REFERENCES

Anonymous (1998) Unocal solves mercury problem of Thailand. Oil and Gas Journal, 96(46), 34-36.

Barton, Allan F.M. (1991) CRC Handbook of Solubility Parameters and Other Cohesion Parameters. New York: CRC Press LLC.

Beck, J., Svrcek, W.Y., and Yarranton, H.W. (2005) Hysteresis in Asphaltene Precipitation and Redissolution. Energy & Fuel, 19, 944-947.

Bloom, N.S. (2000) Analysis and stability of mercury speciation in petroleum hydrocarbons. Fresenius Journal of Analytical Chemistry, 366(2), 438-443.

Burke, J. (1984) Solubility Parameters: Theory and Application. AIC Book and Paper Group Annual, 3, 13-58.

Chang, R. (1998) Chemistry. McGraw-Hill International Editions, 6th edition.

Chongprasith, P., Utoomprurkporn, W., Praehulvanich, E, and Angwichit, P. (2000) Mercury assessment in Thailand. Pollution Control Department, Ministry of Science:, Technology and Environment, Thailand.

Communication Arts High School web site, www.nisd.net/secww/science/science-taks/Solubility%20Factors_files/frame.htm

Daniel High School web site, www.sciencebyjones.com/solubility.htm

Dean, J.A. (1987) Lange's Handbook of Chemistry. McGraw-Hill International Editions, 13rd edition.

Edmonds, B., Moorwood, R.A.S., and Szczepanski, R. (1996, March) Mercury partitioning in natural gas and condensates. Paper presented to the GPA European Chapter Meeting, London.

Hildebrand, J.H. and Scott, R.L. (1962) Regular Solutions. New Jersey: Prentice-hall

Iwamoto, M. and Clever, H.L. (1987) Solubility of mercury in normal alkane. Industrial and Engineering Chemistry Research, 26(1), 336-337.

Kittichaichana, P. (2006) The Study of Temperature Dependence on Mercury Solubility in Condensate/Crude Oil: Part II Cyclic Aliphatics and Aromatics. M.S. Thesis, The Petroleum and Petrochemical College, Chulalongkorn University, Bangkok, Thailand.

Kuntz, R.R. and Main, G.J. (1964) The solubility of mercury in hydrocarbon. The Journal of Physical Chemistry, 68(2), 408-410.

Okouchi, S. and Sasaki, S. (1981) The measurement of the solubility of metallic mercury in hydrocarbon by means of the cold-vapor atomic absorption method. The Chemical Society of Japan, 54(1), 2513-2514.

Onat, E. (1974) Solubility studied of metallic mercury in pure water of various temperature. Journal of Inorganic and Nuclear Chemistry, 36(1), 2029-2032.

Online website. www.cop.ufl.edu/safezone/prokai/pha5100/solbility.htm

Schickling, C. and Broekaert, J.A.C. (1995) Determination of mercury species in gas condensates by on-line coupled HPLC and CVAA spectrometry. Applied Organometallic Chemistry, 9(1), 29-36.

Shafawi, A., Ebdon, L., Foulkes, M., Stockwell, P., and Corns, W. (1999). Determination of total mercury in hydrocarbons and natural gas condensate by atomic fluorescence spectrometry. The Analyst., 124(1), 185-189.

Spencer, J.N. and Voigt, A.F, (1968) Tracer determination of the solubility in various liquids. The Journal of Physical Chemistry, 72(2), 464-470.

Wikipedia (Online Encyclopedia) website: http://en.wikipedia.org/wiki/Solubility

Wilhelm, S.M. (2001) Mercury in petroleum and natural gas: Estimation of emissions from production, processing, and combustion. Prepared for Office of Research and Development, U.S. Environmental Protection Agency, Washington, DC, USA.

Wilhelm, S.M. and Bloom, N. (2000) Mercury in petroleum. Fuel Processing Technology, 63(1), 1-27.

Appendix A Mercury Solubility Result in Hydrocarbons

Table A1 Mercury solubility in single solvent system at 5°C

Solvent	Mercury solubility, ppb (wt)							
	Literature Value*	R1	R2	R3	Avg	SD	% CV	% Diff
n-pentane	549.95	134.22	158.05	143.75	145.34	11.99	8.25	73.57
n-hexane	568.89	330.99	359.39	308.58	332.99	25.46	7.65	41.47
n-heptane	570.37	131.34	119.97	131.17	127.49	6.52	5.11	77.65
n-octane	590.58	283.69	271.93	298.07	284.56	13.09	4.60	51.82
n-decane	N/A	195.48	183.40	186.03	188.00	5.85	3.11	N/A
2,2,4-trimethylpentane	372.82	104.36	98.83	88.61	97.27	7.99	8.22	73.91

* Calculated from the least square equation from Okouchi *et al.* (1981) except 2,2,4-trimethylpentane which was from Spencer *et al.* (1967).

