 32 PCB 149 360, 180 33 ο,p'-DDT 235, 165 34 PCB 153 360, 290 37 PCB 158 360, 290 37 PCB 159 360, 290 37 PCB 159 360, 290 38 Endrin 79, 137 36 PCB 158 360, 290 37 PCB 159 360, 290 37 PCB 159 360, 290 37 PCB 169 360, 290 37 PCB 150 360, 290 37 PCB 168 360, 290 37 PCB 169 360, 290 37 PCB 169 360, 290 41 PCB 188 360, 290 41 PCB 188 360, 290 42 p,p'-DDD 235, 165 44 PCB 180 394, 324 45 PCB 180 394, 324 46 Endrin 137, 77 47 PCB 170 394, 324 48 Benz[a]anthracene 228 50 Endosulfan I 272, 387 51 PCB 194 430, 358 52 Endosulfan I 272, 387 54 PCB 170 394, 324 55 PCB 194 430, 358 56 Dibenz[a,h]anthracene 252 57 Benzo[b]fluoranthene 252 58 Benzo[b]fluoranthene 252 59 Benzo[b]fluoranthene 252 50 Endosulfan sulfate 272, 387 51 PCB 194 56 Dibenz[a,h]anthracene 276	8	δ-HCH	181, 219	
11       PCB 31       186, 256         12       PCB 28       186, 256         13       β-HCH       219, 183         14       PCB 20       186, 256         15       Heptachlor       272, 100         16       γ-HCH       183, 219         17       PCB 52       292, 220         18       Aldrin       66, 263         19       PCB 44       220, 292         20       PCB 155       360, 290         21       o,p*-DDE       246, 318         22       cis-Heptachlor epoxide       183, 353         23       PCB 101       326, 256         24       trans-Heptachlor epoxide       81, 353         25       trans-Chlordane       373, 237         26       cis-Chlordane       373, 237         26       cis-Chlordane       373, 237         27       Fluoranthene       202         28       p,p*-DDE       246, 318         29       Endosulfan I       137, 77         30       o,p*-DDD       235, 165         31       Pyrene       202         32       PCB 149       360, 180         33       o,p*-DDT		Phenanthrene	178	
12 PCB 28   186, 256   13 β-HCH   219, 183   14 PCB 20   186, 256   15 Heptachlor   272, 100   16 γ-HCH   183, 219   17 PCB 52   292, 220   18 Aldrin   66, 263   19 PCB 44   220, 292   20 PCB 155   360, 290   246, 318   22 cis-Heptachlor epoxide   183, 353   23 PCB 101   326, 256   24 trans-Heptachlor epoxide   81, 353   25 trans-Chlordane   373, 237   26 cis-Chlordane   373, 237   27 Fluoranthene   202   28 p.p'-DDE   246, 318   29 Endosulfan I   137, 77   30 o.p'-DDD   235, 165   360, 180   330   30, p'-DDT   235, 165   360, 290   370, 270				
13         β-HCH         219, 183           14         PCB 20         186, 256           15         Heptachlor         272, 100           16         γ-HCH         183, 219           17         PCB 52         292, 220           18         Aldrin         66, 263           19         PCB 44         220, 292           20         PCB 155         360, 290           21         o.p'-DDE         246, 318           22         cis-Heptachlor epoxide         183, 353           23         PCB 101         326, 256           24         trans-Chlordane         373, 237           25         trans-Chlordane         373, 237           26         cis-Chlordane         373, 237           27         Fluoranthene         202           28         p.p'-DDE         246, 318           29         Endosulfan I         137, 77           30         o.p'-DDD         235, 165           31         Pyrene         202           32         PCB 149         360, 180           33         o.p'-DDT         235, 165           34         PCB 18         326, 254           35				
14         PCB 20         186, 256           15         Heptachlor         272, 100           16         y-HCH         183, 219           17         PCB 52         292, 220           18         Aldrin         66, 263           19         PCB 44         220, 292           20         PCB 155         360, 290           21         o,p'-DDE         246, 318           22         cis-Heptachlor epoxide         183, 353           23         PCB 101         326, 256           24         trans-Heptachlor epoxide         81, 353           25         trans-Heptachlor epoxide         81, 353           25         trans-Heptachlor epoxide         81, 353           26         cis-Chlordane         373, 237           26         cis-Chlordane         373, 237           27         Fluoranthene         202           28         p,p'-DDE         246, 318           29         Endosulfan I         137, 77           30         o,p'-DDD         235, 165           31         Pyrene         202           32         PCB 149         360, 180           33         o,p'-DDT         235, 165				
