Vapor Pressures and Liquid Densities of Ammonium Bromide + Ammonia Mixtures

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Vapor pressures and liquid densities for ammonium bromide (NH_4Br) + ammonia (NH_3) mixtures were measured over a wide range of temperatures and molalities. Vapor pressures of the $NH_4Br + NH_3$ mixtures were measured at temperatures ranging from (303.12 to 373.16) K and molalities ranging up to 18.034 $mol \cdot kg^{-1}$ of NH_4Br. Vapor pressures were measured with a static method. The experimental values were correlated with Antoine's equation. Liquid densities of the $NH_4Br + NH_3$ mixtures were measured at temperatures ranging from (303.15 to 373.15) K, pressure ranging from (10.0 to 30.0) MPa, and molalities ranging up to 15.171 $mol \cdot kg^{-1}$ of NH_4Br. Liquid densities were measured with a piezometer. The experimental values were correlated with a Tait-form equation.

Introduction

Gallium nitride (GaN) has attracted considerable attention for the materials as a high-power and high frequency electronics device. Therefore, high quality and large diameter bulk GaN is required. Several methods have been proposed and tested for the GaN crystal growth.[1−3] The ammonothermal method which is a solvothermal method is one of the most promising techniques for achieving this purpose.[2,4−6] In the acidic ammonothemal method, ammonia and ammonium halide are used as solvent and mineralizer, respectively.[6,7] However, there are a few data regarding the thermophysical properties of ammonium halide + ammonia mixtures. The vapor pressures of ammonium bromide + ammonia and ammonium iodide + ammonia solutions over a wide temperature range and at various concentrations were reported by Yamamoto et al.[8] They also reported the liquid densities of these solutions at saturated vapor pressure.[9] However, there are no literature values for liquid densities of these solutions above saturated vapor pressure.

In our previous study, we measured the vapor pressures and liquid densities of ammonium chloride + ammonia mixtures.[10] The present paper describes continuing work on the experimental determination of the vapor pressures and liquid densities consisting of ammonium halide + ammonia mixtures. In this paper, vapor pressures and liquid densities for ammonium bromide (NH_4Br) + ammonia (NH_3) were measured. Vapor pressures of the $NH_4Br + NH_3$ mixtures were measured at temperatures ranging from (303.12 to 373.16) K and molalities ranging up to 18.034 $mol \cdot kg^{-1}$ of NH_4Br. Liquid densities of the $NH_4Br + NH_3$ mixtures were measured at temperatures ranging from (303.15 to 373.15) K, pressure ranging from (10.0 to 30.0) MPa, and molalities ranging up to 15.171 $mol \cdot kg^{-1}$ of NH_4Br.

Table 1. Experimental Results of the Vapor Pressures for the $NH_4Br + NH_3$ Mixtures

T/K	m/($mol \cdot kg^{-1}$)	P/MPa	T/K	m/($mol \cdot kg^{-1}$)	P/MPa
303.12	1.170	1.162	303.12	2.643	1.150
313.14	1.175	1.543	313.14	2.656	1.521
323.16	1.181	2.009	323.16	2.668	1.980
333.13	1.188	2.578	333.13	2.683	2.542
343.13	1.195	3.267	343.13	2.701	3.222
353.13	1.203	4.079	353.13	2.719	4.027
363.12	1.211	5.040	363.12	2.737	4.979
373.16	1.220	6.176	373.16	2.757	6.111
303.12	4.607	1.089	303.12	7.348	0.999
313.14	4.630	1.414	313.14	7.391	1.329
323.16	4.658	1.940	323.16	7.439	1.745
333.13	4.687	2.438	333.13	7.494	2.254
343.13	4.721	3.105	343.13	7.559	2.872
353.13	4.759	3.896	353.13	7.624	3.604
363.12	4.800	4.840	363.12	7.693	4.464
373.16	4.849	5.957	373.16	7.769	5.460
303.12	11.381	0.789	303.12	17.193	0.477
313.14	11.454	1.063	313.14	17.281	0.664
323.16	11.532	1.400	323.16	17.385	0.898
333.13	11.621	1.807	333.13	17.505	1.175
343.13	11.714	2.305	343.13	17.626	1.520
353.13	11.814	2.891	353.13	17.756	1.916
363.12	11.919	3.571	363.12	17.886	2.395
373.16	11.986	4.340	373.16	18.034	2.945

