## REFERENCES


1. K. Kruawal, F. Sacher, A. Werner, J. Müller and T. P. Knepper, "Chemical water quality in Thailand and its impacts on the drinking water production in Thailand", *Sci. Total Environ.*, 2005, **340**, 57-70.
2. S. D. Richardson, "Water analysis: Emerging contaminants and current issues", *Anal. Chem.*, 2003, **75**, 2831-2857.
3. M. Petrović, S. Gonzalez and D. Barceló, "Analysis and removal of emerging contaminants in wastewater and drinking water", *Trends Anal. Chem.*, 2003, **22**, 685-696.
4. S. D. Richardson, "Disinfection by-products and other emerging contaminants in drinking water", *Trends Anal. Chem.*, 2003, **22**, 666-684.
5. W. R. Kusamran, N. Tanthasri, N. Meesiripan and A. Tepsuwan, "Mutagenicity of the drinking water supply in Bangkok", *Asian Pacific J. Cancer Prev.*, 2003, **4**, 31-38.
6. B. Panyapinyopol, T. F. Marhaba, V. Kanokkantapong and P. Pavasant, "Characterization of precursors to trihalomethanes formation in Bangkok source water", *J. Hazard. Mater.*, 2005, **B120**, 229-236.
7. H. Weinberg, "Disinfection by-products in drinking water: The analytical challenge", *Anal. Chem.*, 1999, **71**, 801A-808A.
8. World Health Organization (WHO), *Environmental health criteria 216: Disinfectants and disinfection by-products*, Geneva: WHO, 2000.
9. C. M. Villanueva, F. Fernández, N. Malats, J. O. Grimalt and M. Kogevinas, "Meta-analysis of studies on individual consumption of chlorinated drinking water and bladder cancer", *J. Epidemiol. Community Health*, 2003, **57**, 166-173.
10. R. D. Morris, "Drinking water and cancer", *Environ. Health Perspect.*, 1995, **103(S8)**, 225-231.
11. R. D. Morris, A. M. Audet, I. F. Angelillo, T. C. Chalmers and F. Mostelles, "Chlorination, chlorination by-products, and cancer: a meta-analysis", *Am. J. Public Health*, 1992, **82**, 955-963.
12. United States Environmental Protection Agency (US EPA), "National primary drinking regulations: Disinfectants and disinfection byproducts; Final Rule", *Fed. Regist.*, 1998, **63**, 69390-69476.

13. Official Journal of the European Communities, Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption.

14. World Health Organization (WHO), *Guidelines for Drinking-water Quality*, 3rd edition, vol. 1, Geneva: WHO, 2004.

15. A. Nikolaou, S. Golfinopoulos, L. Rizzo, G. Lofrano, T. Lekkas and V. Belgiorno, Optimization of analytical methods for the determination of DBPs: Application to drinking water from Greece and Italy", *Desalination*, 2005, **176**, 25-36.

16. L. Liang and P. C. Singer, "Factors influencing the formation and relative distribution of haloacetic acids and trihalomethanes in drinking water", *Environ. Sci. Technol.*, 2003, **37**, 2920-2928.

17. D. T. Williams, G. L. LeBel and F. M. Benoit, "Disinfection by-products in Canadian drinking water", *Chemosphere*, 1997, **34**, 299-316.

18. M. M. Domino, B. V. Pepich, D. J. Munch and P. S. Fair, "Optimizing the determination of haloacetic acids in drinking waters", *J. Chromatogr. A*, 2004, **1035**, 9-16.

19. M. Carpi and C. Zufall, "GC analysis of trihalomethanes in drinking water - A rapid and direct quantitative method", *LC·GC N. Am.*, 2003, **21**, 60-66.

20. I. F. M. M. Temmerman and D. J. M. Quaghebeur, "Analysis of trihalomethanes by direct aqueous injection THM-DAI", *J. High Resolut. Chromatogr.*, 1990, **13**, 379-381.

21. S. Onodera, C. Siriwong and M. Tabucanon, "Comparison of methods for determination of trihalomethanes in drinking water", *J. Sci. Soc. Thailand*, 1984, **10**, 221-237.

22. E. A. Dietz, Jr. and K. F. Singley, "Determination of chlorinated hydrocarbons in water by headspace gas chromatography", *Anal. Chem.*, 1979, **51**, 1809-1814.

23. Y. H. Wang and P. K. Wong, "Determination of dichloroacetic acid and trichloroacetic acid in drinking water by acidic methanol esterification and headspace gas chromatography", *Water Res.*, 2005, **39**, 1844-1848.

24. P. L. Neitzel, W. Walther and W. Nestler, "In-situ methylation of strongly polar organic acids in natural waters supported by ion-pairing agents for headspace GC-MSD analysis", *Fresenius' J. Anal. Chem.*, 1998, **361**, 318-323.

25. L. Zoccolillo, L. Amendola, C. Cafaro and S. Insogna, "Improved analysis of volatile halogenated hydrocarbons in water by purge and trap with gas chromatography and mass spectrometric detection", *J. Chromatogr. A*, 2005, **1077**, 181-187.

26. L. Lépine and J. -F Archambult, "Parts-per-trillion determination of trihalomethanes in water by purge and trap gas chromatography with electron capture detection", *Anal. Chem.*, 1992, **64**, 810-814.

27. D. -H. Cho, S. -H. Kong and S. -G. Oh, "Analysis of trihalomethanes in drinking water using headspace-SPME technique with gas chromatography", *Water Res.*, 2003, **37**, 402-408.

28. M. A. Stack, G. Fitzgerald, S. O'Connell and K. J. James, "Measurement of trihalomethanes in potable and recreational waters using solid phase microextraction with gas chromatography-mass spectrometry", *Chemosphere*, 2000, **41**, 1821-1826.

29. F. Wu, W. Gabryelski and K. Froese, "Improved gas chromatography methods for micro-volume analysis of haloacetic acids in water and biological matrices", *Analyst*, 2002, **127**, 1318-1323.

30. M. N. Sarrión, F. J. Santos and M. T. Galceran, "Solid-phase extraction coupled with gas chromatography-ion trap mass spectrometry for the analysis of haloacetic acids in water", *J. Chromatogr. A*, 1999, **859**, 159-171.

31. M. N. Sarrión, F. J. Santos and M. T. Galceran, "In situ derivatization/solid-phase microextraction for the determination of haloacetic acids in water", *Anal. Chem.*, 2000, **72**, 4865-4873.

32. B. Aikawa and R. C. Burk, "Determination of chlorinated acetic acids in drinking water by in-situ derivatization and solid phase microextraction", *Int. J. Environ. Anal. Chem.*, 1997, **66**, 215-224.

33. E. T. Urbansky, "Techniques and methods for the determination of haloacetic acids in potable water", *J. Environ. Monit.*, 2000, **2**, 285-291.

34. J. -X. Wang, D. -Q. Jiang and X. -P. Yan, "Determination of substituted benzenes in water samples by fiber-in-tube liquid phase microextraction coupled with gas chromatography", *Talanta*, 2006, **68**, 945-950.

35. L. Hou, G. Shen and H. K. Lee, "Automated hollow fiber-protected dynamic liquid-phase microextraction of pesticides for gas chromatography-mass spectrometric analysis", *J. Chromatogr. A*, 2003, **985**, 107-116.

36. J. C. F. Menéndez, M. L. F. Sánchez, J. E. S. Uría, E. F. Martínez and A. Sanz-Medel, "Static headspace, solid-phase microextraction and headspace solid-phase microextraction for BTEX determination in aqueous samples by gas chromatography", *Anal. Chim. Acta*, 2000, **415**, 9-20.

37. T. C. Schmidt, "Analysis of methyl *tert*-butyl ether (MTBE) and *tert*-butyl alcohol (TBA) in ground and surface water", *Trends Anal. Chem.*, 2003, **22**, 776-784.

38. P. Kuráň and L. Soják, "Environmental analysis of volatile organic compounds in water and sediment by gas chromatography", *J. Chromatogr. A*, 1996, **733**, 119-141.

39. R. Otson, D. T. Williams and P. D. Bothwell, "A comparison of dynamic and static head space and solvent extraction techniques for the determination of trihalomethanes in water", *Environ. Sci. Technol.*, 1979, **13**, 936-939.

40. J. Pawliszyn, "New directions in sample preparation for analysis of organic compounds", *Trends Anal. Chem.*, 1995, **14**, 113-122.

41. A. D. Nikolao, T. D. Lekkas, S. K. Golfnopoulos and M. N. Kostopoulou, "Application of difference analytical methods for determination of volatile chlorination by-products in drinking water", *Talanta*, 2002, **56**, 717-726.

42. S. K. Golfnopoulos, T. D. Lekkas and A. D. Nikolao, "Comparision of method for determination of volatile organic compound in drinking water", *Chemosphere*, 2001, **45**, 275-284.

43. C. Dietz, J. Sanz and C. Cámara, "Recent developments in solid-phase microextraction coatings and related techniques", *J. Chromatogr. A*, 2006, **1103**, 183-192.

44. E. Psillakis and N. Kalogerakis, "Application of solvent microextraction to the analysis of nitroaromatic explosives in water samples", *J. Chromatogr. A*, 2001, **907**, 211-219.

45. H. Prosen and L. Zupanćić-Kralj, "Solid-phase microextraction", *Trends Anal. Chem.*, 1999, **18**, 272-282.

46. Y. Li, T. Zhang and P. Liang, "Application of continuous-flow liquid-phase microextraction to the analysis of volatile halohydrocarbons in water", *Anal. Chim. Acta*, 2005, **536**, 245-249.

47. R. -S. Zhoa, W. -J. Lao and X. -B. Xu, "Headspace liquid-phase microextraction of trihalomethanes in drinking water and their gas chromatographic determination", *Talanta*, 2004, **62**, 751-756.

48. B. Buszewski and T. Ligor, "Single-drop extraction versus solid-phase microextraction for the analysis of VOCs in water", *LC·GC Eur.*, 2002, **15**, 2-6.

49. E. Psillakis and N. Kalogerakis, "Developments in single-drop microextraction", *Trends Anal. Chem.*, 2002, **21**, 53-63.

50. G. Shen and H. K. Lee, "Hollow fiber-protected liquid-phase microextraction of triazine herbicides", *Anal. Chem.*, 2002, **74**, 648-654.

51. L. Zhao and H. K. Lee, "Liquid-phase microextraction combined with hollow fiber as a sample preparation technique prior to gas chromatography/mass spectrometry", *Anal. Chem.*, 2002, **74**, 2486-2492.

52. S. Pedersen-Bjergaard and K. E. Rasmussen, "Liquid-liquid-liquid microextraction for sample preparation of biological fluids prior to capillary electrophoresis", *Anal. Chem.*, 1999, **71**, 2650-2656.

53. S. Pedersen-Bjergaard and K. E. Rasmussen, "Liquid-phase microextraction and capillary electrophoresis of acidic drugs", *Electrophoresis*, 2000, **21**, 579-589.

54. T. S. Ho, S. Pedersen-Bjergaard and K. E. Rasmussen, "Liquid-phase microextraction of protein-bound drugs under non-equilibrium conditions", *Analyst*, 2002, **127**, 608–613.

55. S. Pedersen-Bjergaard and K. E. Rasmussen, "Bioanalysis of drugs by liquid-phase microextraction coupled to separation techniques", *J. Chromatogr. B*, 2005, **817**, 3-12.

56. K. E. Rasmussen and S. Pedersen-Bjergaard, "Developments in hollow fiber-based, liquid-phase microextraction", *Trends Anal. Chem.*, 2004, **23**, 1-10.

57. E. Psillakis and N. Kalogerakis, "Developments in liquid-phase microextraction", *Trends Anal. Chem.*, 2003, **22**, 565-574.

58. J. J. Rook, "Formation of haloforms during the chlorination of natural water", *Water Treat. Exam.*, 1974, **23**, 234-243.

59. Y. F. Xie, *Disinfection byproducts in drinking water: Formation, analysis and control*, Florida: Lewis Publishers, 2003.

60. http://www.waterquality.crc.org.au

61. H. Galal-Gorchev, "Chlorine in water disinfection", *Pure Appl. Chem.*, 1996, **68**, 1731-1735.

62. S. D. Richardson, A. D. Thruston, Jr., T. V. Caughran, P. H. Chen, T. W. Collette, K. M. Schenck, B. W. Lykins, Jr., C. Rav-acha and V. Glezer, "Indentification of new drinking water disinfection by-products from ozone, chlorine dioxide, chloramine and chlorine", *Water Air Soil Pollut.*, 2000, **123**, 95-102.

63. R. Sadiq and M. J. Rodriguez, "Disinfection by-products (DBPs) in drinking water and predictive models for their occurrence: a review", *Sci. Total Environ.*, 2004, **321**, 21-46.

64. M. L. Magnuson, E. T. Urbansky, K. M. Schenck and M. S. Elovitz, "Disinfection by-product (DBP) chemistry: Formation and determination", in R. M. Clark and B. K. Boutin Editors, *Controlling disinfection by-products and microbial contaminants in drinking water*, Ohio: US EPA, 2001.

65. J. Gibbons and S. Laha, "Water purification systems: A comparative analysis based on the occurrence of disinfection by-products", *Environ. Pollut.*, 1998, **106**, 425-428.

66. S. D. Richardson, "Drinking water disinfection by-products", in R. A. Meyers Editor, *The encyclopedia of environmental analysis and remediation*, vol. 3, New York: Wiley, 1998.

67. Y. Xie, "Disinfection by-product analysis in drinking water", *Am. Lab.*, 2000, **32**, 50-54.

68. K. Verschueren, *Handbook of environmental data on organic chemicals*, 3rd edition, New York: Van Nostrand Reinhold an International Thomson Publishing Company, 1996.

69. D. R. Lide editor-in-chief, *Handbook of chemistry and physics*, 84th edition, Florida: CRC press LLC, 2003.

70. S. Batterman, L. Zhang, S. Wang and A. Franzblau, "Partition coefficients for the trihalomethanes among blood, urine, water, milk and air", *Sci. Total Environ.*, 2002, **284**, 237-247.

71. M. J. M. Wells, "Principles of extraction and the extraction of semivolatile organics from liquid", in S. Mitra Editor, *Sample preparation techniques in analytical chemistry*, New Jersey: John Wiley & Sons, 2003.

72. United States Environmental Protection Agency (US EPA), "National primary drinking water regulations: Monitoring requirements for public drinking water supplies; Final Rule", *Fed. Regist.*, 1996, **61**, 24353-24388.

73. D. Kou, X. Wang and S. Mitra, "Supported liquid membrane microextraction with high-performance liquid chromatography-UV detection for monitoring trace haloacetic acids in water", *J. Chromatogr. A*, 2004, **1055**, 63-69.

74. C. Sarzanini, M. C. Bruzzoniti and E. Mentasti, "Preconcentration and separation of haloacetic acids by ion chromatography", *J. Chromatogr. A*, 1999, **850**, 197-211.

75. D. Martínez, J. Farré, F. Borrull, M. Calull, J. Ruana and A. Colom, "Capillary zone electrophoresis with indirect UV detection of haloacetic acids in water", *J. Chromatogr. A*, 1998, **808**, 229-236.

76. United States Environmental Protection Agency (US EPA), *Methods and guidance for analysis of water*, US EPA, [CD-ROM].

77. L. S. Clesceri, A. E. Greengerg and A. D. Eaton Editors, *Standard methods for the examination of water and wastewater*, 20$^{th}$ edition, Maryland: United Book Press, 1998.

78. M. R. Rompa, E. Kremer and B. Zygmunt, "Derivatisation in gas chromatographic determination of acidic herbicides in aqueous environmental samples", *Anal. Bioanal. Chem.*, 2003, **377**, 590-599.