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17         PCB 52         292, 220           18         Aldrin         66, 263           19         PCB 44         220, 292           20         PCB 155         360, 290           21         o,p'-DDE         246, 318           22         cis-Heptachlor epoxide         183, 353           23         PCB 101         326, 256           24         trans-Heptachlor epoxide         81, 353           25         trans-Chlordane         373, 237           26         cis-Chlordane         373, 237           27         Fluoranthene         202           28         p,p'-DDE         246, 318           29         Endosulfan I         137, 77           30         o,p'-DDD         235, 165           31         Pyrene         202           32         PCB 149         360, 180           33         o,p'-DDT         235, 165           34         PCB 118         326, 254           35         Dieldrin         79, 137           36         PCB 153         360, 290           37         PCB 153         360, 290           41         PCB 163         360, 290		Heptachlor	272, 100	
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22         cis-Heptachlor epoxide         183, 353           23         PCB 101         326, 256           24         trans-Heptachlor epoxide         81, 353           25         trans-Chlordane         373, 237           26         cis-Chlordane         373, 237           27         Fluoranthene         202           28         p.p'-DDE         246, 318           29         Endosulfan I         137, 77           30         o.p'-DDD         235, 165           31         Pyrene         202           32         PCB 149         360, 180           33         o.p'-DDT         235, 165           34         PCB 118         326, 254           35         Dieldrin         79, 137           36         PCB 153         360, 290           37         PCB 105         326, 254           38         Endrin         137, 77           39         p.p'-DDD         235, 165           40         PCB 138         360, 290           41         PCB 163         360, 290           42         p.p'-DDT         235, 165           43         Endosulfan II         137, 77				
23       PCB 101       326, 256         24       trans-Heptachlor epoxide       81, 353         25       trans-Chlordane       373, 237         26       cis-Chlordane       373, 237         27       Fluoranthene       202         28       p,p'-DDE       246, 318         29       Endosulfan I       137, 77         30       o,p'-DDD       235, 165         31       Pyrene       202         32       PCB 149       360, 180         33       o,p'-DDT       235, 165         34       PCB 118       326, 254         35       Dieldrin       79, 137         36       PCB 153       360, 290         37       PCB 105       326, 254         38       Endrin       137, 77         39       p,p'-DDD       235, 165         40       PCB 138       360, 290         41       PCB 163       360, 290         42       p,p'-DDT       235, 165         43       Endosulfan II       137, 77         44       Methoxychlor       227         45       PCB 180       394, 324         46       Endrinaldehyde <td< td=""><td>21</td><td>-</td><td></td></td<>	21	-		
24       trans-Heptachlor epoxide       81, 353         25       trans-Chlordane       373, 237         26       cis-Chlordane       373, 237         27       Fluoranthene       202         28       p.p'-DDE       246, 318         29       Endosulfan I       137, 77         30       o.p'-DDD       235, 165         31       Pyrene       202         32       PCB 149       360, 180         33       o.p'-DDT       235, 165         34       PCB 118       326, 254         35       Dieldrin       79, 137         36       PCB 153       360, 290         37       PCB 105       326, 254         38       Endrin       137, 77         39       p.p'-DDD       235, 165         40       PCB 138       360, 290         41       PCB 163       360, 290         42       p.p'-DDT       235, 165         43       Endosulfan II       137, 77         44       Methoxychlor       227         45       PCB 180       394, 324         46       Endrinaldehyde       67, 345         47       PCB 170				