Table 2. Antoine's Equation Parameters

a_0	3.7998	b_0	$1.0819 \cdot 10^{3}$
a_1	$-7.2179 \cdot 10^{-3}$	b_1	−1.1810
a_2	$4.9158 \cdot 10^{-3}$	b_2	1.5418
a_3	$-6.0406 \cdot 10^{-4}$	b_3	$-1.5073 \cdot 10^{-1}$
a_4	$2.0322 \cdot 10^{-5}$	b_4	$5.1599 \cdot 10^{-3}$

Experimental Section

Materials. NH_4Br which had minimum purities of 99.0 % was purchased from Wako Pure Chemical Industries. It was dried at 373.15 K for 12 h before measurement. The NH_3 of 99.999 % purity was supplied by Japan Fine Products Co. Ltd. The samples were used without further purification.

Apparatus and Procedure. The vapor pressure was measured with a static method. The experimental apparatus and procedures were the same as that described in our previous study.[10] Temperature and pressure values have an uncertainty of ± 0.02

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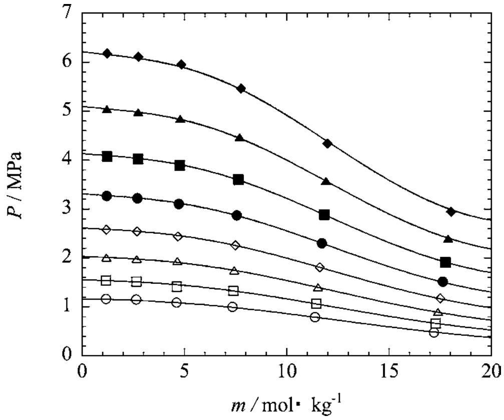

Figure 1. Comparison of the vapor pressure data for the NH_4Br + NH_3 mixtures with results from Antoine's equation. ○, 303.12 K; □, 313.14 K; Δ, 323.16 K; ◇, 333.13 K; ●, 343.13 K; ■, 353.13 K; ▲, 363.12 K; ◆, 373.16 K; −, correlations.

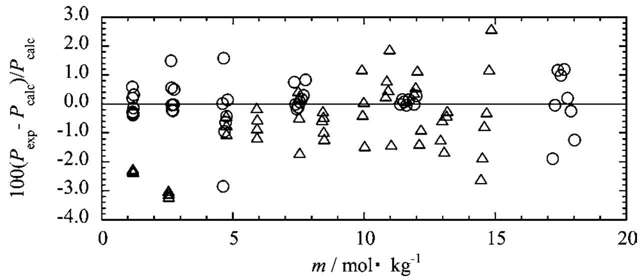

Figure 2. Deviations of experimental data from Antoine's equation. ○, this work; Δ, Yamamoto et al.[8]

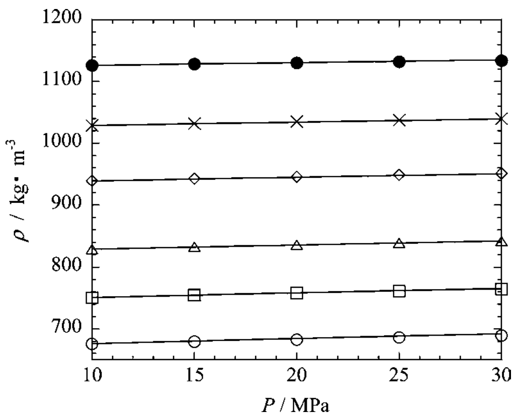

Figure 3. Comparison of the liquid density data for the ammonium bromide + ammonia mixture with results from the Tait-form equation at 303.15 K. ○, $m = 1.143$; □, $m = 2.601$; Δ, $m = 4.381$; ◇, $m = 7.359$; ×, $m = 10.349$; ●, $m = 15.171$; −, correlations.