79. T. W. G. Solomons and C. B. Fryhle, *Organic Chemistry*, 7$^{th}$ edition, New York: John Wiley & Sons, 2000.

80. H. M. McNair and J. M. Miller, *Basic gas chromatography*, New York: John Wiley & Sons, 1997.

81. S. P. J. Higson, *Analytical Chemistry*, New York: Oxford University Press, 2004.

82. L. Wolska, C. Olszewska, M. Turska, B. Zygmunt and J. Namieśnik, "Volatile and semivolatile organo-halogen trace analysis in surface water by direct aqueous injection GC-ECD", *Chemosphere*, 1998, **37**, 2645-2651.

83. B. Kolb and L. S. Ettre, *Static headspace-gas chromatography theory and practice*, New York: Wiley-VCH, 1997.

84. C. L. Arthur and J. Pawliszyn, "Solid phase microextraction with thermal desorption using fused silica optical fibers", *Anal. Chem.*, 1990, **62**, 2145-2148.

85. M. A. Jeannot and F. F. Cantwell, "Solvent microextraction into a single drop", *Anal. Chem.*, 1996, **68**, 2236-2240.

86. Y. He and H. K. Lee, "Liquid-phase microextraction in a single drop of organic solvent by using a conventional microsyringe", *Anal. Chem.*, 1997, **69**, 4634-4640.

87. T. S. Ho, S. Pedersen-Bjergaard and K. E. Rasmussen, "Recovery, enrichment and selectivity in liquid-phase microextraction comparison with conventional liquid-liquid extraction", *J. Chromatogr. A*, 2002, **963**, 3-17.

88. D. Louch, S. Motlagh, and J. Pawliszyn, "Dynamics of organic compound extraction from water using liquid-coated fused silica fibers", *Anal. Chem.*, 1992, **64**, 1187-1199.

89. Z. Zhang and J. Pawliszyn, "Headspace solid-phase microextraction", *Anal. Chem.*, 1993, **65**, 1843-1852.

90. J. Pawliszyn, *Solid-phase microextraction, Theory and practice*, New York: Wiley-VCH, 1997.

91. T. G. Halvorsen, S. Pedersen-Bjergaard and K. E. Rasmussen, "Reduction of extraction times in liquid-phase microextraction", *J. Chromatogr. B*, 2001, 760, 219-226.

92. L. S. de Jager and A. R. J. Andrews, "Preliminary studies of a fast screening method for cocaine and cocaine metabolites in urine using hollow fiber membrane solvent microextraction (HFMSME)", *Analyst*, 2001, **126**, 1298-1303.

93. A. L. Theis, A. J. Waldack, S. M. Hansen and M. A. Jeannot, "Headspace solvent microextraction", *Anal. Chem.*, 2001, **73**, 5651-5654.

94. M. L. Reyzer and J. S. Brodbelt, "Analysis of fire ant pesticides in water by solid-phase microextraction and gas chromatography/mass spectrometry or high-performance liquid chromatography/mass spectrometry", *Anal. Chim. Acta*, 2001, **436**, 11-20.

95. I. Taverniers, M. D. Loose and E. V. Bockstaele, "Trends in quality in the analytical laboratory. II. Analytical method validation and quality assurance", *Trends Anal. Chem.*, 2004, **23**, 535-552.

96. J. Ai, "Solid phase microextraction for quantitative analysis in nonequilibrium situations", *Anal. Chem.*, 1997, **69**, 1230-1236.

97. H. Bagheri, A. Saber and S. R. Mousavi, "Immersed solvent microextraction of phenol and chlorophenols from water samples followed by gas chromatography - mass spectrometry", *J. Chromatogr. A*, 2004, **1046**, 27–33.

98. Y. Xie, "Analyzing haloacetic acids using gas chromatography/mass spectrometry", *Water Res.*, 2001, **35**, 1599-1602.

99. D. Benanou, F. Acobas and P. Sztajnbok, "Analysis of haloacetic acids in water by a novel technique: simultaneous extraction-derivatization", *Water Res.*, 1998, **32**, 2798-2806.

