

This article was downloaded by:

On: 28 January 2011

Access details: *Access Details: Free Access*

Publisher *Taylor & Francis*

Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK



Physics and Chemistry of Liquids

Publication details, including instructions for authors and subscription information:

<http://www.informaworld.com/smpp/title~content=t713646857>

Bubble temperature measurements on the binary mixtures formed by chlorobenzene with methanol, ethanol, *n*-propanol and sec-butanol at 94.6 kPa

T.E.Vittal Prasad^a; M. Haritha^b; N. B. Geetha^b; Y.P. Pavan Kumar^b; K. I. Kalyan^b; D. H. L. Prasad^a

^a Properties Group, Chemical Engineering Laboratory, Indian Institute of Chemical Technology,

Hyderabad - 500 007, India ^b College of Technology, Osmania University, Hyderabad - 500 007, India

To cite this Article Prasad, T.E.Vittal, Haritha, M., Geetha, N. B., Kumar, Y.P. Pavan, Kalyan, K. I. and Prasad, D. H. L.(2004) 'Bubble temperature measurements on the binary mixtures formed by chlorobenzene with methanol, ethanol, *n*-propanol and sec-butanol at 94.6 kPa', *Physics and Chemistry of Liquids*, 42: 4, 385 – 389

To link to this Article: DOI: 10.1080/00319100410001684480

URL: <http://dx.doi.org/10.1080/00319100410001684480>

PLEASE SCROLL DOWN FOR ARTICLE

Full terms and conditions of use: <http://www.informaworld.com/terms-and-conditions-of-access.pdf>

This article may be used for research, teaching and private study purposes. Any substantial or systematic reproduction, re-distribution, re-selling, loan or sub-licensing, systematic supply or distribution in any form to anyone is expressly forbidden.

The publisher does not give any warranty express or implied or make any representation that the contents will be complete or accurate or up to date. The accuracy of any instructions, formulae and drug doses should be independently verified with primary sources. The publisher shall not be liable for any loss, actions, claims, proceedings, demand or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of this material.

BUBBLE TEMPERATURE MEASUREMENTS ON THE BINARY MIXTURES FORMED BY CHLOROBENZENE WITH METHANOL, ETHANOL, *n*-PROPANOL AND *sec*-BUTANOL AT 94.6 kPa

T.E. VITTAL PRASAD^a, M. HARITHA^b, N.B. GEETHA^b,
Y.P. PAVAN KUMAR^b, K.I. KALYAN^b and D.H.L. PRASAD^{a,*}

^aProperties Group, Chemical Engineering Laboratory, Indian Institute of Chemical Technology,
Hyderabad – 500 007, India; ^bCollege of Technology, Osmania University,
Hyderabad – 500 007, India

(Received 30 August 2003)

Bubble temperatures at 94.6 kPa, over the entire composition range have been measured for the binary mixtures formed by chlorobenzene with methanol, ethanol, *n*-propanol and *sec*-butanol using a Swietoslowski type ebulliometer. The liquid phase composition *versus* temperature data are found to be well represented by the Wilson model.

Keywords: Bubble temperature; Aliphatic alcohols; Chlorobenzene

INTRODUCTION

This investigation leading to the vapor–liquid equilibria of the binary mixtures formed by chlorobenzene with methanol, ethanol, *n*-propanol and *sec*-butanol, is in continuation of our systematic phase equilibrium studies on the binary mixtures containing alcohols and chlorohydrocarbons [1–10]. Methanol(1) + chlorobenzene(2) system has been investigated isobarically at kPa by Nakanishi *et al.* [11] and Narasimha Rao and Subba Rao [12], and isothermally at 328.15 K by Nagata [13]. Ethanol(1) + chlorobenzene(2) system has been studied at 101.3 kPa by Arzhanov *et al.* [14]. Experimental work on the *n*-propanol(1) + chlorobenzene(2) system has been carried out at 0.4 kPa and 363.15 K by Ellis *et al.* [15] and at 101.3 kPa by Venkateswara Rao *et al.* [16]. Isobaric studied at 101.3 kPa on the *sec*-butanol(1) + chlorobenzene(2) system have been reported by Venkateswara Rao *et al.* [17]. The measurements of the present work are found to compare favorably with the available literature data.