K and ± 0.001 MPa, respectively. The composition of the sample mixtures were determined by weighing. The uncertainty of the composition determination was estimated to be less than 0.05 wt %. On the basis of the uncertainties of these properties, the uncertainty of the vapor pressure data is estimated to be within ± 0.5 %. The stainless-steel pressure resistant cell was dried at 373.15 K under vacuum for 2 h to remove moisture. Then, weighed amounts of the NH_4Br and stirring bar are charged in the cell. The valve and transducer were attached with the cell. After degassing for about 5 min, the NH_3 was introduced into the cell with a plunger pump. The amount of NH_3 charged in the cell was determined by weighing the cell with the electrical balance, accurate to within 0.01 g, before and after loading NH_3. After introducing NH_3 and weighing the cell, the NH_4Br + NH_3 mixture was stirred with a magnetic

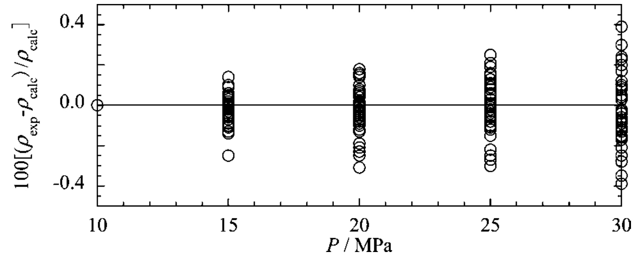

Figure 4. Deviations of the liquid density data from the Tait-form equation.

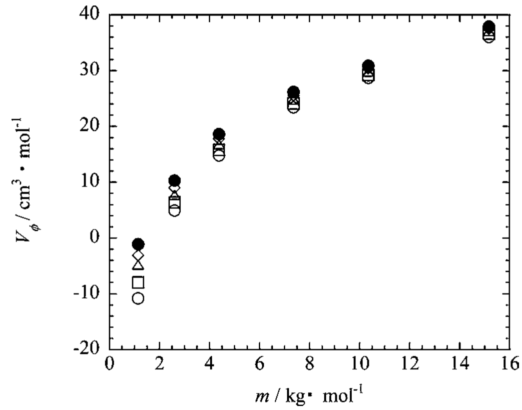

Figure 5. Molality dependence of apparent molar volume of NH_4Br in NH_3 at 303.15 K. ○, 10 MPa; □, 15 MPa; Δ, 20 MPa; ◇, 25 MPa; ●, 30 MPa.

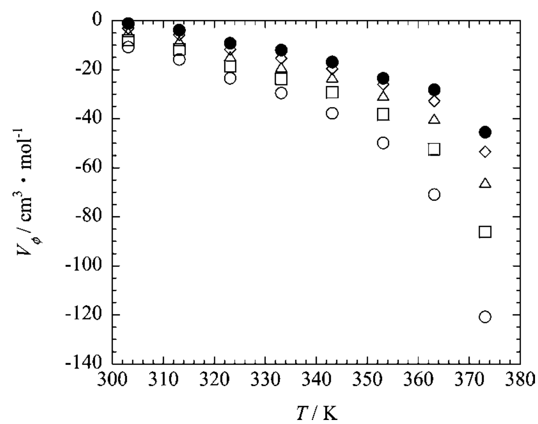

Figure 6. Temperature dependence of apparent molar volume of NH_4Br in NH_3 at $m = 1.143$. ○, 10 MPa; □, 15 MPa; Δ, 20 MPa; ◇, 25 MPa; ●, 30 MPa.

stirring bar for 1 h to dissolve NH_4Br in NH_3. Then, the cell was immersed in the oil bath. After it maintained a constant temperature for more than 1 h to achieve equilibrium, the vapor pressure was measured.

In this study, we used a static method for vapor pressure measurement. Therefore, the concentration was changed at each temperature. The concentration of the liquid mixture was determined as follows. The two assumptions were adopted: (1) NH_4Br does not exist in the vapor phase; (2) the vapor phase is ideal. The amounts of NH_4Br and NH_3 and the volume of the cell were known experimentally. Therefore, if the density of the liquid mixture was known, we can evaluate the volumes of the vapor and liquid phase. Therefore, the concentration of the NH_4Br in the NH_3 solution is determined by a material balance. It should be mentioned that the vapor phase should be as small as possible to reduce the effect of ambiguity of assumption (2).