# APPENDICES

## APPENDIX A

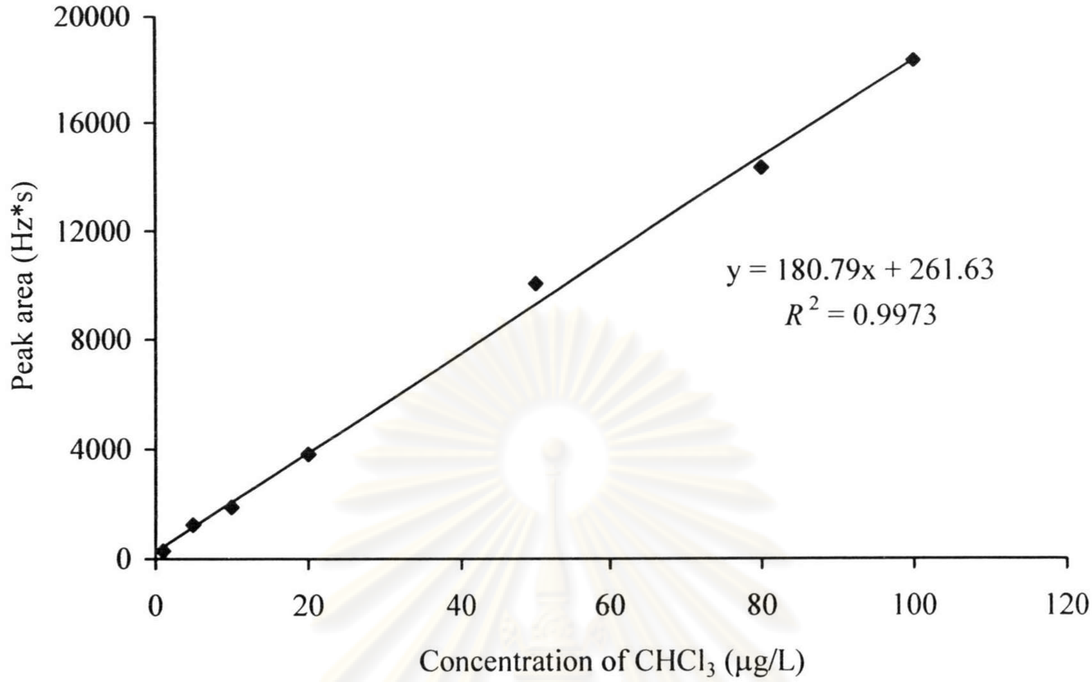


**Figure A-1** The calibration curve of chloroform by condition in Table 3.4.

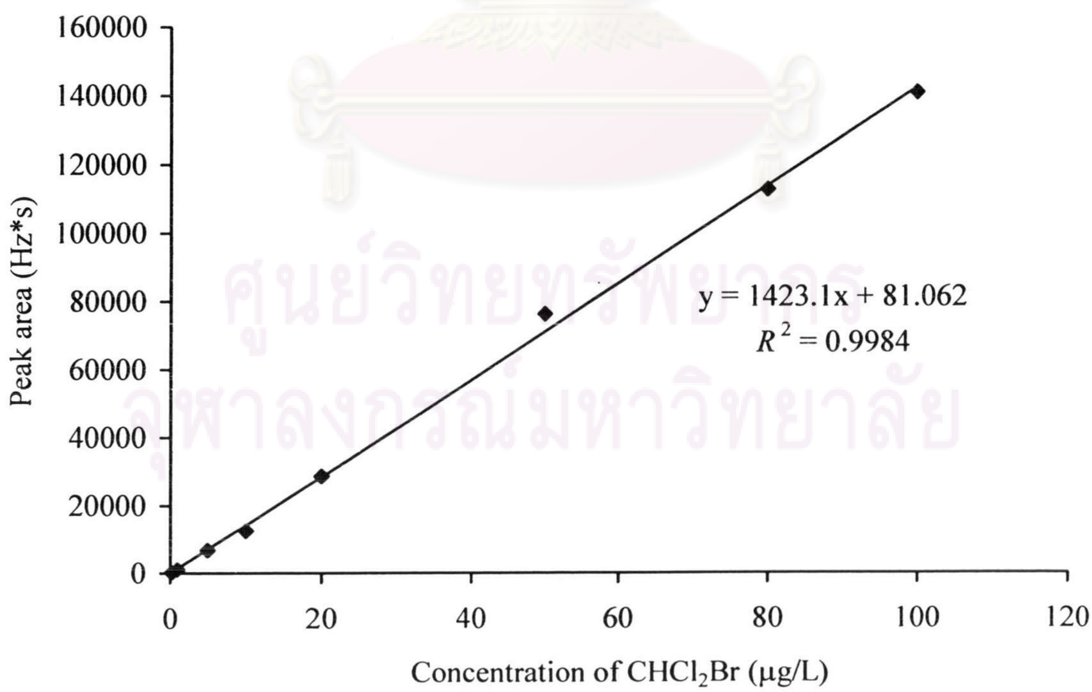


**Figure A-2** The calibration curve of bromodichloromethane by condition in Table 3.4.

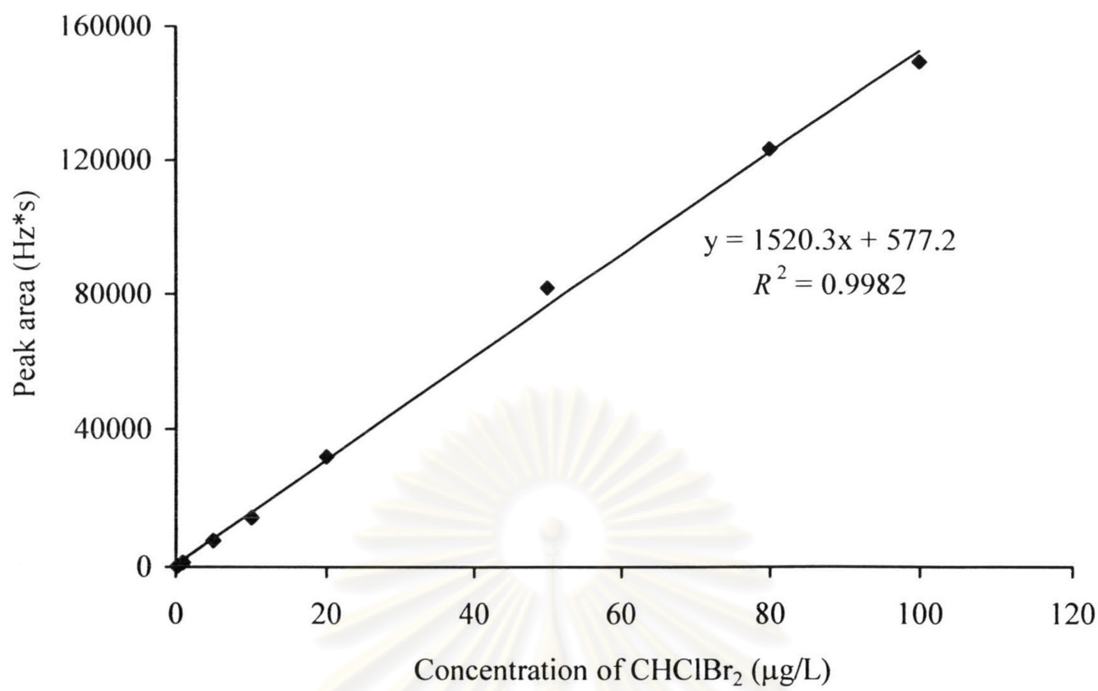


**Figure A-3** The calibration curve of chlorodibromomethane by condition in Table 3.4.

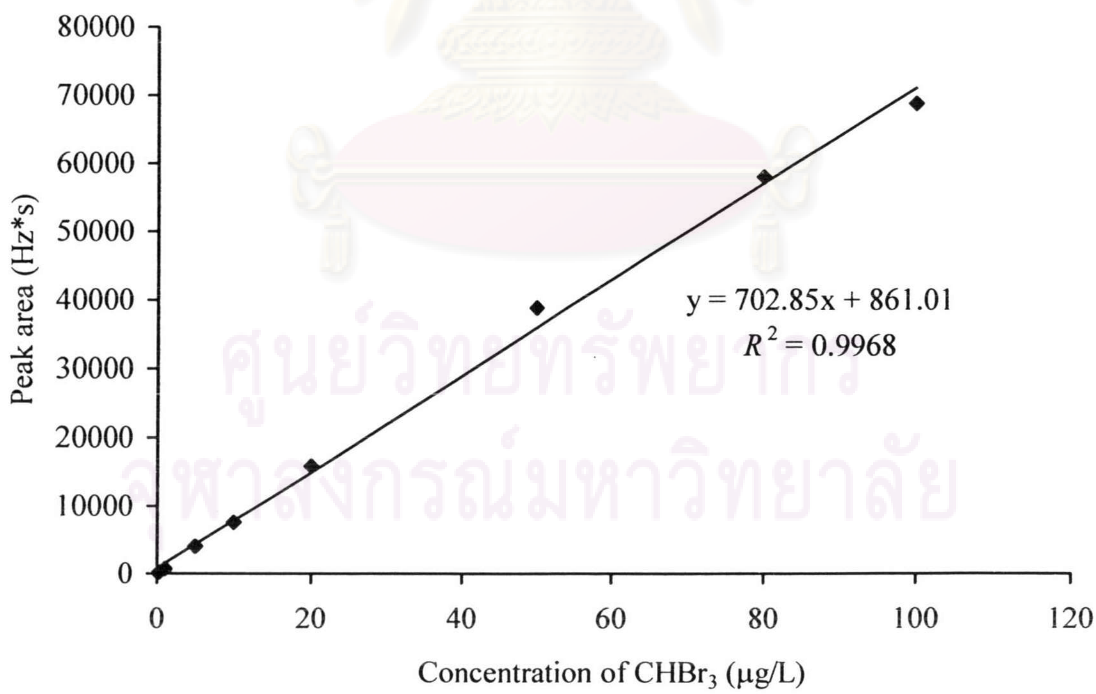


**Figure A-4** The calibration curve of bromoform by condition in Table 3.4.

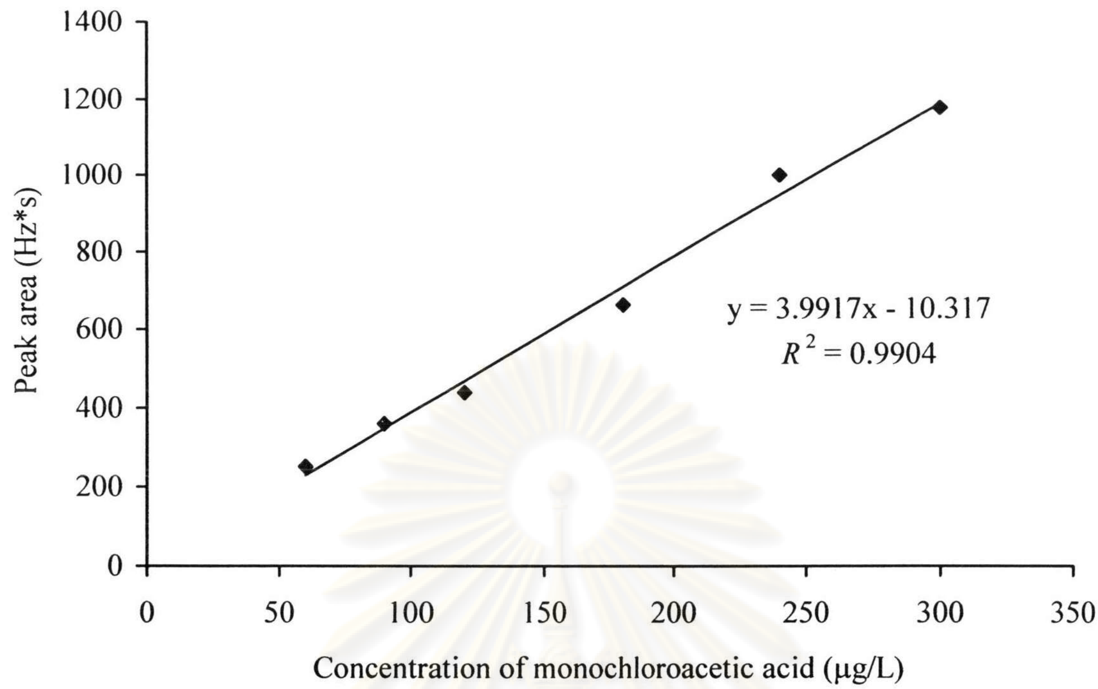


**Figure A-5** The calibration curve of monochloroacetic acid by condition in Table 3.5.

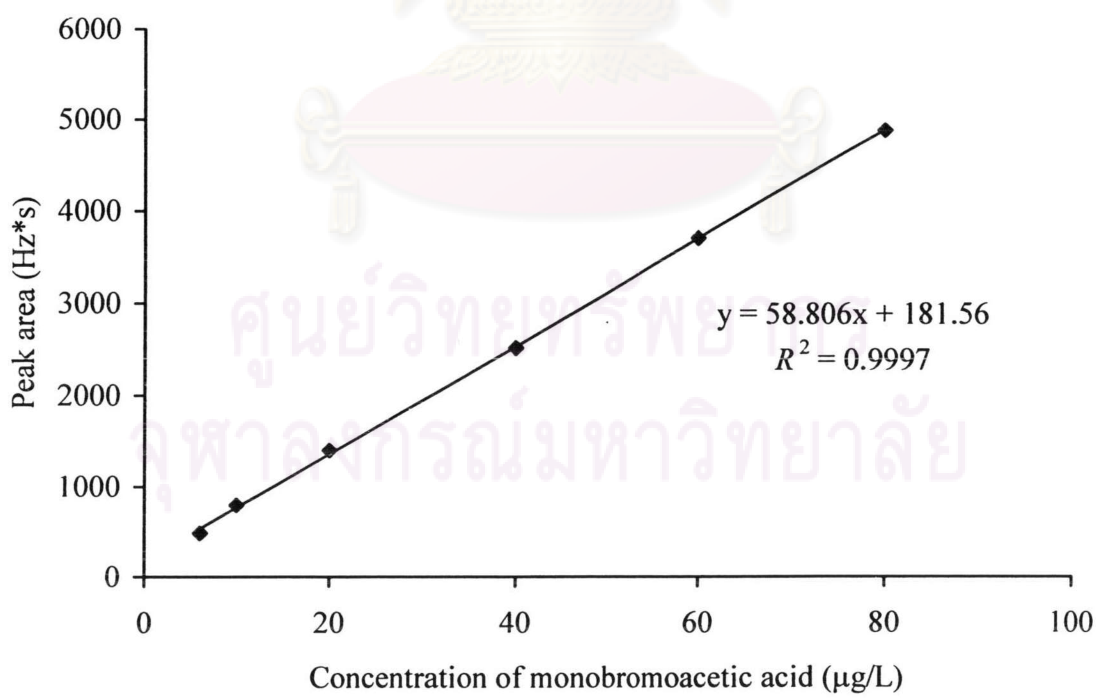


**Figure A-6** The calibration curve of monobromoacetic acid by condition in Table 3.5.

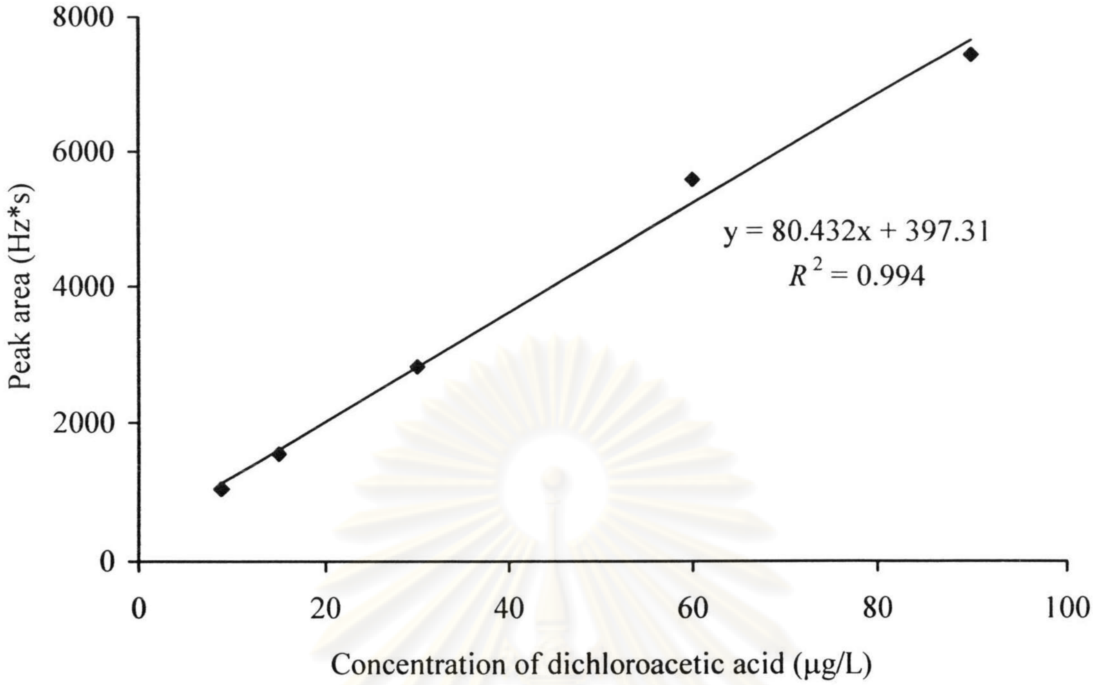


**Figure A-7** The calibration curve of dichloroacetic acid by condition in Table 3.5.

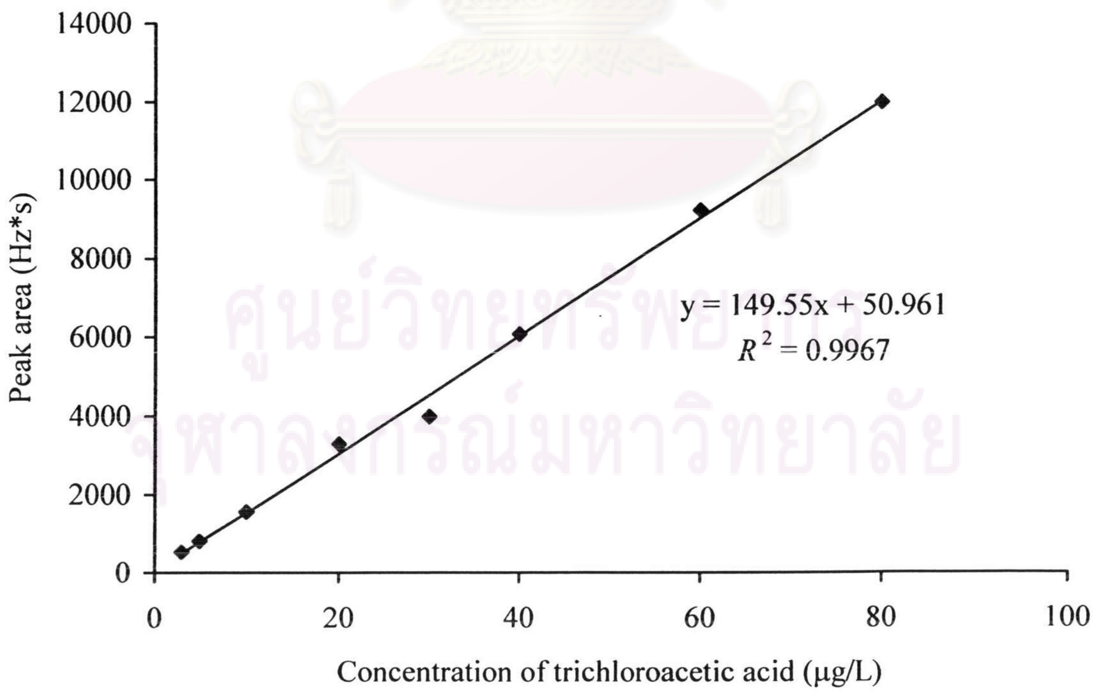


**Figure A-8** The calibration curve of trichloroacetic acid by condition in Table 3.5.

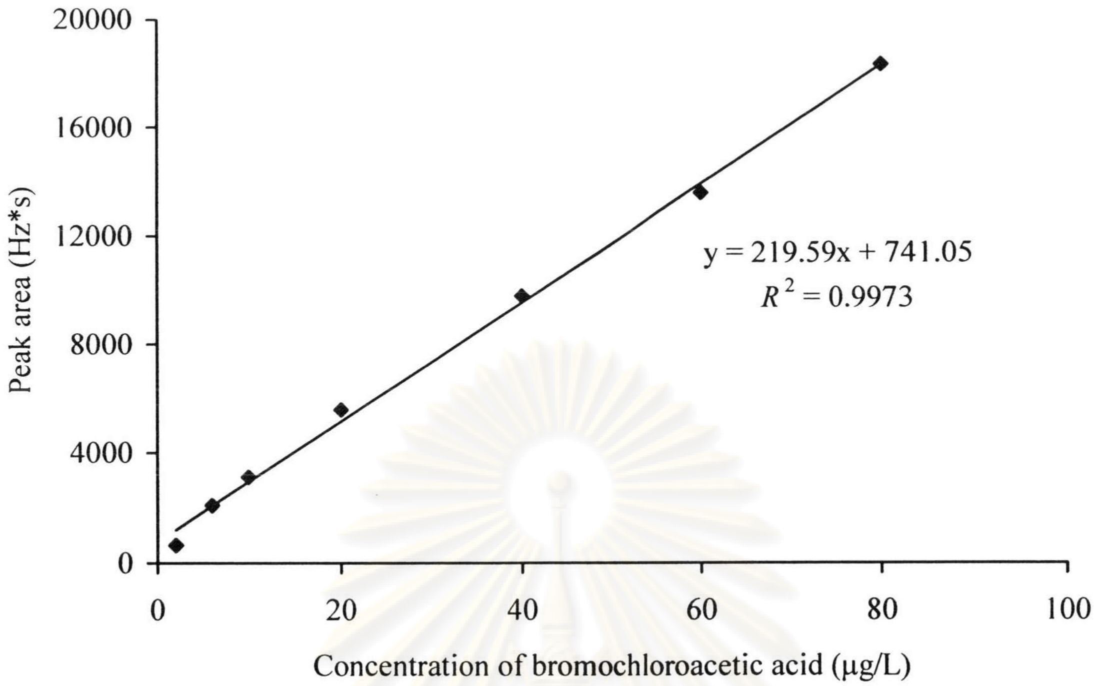


