REFERENCES

1. Feng, C. Application of a microtrap for on-line monitoring of volatile organics. Doctoral Dissertation, Department of Chemistry and Environmental Science, New Jersey Institute of Technology, 1999.

2. Mitra, S. Sample preparation techniques in analytical chemistry. Volume 162, New Jersey: Wiley Interscience, A John Wiley & Sons, Publication, 2003.

3. Kebbekus, B.B., Mitra, S. Environmental chemical analysis. (n.p.): Blackie Academic & Professional, 1998.

4. 40 CFR part 141-142,1997.

5. Healthy vermonters 2010, An air quality fact sheet on VOCs. (n.d.). Available from: http://www.state.vt.us/health/_/hp/airquality/vocs/vocs.htm [2001, July].

6. U.S. EPA, Compendium of Methods for the Determination of Toxic Organic compounds in Ambient Air, US EPA Document No.600/4-84-041, April 1984.

7. Mitra, S., Xu, Y., Chen, W. and Lai, A. Characteristics of microtrap-based injection systems for continuous monitoring of volatile organic compounds by gas chromatography. J. Chromatogr. A. 727 (1996): 111 – 118.

8. Chen, Y. A thermal desorption modulator for continuous monitoring of volatile organic compounds. Master's Thesis, Department of Chemistry and Environmental Science, New Jersey Institute of Technology, 1993.

9. Mitra, S., and Yun, C. Continuous gas chromatographic monitoring of low concentration sample streams using an on-line microtrap. J. Chromatogr. A. 648 (1993): 415 – 421.

10. Mitra, S., and Lai, A. A sequential valve-microtrap injection system for continuous online gas chromatographic analysis at trace levels. J. Chromatogr. Sci. 33 (1995): 285-289.

11. Zhang, L., Guo, X., and Mitra, S. Using a composite membrane for enhanced sensitivity and faster response in on-line membrane extraction microtrap GC monitoring of VOCs in water. Environ. Monit. Assess. 44 (1997): 529 – 540.

12. Xu, Y., and Mitra, S. Continuous monitoring of volatile organic compounds in water using on-line membrane extraction microtrap GC system. J. Chromatogr. A. 688 (1994): 171 – 180.

13. Feng, C., and Mitra, S. Two-stage microtrap as injection device for continuous on-line gas chromatographic monitoring. J. Chromatogr. A. 805 (1998): 169 – 176.

14. Manura, J.J. Calculation and use of breakthrough volume data: Selection and use of adsorbent resin for purge and trap thermal desorption applications; Preparation and conditioning of desorption tubes and resin beds. SISWEB™ Application Note 32. NJ: Scientific Instrument Services, 1997.

15. Feng, C., and Mitra, S. Breakthrough and desorption characteristic of a microtrap. J. Microcolumn Sep. 12, 4 (2000): 267 – 275.

16. Mitra, S., Zhu, N., Zhang, X., and Kebbekus, B. Continuous monitoring of volatile organic compounds in air emissions using an on-line membrane extraction-microtrap-gas chromatographic system. J. Chromatogr. A. 736 (1996): 165 – 173.

17. Xiang, Q. Improvement of continuous nonmethane organic carbon (C-NMOC) system to measure small organic molecules. Doctoral Dissertation, Department of Chemistry and Environmental Science, New Jersey Institute of Technology, 2001.

18. Hollis, O.L., and Hayes, W.V. Porous polymers as packing material J. Chromatogr. A. (1966): 235-237.

19. Kiselev, A.V., and Yashin, Y.I. Gas Adsorption Chromatography, New York: Plenum Press, 1969.

20. Harper, M. Evaluation of solid sorbent sampling methods by breakthrough volume studies. Ann. Occup. Hyg. 409 (1987): 235-242.

21. Simon, V., Riba, M., Waldhart, A., and Torres, L. Breakthrough volume of monoterpenes on Tenax TA: influence of temperature and concentration for α-pinene. J. Chromatogr. A. 704 (1995): 465-471.

22. Ventura, K., Dostal, M., and Churacek, J. Retention characteristics of some volatile compounds on Tenax GR. J. Chromatogr. A. 642 (1993): 379-382.

23. Mitra, S., Xu, Y., Chen, W., and McAllister, G. Development of Instrument for Continuous On-line Monitoring of Non-methanr Organic Carbon in Air Emissions. J. Air Waste Manage. Assoc. 48 (1998): 743-749.