The liquid densities of the NH_4Br + NH_3 mixtures were measured with a glass piezometer, which has been described

Table 3. Experimental Results of the Liquid Densities of the $NH_4Br + NH_3$ Mixtures

T	m	P	ρ	T	m	P	ρ	T	m	P	ρ	T	m	P	ρ
K	(mol·kg^{-1})	MPa	(kg·m^{-3})	K	(mol·kg^{-1})	MPa	(kg·m^{-3})	K	(mol·kg^{-1})	MPa	(kg·m^{-3})	K	(mol·kg^{-1})	MPa	(kg·m^{-3})
303.15	1.143	10.0	675.9	313.15	1.143	10.0	661.3	343.15	1.143	10.0	612.8	353.15	1.143	10.0	594.5
		15.0	679.5			15.0	665.1			15.0	618.5			15.0	601.3
		20.0	682.7			20.0	668.9			20.0	624.1			20.0	607.9
		25.0	686.3			25.0	672.6			25.0	629.9			25.0	614.6
		30.0	689.5			30.0	676.3			30.0	635.4			30.0	621.2
	2.601	10.0	750.8		2.601	10.0	737.8		2.601	10.0	693.7		2.601	10.0	676.6
		15.0	754.5			15.0	741.4			15.0	698.1			15.0	681.9
		20.0	758.0			20.0	745.0			20.0	702.6			20.0	687.1
		25.0	761.3			25.0	748.6			25.0	707.2			25.0	692.0
		30.0	764.4			30.0	752.1			30.0	711.7			30.0	697.0
	4.381	10.0	829.0		4.381	10.0	817.3		4.381	10.0	778.3		4.381	10.0	765.5
		15.0	832.7			15.0	820.9			15.0	782.6			15.0	769.6
		20.0	836.1			20.0	824.2			20.0	786.7			20.0	773.8
		25.0	839.1			25.0	827.6			25.0	790.7			25.0	778.1
		30.0	842.1			30.0	830.7			30.0	794.2			30.0	782.2
	7.359	10.0	939.1		7.359	10.0	926.8		7.359	10.0	891.2		7.359	10.0	878.6
		15.0	942.7			15.0	929.8			15.0	894.7			15.0	882.5
		20.0	945.8			20.0	932.8			20.0	898.2			20.0	886.2
		25.0	948.9			25.0	935.5			25.0	901.6			25.0	889.7
		30.0	951.2			30.0	938.0			30.0	904.9			30.0	893.2
	10.349	10.0	1028.9		10.349	10.0	1017.0		10.349	10.0	983.9		10.349	10.0	973.0
		15.0	1032.2			15.0	1020.3			15.0	987.4			15.0	976.5
		20.0	1034.9			20.0	1023.2			20.0	991.3			20.0	979.8
		25.0	1037.4			25.0	1025.9			25.0	993.6			25.0	983.0
		30.0	1039.8			30.0	1028.6			30.0	995.8			30.0	986.6
	15.171	10.0	1126.2		15.171	10.0	1116.9		15.171	10.0	1086.6		15.171	10.0	1077.7
		15.0	1128.1			15.0	1118.8			15.0	1089.1			15.0	1080.1
		20.0	1130.1			20.0	1120.4			20.0	1091.2			20.0	1082.2
		25.0	1132.0			25.0	1122.0			25.0	1093.3			25.0	1084.5
		30.0	1134.0			30.0	1123.6			30.0	1095.4			30.0	1086.3
323.15	1.143	10.0	646.8	333.15	1.143	10.0	630.2	363.15	1.143	10.0	576.0	373.15	1.143	10.0	561.5
		15.0	651.2			15.0	635.4			15.0	583.7			15.0	569.5
		20.0	655.4			20.0	640.3			20.0	590.9			20.0	577.4
		25.0	659.7			25.0	645.1			25.0	598.2			25.0	585.2
		30.0	663.8			30.0	649.5			30.0	605.2			30.0	592.7
	2.601	10.0	724.3		2.601	10.0	709.5		2.601	10.0	659.3		2.601	10.0	646.4
		15.0	727.7			15.0	714.0			15.0	665.4			15.0	652.4
		20.0	731.4			20.0	718.3			20.0	671.2			20.0	658.4
		25.0	734.9			25.0	722.5			25.0	677.1			25.0	664.3
		30.0	738.7			30.0	726.3			30.0	682.6			30.0	670.0
	4.381	10.0	805.0		4.381	10.0	791.1		4.381	10.0	748.7		4.381	10.0	737.7
		15.0	808.9			15.0	795.1			15.0	754.3			15.0	742.9
		20.0	812.6			20.0	799.1			20.0	759.5			20.0	748.0
		25.0	816.1			25.0	803.0			25.0	764.4			25.0	752.9
		30.0	819.4			30.0	807.1			30.0	769.0			30.0	757.6
	7.359	10.0	914.3		7.359	10.0	903.1		7.359	10.0	866.4		7.359	10.0	854.6
		15.0	917.4			15.0	906.7			15.0	870.2			15.0	858.5
		20.0	920.3			20.0	909.8			20.0	873.8			20.0	862.2
		25.0	923.0			25.0	912.7			25.0	877.4			25.0	865.9
		30.0	926.0			30.0	915.6			30.0	881.3			30.0	870.0
	10.349	10.0	1005.2		10.349	10.0	994.4		10.349	10.0	961.1		10.349	10.0	950.1
		15.0	1008.3			15.0	997.8			15.0	965.6			15.0	954.3
		20.0	1011.2			20.0	1001.2			20.0	969.0			20.0	958.0
		25.0	1014.1			25.0	1004.0			25.0	972.5			25.0	961.3
		30.0	1016.7			30.0	1006.9			30.0	975.7			30.0	964.7
	15.171	10.0	1105.9		15.171	10.0	1096.0		15.171	10.0	1067.8		15.171	10.0	1057.7
		15.0	1107.8			15.0	1098.2			15.0	1070.1			15.0	1060.3
		20.0	1109.7			20.0	1100.3			20.0	1072.4			20.0	1062.6
		25.0	1111.5			25.0	1102.2			25.0	1074.8			25.0	1065.1
		30.0	1113.4			30.0	1104.0			30.0	1076.8			30.0	1067.1