Table A2 Mercury solubility in single solvent system at 15°C

Solvent	Mercury solubility, ppb (wt)							
	Literature Value*	R1	R2	R3	Avg	SD	% CV	% Diff
n-pentane	1016.21	215.93	225.51	201.53	214.32	12.07	5.63	78.91
n-hexane	1041.41	357.11	346.47	371.52	358.37	12.57	3.51	65.59
n-heptane	1049.45	159.04	158.91	159.65	159.20	0.40	0.25	84.83
n-octane	1058.05	307.91	339.39	310.27	319.19	17.53	5.49	69.83
n-decane	N/A	245.17	246.63	241.70	244.50	2.53	1.04	N/A
2,2,4-trimethylpentane	666.97	170.14	167.12	176.21	171.16	4.63	2.70	74.34

* Calculated from the least square equation from Okouchi *et al.* (1981) except 2,2,4-trimethylpentane which was from Spencer *et al.* (1967).

Table A3 Mercury solubility in single solvent system at 25°C

Solvent	Mercury solubility, ppb (wt)							
	Literature Value*	R1	R2	R3	Avg	SD	% CV	% Diff
n-pentane	1839.18	395.17	375.07	395.35	388.53	11.66	3.00	78.87
n-hexane	1867.50	500.24	511.63	522.94	511.60	11.35	2.22	72.60
n-heptane	1891.09	476.91	433.09	446.91	452.30	22.40	4.95	76.08
n-octane	1843.91	509.00	532.86	519.81	520.56	11.95	2.30	71.77
n-decane	1508.48	546.50	521.75	539.21	535.82	12.72	2.37	64.48
2,2,4-trimethylpentane	1166.23	371.15	342.78	368.11	360.68	15.58	4.32	69.07

* Calculated from the least square equation from Okouchi *et al.* (1981) except 2,2,4-trimethylpentane which was from Spencer *et al.* (1967).

Table A4 Mercury solubility in single solvent system at 40°C

Solvent	Mercury solubility, ppb (wt)							
	Literature Value*	R1	R2	R3	Avg	SD	% CV	% Diff
n-pentane	4315.05	1015.55	1054.22	1011.17	1026.98	23.69	2.31	76.20
n-hexane	4327.17	1407.50	1449.70	1318.05	1391.75	67.22	4.83	67.84
n-heptane	4412.40	1230.39	1121.26	1297.64	1216.43	89.01	7.32	72.43
n-octane	4177.78	1451.82	1436.55	1439.96	1442.78	8.02	0.56	65.47
n-decane	N/A	1009.23	1144.68	1055.87	1069.93	68.81	6.43	N/A
2,2,4-trimethylpentane	2606.06	968.67	949.97	963.22	960.62	9.62	1.00	63.14

* Calculated from the least square equation from Okouchi *et al.* (1981) except 2,2,4-trimethylpentane which was from Spencer *et al.* (1967).

Table A5 Mercury solubility in simulated condensate at various temperatures

Temperature (°C)	Mercury solubility, ppb (wt)					
	R1	R2	R3	Avg	SD	% CV
5	264.16	276.62	262.85	267.88	7.60	2.84
15	332.29	335.05	350.45	339.26	9.79	2.88
25	876.96	833.28	875.52	861.99	24.87	2.89
40	1787.97	1882.54	1782.83	1817.78	56.14	3.09

Appendix B Hysteresis of Mercury Solubility in Hydrocarbons

Table B1 Hysteresis of mercury solubility in single solvent system at 5°C

Solvent	Mercury solubility, ppb (wt)					
	R1	R2	R3	Avg	SD	% CV
n-pentane	126.24	118.91	130.03	125.06	5.65	4.52
n-hexane	223.93	207.66	223.90	218.50	9.38	4.30
n-heptane	164.74	179.31	170.21	171.42	7.36	4.29
n-octane	235.01	229.77	233.43	232.74	2.69	1.15
n-decane	194.21	199.29	185.12	192.87	7.18	3.72
2,2,4-trimethylpentane	111.60	117.61	102.84	110.68	7.43	6.71