25       trans-Chlordane       373, 237         26       cis-Chlordane       373, 237         27       Fluoranthene       202         28       p.p'-DDE       246, 318         29       Endosulfan I       137, 77         30       o.p'-DDD       235, 165         31       Pyrene       202         32       PCB 149       360, 180         33       o.p'-DDT       235, 165         34       PCB 118       326, 254         35       Dieldrin       79, 137         36       PCB 153       360, 290         37       PCB 105       326, 254         38       Endrin       137, 77         39       p.p'-DDD       235, 165         40       PCB 138       360, 290         41       PCB 163       360, 290         42       p.p'-DDT       235, 165         43       Endosulfan II       137, 77         44       Methoxychlor       227         45       PCB 180       394, 324         46       Endrinaldehyde       67, 345         47       PCB 170       394, 324         48       Benz[a]anthracene       228 <td></td> <td></td> <td>326, 256</td>			326, 256	
26         cis-Chlordane         373, 237           27         Fluoranthene         202           28         p.p'-DDE         246, 318           29         Endosulfan I         137, 77           30         o.p'-DDD         235, 165           31         Pyrene         202           32         PCB 149         360, 180           33         o.p'-DDT         235, 165           34         PCB 118         326, 254           35         Dieldrin         79, 137           36         PCB 153         360, 290           37         PCB 105         326, 254           38         Endrin         137, 77           39         p.p'-DDD         235, 165           40         PCB 138         360, 290           41         PCB 163         360, 290           42         p.p'-DDT         235, 165           43         Endosulfan II         137, 77           44         Methoxychlor         227           45         PCB 180         394, 324           46         Endrinaldehyde         67, 345           47         PCB 170         394, 324           48         Benz[	24	trans-Heptachlor epoxide	81, 353	
27       Fluoranthene       202         28       p,p'-DDE       246, 318         29       Endosulfan I       137, 77         30       o,p'-DDD       235, 165         31       Pyrene       202         32       PCB 149       360, 180         33       o,p'-DDT       235, 165         34       PCB 118       326, 254         35       Dieldrin       79, 137         36       PCB 153       360, 290         37       PCB 105       326, 254         38       Endrin       137, 77         39       p,p'-DDD       235, 165         40       PCB 138       360, 290         41       PCB 163       360, 290         42       p,p'-DDT       235, 165         43       Endosulfan II       137, 77         44       Methoxychlor       227         45       PCB 180       394, 324         46       Endrinaldehyde       67, 345         47       PCB 170       394, 324         48       Benz[a]anthracene       228         50       Endosulfan sulfate       272, 387         51       PCB 194       430, 358	25	trans-Chlordane	373, 237	
28         p,p'-DDE         246, 318           29         Endosulfan I         137, 77           30         o,p'-DDD         235, 165           31         Pyrene         202           32         PCB 149         360, 180           33         o,p'-DDT         235, 165           34         PCB 118         326, 254           35         Dieldrin         79, 137           36         PCB 153         360, 290           37         PCB 105         326, 254           38         Endrin         137, 77           39         p,p'-DDD         235, 165           40         PCB 138         360, 290           41         PCB 163         360, 290           42         p,p'-DDT         235, 165           43         Endosulfan II         137, 77           44         Methoxychlor         227           45         PCB 180         394, 324           46         Endrinaldehyde         67, 345           47         PCB 170         394, 324           48         Benz[a]anthracene         228           50         Endosulfan sulfate         272, 387           51	26	cis-Chlordane	373, 237	