in detail elsewhere.[11] Weighed NH_4Br is charged in the glass cell, and the valve was attached with the glass cell. After degassing for about 5 min, NH_3 was introduced into the glass cell from the valve by immersing the glass cell in the methanol which was cooled at about 233 K. The amount of NH_3 charged in the cell was determined by weighing the cell with the electrical balance, accurate to within 0.001 g, before and after loading NH_3. After dissolving NH_4Br in NH_3, the glass cell set into the pressure vessel. The sample cell volume was approximately 13 cm^3. The estimated uncertainties in the liquid densities are ± 0.2 %.

Results and Discussion

Vapor Pressure Measurement of the $NH_4Br + NH_3$ Mixtures. The experimental results of the vapor pressures for the $NH_4Br + NH_3$ mixtures are given in Table 1. The vapor pressures were correlated with Antoine's equation. The Antoine constants were expressed as the fourth-degree function of molality.

$$\log P/\text{MPa} = A - B/(C + T/\text{K} - 273.15) \quad (1)$$

$$A = \sum_{i=0}^{4} a_i (m/\text{mol}\cdot\text{kg}^{-1})^i \quad (2)$$

$$B = \sum_{i=0}^{4} b_i (m/\text{mol}\cdot\text{kg}^{-1})^i \quad (3)$$

$$C = 259.86 \quad (4)$$

The values of these parameters were determined by using the present experimental results with a least-squares method and are listed in Table 2. Comparisons of the vapor pressure data for the $NH_4Br + NH_3$ mixtures with the results from Antoine's equation are shown in Figure 1. The Antoine equation correlated the experimental values of the $NH_4Br + NH_3$ mixture within ± 2.9 %. Figure 2 shows the deviations of the experimental vapor pressure data in the literature[8] from the values calculated