*Corresponding author.

EXPERIMENTAL SECTION

Method

A Swietoslowski type ebulliometer, very similar to the one described by Hala *et al.* [18], is used for the present set of experiments. The ebulliometer is connected to a vacuum pump and a dry nitrogen gas cylinder, with a closed end manometer in line, to enable the measurements and maintenance of the total pressure of the system at the chosen level of 95 kPa, by adjusting the opening of the needle valve of the gas cylinder or the opening of the by pass line of the vacuum pump. The total pressure in the present set of experiments is maintained within ± 0.1 kPa of the required value by frequently reading the mercury manometer and carrying out the needed corrective adjustment. A mercury-in-glass thermometer, calibrated by means of point-to-point comparison with a platinum resistance thermometer (certified by the National Institute of Standards and Technology, Boulder, USA) is used to measure the equilibrium temperature to an accuracy of ± 0.05 K. The thermometer is placed in the thermowell (filled with mercury) located at a place in the apparatus, where the gas-liquid mixture impinges the outer surface of the thermowell continuously, under equilibrium conditions. The mixtures to be studied are prepared gravimetrically, by weighing the required quantities of the two components and mixing them well, before charging to the apparatus. A Mettler balance of ± 0.0001 g accuracy is used for the necessary weighings. The heating rate is adjusted to yield the desirable condensate drop rate of about 30 drops per minute in accordance with the suggestion of Hala *et al.* [18]. The technique of subjecting the test sample to the lowest pressure/highest temperature, proposed for the study and reverting to the prevailing ambient conditions several times, before commencing the actual experiment is followed to achieve and retain the constancy of composition throughout the experiment.

A gas chromatograph is used to verify the composition at the beginning as well as after the experiment. The equilibrium temperature is recorded, after steady state condition (judged by the recording of constant temperature and uniform drop rate for atleast 30 min) have been achieved.

Materials

Laboratory Reagent grade chlorobenzene supplied by Ranbaxy Laboratories, SAS Nagar Punjab (India) is stored over phosphorous pentoxide for two days and fractionally distilled twice. The middle fraction of the second distillation is stored in amber colored bottles for use in the phase equilibrium experiments.

Spectroscopic grade methanol and ethanol procured from SD's Fine Chemicals, Boisar (India) are distilled twice, fractionally, after initial drying over silica gel. The middle fraction of the second distillation is collected and stored in amber colored bottles for use in the experiments.

Laboratory Reagent grade *n*-propanol, procured from E. Merc, Mumbai (India) is purified by adding a small quantity of sodium metal and refluxing for 2 h, followed by treatment with anhydrous sodium carbonate and drying over calcium hydroxide and fractionally distilled twice.

Extrapure AR grade sec-butanol purchased from SISCO Research Laboratories, Mumbai (India) is distilled twice, fractionally, after drying over potassium carbonate.

TABLE I Comparison of the density (ρ) and refractive-index (n_D) at 293.15 K with literature [19]

Substance	ρ (kg m ⁻³)		n_D	
	This work	Literature	This work	Literature
Chlorobenzene	1106.0	1106.30	1.5248	1.52481
Methanol	791.1	791.04	1.3284	1.32840
Ethanol	789.2	789.20	1.3614	1.36143
<i>n</i> -Propanol	803.6	803.61	1.3994	1.33993
sec-Butanol	806.5	806.52	1.3971	1.39706