29       Endosulfan I       137, 77         30       o,p'-DDD       235, 165         31       Pyrene       202         32       PCB 149       360, 180         33       o,p'-DDT       235, 165         34       PCB 118       326, 254         35       Dieldrin       79, 137         36       PCB 153       360, 290         37       PCB 105       326, 254         38       Endrin       137, 77         39       p,p'-DDD       235, 165         40       PCB 138       360, 290         41       PCB 163       360, 290         42       p,p'-DDT       235, 165         43       Endosulfan II       137, 77         44       Methoxychlor       227         45       PCB 180       394, 324         46       Endrinaldehyde       67, 345         47       PCB 170       394, 324         48       Benz[a]anthracene       228         50       Endosulfan sulfate       272, 387         51       PCB 194       430, 358         52       Benzo[b]fluoranthene       252         53       Benzo[a]pyrene	27	Fluoranthene	202	
30       o,p'-DDD       235, 165         31       Pyrene       202         32       PCB 149       360, 180         33       o,p'-DDT       235, 165         34       PCB 118       326, 254         35       Dieldrin       79, 137         36       PCB 153       360, 290         37       PCB 105       326, 254         38       Endrin       137, 77         39       p,p'-DDD       235, 165         40       PCB 138       360, 290         41       PCB 163       360, 290         42       p,p'-DDT       235, 165         43       Endosulfan II       137, 77         44       Methoxychlor       227         45       PCB 180       394, 324         46       Endrinaldehyde       67, 345         47       PCB 170       394, 324         48       Benz[a]anthracene       228         50       Endosulfan sulfate       272, 387         51       PCB 194       430, 358         52       Benzo[b]fluoranthene       252         53       Benzo[a]pyrene       252         54       Benzo[a]pyrene       25	-	p,p'-DDE	246, 318	
31       Pyrene       202         32       PCB 149       360, 180         33       o,p'-DDT       235, 165         34       PCB 118       326, 254         35       Dieldrin       79, 137         36       PCB 153       360, 290         37       PCB 105       326, 254         38       Endrin       137, 77         39       p,p'-DDD       235, 165         40       PCB 138       360, 290         41       PCB 163       360, 290         42       p,p'-DDT       235, 165         43       Endosulfan II       137, 77         44       Methoxychlor       227         45       PCB 180       394, 324         46       Endrinaldehyde       67, 345         47       PCB 170       394, 324         48       Benz[a]anthracene       228         49       Chrysene       228         50       Endosulfan sulfate       272, 387         51       PCB 194       430, 358         52       Benzo[b]fluoranthene       252         53       Benzo[a]pyrene       252         54       Benzo[a]pyrene       252 <td>29</td> <td>Endosulfan I</td> <td>137, 77</td>	29	Endosulfan I	137, 77	
32       PCB 149       360, 180         33       o,p'-DDT       235, 165         34       PCB 118       326, 254         35       Dieldrin       79, 137         36       PCB 153       360, 290         37       PCB 105       326, 254         38       Endrin       137, 77         39       p,p'-DDD       235, 165         40       PCB 138       360, 290         41       PCB 163       360, 290         42       p,p'-DDT       235, 165         43       Endosulfan II       137, 77         44       Methoxychlor       227         45       PCB 180       394, 324         46       Endrinaldehyde       67, 345         47       PCB 170       394, 324         48       Benz[a]anthracene       228         49       Chrysene       228         50       Endosulfan sulfate       272, 387         51       PCB 194       430, 358         52       Benzo[b]fluoranthene       252         53       Benzo[k]fluoranthene       252         54       Benzo[a]pyrene       252         55       Indeno[1,2,3-c,d]pyrene	30	o,p'-DDD	235, 165	
33       o,p'-DDT       235, 165         34       PCB 118       326, 254         35       Dieldrin       79, 137         36       PCB 153       360, 290         37       PCB 105       326, 254         38       Endrin       137, 77         39       p,p'-DDD       235, 165         40       PCB 138       360, 290         41       PCB 163       360, 290         42       p,p'-DDT       235, 165         43       Endosulfan II       137, 77         44       Methoxychlor       227         45       PCB 180       394, 324         46       Endrinaldehyde       67, 345         47       PCB 170       394, 324         48       Benz[a]anthracene       228         49       Chrysene       228         50       Endosulfan sulfate       272, 387         51       PCB 194       430, 358         52       Benzo[b]fluoranthene       252         53       Benzo[k]fluoranthene       252         54       Benzo[a]pyrene       252         55       Indeno[1,2,3-c,d]pyrene       276	31	Pyrene	202	