Table B2 Hysteresis of mercury solubility in single solvent system at 15°C

Solvent	Mercury solubility, ppb (wt)					
	R1	R2	R3	Avg	SD	% CV
n-pentane	145.01	144.65	132.41	140.69	7.17	5.10
n-hexane	488.28	489.29	528.45	502.07	22.85	4.55
n-heptane	276.87	264.03	275.66	272.19	7.09	2.60
n-octane	311.67	314.67	319.85	315.40	4.14	1.31
n-decane	259.76	261.53	268.36	263.22	4.54	1.73
2,2,4-trimethylpentane	113.29	112.76	118.76	114.94	3.32	2.89

Table B3 Hysteresis of mercury solubility in single solvent system at 25°C

Solvent	Mercury solubility, ppb (wt)					
	R1	R2	R3	Avg	SD	% CV
n-pentane	353.81	394.74	399.91	382.82	25.26	6.60
n-hexane	615.36	644.96	613.51	625.28	17.15	2.74
n-heptane	468.01	435.54	451.47	451.67	16.24	3.59
n-octane	563.47	584.19	514.93	554.20	35.55	6.41
n-decane	577.57	506.86	505.31	529.91	41.28	7.79
2,2,4-trimethylpentane	379.57	339.58	369.93	363.03	20.87	5.75

Table B4 Hysteresis of mercury solubility in simulated condensate at various temperatures

Temperature (°C)	Mercury solubility, ppb (wt)					
	R1	R2	R3	Avg	SD	% CV
5	200.62	197.03	198.56	198.74	1.80	0.91
15	231.83	204.15	221.40	219.13	13.98	6.38
25	445.01	457.35	437.63	446.66	9.96	2.23

Appendix C Least Square Equation for the Temperature Dependence of the Solubility of Mercury

From Spencer *et al.* (1967) and Okouchi *et al.* (1981), the raw experimental data were not published, but the least square equations for the temperature dependence of the mercury solubility in hydrocarbons were given instead.

$$Log\ X = A Log\ T + B \qquad (C.1)$$

where X = the mole fraction of mercury
T = the absolute temperature.

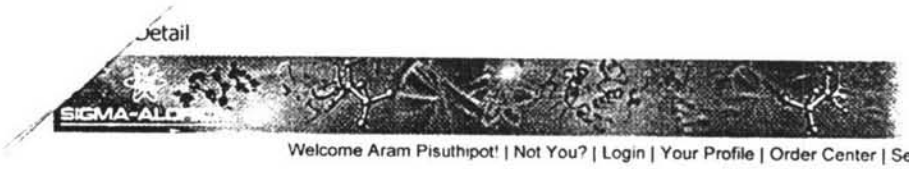
From equation C.1, coefficients A and B for each hydrocarbon from previous works were tabulated in Table C.1.

Table C.1 Constants of equation C.1

Solvent	Spencer et al., 1967		Okouchi et al., 1981	
	A	B	A	B
n-pentane			17.375	-49.169
n-hexane	17.084 ± 0.420	-48.366	17.111	-48.432
n-heptane	17.462 ± 0.301	-49.234	17.250	-48.705
n-octane	16.583 ± 0.228	-47.003	16.500	-46.800
2,2,4-trimethylpentane	16.377 ± 0.451	-46.698		

However, the temperature range covered by this equation is about 0-40°C.

Appendix D Certificate of Analysis of 3-methylpentane



Related Documents
MSDS
FT-IR Condensed Phase
FT-IR Raman
FT NMR
DEA Instructions
Lot Specific Information
Certificate of Analysis
Lot #:
Options
Print Preview
Bulk Quote
Ask A Scientist

SIGMA-ALDRICH

Certificate of Analysis

Product Name	3-Methylpentane, purum ≥99.0% (GC)
Product Number	68322
Product Brand	Fluka
CAS Number	96-14-0
Molecular Formula	C_6H_{14}
Molecular Weight	86.18

TEST	LOT 1146923 RESULTS
APPEARANCE (COLOR)	COLORLESS
APPEARANCE (FORM)	CLEAR LIQUID
ASSAY (GC AREA %)	99.3 % rel
REMARKS ON GC	0.7 % 2,3-Dimethylbutane
DENSITY D20/4	0.664
REFRACTIVE INDEX N20/D	1.377
INFRARED SPECTRUM	CORRESPONDS
DATE OF QC-RELEASE	18/NOV/04

Fluka guarantees the 'Sales-Specification' values only, non-specified tests may be included as additional information. The current 'Sales Specifications' sheet is available on request. For further inquiries, please contact our Technical Service. Fluka warrants, that its products conform to the information contained in this and other Fluka publications. Purchaser must determine the suitability of the product for its particular use. See reverse side of invoice for additional terms and conditions of sale. The values given on the 'Certificate of Analysis' are the results determined at the time of analysis.