**Figure A-9** The calibration curve of bromochloroacetic acid by condition in Table 3.5.

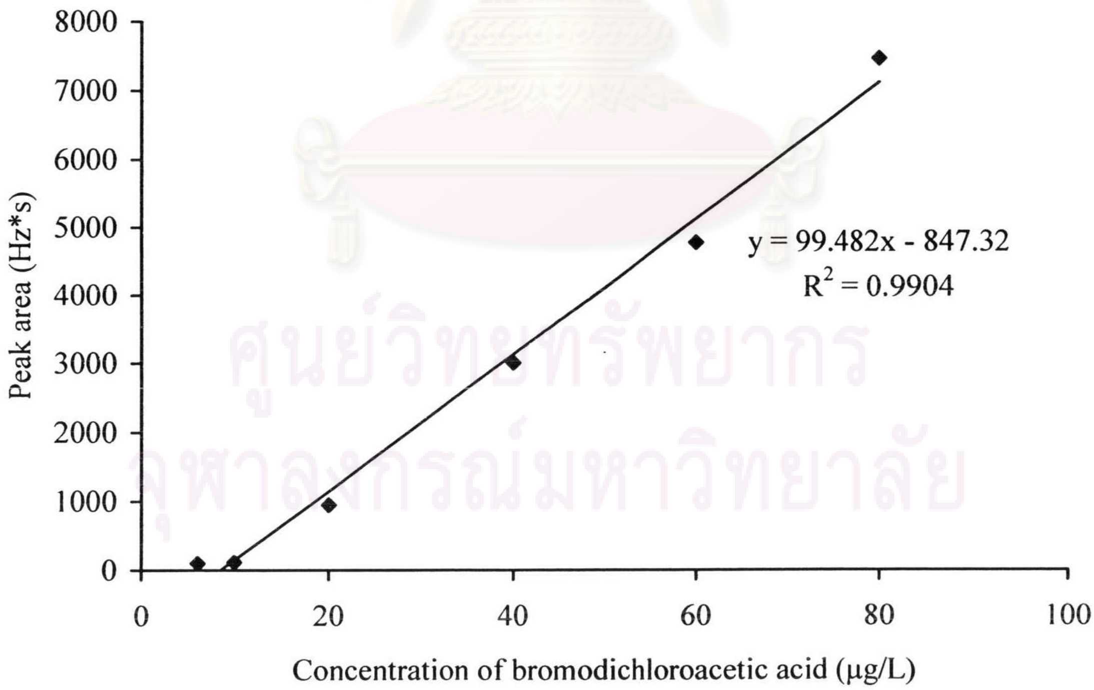


**Figure A-10** The calibration curve of bromodichloroacetic acid by condition in Table 3.5.

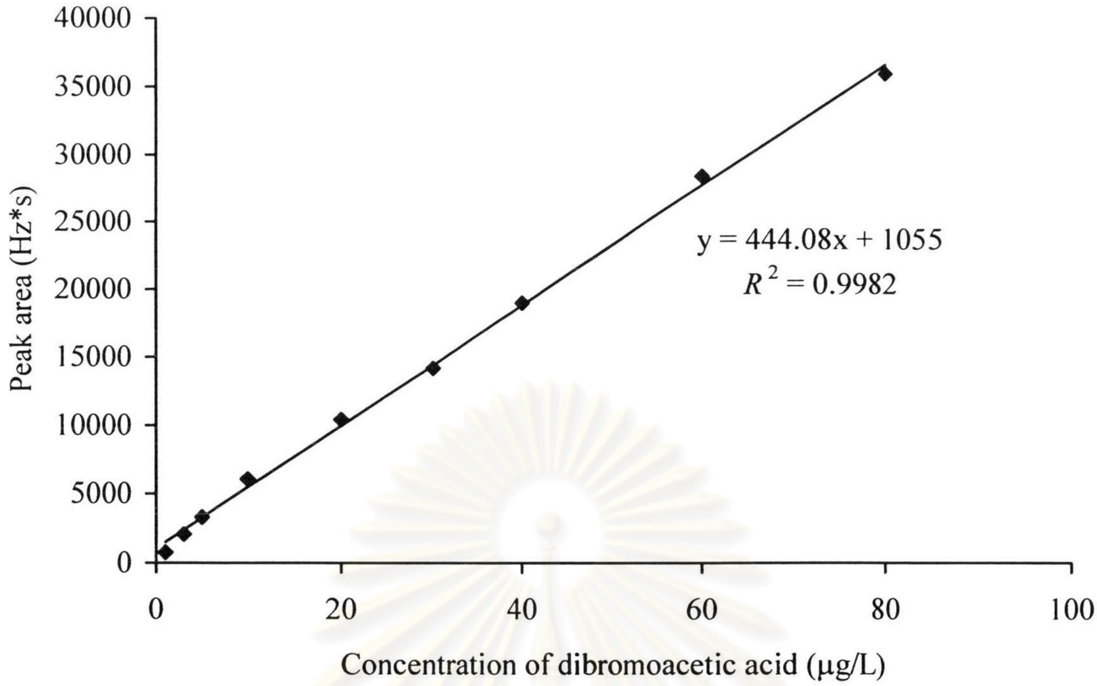


**Figure A-11** The calibration curve of dibromoacetic acid by condition in Table 3.5.

## APPENDIX B

**Table B-1** The peak area of stirring and non stirring solution after extracted with LPME.

| Analyte | Batch | Peak area (Hz*s) | |
|---|---|---|---|
| | | Stir | Non stir |
| MCAA | 1 | 370 | 422 |
| | 2 | 362 | 339 |
| | 3 | 354 | 395 |
| BCAA | 1 | 4744 | 4771 |
| | 2 | 4392 | 3981 |
| | 3 | 4551 | 5017 |
| DCAA | 1 | 10056 | 9057 |
| | 2 | 8206 | 7836 |
| | 3 | 10753 | 9401 |
| TCAA | 1 | 6491 | 5226 |
| | 2 | 4752 | 4399 |
| | 3 | 6410 | 5249 |
| BCAA | 1 | 18773 | 16229 |
| | 2 | 14451 | 15573 |
| | 3 | 19945 | 16956 |
| BDCAA | 1 | 6679 | 5063 |
| | 2 | 4051 | 3183 |
| | 3 | 6415 | 5079 |
| DBAA | 1 | 21519 | 17455 |
| | 2 | 14871 | 18234 |
| | 3 | 21669 | 19163 |

**Table B-2** The comparison of peak area of MCAA between stirring and non stirring solution using *F*-test and *t*-test at 95% confidence level.