34       PCB 118       326, 254         35       Dieldrin       79, 137         36       PCB 153       360, 290         37       PCB 105       326, 254         38       Endrin       137, 77         39       p,p'-DDD       235, 165         40       PCB 138       360, 290         41       PCB 163       360, 290         42       p,p'-DDT       235, 165         43       Endosulfan II       137, 77         44       Methoxychlor       227         45       PCB 180       394, 324         46       Endrinaldehyde       67, 345         47       PCB 170       394, 324         48       Benz[a]anthracene       228         49       Chrysene       228         50       Endosulfan sulfate       272, 387         51       PCB 194       430, 358         52       Benzo[b]fluoranthene       252         53       Benzo[k]fluoranthene       252         54       Benzo[a]pyrene       252         55       Indeno[1,2,3-c,d]pyrene       276	32	PCB 149	360, 180	
35         Dieldrin         79, 137           36         PCB 153         360, 290           37         PCB 105         326, 254           38         Endrin         137, 77           39         p,p'-DDD         235, 165           40         PCB 138         360, 290           41         PCB 163         360, 290           42         p,p'-DDT         235, 165           43         Endosulfan II         137, 77           44         Methoxychlor         227           45         PCB 180         394, 324           46         Endrinaldehyde         67, 345           47         PCB 170         394, 324           48         Benz[a]anthracene         228           49         Chrysene         228           50         Endosulfan sulfate         272, 387           51         PCB 194         430, 358           52         Benzo[b]fluoranthene         252           53         Benzo[k]fluoranthene         252           54         Benzo[a]pyrene         252           55         Indeno[1,2,3-c,d]pyrene         278           56         Dibenz[a,h]anthracene         276 <td>33</td> <td>o,p'-DDT</td> <td>235, 165</td>	33	o,p'-DDT	235, 165	
36         PCB 153         360, 290           37         PCB 105         326, 254           38         Endrin         137, 77           39         p,p'-DDD         235, 165           40         PCB 138         360, 290           41         PCB 163         360, 290           42         p,p'-DDT         235, 165           43         Endosulfan II         137, 77           44         Methoxychlor         227           45         PCB 180         394, 324           46         Endrinaldehyde         67, 345           47         PCB 170         394, 324           48         Benz[a]anthracene         228           49         Chrysene         228           50         Endosulfan sulfate         272, 387           51         PCB 194         430, 358           52         Benzo[b]fluoranthene         252           53         Benzo[k]fluoranthene         252           54         Benzo[a]pyrene         252           55         Indeno[1,2,3-c,d]pyrene         276           56         Dibenz[a,h]anthracene         276	34	PCB 118	326, 254	
37       PCB 105       326, 254         38       Endrin       137, 77         39       p,p'-DDD       235, 165         40       PCB 138       360, 290         41       PCB 163       360, 290         42       p,p'-DDT       235, 165         43       Endosulfan II       137, 77         44       Methoxychlor       227         45       PCB 180       394, 324         46       Endrinaldehyde       67, 345         47       PCB 170       394, 324         48       Benz[a]anthracene       228         49       Chrysene       228         50       Endosulfan sulfate       272, 387         51       PCB 194       430, 358         52       Benzo[b]fluoranthene       252         53       Benzo[k]fluoranthene       252         54       Benzo[a]pyrene       252         55       Indeno[1,2,3-c,d]pyrene       276         56       Dibenz[a,h]anthracene       276	35	Dieldrin	79, 137	