24. Mitra, S., Xu, Y., Chen, W., and McAllister, G. Instrumentation for On-line Monitoring of Non-methane Organic Carbon in Air. Proceedings of the EPA/AWMA Conference on Measurement of Toxic and Related Compounds in Air, Durham, NC, May 1997.

25. Mitra, S., Feng, C., Zhang, L., Ho, W., and McAllister, G. Microtrap interface for on-line mass spectrometric monitoring of air emission. J. Mass Spectrom. 34 (1999): 478-485.

26. Waldack, L.A., Hansen, J.A., and Jeannot, A.M. Head space solvent microextraction. Anal. Chem. 73 (2001): 5651 – 5654.

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

28. Kuran, P., and Sojak, L. Environmental analysis of volatile organic compounds in water and sediment by gas chromatography. J. Air Waste Manage. Assoc. 733 (1996): 119-141.

29. Zygmunt, B. Determination of trihalomethane in aqueous samples by means of a purge and trap system with on sorbent focusing coupled to gas chromatography with electron capture detection. J. Chromatogr. A. 725 (1996): 157 – 163.

30. Heglund, D.L., and Tilotta, D.C. Determination of volatile organic compounds in water by solid phase microextraction and infrared spectroscopy. Environ. Sci. Technol. 30, 4 (1995): 1212 – 1219.

31. EPA method 5030B. Purge and Trap for aqueous sample, methods for evaluating solid waste, physical / chemical methods, 1996. Available from: http://www. epa.gov/epaoswer/hazwaste/test/sw846.htm

32. Bellar, T.A., and Lichtenberg, J.J. Determining volatile organics at microgram per-liter level by gas chromatography. J. Am. Water Works Assoc. 66 (1994): 739.

33. Mitra, S., and Guo, X. Development of membrane purge and trap for measurement of volatile organics in water Anal. Lett. 31(1998): 367 – 379.

34. Headspace analysis: Purge and trap, D. Kou and S. Mitra in Encyclopedia of Analytical Science. 2 nd Edition. (n.p.): Elsevier. (In press 2004).

35. Kou, D. Development of membrane extraction technique for water quality analysis. Ph. D Dissertation. Department of Chemistry and Environmental Science, New Jersey Institute of Technology, 2002.

36. Brukh, R., Salem, T., Slanvetpan, T., Barat, R., and Mitra, S. Process modeling and on-line monitoring of benzene and other species during the two-stage combustion of ethylene in air. Environ. Res. 6 (2002): 359-367.

37. Guo, X., and Mitra, S. Development of pulse introduction membrane extraction for analysis of volatile organic compounds in individual aqueous samples and for continuous on-line monitoring. J. Chromatogr. A. 826 (1998): 39-47.

38. Mitra, S., and Chen, Y. Continuous GC monitoring at trace levels using on-line microtrap. J. Chromatogr. A. 684, 415 (1993).

39. Bier, M.E., and Cooks, R.G. Membrane interface for selective introduction of volatile compounds directly into the ionization chamber of a mass spectrometer. Anal. Chem. 59 (1987): 597-601.

40. Slivon, L.E., Bauer, M.R., Ho, J.S., and Budde, W.L. Helium-purged hollow fiber membrane mass spectrometer interface for continuous measurement of organic compounds in water. Anal. Chem. 63 (1991): 1335 – 1340.

41. Allen, T.M., Falconer, T.M., Cisper, M.E., Borgerding, A.J., and Wilkerson, C.W. Real-Time Analysis of Methanol in Air and Water by Membrane Introduction Mass Spectrometry Anal. Chem. 73 (2001): 4830-4835.

42. Guo, X., and Mitra, S. Theoretical analysis of non-steady-state, pulse introduction membrane extraction with a sorbent trap interface for gas chromatographic detection. Anal Chem. 71 (1999): 4587-4593.

43. Kou, D., Juan, A.S., and Mitra, S. Gas injection membrane extraction for fast on-line analysis using GC detection. Anal Chem. 73 (2001): 5462-5467.