Dr. Gert van Look, Manager
Quality Control
Buchs, Switzerland

Appendix E Hysteresis Curve with the 10% Acceptable Deviation Range

In this work, the maximum acceptable deviation range for the mercury solubility was set to 10%. When we plotted the hysteresis curve with the 10% deviation range instead of the standard deviation for each point, the curve shows in Figures E.1 – E.7.

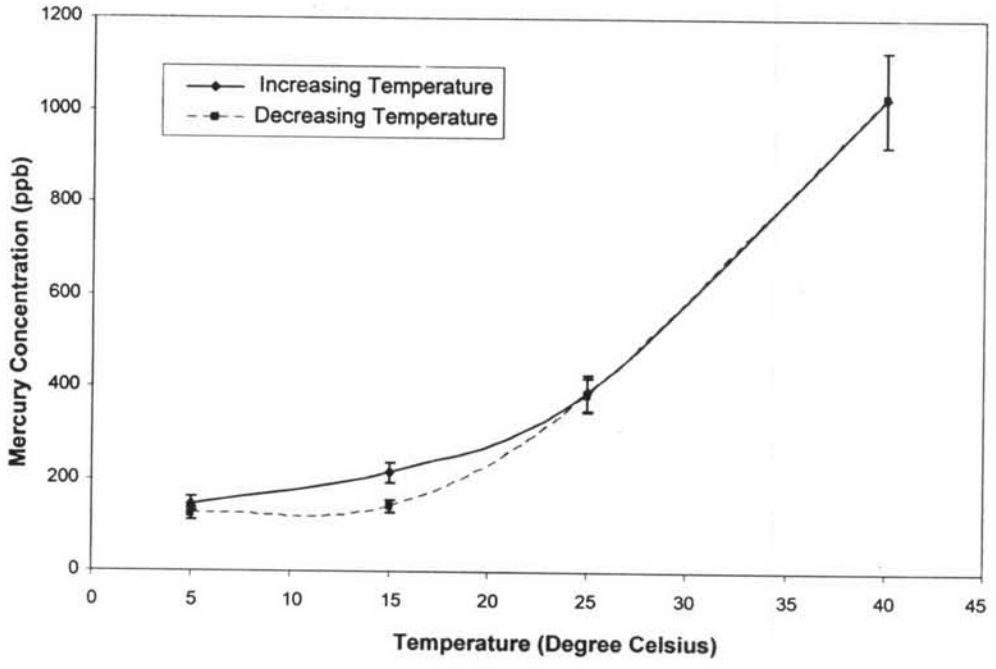


Figure E.1 Hysteresis study on mercury solubility in *n*-pentane.