Table 4. Apparent Molar Volumes of NH_4Br in NH_3

T	m	P	V_ϕ	T	m	P	V_ϕ	T	m	P	V_ϕ	T	m	P	V_ϕ
K	(mol·kg^{-1})	MPa	(cm^3·mol^{-1})	K	(mol·kg^{-1})	MPa	(cm^3·mol^{-1})	K	(mol·kg^{-1})	MPa	(cm^3·mol^{-1})	K	(mol·kg^{-1})	MPa	(cm^3·mol^{-1})
303.15	1.143	10.0	−10.8	313.15	1.143	10.0	−15.8	343.15	1.143	10.0	−37.8	353.15	1.143	10.0	−49.9
		15.0	−8.0			15.0	−11.7			15.0	−29.2			15.0	−38.3
		20.0	−4.8			20.0	−8.5			20.0	−23.1			20.0	−30.5
		25.0	−3.1			25.0	−5.8			25.0	−19.6			25.0	−26.0
		30.0	−1.1			30.0	−3.8			30.0	−16.8			30.0	−23.5
	2.601	10.0	4.9		2.601	10.0	0.1		2.601	10.0	−19.3		2.601	10.0	−28.5
		15.0	6.4			15.0	2.4			15.0	−13.4			15.0	−20.8
		20.0	7.7			20.0	4.3			20.0	−9.0			20.0	−15.0
		25.0	9.0			25.0	5.9			25.0	−5.6			25.0	−10.3
		30.0	10.3			30.0	7.3			30.0	−2.8			30.0	−6.8
	4.381	10.0	14.8		4.381	10.0	10.8		4.381	10.0	−5.4		4.381	10.0	−14.3
		15.0	15.8			15.0	12.3			15.0	−1.6			15.0	−8.7
		20.0	16.8			20.0	13.7			20.0	1.5			20.0	−4.4
		25.0	17.8			25.0	14.9			25.0	4.1			25.0	−1.0
		30.0	18.6			30.0	16.0			30.0	6.5			30.0	1.9
	7.359	10.0	23.4		7.359	10.0	21.0		7.359	10.0	9.5		7.359	10.0	3.8
		15.0	24.1			15.0	22.1			15.0	12.1			15.0	7.3
		20.0	24.8			20.0	23.1			20.0	14.3			20.0	10.2
		25.0	25.5			25.0	24.1			25.0	16.1			25.0	12.5
		30.0	26.2			30.0	25.0			30.0	17.6			30.0	14.5
	10.349	10.0	28.7		10.349	10.0	26.8		10.349	10.0	17.9		10.349	10.0	13.4
		15.0	29.2			15.0	27.6			15.0	19.8			15.0	16.0
		20.0	29.8			20.0	28.3			20.0	21.2			20.0	18.1
		25.0	30.4			25.0	29.0			25.0	22.8			25.0	19.9
		30.0	30.9			30.0	29.6			30.0	24.1			30.0	21.3
	15.171	10.0	36.0		15.171	10.0	34.5		15.171	10.0	28.1		15.171	10.0	24.7
		15.0	36.6			15.0	35.1			15.0	29.5			15.0	26.7
		20.0	37.1			20.0	35.8			20.0	30.7			20.0	28.3
		25.0	37.5			25.0	36.4			25.0	31.8			25.0	29.6
		30.0	37.9			30.0	37.0			30.0	32.7			30.0	30.8
323.15	1.143	10.0	−23.5	333.15	1.143	10.0	−29.5	363.15	1.143	10.0	−70.9	373.15	1.143	10.0	−120.8
		15.0	−18.6			15.0	−23.7			15.0	−52.4			15.0	−86.2
		20.0	−14.5			20.0	−18.9			20.0	−40.0			20.0	−66.0
		25.0	−11.7			25.0	−15.3			25.0	−32.8			25.0	−53.5
		30.0	−9.2			30.0	−11.9			30.0	−28.1			30.0	−45.4
	2.601	10.0	−5.7		2.601	10.0	−11.8		2.601	10.0	−42.2		2.601	10.0	−68.7
		15.0	−2.1			15.0	−8.0			15.0	−31.0			15.0	−49.7
		20.0	0.5			20.0	−4.8			20.0	−22.8			20.0	−37.2
		25.0	2.9			25.0	−2.2			25.0	−17.1			25.0	−28.4
		30.0	4.6			30.0	0.4			30.0	−12.4			30.0	−21.7
	4.381	10.0	6.3		4.381	10.0	1.5		4.381	10.0	−24.0		4.381	10.0	−41.9
		15.0	8.3			15.0	4.2			15.0	−16.5			15.0	−29.6
		20.0	10.0			20.0	6.5			20.0	−11.0			20.0	−21.2
		25.0	11.6			25.0	8.4			25.0	−6.6			25.0	−14.9
		30.0	13.0			30.0	9.9			30.0	−3.0			30.0	−10.0
	7.359	10.0	18.1		7.359	10.0	14.2		7.359	10.0	−3.9		7.359	10.0	−14.7
		15.0	19.6			15.0	16.0			15.0	1.3			15.0	−6.8
		20.0	20.9			20.0	17.7			20.0	5.2			20.0	−1.2
		25.0	22.1			25.0	19.2			25.0	8.4			25.0	3.1
		30.0	23.1			30.0	20.5			30.0	10.9			30.0	6.4
	10.349	10.0	24.5		10.349	10.0	21.6		10.349	10.0	7.7		10.349	10.0	−0.3
		15.0	25.6			15.0	23.0			15.0	11.3			15.0	5.3
		20.0	26.6			20.0	24.1			20.0	14.2			20.0	9.4
		25.0	27.4			25.0	25.2			25.0	16.5			25.0	12.5
		30.0	28.2			30.0	26.2			30.0	18.4			30.0	15.0
	15.171	10.0	32.8		15.171	10.0	30.7		15.171	10.0	20.6		15.171	10.0	15.0
		15.0	33.7			15.0	31.8			15.0	23.3			15.0	19.0
		20.0	34.5			20.0	32.8			20.0	25.5			20.0	22.0
		25.0	35.2			25.0	33.7			25.0	27.2			25.0	24.3
		30.0	35.8			30.0	34.4			30.0	28.7			30.0	26.2