44. http://www.sigmaaldrich.com/Area_of_Interest/The_Americas/United_States.html

45. http://www.sigmaaldrich.com/Brands/Supelco_Home.html

46. http://www.sigmaaldrich.com/Brands/Supelco_Home/Datanodes.html?cat_path=989104,989116&supelco_name=Air%20Monitoring&id=989116

47. LaGrega, M., Buckingam, P., and Evans, J. Hazardous waste management. 2nd ed. (n.p): McGraw-Hill, 2001. pp. 108-110.

48. Code Fed. Register.1994, Part136, Appendix B.

49. Iijima, S. Helical microtubules of graphitic carbon. Nature 354 (1991): 56-58.

50. Thess, A., Lee, R., Nikolaev, P., Dai, H., Petit, P., Robert, J., Xu, C., Lee, Y.H., and Smalley, R. E. Crystalline Ropes of Metallic Carbon Nanotubes. Science 273 (1996): 483-487.

51. Journet, C., Matser, W.K., Bernier, P., Laiseau, L., Lefrant, S., Deniard, P., Lee, R., and Fischer, J.E. Large-scale production of single-walled carbon nanotubes by the electric-arc technique. Nature 388 (1997): 756-758.

52. Amelinckx, S., Zhang, X.B., Bernaerts, D., Zhang, X.F., Ivanov, V., and Nagy, J.B. A formation mechanism for catalytically grown Helix-shaped graphite nanotubes. Science 265 (1994): 635-639.

53. Kong, J., Cassell, A., and Dai, H. Chemical vapor deposition of methane for single-walled carbon nanotubes. Chem. Phys. Lett. 292 (1998): 567-574.

54. Nikolaev, P., Bronikowski, M.J., Bradley, R.K., Rohmund, F., Colbert, D.T., Smith, K.A., and Smalley, R.E. Gas-phase catalytic growth of single-walled carbon nanotubes from carbon monoxide. Chem. Phys. Lett. 313 (1999): 91-97.

55. Lan, A., Zhang, Y., Iqbal, Z., and Grebel, H. Is molybdenum necessary for the growth of single-wall carbon nanotubes from CO?. Chem. Phys. Lett. 379 (2003): 395-400.

56. Cheng, H., Li, F., Su, G., Pan, H.Y., He, L.L., Sun, X., and Dresselhaus, M. Large-scale and low-cost synthesis of single-walled carbon nanotubes by the catalytic pyrolysis of hydrocarbons. Appl. Phys. Lett. 72 (1998): 3282-3284.

57. Murakami, Y., Chiashi, S., Miyauchi, Y., Hu, M., Ogura, M., Okubu, T., and Maruyama, S. Growth of vertically aligned single-walled carbon nanotube films on quartz substrates and their optical anisotropy. Chem. Phys. Lett. 385 (2004): 298-303.

58. Sharma, R., and Iqbal, Z. *In situ* observations of carbon nanotube formation using environmental transmission electron microscopy. Appl. Phys. Lett. 84 (2004): 990-992.

59. Chan, S., Chen, G., Gang, X. G., and Lin. Z. Chemisorption of Hydrogen Molecules on Carbon Nanotubes under High Pressure. Phys. Rev. Lett. 87-20 (2001): 205502-1.

60. Ago, H., Azumi, R., Oshima, S., Zhang, Y., Katanra, H., and Yumura, M. STM study of molecular adsorption on single-wall carbon nanotube surface. Chem. Phys. Lett. 384 (2004): 469-474.

61. Chakrapani, N., Zhang, Y. M., Nayak, S., Moor, J. A., Canol, D., Chi, Y., and Ajayan, P. M. Chemisorption of Acetone on Carbon Nanotubes. J. Phys. Chem. B. 107 (2003): 9308-9311.

62. Huang, W. Z., Zhang, X. B., Tu, J. P., Kong, F. Z., Ma, J. X., Liu, F., Lu, H. M., Chen. Mat, C. P. Materials Chemistry and Physics Chem. Phys. 78 (2002): 144-148. The effect of pretreatments on hydrogen adsorption of multi-walled carbon nanotubes.

63. Peng, X., Li, Y., Luan, Z., Di, Z. Wang, H. Tian, B., and Jia, Z. Adsorption of 1,2-dichlorobenzene from water to carbon nanotubes. Chem. Phys. Lett. 376 (2003): 154-158.

64. Karwa, M., Mitra, S., and Iqbal, Z. Self-assembly of carbon nanotubes inside stainless steel tubings To be submitted to Carbon. (2004).