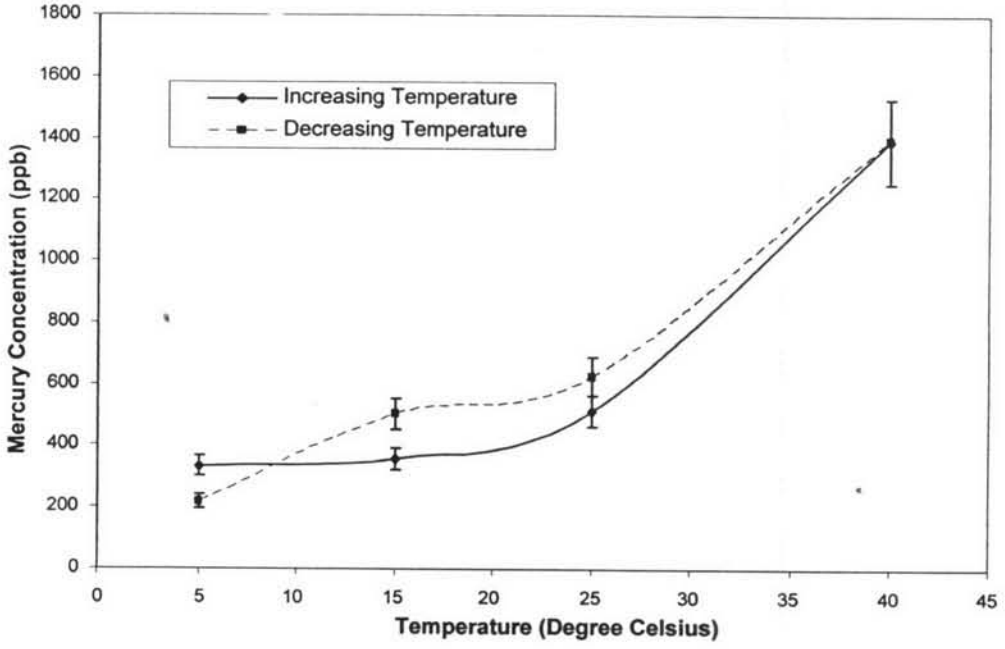


Figure E.2 Hysteresis study on mercury solubility in *n*-hexane.

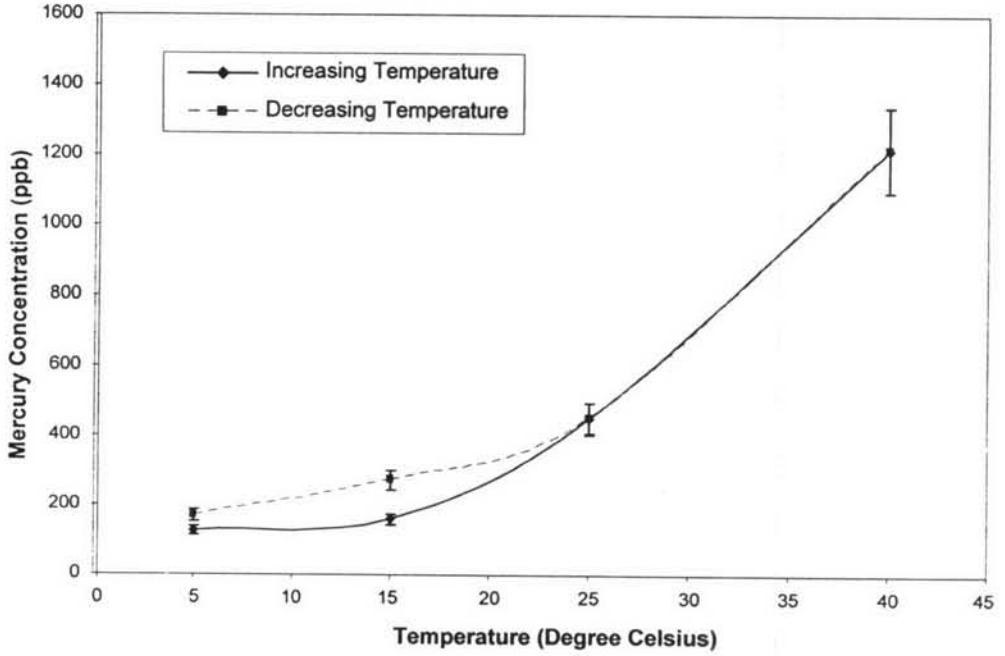


Figure E.3 Hysteresis study on mercury solubility in *n*-heptane.