*F*-Test Two-Sample for Variances

| | *Variable 1* | *Variable 2* |
|---|---|---|
| Mean | 362.4567 | 385.8667 |
| Variance | 59.14263 | 1812.295 |
| Observations | 3 | 3 |
| df | 2 | 2 |
| F | 0.032634 | |
| P(F<=f) one-tail | 0.031603 | |
| F Critical one-tail | 0.052632 | |

*t*-Test: Two-Sample Assuming Equal Variances

| | *Variable 1* | *Variable 2* |
|---|---|---|
| Mean | 362.4567 | 385.8667 |
| Variance | 59.14263 | 1812.295 |
| Observations | 3 | 3 |
| Pooled Variance | 935.719 | |
| Hypothesized Mean Difference | 0 | |
| df | 4 | |
| t Stat | -0.93729 | |
| P(T<=t) one-tail | 0.200837 | |
| t Critical one-tail | 2.131846 | |
| P(T<=t) two-tail | 0.401674 | |
| t Critical two-tail | 2.776451 | |

**Table B-3** The comparison of peak area of MBAA between stirring and non stirring solution using *F*-test and *t*-test at 95% confidence level.

*F*-Test Two-Sample for Variances

| | *Variable 1* | *Variable 2* |
|---|---|---|
| Mean | 4562.663 | 4590.177 |
| Variance | 30937.94 | 293168.9 |
| Observations | 3 | 3 |
| df | 2 | 2 |
| F | 0.105529 | |
| P(F<=f) one-tail | 0.095456 | |
| F Critical one-tail | 0.052632 | |

*t*-Test: Two-Sample Assuming Unequal Variances

| | *Variable 1* | *Variable 2* |
|---|---|---|
| Mean | 4562.663 | 4590.177 |
| Variance | 30937.94 | 293168.9 |
| Observations | 3 | 3 |
| Hypothesized Mean Difference | 0 | |
| df | 2 | |
| t Stat | -0.08371 | |
| P(T<=t) one-tail | 0.470457 | |
| t Critical one-tail | 2.919987 | |
| P(T<=t) two-tail | 0.940914 | |
| t Critical two-tail | 4.302656 | |

**Table B-4** The comparison of peak area of DCAA between stirring and non stirring solution using *F*-test and *t*-test at 95% confidence level.

*F*-Test Two-Sample for Variances

| | *Variable 1* | *Variable 2* |
|---|---|---|
| Mean | 9671.87 | 8765.217 |
| Variance | 1732387 | 676121.8 |
| Observations | 3 | 3 |
| df | 2 | 2 |
| F | 2.562241 | |
| P(F<=f) one-tail | 0.280722 | |
| F Critical one-tail | 19.00003 | |

*t*-Test: Two-Sample Assuming Equal Variances

| | *Variable 1* | *Variable 2* |
|---|---|---|
| Mean | 9671.87 | 8765.217 |
| Variance | 1732387 | 676121.8 |
| Observations | 3 | 3 |
| Pooled Variance | 1204254 | |
| Hypothesized Mean Difference | 0 | |
| df | 4 | |
| t Stat | 1.011877 | |
| P(T<=t) one-tail | 0.184416 | |
| t Critical one-tail | 2.131846 | |
| P(T<=t) two-tail | 0.368832 | |
| t Critical two-tail | 2.776451 | |

**Table B-5** The comparison of peak area of TCAA between stirring and non stirring solution using *F*-test and *t*-test at 95% confidence level.

*F*-Test Two-Sample for Variances

| | *Variable 1* | *Variable 2* |
|---|---|---|
| Mean | 5884.693 | 4958.383 |
| Variance | 963587.8 | 234603.3 |
| Observations | 3 | 3 |
| df | 2 | 2 |
| F | 4.107307 | |
| P(F<=f) one-tail | 0.195798 | |
| F Critical one-tail | 19.00003 | |

*t*-Test: Two-Sample Assuming Equal Variances

| | *Variable 1* | *Variable 2* |
|---|---|---|
| Mean | 5884.693 | 4958.383 |
| Variance | 963587.8 | 234603.3 |
| Observations | 3 | 3 |
| Pooled Variance | 599095.5 | |
| Hypothesized Mean Difference | 0 | |
| df | 4 | |
| t Stat | 1.46573 | |
| P(T<=t) one-tail | 0.108299 | |
| t Critical one-tail | 2.131846 | |
| P(T<=t) two-tail | 0.216597 | |
| t Critical two-tail | 2.776451 | |

**Table B-6** The comparison of peak area of BCAA between stirring and non stirring solution using *F*-test and *t*-test at 95% confidence level.

*F*-Test Two-Sample for Variances

| | *Variable 1* | *Variable 2* |
|---|---|---|
| Mean | 17723.77 | 16253.17 |
| Variance | 8373211 | 478745 |
| Observations | 3 | 3 |
| df | 2 | 2 |
| F | 17.48992 | |
| P(F<=f) one-tail | 0.054084 | |
| F Critical one-tail | 19.00003 | |

*t*-Test: Two-Sample Assuming Equal Variances

| | *Variable 1* | *Variable 2* |
|---|---|---|
| Mean | 17723.77 | 16253.17 |
| Variance | 8373211 | 478745 |
| Observations | 3 | 3 |
| Pooled Variance | 4425978 | |
| Hypothesized Mean Difference | 0 | |
| df | 4 | |
| t Stat | 0.856122 | |
| P(T<=t) one-tail | 0.220093 | |
| t Critical one-tail | 2.131846 | |
| P(T<=t) two-tail | 0.440186 | |
| t Critical two-tail | 2.776451 | |

**Table B-7** The comparison of peak area of BDCAA between stirring and non stirring solution using *F*-test and *t*-test at 95% confidence level.

*F*-Test Two-Sample for Variances

| | *Variable 1* | *Variable 2* |
|---|---|---|
| Mean | 5715.48 | 4442.267 |
| Variance | 2093620 | 1188751 |
| Observations | 3 | 3 |
| df | 2 | 2 |
| F | 1.761193 | |
| P(F<=f) one-tail | 0.362162 | |
| F Critical one-tail | 19.00003 | |

*t*-Test: Two-Sample Assuming Equal Variances

| | *Variable 1* | *Variable 2* |
|---|---|---|
| Mean | 5715.48 | 4442.267 |
| Variance | 2093620 | 1188751 |
| Observations | 3 | 3 |
| Pooled Variance | 1641186 | |
| Hypothesized Mean Difference | 0 | |
| df | 4 | |
| t Stat | 1.217217 | |
| P(T<=t) one-tail | 0.145211 | |
| t Critical one-tail | 2.131846 | |
| P(T<=t) two-tail | 0.290422 | |
| t Critical two-tail | 2.776451 | |

**Table B-8** The comparison of peak area of DBAA between stirring and non stirring solution using *F*-test and *t*-test at 95% confidence level.

*F*-Test Two-Sample for Variances

| | *Variable 1* | *Variable 2* |
|---|---|---|
| Mean | 19353.5 | 18284.6 |
| Variance | 15073877 | 731143.3 |
| Observations | 3 | 3 |
| df | 2 | 2 |
| F | 20.61686 | |
| P(F<=f) one-tail | 0.04626 | |
| F Critical one-tail | 19.00003 | |

*t*-Test: Two-Sample Assuming Unequal Variances

| | *Variable 1* | *Variable 2* |
|---|---|---|
| Mean | 19353.5 | 18284.6 |
| Variance | 15073877 | 731143.3 |
| Observations | 3 | 3 |
| Hypothesized Mean Difference | 0 | |
| df | 2 | |
| t Stat | 0.465693 | |
| P(T<=t) one-tail | 0.343613 | |
| t Critical one-tail | 2.919987 | |
| P(T<=t) two-tail | 0.687226 | |
| t Critical two-tail | 4.302656 | |