65. Ago, H., Azumi, R., Oshima, S., Zhang, Y., Katanra, H., and Yumura, M. STM study of molecular adsorption on single-wall carbon nanotube surface. Chem. Phys. Lett. 384 (2004): 469-474.

66. Chakrapani, N., Zhang, Y. M., Nayak, S., Moor, J. A., Canol, D., Chi, Y., and Ajayan, P. M. Chemisorption of Acetone on Carbon Nanotubes. J. Phys. Chem. B. 107 (2003): 9308-9311.

67. Savitsky, A. C., and Sigga, S. Anal. Chem 44 (1972): 1712. Kim, M., and Mitra, S. Microfabricated microconcentrator for sensors andgas chromatography. J. Chromatogr. A. 996 (2003): 1-11.

68. Kim, M., and Mitra, S. A microfabricated microconcentrator for sensors and gas chromatography. J. Chromatogr. A. 996 (2003): 1-11.

69. Brukh, R., Mitra, S., and Barat, R. Pathways to methylene chloride destruction at low and high concentrations. Combust. Sci. and Tech. 176 (2004): 531-555.

APPENDICES

APPENDIX A

Preparation of Synthesis Water

1. Calculating the concentration of standard solution for hexane, benzene, trichloethylene and toluene. From all of standard solution which have individual density and assay (% by weight)

M	=	VD, V = 100 / D
M	=	Mass (gram = g)
V	=	Volume(milliliter = ml)
D	=	Density (g / ml)
Concentration of standard	=	(assay x 1000) / V = A g / l
ppm of standard	=	A x 10^3 mg / l

2. Preparing 50 ml of 1000 ppm from standard solution

Volume of Std to be used = expected conc.x expected volume/Conc of Std

= 1000 x 50 / A x 10^3 ml

Make up this volume to 50 ml by methanol

3. Preparing 1 ppm of 1000 ml synthesis water

Volume of 1000 ppm to be used = expected conc.x expected volume/1000ppm

= 1 x 1000 / 1000 ml = 1 ml

So, taked 1 ml of 1000 ppm solution then make up volume to 1000 ml

APPENDIX B

Calculation of Method Detection Limits

Method detection limits (MDLs) were calculated using standard EPA method for all analytes, using water synthesis at a concentration of two to five times the estimated detection limit. To determine MDLs values, take seven replicate water sample .Perform all calculations defined in the method and report the concentration values in the appropriate units.

Calculate the MDL as follows:

MDL = (Std / Ave) x (Conc.) x (t)

where :

Std = Standard deviation of the replicate analyses

Ave = Average of peak area

t = Student's t value for a 99% confidence level and a standard deviation estimate with n-1 degrees of freedom [t = 3.14 for seven replicates].

Calculation of Relative Standard deviation (RSD)

Relative standard deviation is the parameter of choice for expressing precision in analytical sciences.

Relative Standard Deviation(RSD) :

$$\%RSD = (S / \overline{X}) \times 100$$

S = Standard deviation

$\overline{X}$ = Arithmetic mean

BIOGRAPHY

Ms.Chutarat Saridara was born on May 8,1955 in Suphanburi, Thailand. She received Bachelor of Education (Major : Chemistry) from Srinakarinwirot University, Bangkok, Thailand in 1977. Afterward, she enrolled in Master's degree in Education (Chemistry) at Srinakarinvirot University,Bangkok, Thailand and graduated in 1980. She worked at Rajamangala University of Technology Thanyaburi (RMUTT) for 20 years. In 2000, She started her Ph.D. degree in International Program in Environmental Management, Chulalongkorn University and completed the program in May 2005.

During her Ph.D. she had an opportunity to carry out all of her research work at New Jersey Institute of Technology since August 2002 – December 2004.

Selected Publications and Presentation :

1. Chutarat Saridara, Roman Brukh and Somenath Mitra*

   On-line purge and trap for real time water monitoring , poster presentation for the division of Analytical Chemistry at the 227th American Chemical Society (ACS) National Meeting, Anaheim, CA, March 28-April 1, 2004.

2. Chutarat Saridara, Roman Brukh and Somenath Mitra*

   Development of continuous on-line purge and trap, oral presentation at the Eastern Analytical Symposium (EAS), Somerset, New Jersey, USA, November 15-18, 2004.