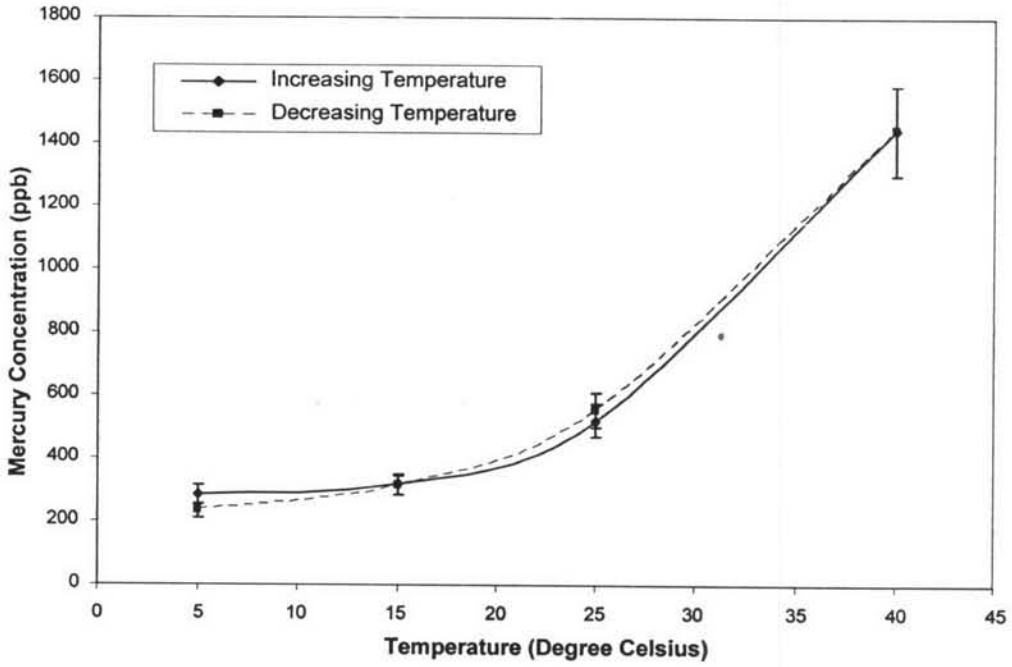


Figure E.4 Hysteresis study on mercury solubility in *n*-octane.

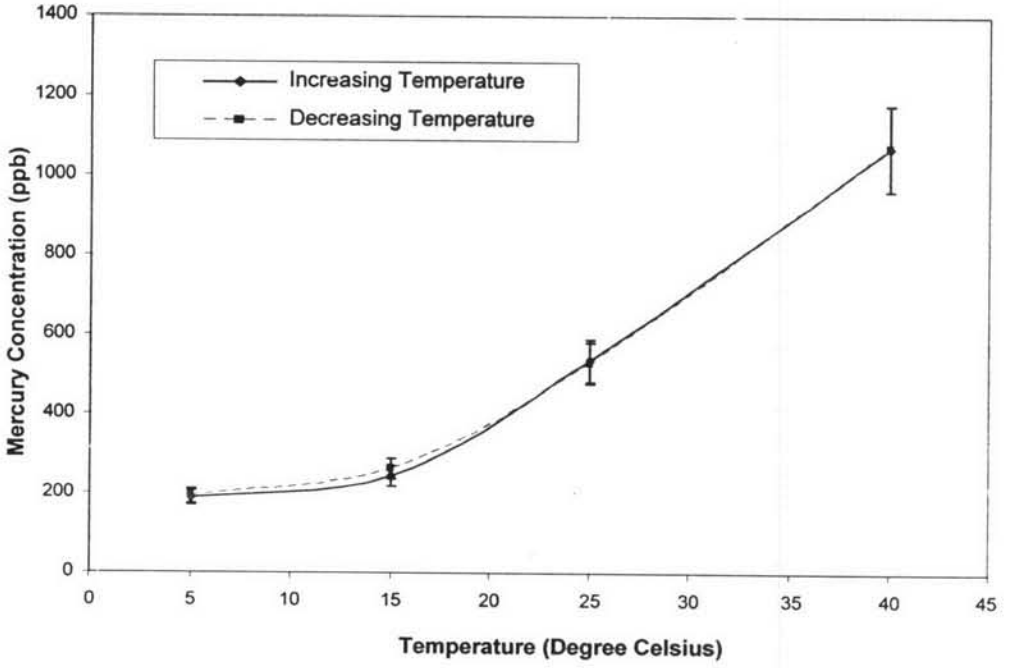


Figure E.5 Hysteresis study on mercury solubility in *n*-decane.