**APPENDIX C**

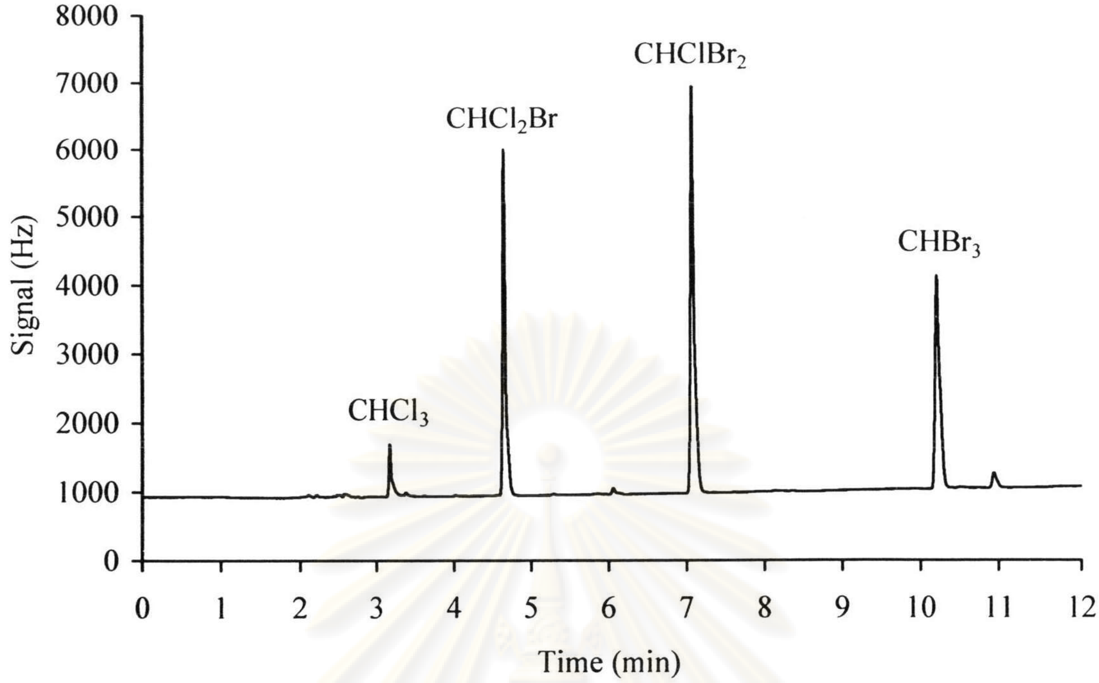


**Figure C-1** Chromatogram of THMs in dodecane after extracted using liquid-phase microextraction.

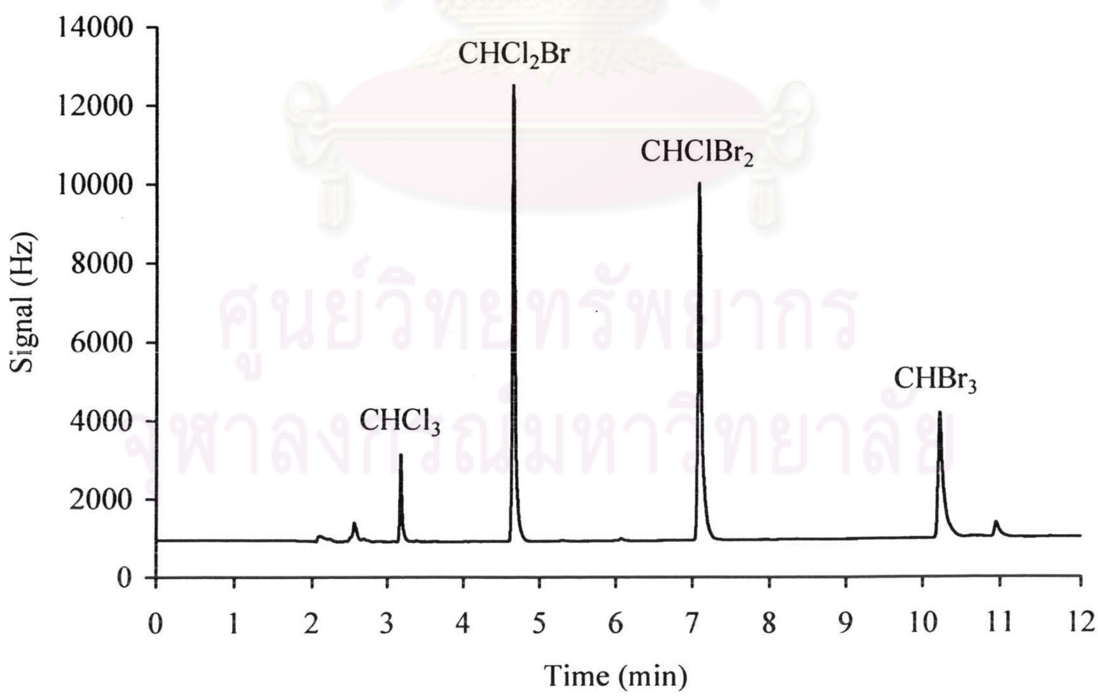


**Figure C-2** Chromatogram of THMs in 1-octanol after extracted using liquid-phase microextraction.

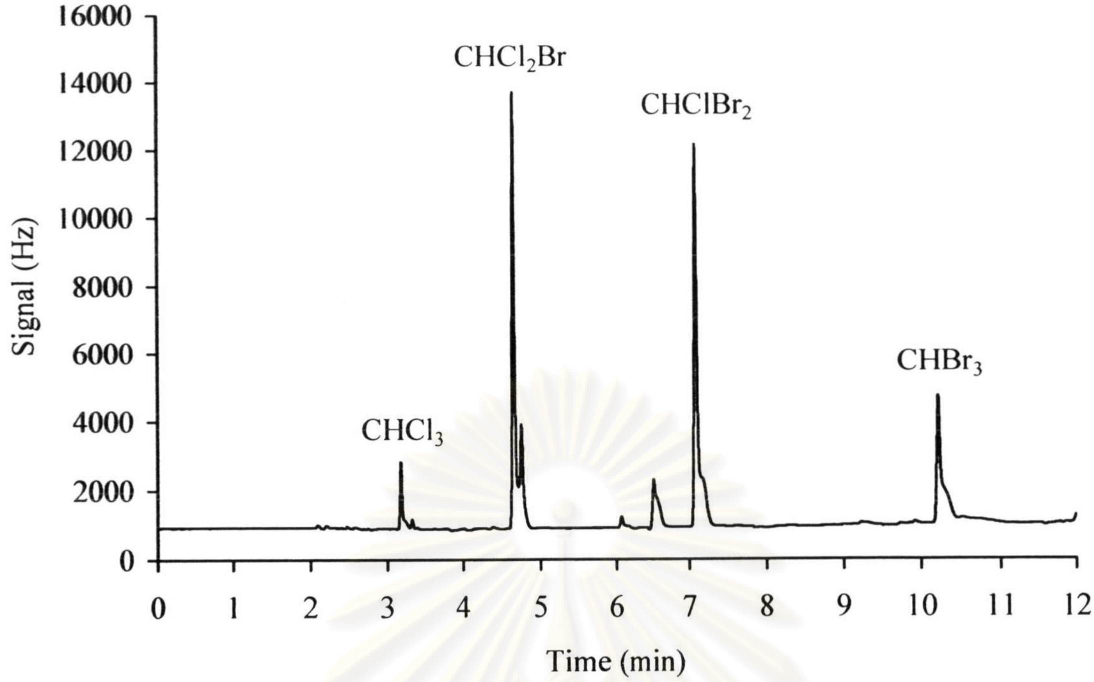


**Figure C-3** Chromatogram of THMs in dihexyl ether after extracted using liquid-phase microextraction.

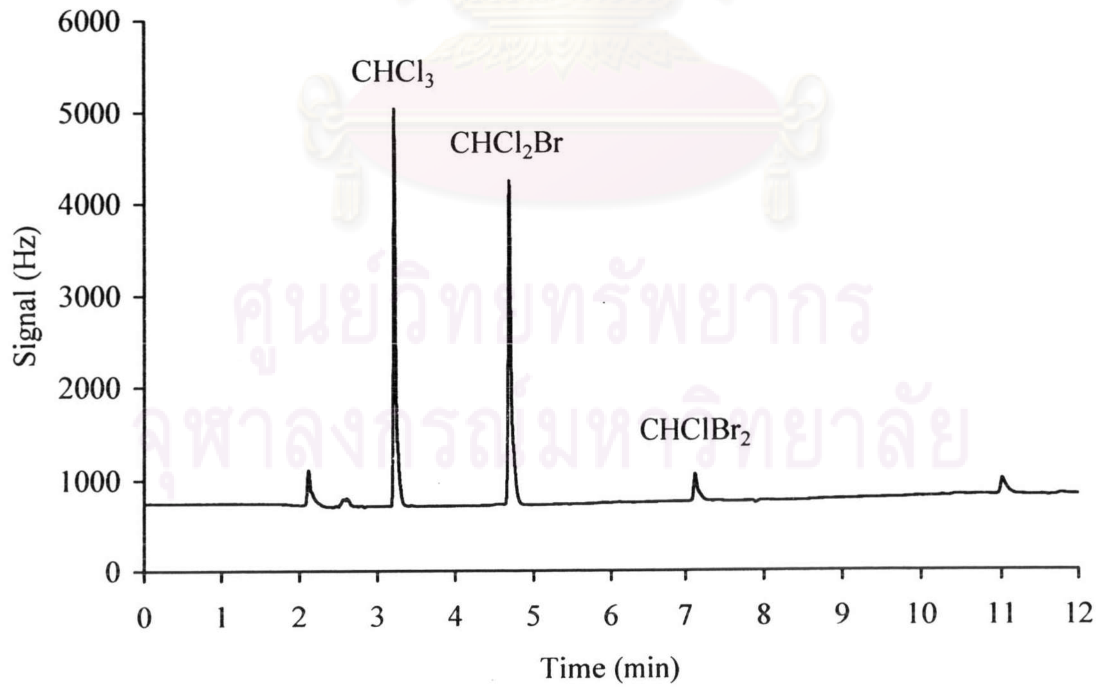


**Figure C-4** Chromatogram of THMs in drinking water 1 after extracted using liquid-phase microextraction.

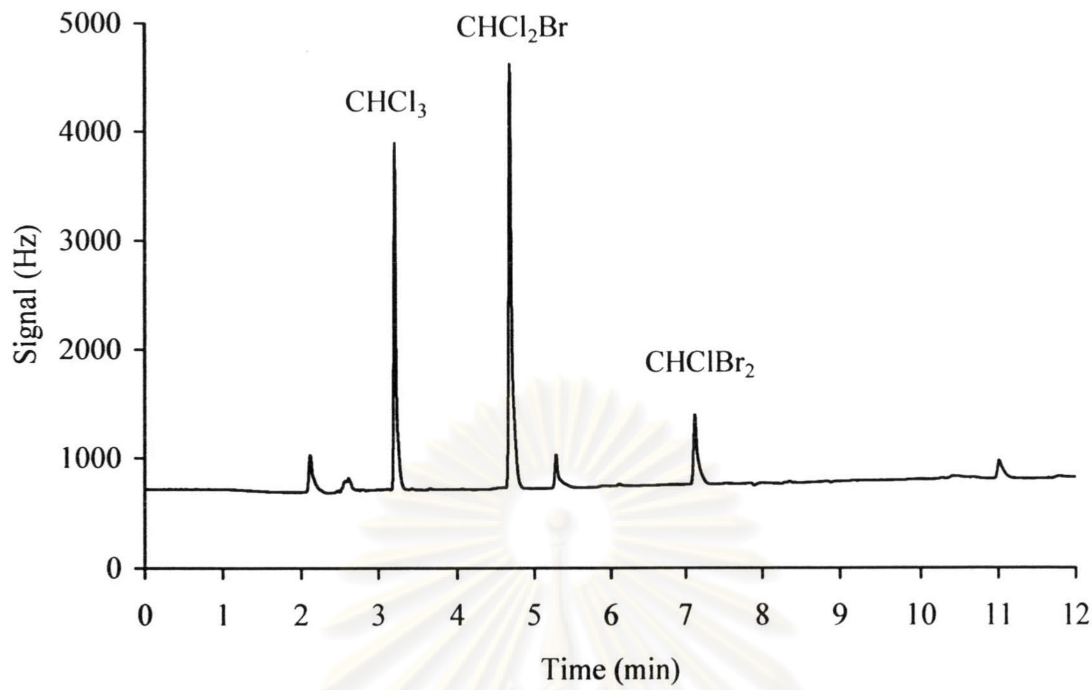


**Figure C-5** Chromatogram of THMs in drinking water 2 after extracted using liquid-phase microextraction.

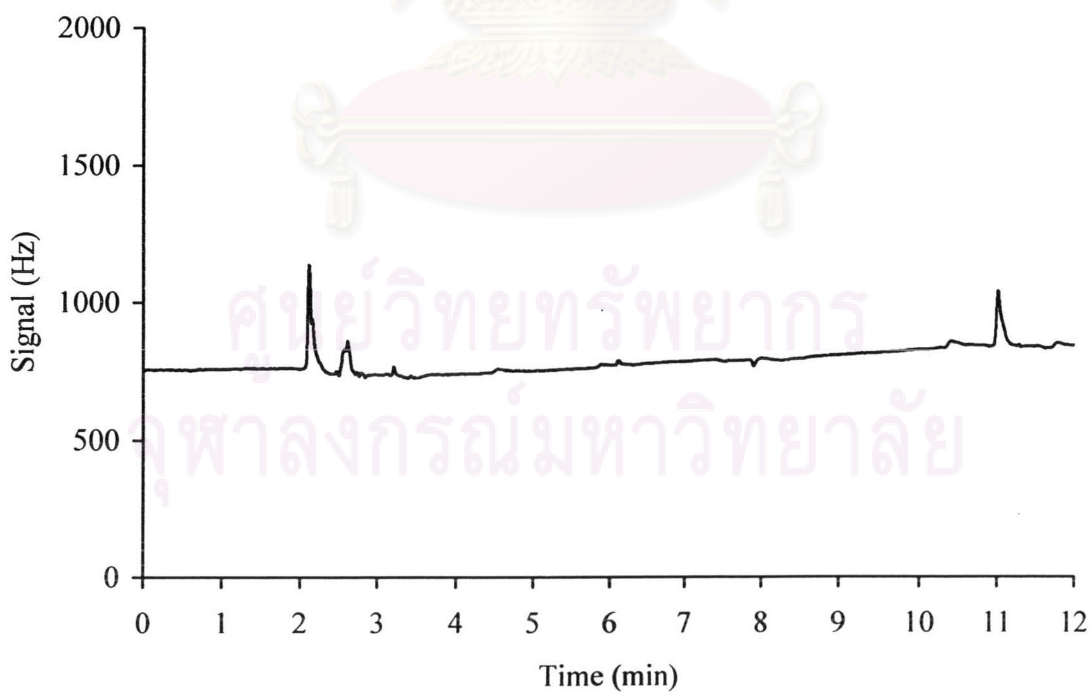


**Figure C-6** Chromatogram of THMs in drinking water 3 after extracted using liquid-phase microextraction.

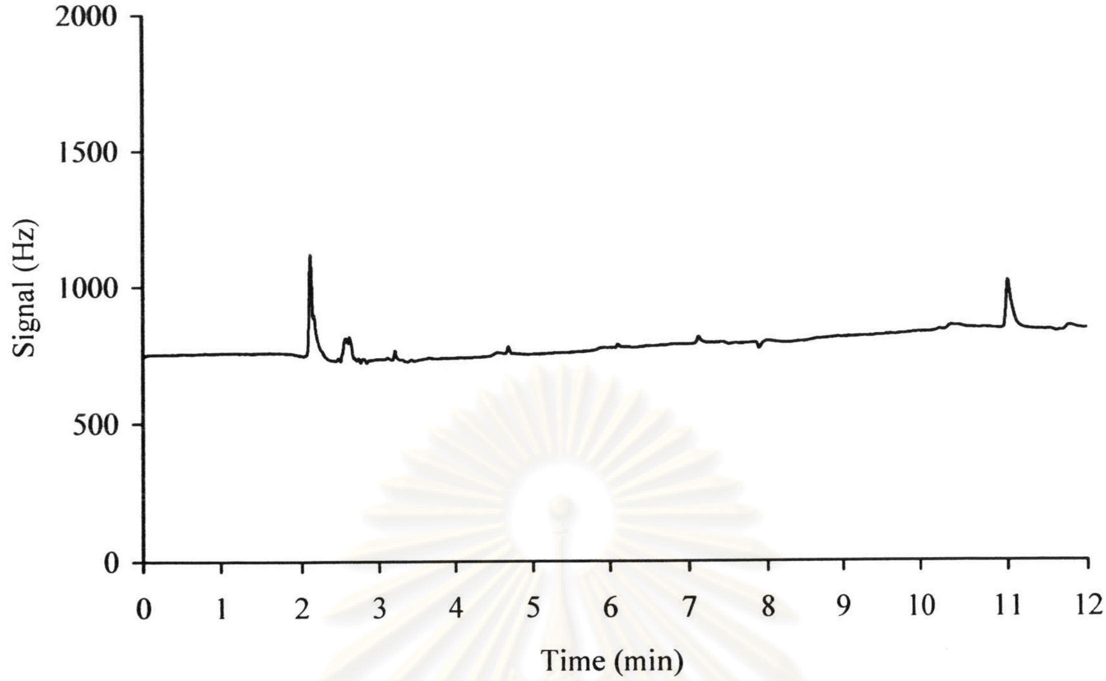


**Figure C-7** Chromatogram of THMs in drinking water 4 after extracted using liquid-phase microextraction.

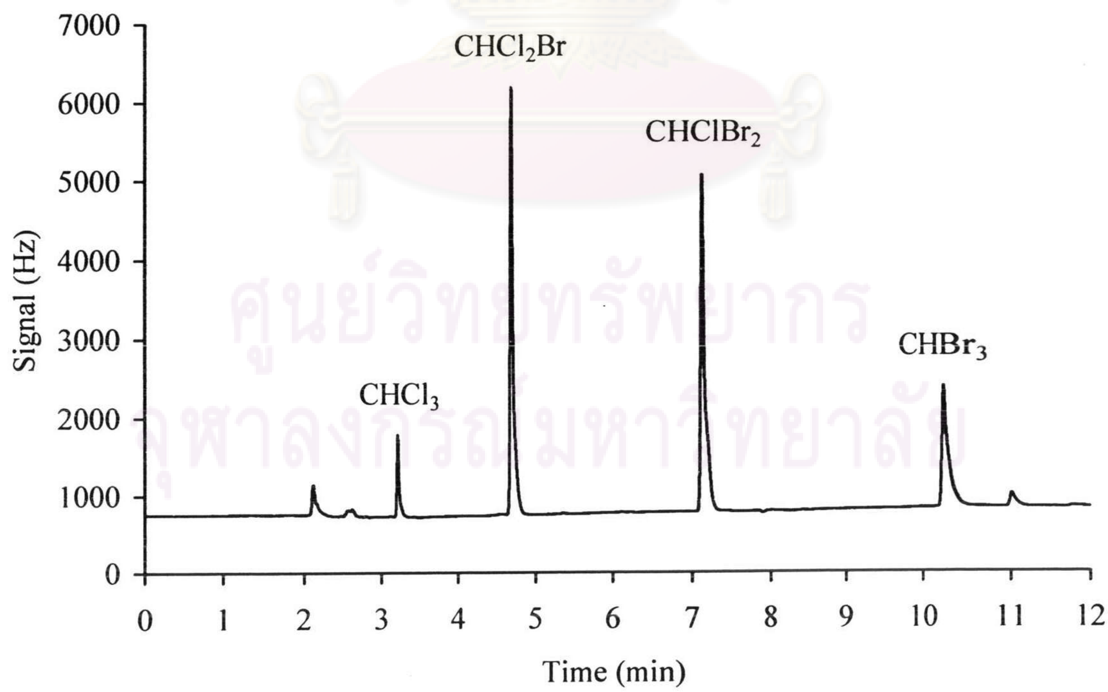


**Figure C-8** Chromatogram of THMs in drinking water 4 + spiked THMs 10 μg/L after extracted using liquid-phase microextraction.