38       Endrin       137, 77         39       p,p'-DDD       235, 165         40       PCB 138       360, 290         41       PCB 163       360, 290         42       p,p'-DDT       235, 165         43       Endosulfan II       137, 77         44       Methoxychlor       227         45       PCB 180       394, 324         46       Endrinaldehyde       67, 345         47       PCB 170       394, 324         48       Benz[a]anthracene       228         49       Chrysene       228         50       Endosulfan sulfate       272, 387         51       PCB 194       430, 358         52       Benzo[b]fluoranthene       252         53       Benzo[k]fluoranthene       252         54       Benzo[a]pyrene       252         55       Indeno[1,2,3-c,d]pyrene       278         56       Dibenz[a,h]anthracene       276	36	PCB 153	360, 290	
39         p,p'-DDD         235, 165           40         PCB 138         360, 290           41         PCB 163         360, 290           42         p,p'-DDT         235, 165           43         Endosulfan II         137, 77           44         Methoxychlor         227           45         PCB 180         394, 324           46         Endrinaldehyde         67, 345           47         PCB 170         394, 324           48         Benz[a]anthracene         228           49         Chrysene         228           50         Endosulfan sulfate         272, 387           51         PCB 194         430, 358           52         Benzo[b]fluoranthene         252           53         Benzo[k]fluoranthene         252           54         Benzo[a]pyrene         252           55         Indeno[1,2,3-c,d]pyrene         278           56         Dibenz[a,h]anthracene         276	37	PCB 105	326, 254	
40       PCB 138       360, 290         41       PCB 163       360, 290         42       p,p'-DDT       235, 165         43       Endosulfan II       137, 77         44       Methoxychlor       227         45       PCB 180       394, 324         46       Endrinaldehyde       67, 345         47       PCB 170       394, 324         48       Benz[a]anthracene       228         49       Chrysene       228         50       Endosulfan sulfate       272, 387         51       PCB 194       430, 358         52       Benzo[b]fluoranthene       252         53       Benzo[k]fluoranthene       252         54       Benzo[a]pyrene       252         55       Indeno[1,2,3-c,d]pyrene       278         56       Dibenz[a,h]anthracene       276	38	Endrin	137, 77	
41       PCB 163       360, 290         42       p,p'-DDT       235, 165         43       Endosulfan II       137, 77         44       Methoxychlor       227         45       PCB 180       394, 324         46       Endrinaldehyde       67, 345         47       PCB 170       394, 324         48       Benz[a]anthracene       228         49       Chrysene       228         50       Endosulfan sulfate       272, 387         51       PCB 194       430, 358         52       Benzo[b]fluoranthene       252         53       Benzo[k]fluoranthene       252         54       Benzo[a]pyrene       252         55       Indeno[1,2,3-c,d]pyrene       278         56       Dibenz[a,h]anthracene       276	39	p,p'-DDD	235, 165	
42     p,p'-DDT     235, 165       43     Endosulfan II     137, 77       44     Methoxychlor     227       45     PCB 180     394, 324       46     Endrinaldehyde     67, 345       47     PCB 170     394, 324       48     Benz[a]anthracene     228       49     Chrysene     228       50     Endosulfan sulfate     272, 387       51     PCB 194     430, 358       52     Benzo[b]fluoranthene     252       53     Benzo[k]fluoranthene     252       54     Benzo[a]pyrene     252       55     Indeno[1,2,3-c,d]pyrene     278       56     Dibenz[a,h]anthracene     276	40	PCB 138	360, 290	
43       Endosulfan II       137, 77         44       Methoxychlor       227         45       PCB 180       394, 324         46       Endrinaldehyde       67, 345         47       PCB 170       394, 324         48       Benz[a]anthracene       228         49       Chrysene       228         50       Endosulfan sulfate       272, 387         51       PCB 194       430, 358         52       Benzo[b]fluoranthene       252         53       Benzo[k]fluoranthene       252         54       Benzo[a]pyrene       252         55       Indeno[1,2,3-c,d]pyrene       278         56       Dibenz[a,h]anthracene       276	41	PCB 163	360, 290	
44       Methoxychlor       227         45       PCB 180       394, 324         46       Endrinaldehyde       67, 345         47       PCB 170       394, 324         48       Benz[a]anthracene       228         49       Chrysene       228         50       Endosulfan sulfate       272, 387         51       PCB 194       430, 358         52       Benzo[b]fluoranthene       252         53       Benzo[k]fluoranthene       252         54       Benzo[a]pyrene       252         55       Indeno[1,2,3-c,d]pyrene       278         56       Dibenz[a,h]anthracene       276	42	p,p'-DDT	235, 165	