TABLE II Bubble temperature measurements at 94.6 kPa

Methanol(1) + chlorobenzene(2)		Ethanol(1) + chlorobenzene(2)		<i>n</i> -Propanol(1) + chlorobenzene(2)		sec-Butanol(1) + chlorobenzene(2)	
x_1	T/K	x_1	T/K	x_1	T/K	x_1	T/K
0.0000	402.35	0.0000	402.35	0.0000	402.35	0.0000	402.35
0.1133	346.45	0.1122	369.65	0.1503	380.25	0.1528	383.25
0.2046	342.65	0.2016	361.45	0.3005	373.95	0.3010	377.75
0.3100	340.85	0.3067	356.65	0.4494	371.35	0.4450	375.05
0.4015	340.05	0.4014	354.15	0.5958	369.55	0.6046	373.15
0.5019	339.55	0.5054	352.45	0.7518	368.65	0.7496	371.95
0.6040	338.75	0.6073	351.45	0.9011	368.25	0.8996	371.25
0.7040	337.95	0.7052	350.65	1.0000	368.75	1.0000	371.05
0.8040	337.45	0.8049	350.15				
0.9020	336.55	0.9038	349.65				
1.0000	336.15	1.0000	349.75				

The middle fraction of the second distillation is stored in amber colored bottles for use in the experiments.

Purification of all the substances is carried out only a few hours before the phase equilibrium experiments are commenced and sufficient care is taken to avoid absorption of moisture, oxidation etc., during the intervening period. Based on a comparison of the density and refractive-index data with the literature data of Riddick *et al.* [19], shown in Table I the pure liquids used in the present work are expected to be 99.9% pure.

RESULTS AND DISCUSSION

The experimental composition (x_1) versus temperature (T) data, summarized in Table II, are fitted to the Wilson model. The optimum Wilson parameters are obtained by minimizing the objective function defined as

$$\varphi = [P_{\text{Cal}}/P_{\text{Expt}} - 1]^2 \tag{1}$$

The Nelder–Mead optimization technique, described in detail by Kuester and Mize [20] is used. Vapor pressures of the pure liquids needed in the computations are calculated from the Antoine equation with the constants collected from Reid *et al.* [21] and noted in Table III for ready reference. Molar volumes of the pure liquids are calculated from

TABLE III Antoine constants used in $\ln [P/\text{kPa}] = A - B/[(T/\text{K}) + C]$

Substance	A	B	C
Chlorobenzene	14.0502	3295.12	- 55.60
Methanol	16.5701	3626.55	- 34.29
Ethanol	16.8945	3803.98	- 41.08
<i>n</i> -Propanol	15.5265	3166.38	- 80.15
sec-Butanol	15.1928	3026.03	- 86.55

TABLE IV Representation of the boiling temperature measurements by Wilson model

Mixture	$[(\lambda_{12} - \lambda_{11})/R]/\text{K}$	$[(\lambda_{12} - \lambda_{22})/R]/\text{K}$	Std. Dev./K
Methanol(1) + chlorobenzene(2)	672.4	365.7	0.07
Ethanol(1) + chlorobenzene(2)	216.6	532.9	0.10
<i>n</i> -Propanol(1) + chlorobenzene(2)	282.5	274.3	0.10
sec-Butanol(1) + chlorobenzene(2)	370.8	99.1	0.08

TABLE V Comparisons with literature data

System	Source of Literature Data	Av. Abs Dev. in y_1
Methanol(1) + chlorobenzene(2)	Ref. [11]	0.01
	Ref. [12]	0.01
	Ref. [13]	0.08
Ethanol(1) + chlorobenzene(2)	Ref. [14]	0.01
<i>n</i> -Propanol(1) + chlorobenzene(2)	Ref. [15]	0.01
	Ref. [16]	0.02
sec-Butanol(1) + chlorobenzene(2)	Ref. [17]	0.01

the liquid density data of the present work given in Table I. Results of the representation of the data by the Wilson model are presented in Table IV. The Wilson parameters given in Table IV, are used to predict the vapor phase compositions at the conditions of the available literature data. Summarized comparisons, presented in Table V, shows good agreement except at a few measurements in the very low concentrations of the more volatile component. Some of the isothermal data are also not in good agreement. The data and the representation given in the article are expected to be useful for design purposes.