by eq 1 in our experimental range. The results of Yamamoto et al. are in good agreement with ours.

Liquid Density Measurement of the $NH_4Br + NH_3$ Mixtures. The experimental results of the liquid densities of the $NH_4Br + NH_3$ mixtures are shown in Table 3. The $P\rho Tm$ relations for the $NH_4Br + NH_3$ mixtures were correlated with the Tait equation.[12]

$$\frac{\rho/\mathrm{kg\cdot m^{-3}} - \rho_0/\mathrm{kg\cdot m^{-3}}}{\rho/\mathrm{kg\cdot m^{-3}}} = E\ln\left(\frac{D + P/\mathrm{MPa}}{D + P_0}\right) \quad (5)$$

where ρ and ρ_0 are the densities at P and P_0 (= 10.0 MPa), respectively. E and D are adjustable parameters. The parameters were optimized by minimizing the deviation of the calculated density from the experimental one. For ammonia according to literature values,[13] E was equal to 0.09761 and D was expressed by a linear function of temperature as follows

$$D = 249.27 - 0.66019T/\mathrm{K} \quad (6)$$

For the $NH_4Br + NH_3$ mixtures, E could be treated as a constant, 0.09761. The parameter D could be expressed by the following equation

$$D = D_0 + 12.50m/\mathrm{mol\cdot kg^{-1}} - 0.038(m/\mathrm{mol\cdot kg^{-1}})^2 \quad (7)$$

where D_0 is the value of D calculated from eq 6 and m is the molality. Comparisons of the liquid density data for the $NH_4Br + NH_3$ mixture with results from the Tait-form equation at 303.15 K are shown in Figure 3. Figure 4 shows deviations of the experimental data from the Tait-form equation. The Tait-form equation correlated the experimental values of the $NH_4Br + NH_3$ mixtures within 0.4 %.

The apparent molar volumes V_ϕ of NH_4Br can be expressed as follows

$$V_\phi/\mathrm{cm^3\cdot mol^{-1}} = \frac{1000(d^\circ/\mathrm{g\cdot cm^{-3}} - d/\mathrm{g\cdot cm^{-3}})}{m/\mathrm{mol\cdot kg^{-1}}\,d/\mathrm{g\cdot cm^{-3}}\,d^\circ/\mathrm{g\cdot cm^{-3}}} + \frac{M}{d/\mathrm{g\cdot cm^{-3}}} \quad (8)$$

where M is the molecular weight of the NH_4Br; m is the molality; d is the density of the solution; and d° is the density of the NH_3. Literature values were used for the density of NH_3.[13] Table 4 shows the apparent molar volumes of NH_4Br in NH_3. No literature values for the apparent molar volumes of NH_4Br in NH_3 are available. Figure 5 shows the plot of the apparent molar volumes of NH_4Br in NH_3 against molality at 303.15 K. The pressure of the apparent molar volume decreased with increasing molality. Figure 6 shows the plot of the apparent molar volumes of NH_4Br in NH_3 against temperature at $m = 1.143\ \mathrm{mol\cdot kg^{-1}}$. The pressure dependence of the apparent molar volume increased with increasing temperature.

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