45     PCB 180     394, 324       46     Endrinaldehyde     67, 345       47     PCB 170     394, 324       48     Benz[a]anthracene     228       49     Chrysene     228       50     Endosulfan sulfate     272, 387       51     PCB 194     430, 358       52     Benzo[b]fluoranthene     252       53     Benzo[k]fluoranthene     252       54     Benzo[a]pyrene     252       55     Indeno[1,2,3-c,d]pyrene     278       56     Dibenz[a,h]anthracene     276	43	Endosulfan II	137, 77	
46         Endrinaldehyde         67, 345           47         PCB 170         394, 324           48         Benz[a]anthracene         228           49         Chrysene         228           50         Endosulfan sulfate         272, 387           51         PCB 194         430, 358           52         Benzo[b]fluoranthene         252           53         Benzo[k]fluoranthene         252           54         Benzo[a]pyrene         252           55         Indeno[1,2,3-c,d]pyrene         278           56         Dibenz[a,h]anthracene         276	44	Methoxychlor	227	
47         PCB 170         394, 324           48         Benz[a]anthracene         228           49         Chrysene         228           50         Endosulfan sulfate         272, 387           51         PCB 194         430, 358           52         Benzo[b]fluoranthene         252           53         Benzo[k]fluoranthene         252           54         Benzo[a]pyrene         252           55         Indeno[1,2,3-c,d]pyrene         278           56         Dibenz[a,h]anthracene         276	45	PCB 180	394, 324	
48       Benz[a]anthracene       228         49       Chrysene       228         50       Endosulfan sulfate       272, 387         51       PCB 194       430, 358         52       Benzo[b]fluoranthene       252         53       Benzo[k]fluoranthene       252         54       Benzo[a]pyrene       252         55       Indeno[1,2,3-c,d]pyrene       278         56       Dibenz[a,h]anthracene       276	46	Endrinaldehyde	67, 345	
49         Chrysene         228           50         Endosulfan sulfate         272, 387           51         PCB 194         430, 358           52         Benzo[b]fluoranthene         252           53         Benzo[k]fluoranthene         252           54         Benzo[a]pyrene         252           55         Indeno[1,2,3-c,d]pyrene         278           56         Dibenz[a,h]anthracene         276	47	PCB 170	394, 324	
50         Endosulfan sulfate         272, 387           51         PCB 194         430, 358           52         Benzo[b]fluoranthene         252           53         Benzo[k]fluoranthene         252           54         Benzo[a]pyrene         252           55         Indeno[1,2,3-c,d]pyrene         278           56         Dibenz[a,h]anthracene         276	48	Benz[a]anthracene	228	
51       PCB 194       430, 358         52       Benzo[b]fluoranthene       252         53       Benzo[k]fluoranthene       252         54       Benzo[a]pyrene       252         55       Indeno[1,2,3-c,d]pyrene       278         56       Dibenz[a,h]anthracene       276	49	Chrysene	228	
52         Benzo[b]fluoranthene         252           53         Benzo[k]fluoranthene         252           54         Benzo[a]pyrene         252           55         Indeno[1,2,3-c,d]pyrene         278           56         Dibenz[a,h]anthracene         276	50	Endosulfan sulfate	272, 387	
52         Benzo[b]fluoranthene         252           53         Benzo[k]fluoranthene         252           54         Benzo[a]pyrene         252           55         Indeno[1,2,3-c,d]pyrene         278           56         Dibenz[a,h]anthracene         276	51		430, 358	
53         Benzo[k]fluoranthene         252           54         Benzo[a]pyrene         252           55         Indeno[1,2,3-c,d]pyrene         278           56         Dibenz[a,h]anthracene         276	52	Benzo[b]fluoranthene		
54         Benzo[a]pyrene         252           55         Indeno[1,2,3-c,d]pyrene         278           56         Dibenz[a,h]anthracene         276	53		252	
55         Indeno[1,2,3-c,d]pyrene         278           56         Dibenz[a,h]anthracene         276				
56 Dibenz[a,h]anthracene 276	55			
	56		276	