References

- [1] Ch. Srinivas, M. Venkateshwara Rao and D.H.L. Prasad (1991). *Fluid Phase Equilibria*, **69**, 285.
- [2] V. Lakshman, M. Venkateshwara Rao and D.H.L. Prasad (1991). *Fluid Phase Equilibria*, **69**, 271.
- [3] R. Kiran Kumar, M. Venkateshwara Rao and D.H.L. Prasad (1991). *Fluid Phase Equilibria*, **70**, 19.
- [4] R. Vijaya Kumar, M. Anand Rao, M. Venkateshwara Rao, Y.V.L. Ravikumar and D.H.L. Prasad (1996). *J. Chem. Eng. Data*, **41**, 1020.
- [5] R. Vijaya Kumar, M. Anand Rao, M. Venkateshwara Rao, Y.V.L. Ravikumar and D.H.L. Prasad (1996). *Physics and Chemistry of Liquids*, **32**, 177.
- [6] R. Vijaya Kumar, M. Anand Rao, M. Venkateshwara Rao, Y.V.L. Ravikumar and D.H.L. Prasad (1996). *Thermochimica Acta*, **287**, 7.

- [7] R. Vijaya Kumar, M. Anand Rao, M. Venkateshwara Rao and D.H.L. Prasad (1996). *Physics and Chemistry of Liquids*, **32**, 233.
- [8] R. Vijaya Kumar, M. Anand Rao, M. Venkateshwara Rao and D.H.L. Prasad (1997). *Physics and Chemistry of Liquids*, **35**, 81.
- [9] R. Vijaya Kumar, M. Anand Rao, M. Venkateshwara Rao and D.H.L. Prasad (1997). *Physics and Chemistry of Liquids*, **35**, 121.
- [10] R. Vijaya Kumar, M. Anand Rao, M. Venkateshwara Rao and D.H.L. Prasad (1999). *Physics and Chemistry of Liquids*, **37**, 345.
- [11] K. Nakanishi, H. Shirai and K. Nakasato (1968). *J. Chem. Eng. Data*, **13**, 188.
- [12] M. Narasimha Rao and B.V. Subba Rao (1978). *Indian J. Technology*, **16**, 85.
- [13] I. Nagata (1986). *J. Chem. Eng. Data*, **31**, 413.
- [14] P.G. Arzhanov, L.F. Komarova and Yu. N. Garber (1976). *Zh. Prikl. Khim.*, **49**, 103.
- [15] S.R.M. Ellis, C. McDermott and J.C.L. Williams (1960). *Proc. Int. Symp. On Distillation*. Inst. Chem. Engrs., London.
- [16] K. Venkateswara Rao, A. Raviprasad and C. Chiranjivi (1977). *J. Chem. Eng. Data*, **22**, 44.
- [17] K. Venkateswara Rao, A. Raviprasad and C. Chiranjivi (1980). *J. Chem. Eng. Data*, **25**, 21.
- [18] E. Hala, J. Pick, V. Fried and O. Villim (1958). *Vapor-Liquid Equilibrium*. Pergamon, Oxford.
- [19] J.A. Riddick, W.S. Bunger and T.K. Sakno (1986). *Organic Solvents-Physical Properties and Methods of Purification*, 4th Edn., Vol. 2. Wiley – Interscience, New York.
- [20] R.T. Kuester and J.H. Mize (1973). *Optimization Techniques with Fortran*. McGraw-Hill, New York.
- [21] R.C. Ried, J.M. Prausnitz and T.K. Sherwood (1977). *The Properties of Gases and Liquids*, 3rd Edn. McGraw-Hill, New York.