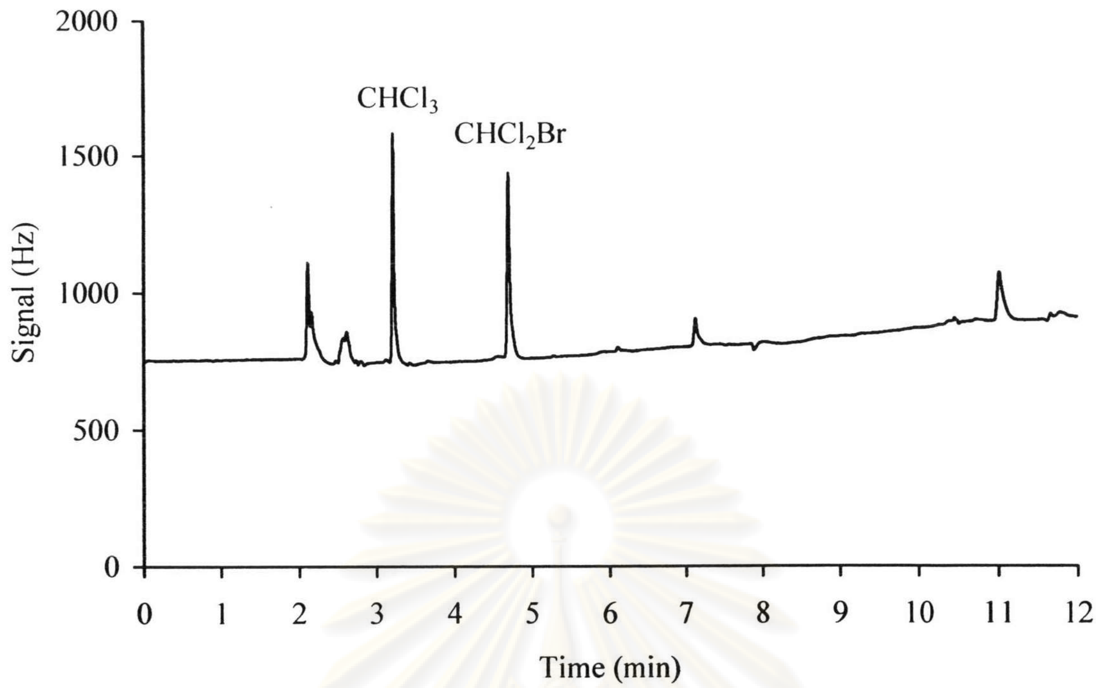


**Figure C-9** Chromatogram of THMs in drinking water 5 after extracted using liquid-phase microextraction.

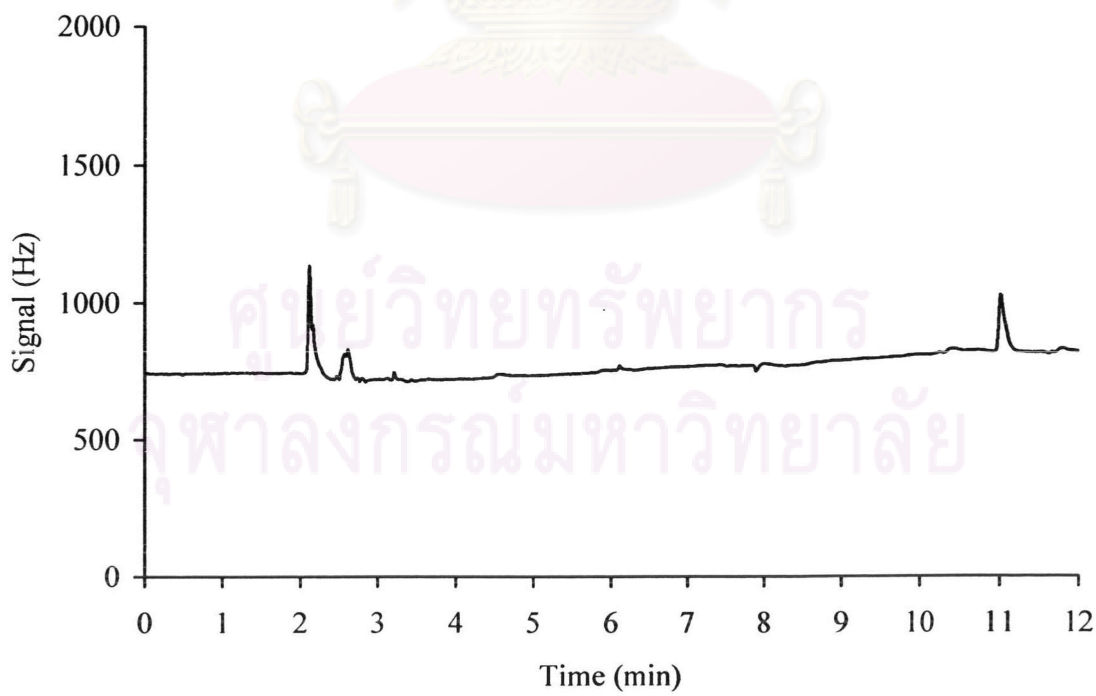


**Figure C-10** Chromatogram of THMs in mineral water 1 after extracted using liquid-phase microextraction.

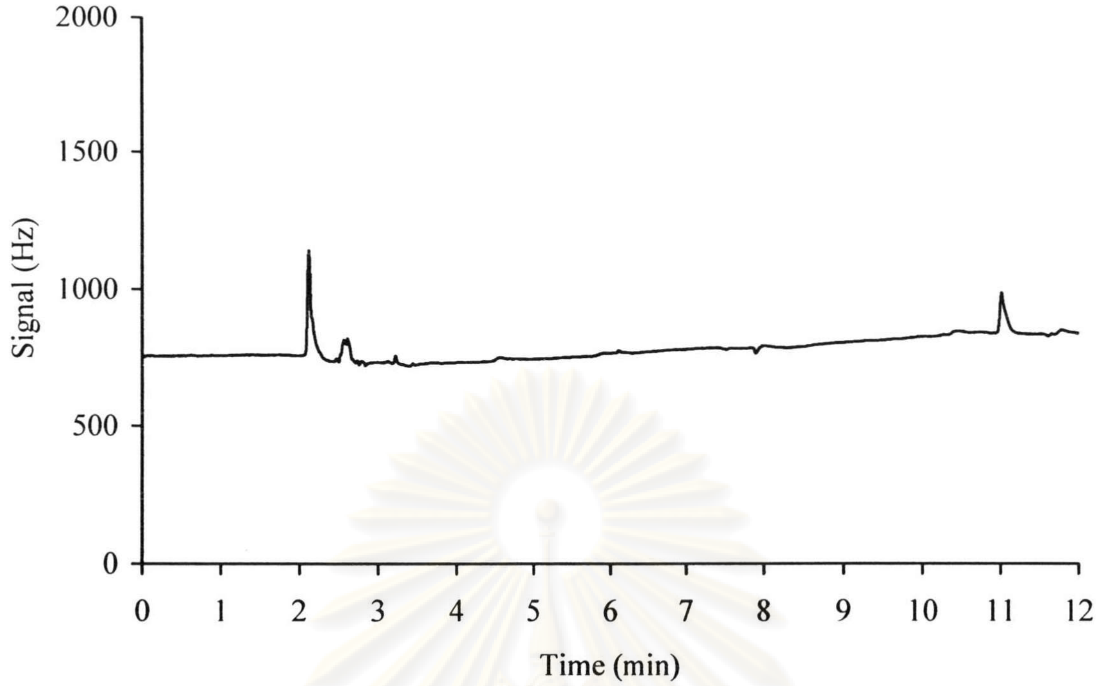


**Figure C-11** Chromatogram of THMs in mineral water 2 after extracted using liquid-phase microextraction.

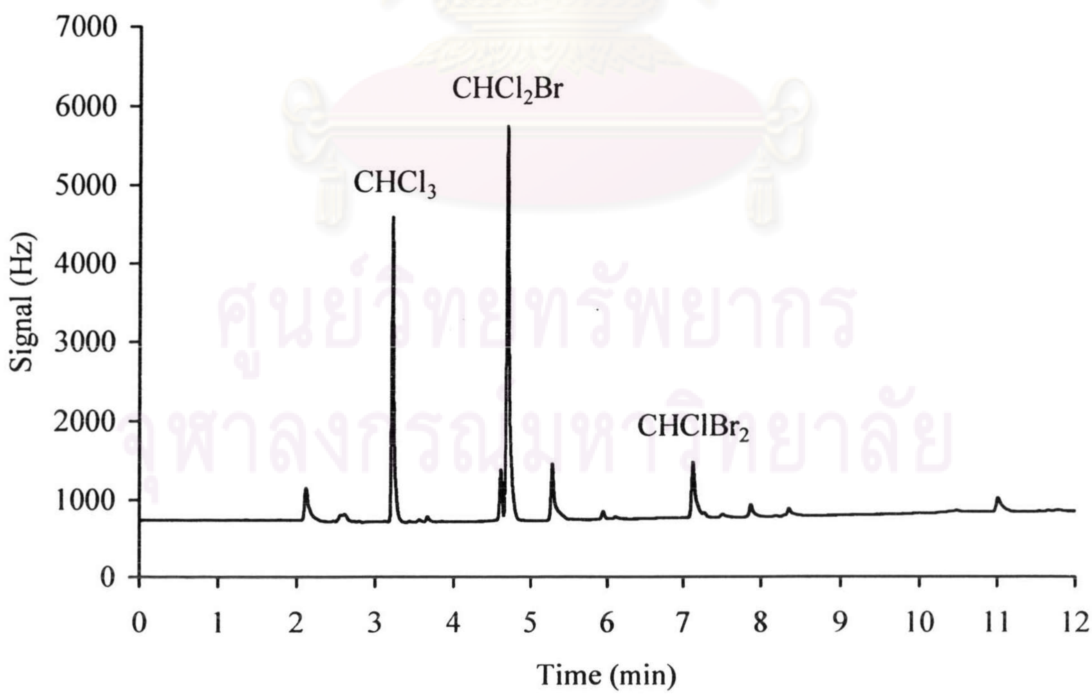


**Figure C-12** Chromatogram of THMs in tap water 1 after extracted using liquid-phase microextraction.

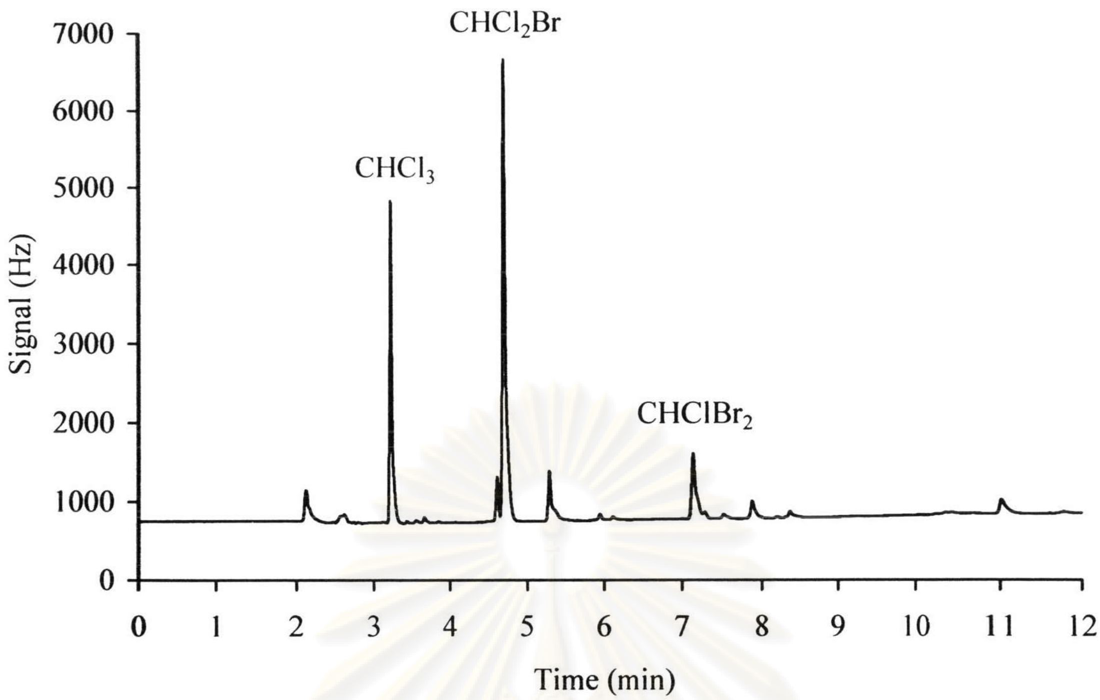


**Figure C-13** Chromatogram of THMs in tap water 2 after extracted using liquid-phase microextraction.

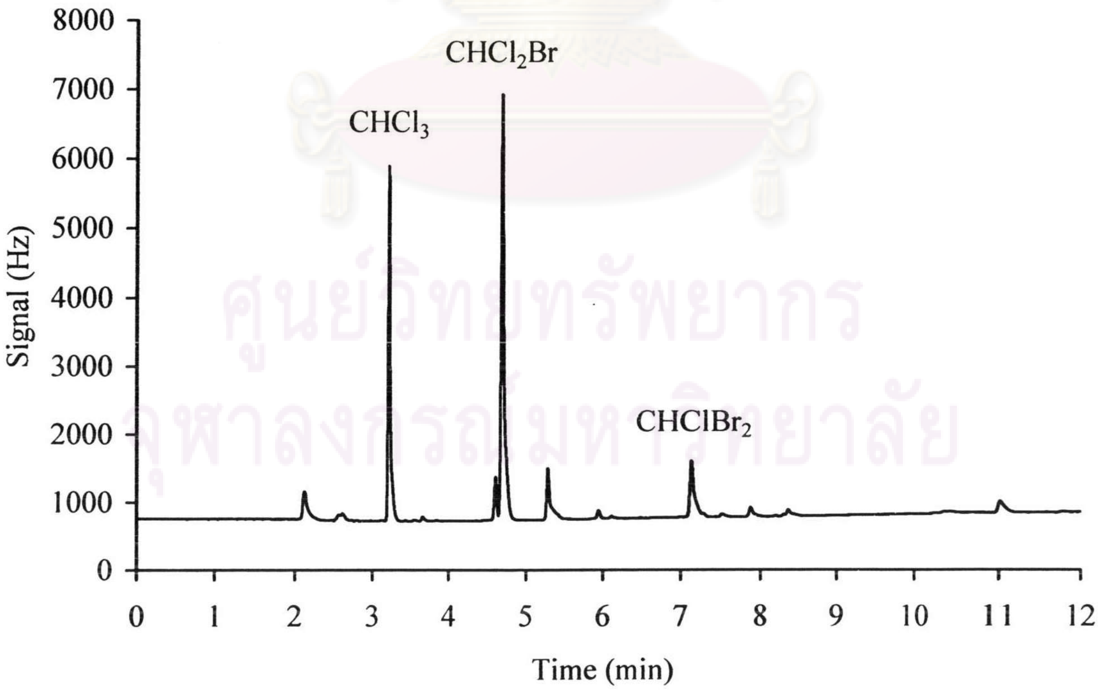


**Figure C-14** Chromatogram of THMs in tap water 3 after extracted using liquid-phase microextraction.

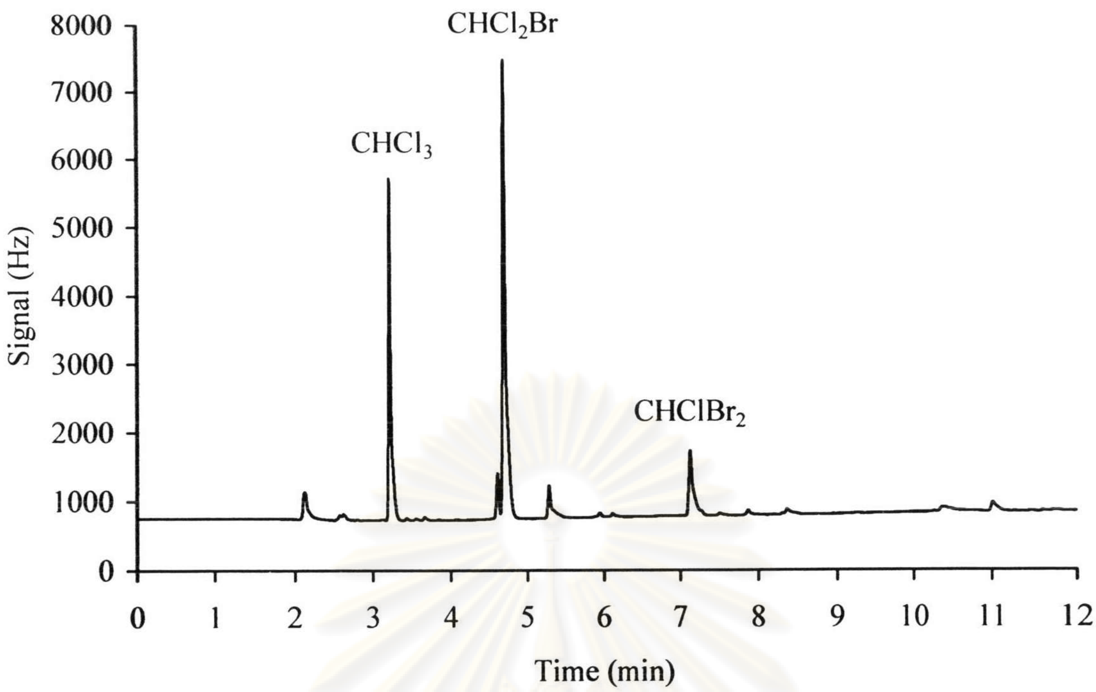


**Figure C-15** Chromatogram of THMs in tap water 4 after extracted using liquid-phase microextraction.

**APPENDIX D**

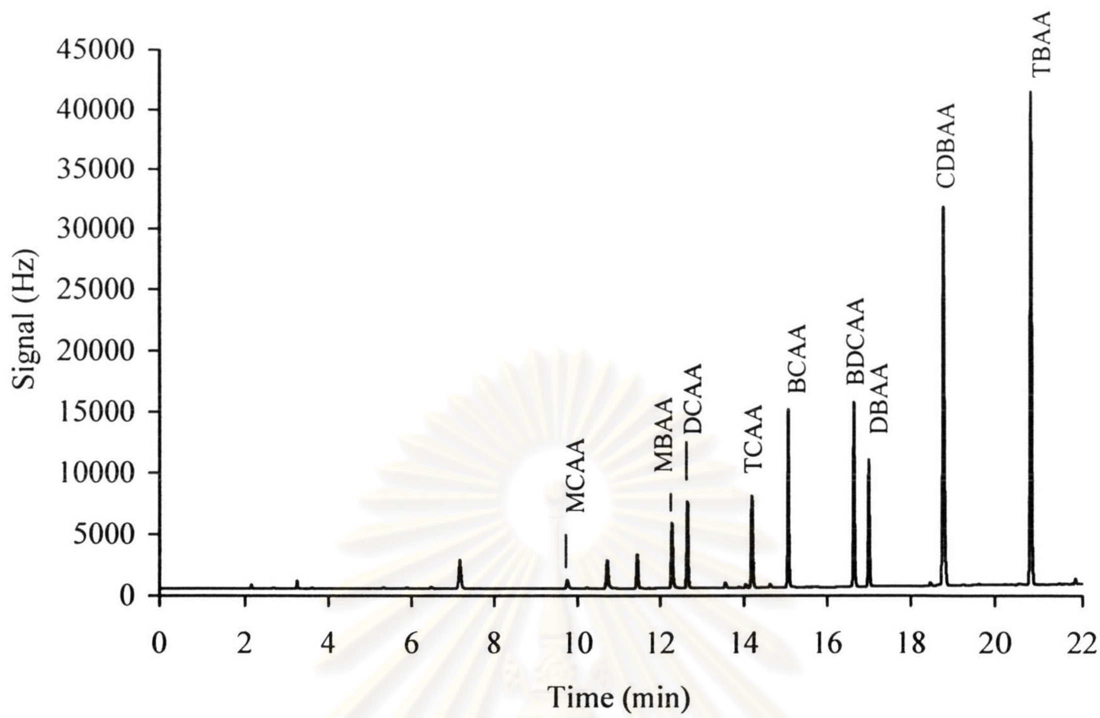


**Figure D-1** Chromatograms of standard haloacetic methyl ester in dodecane.

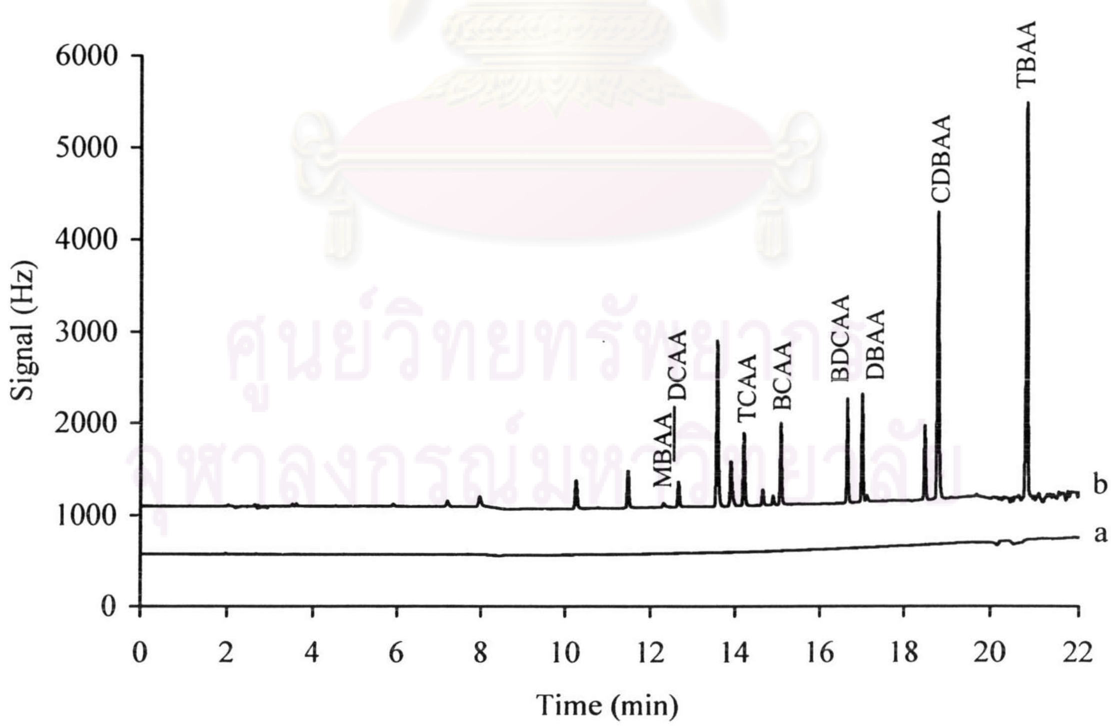


**Figure D-2** Chromatograms of HAAs in dodecane after extracted using liquid-phase microextraction (a) blank; (b) spike water sample with HAAs.

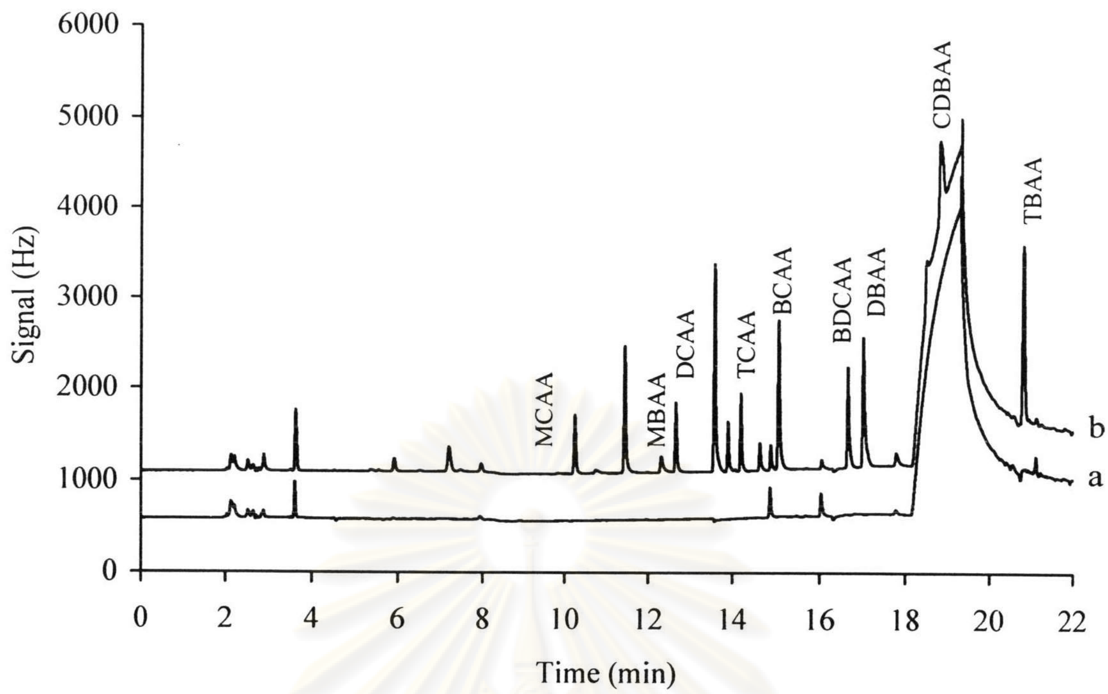


**Figure D-3** Chromatograms of HAAs in 1-octanol after extracted using liquid-phase microextraction (a) blank; (b) spike water sample with HAAs.

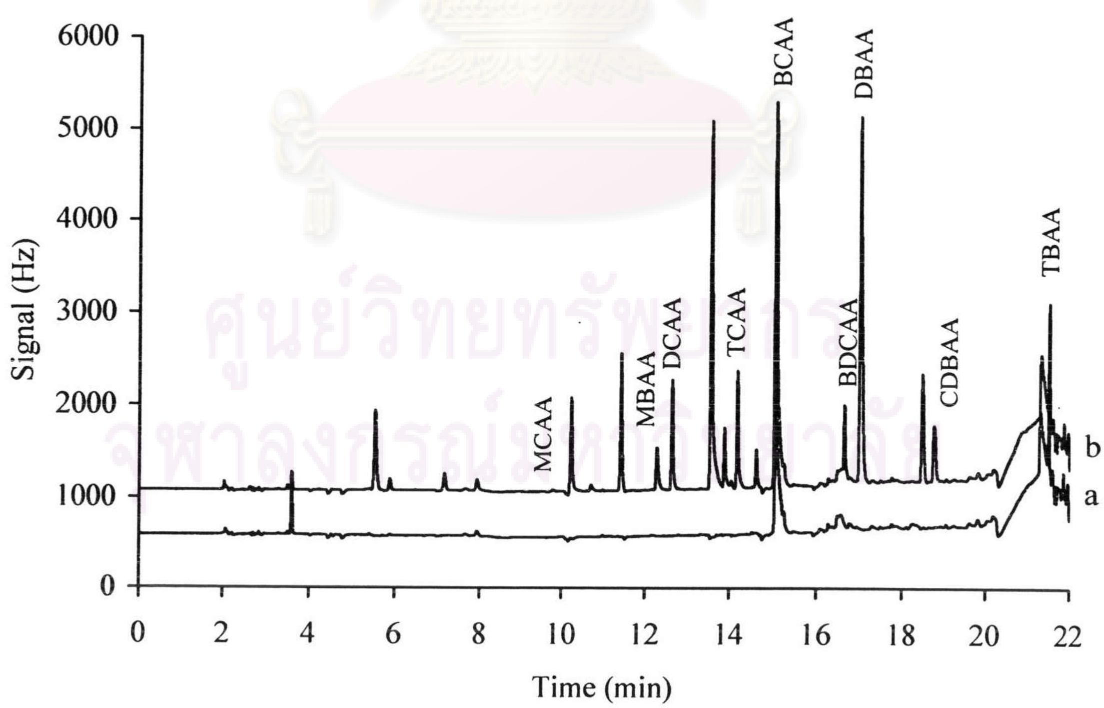


**Figure D-4** Chromatograms of HAAs in dihexyl ether after extracted using liquid-phase microextraction (a) blank; (b) spike water sample with HAAs.