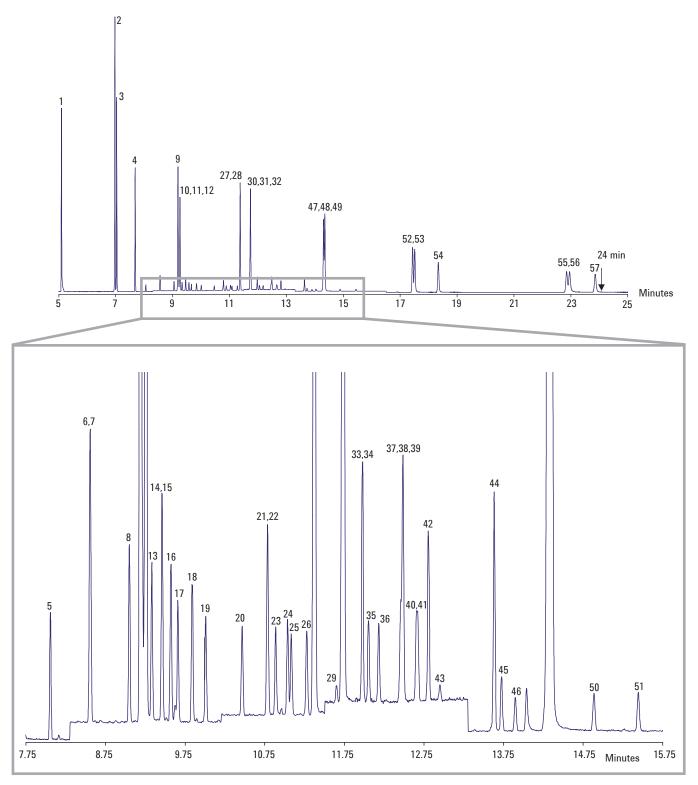


Figure 1. Total ion chromatogram (TIC) multi-residue analysis on a VF-200ms column

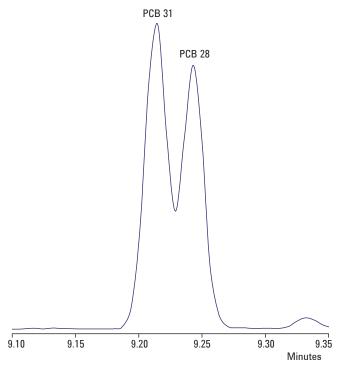


Figure 2. Selected ion chromatogram (m/z 256) of PCB 28/PCB 31

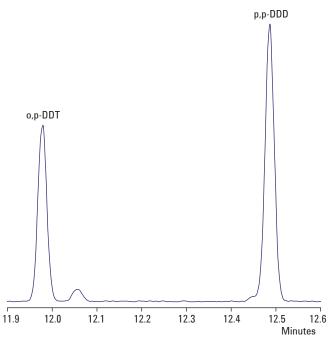


Figure 4. Separation of p,p'-DDD/o,p'-DDT (m/z 235)

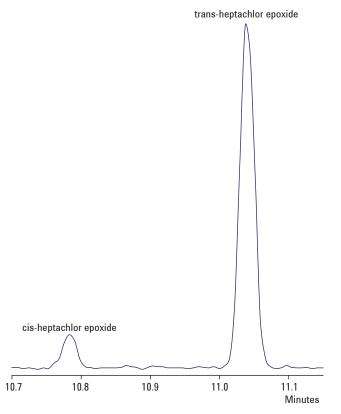


Figure 3. Selected ion chromatogram (m/z 353) of cis-heptachlor epoxide/trans-heptachlor epoxide

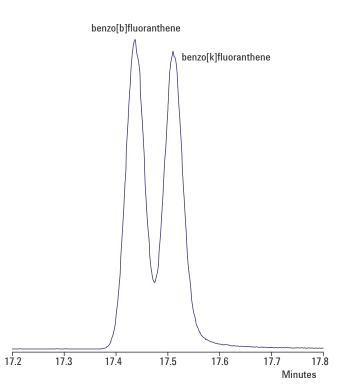


Figure 5. Separation of benzo[b]fluoranthene/benzo[k]fluoranthene (TIC)

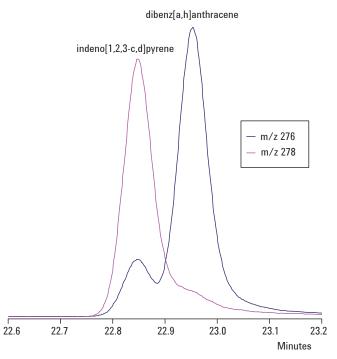


Figure 6. Selected ion chromatogram (m/z 276 and 278) of indeno-[1,2,3-c,d]pyrene and dibenz[a,h]anthracene

# **Conclusion**

A J&W FactorFour VF-200ms column and optimized oven program delivered a multi-residue analysis of 57 environmental pollutants in 24 minutes. The VF-200ms column has a unique selectivity for polar compounds and is especially suited to electron rich, high dipole moment compounds, such as PAHs and chloro-containing molecules.

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