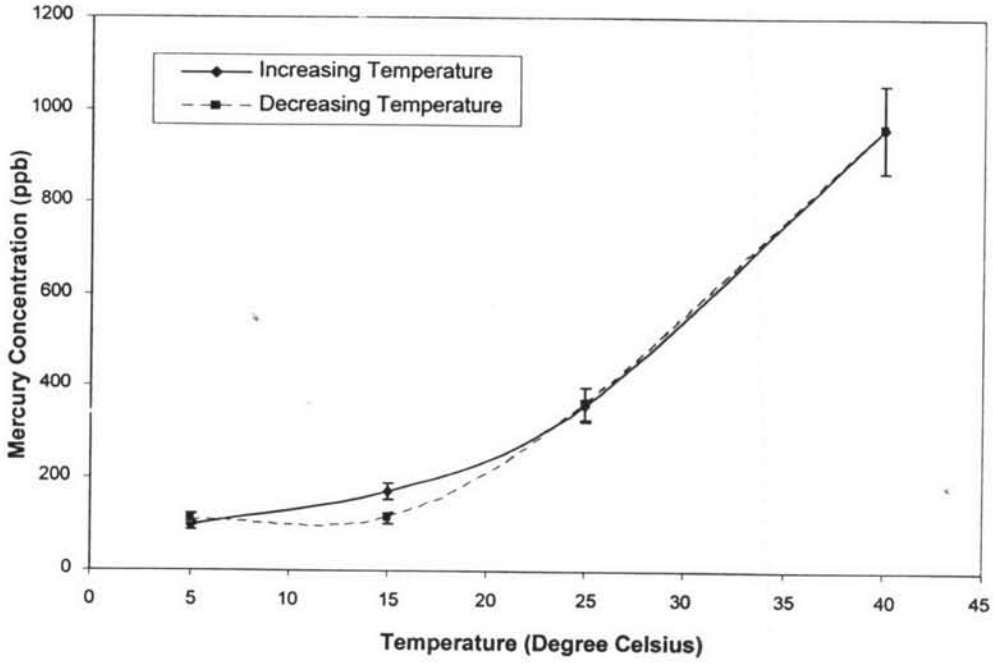


Figure E.6 Hysteresis study on mercury solubility in 2,2,4-trimethylpentane.

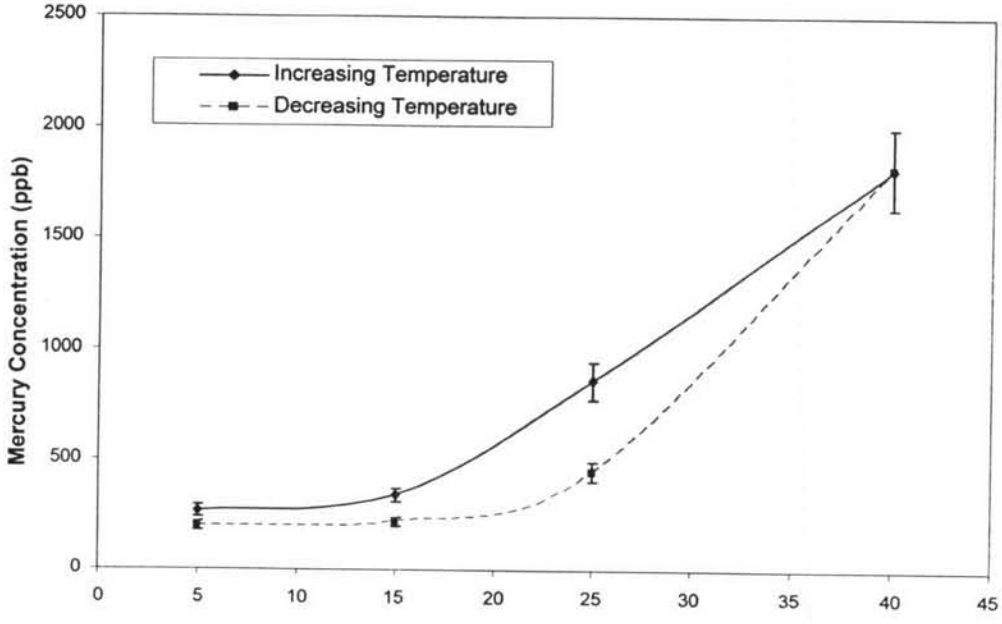


Figure E.7 Hysteresis study on mercury solubility in simulated condensate.

It can be concluded that hysteresis did not exist in *n*-octane and *n*-decane since the differences between the increasing and decreasing temperature curves were

insignificant, whereas the other solvents and simulated condensate show the occurrence of hysteresis.

CURRICULUM VITAE

Name: Ms. Panithita Rochana

Date of Birth: November 29, 1981

Nationality: Thai

University Education:

1999-2003 Bachelor Degree in Chemical Engineering, Faculty of Engineering, Chulalongkorn University, Bangkok, Thailand

Working Experience:

2003-2004	Position:	Quality Guarantee Engineer
	Company name:	Siam Tyre Phra Pradaeng Co., Ltd.
		Michelin Group (Thailand)
2002	Position:	Internship Student
	Company name:	Thai Olefins Co., Ltd.