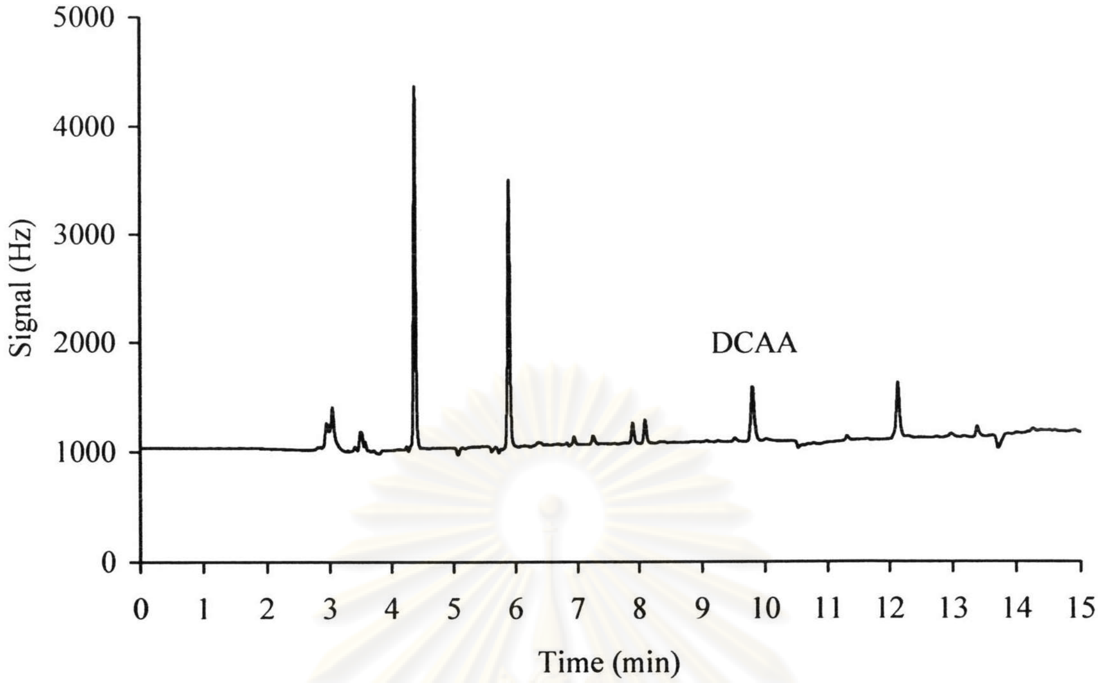


**Figure D-5** Chromatogram of HAAs in drinking water 1 after extracted using liquid-phase microextraction.

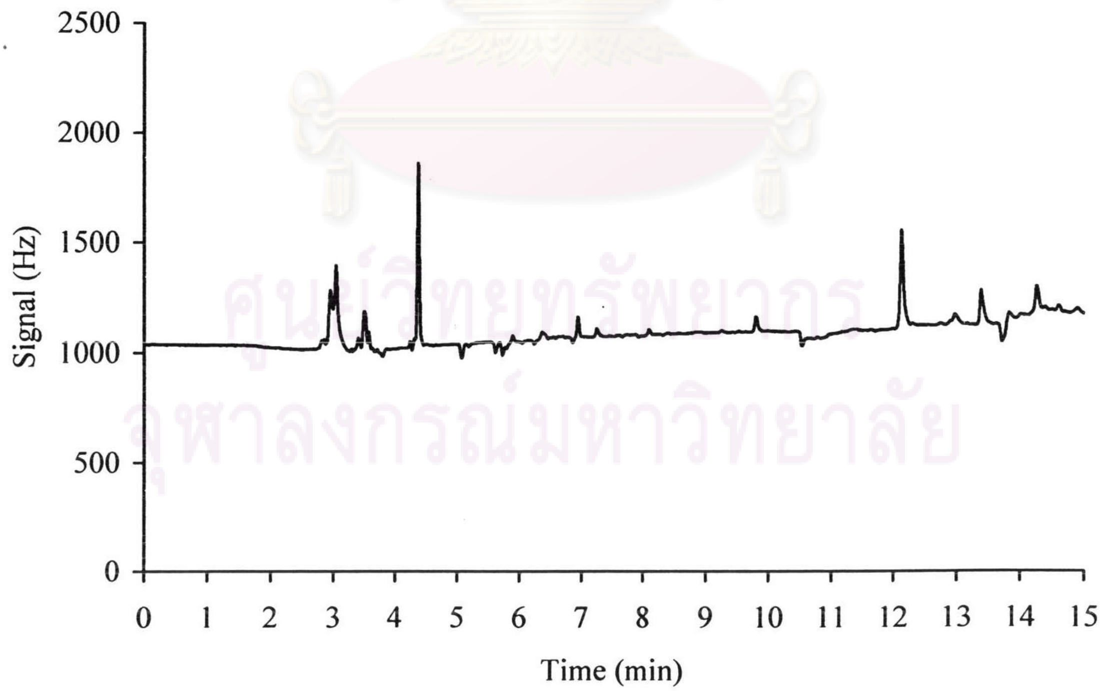


**Figure D-6** Chromatogram of HAAs in drinking water 4 after extracted using liquid-phase microextraction.

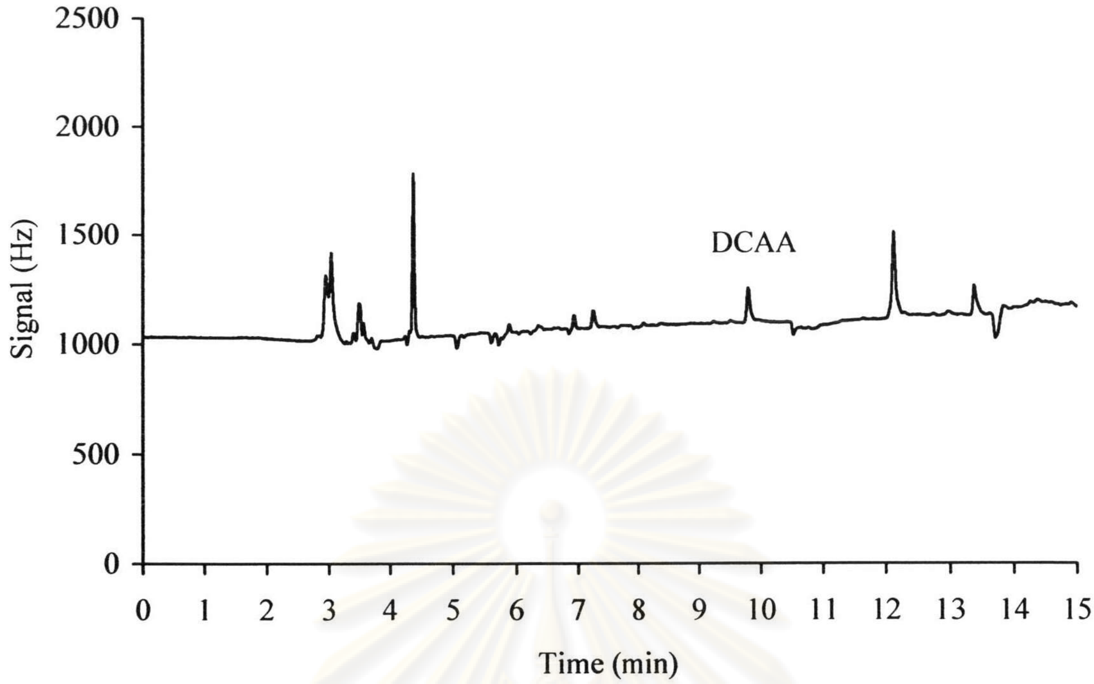


**Figure D-7** Chromatogram of HAAs in drinking water 5 after extracted using liquid-phase microextraction.

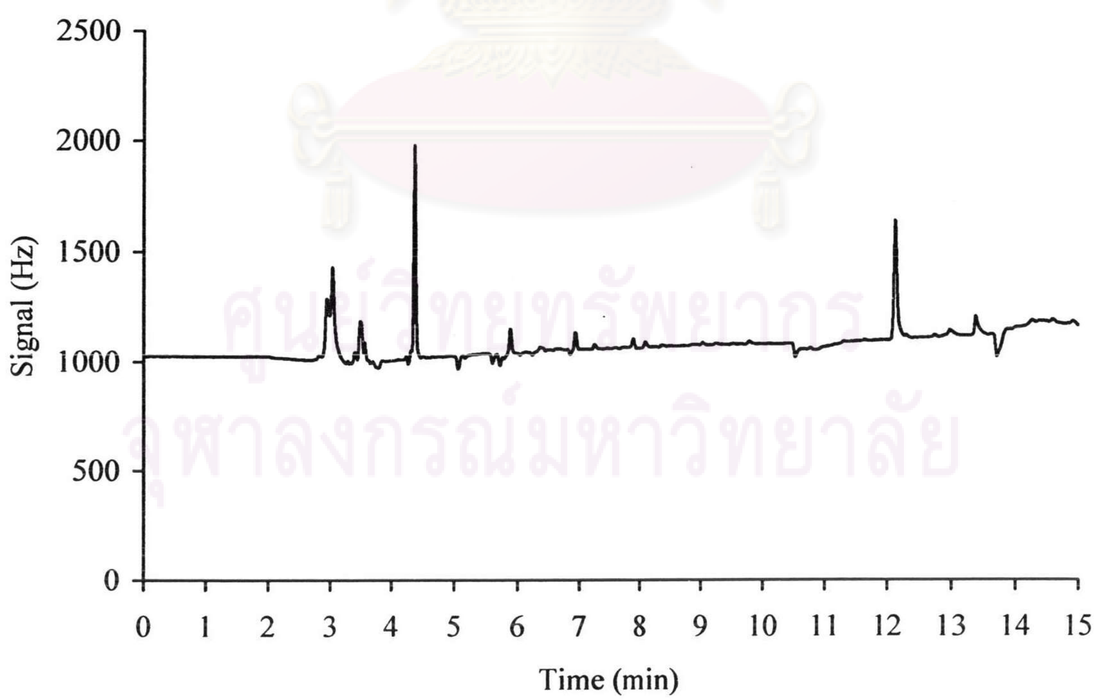


**Figure D-8** Chromatogram of HAAs in drinking water 6 after extracted using liquid-phase microextraction.

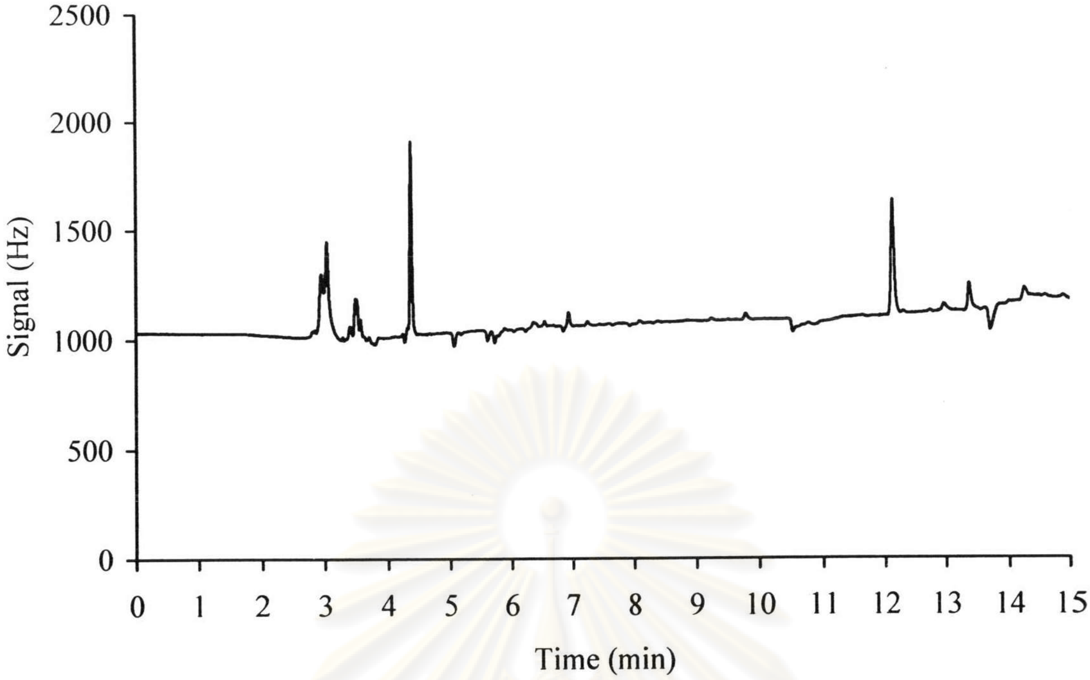


**Figure D-9** Chromatogram of HAAs in mineral water 1 after extracted using liquid-phase microextraction.

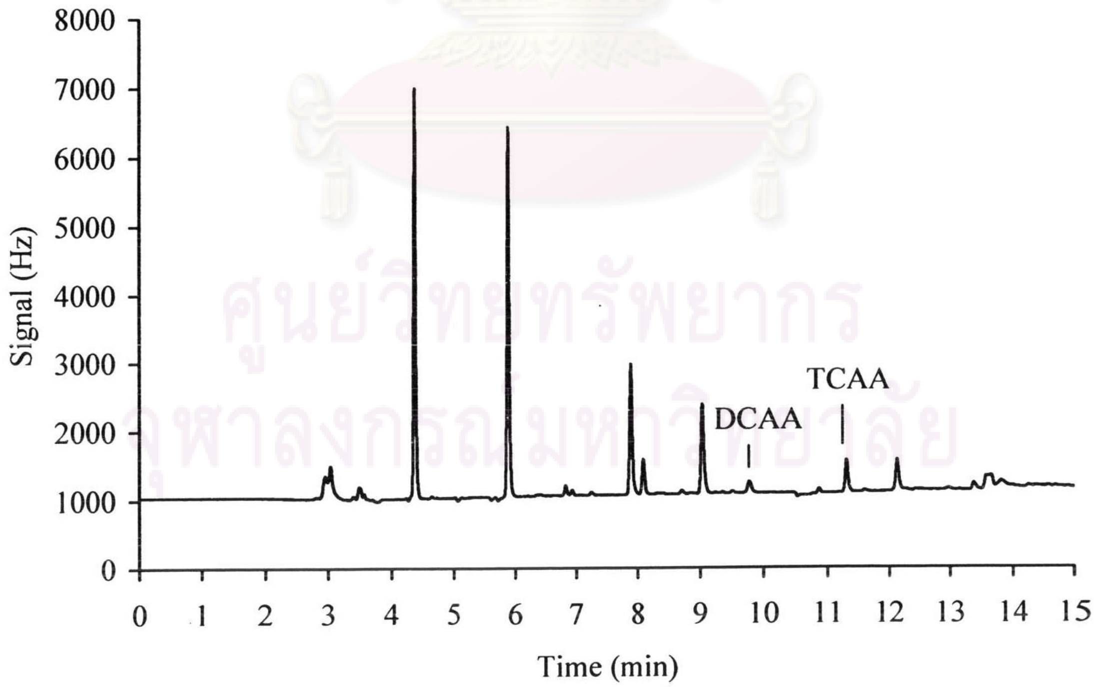


**Figure D-10** Chromatogram of HAAs in tap water 1 after extracted using liquid-phase microextraction.

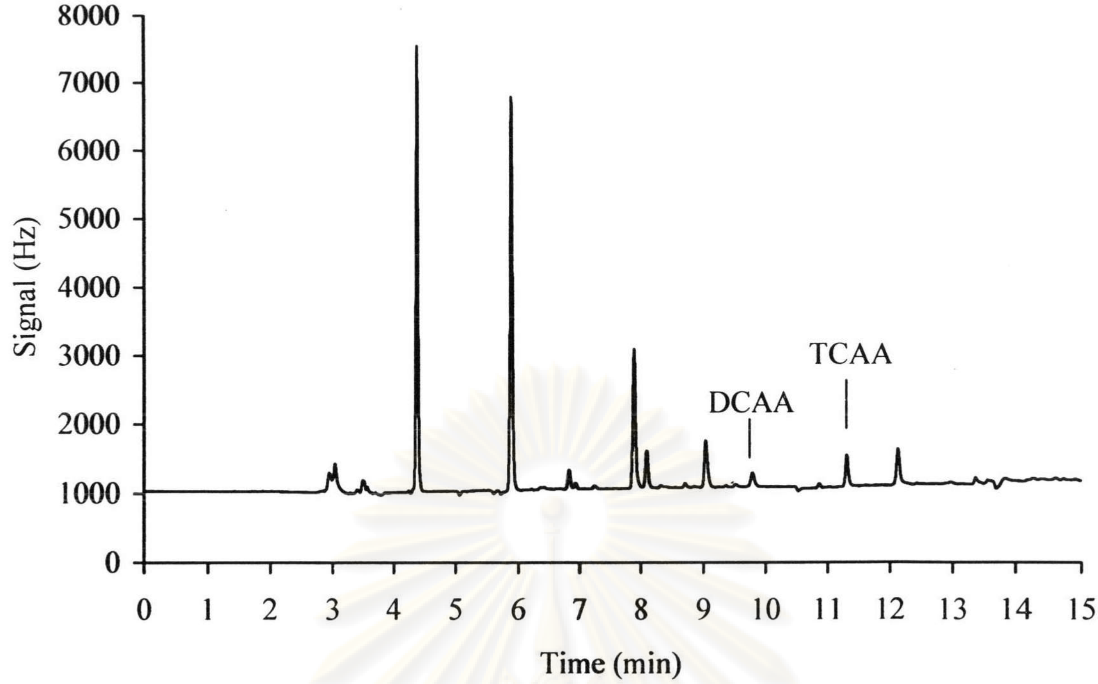


**Figure D-11** Chromatogram of HAAs in tap water 4 after extracted using liquid-phase microextraction.

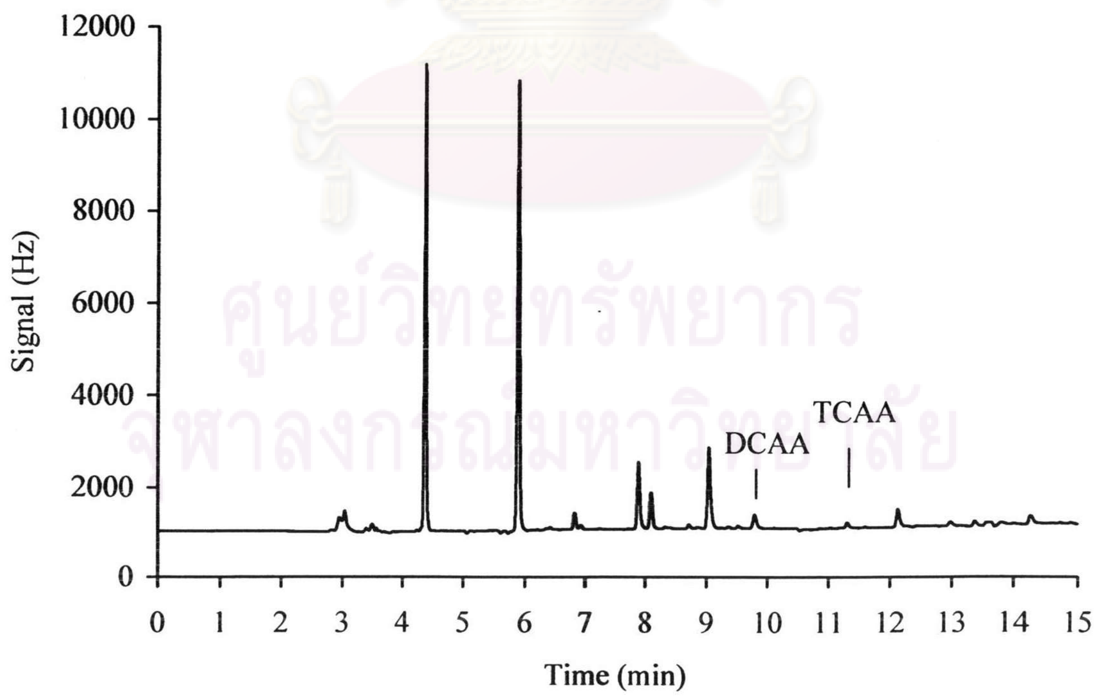


**Figure D-12** Chromatogram of HAAs in tap water 5 after extracted using liquid-phase microextraction.

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1. N. Vora-adisak and P. Varanusupakul, "Liquid phase microextraction using hollow fiber membrane for gas chromatographic determination of trihalomethanes in water samples", Presented at *The First Graduate Congress of Mathematics and Physical Science 2005*, 6-7 December 2005, Bangkok, Thailand. (International)
2. N. Vora-adisak and P. Varanusupakul, "Liquid phase microextraction with supported liquid hollow fiber membrane for sample preparation of trihalomethanes in water samples", Presented at *$31^{st}$ Congress on Science and Technology of Thailand*, 18-20 October 2005, Nakhon Ratchasima, Thailand. (National)



**Publication :**

1. N. Vora-adisak and P. Varanusupakul, "A simple supported liquid hollow fiber membrane microextraction for sample preparation of trihalomethanes in water samples", *J. Chromatogr. A*, In press.