Vapor Pressures, Densities, and Viscosities of the (Water + Lithium Bromide + Sodium Formate) System and (Water + Lithium Bromide + Potassium Formate) System

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Measurements of thermophysical properties (vapor pressure, density, and viscosity) of the water + lithium bromide + sodium formate system (LiBr:CHO_2Na =2:1 by mass ratio) and the water + lithium bromide + potassium formate system (LiBr:CHO_2K =2:1 by mass ratio) were measured. The system, a possible new working fluid for absorption heat pump, consists of absorbent (LiBr + CHO_2Na) or (LiBr + CHO_2K) and refrigerant (H_2O). The vapor pressures were measured in the ranges of temperature and absorbent concentration from 293.15 K to 343.15 K and from 20.0 mass % to 60 mass %. The experimental data were correlated with an Antoine-type equation. Densities and viscosities were measured in the same range of temperature and absorbent concentration that vapor pressure. Regression equations for densities and viscosities were obtained with a minimum mean-square-error criterion.

Introduction

The absorption cooling cycle is one of the best alternatives to the vapor compression cooling cycle. The absorption cycle is similar to the vapor compression cycle, but the major advantage of the cycle is the use of a residual hot stream as the energy source to obtain cooling power instead of expensive electric energy in the form of shaft work.

The increase of electricity costs and the environmental problems of its production has made this heat operated cycle more attractive for both residential and industrial applications with excess of hot water or waste vapor streams.[1−3]

A conventional absorption chiller consisting of a generator, absorber, condenser, and evaporator requires an additional water cooling tower in order to remove heats and maintain desirable temperatures in absorber and condenser units.[4]

Various new working fluids have been developed to improve the performance characteristics of the conventional lithium bromide + water system.[5,6] A general procedure for checking the validity includes the measurements of various basics thermodynamic properties of the solution. These properties are required for the proper design of absorption refrigerators and heat pumps.[7−10]

Extension of the absorption cycle to improve the performance of those machines is often limited by cristallization of the absorbent, which is a function of concentration and pressure in the absorber.[9]

Anticrystallization additives with a high boiling point and hygroscopic property are used to overcome the cristallization problem and ensure a safe cycle operation.[11−16]

The main advantage of the working fluids studied in this work is the reduction of the vapor pressure of the solution with respect to the traditional LIBr−H_2O. It means that the boiling temperature in the generator can be lower, and streams with a minor energetic content (even hot water) can be used in the absorption refrigeration cycle and decrease the refrigeration necessity in the cooling tower.

In this study, the lithium bromide + sodium formate + water system (LiBr/CHO_2Na mass ratio = 2) and the lithium bromide + potassium formate + water system (LiBr/CHO_2K mass ratio = 2) were selected as a possible new working fluid for an air-cooled absorption chiller.

With the employment of this proportion, one can achieve that these systems present quite similar properties to lithium bromide: the relation solubility−vapor pressure, the absorption of vapor water, and the added advantage of the formate salts, an important decrease of the temperature of the generator.[17]

Three basic physical properties (vapor pressure, density, and viscosity) were measured over extensive temperature and concentration ranges. The ranges that these two ternary working fluids can reach in a cycle of an absorption refrigeration machine are in the intervals of temperature and absorbent concentration chosen. Each set of results was correlated with a proper equation.

Experimental Section

Materials. Lithium bromide (98+%), sodium formate (98+%), and potassium formate (98+%) were supplied by Panreac Quimica SA. and were used without further purification.

All solutions were prepared with deionized water and by weighing the corresponding quantity of salts to obtained the required concentration of the working fluid in a precision balance (Mettler, PM200), with an accuracy of ±0.0001 g. The analysis of the samples was carried out by means of atomic absorption (Na and K) and atomic emission (Li), the accuracy of which is ±0.002 ppm and T.O.C. (Total Organic Carbon), with a precision of ±0.001 ppm.

Vapor Pressure. The apparatus used to measured vapor pressure consists of a Pyrex glass vessel with an internal volume of 75 cm^3 sealed by a Teflon adapter, a thermistor thermometer (PM 2820), with an accuracy of ±0.01 K, a constant-temperature bath, a circulator for both cooling and

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Table 1. Vapor Pressures of LiBr + CHO_2Na + H_2O (LiBr/CH_2ONa Mass Ratio = 2) System at Various Concentrations and Temperatures

(a) $w = 0.600$			(b) $w = 0.500$			(c) $w = 0.400$			(d) $w = 0.300$			(e) $w = 0.200$		
expt		theory	expt		theory	expt		theory	expt		theory	expt		theoryl
T/K	P/kPa	P/kPa	T/K	P/kPa	P/kPa	T/K	P/kPa	P/kPa	T/K	P/kPa	P/kPa	T/K	P/kPa	P/kPa
293.15	1.30	0.84	293.15	1.60	1.00	293.15	1.80	1.29	293.15	2.3	1.63	293.15	1.90	1.83
298.15	1.30	1.11	298.15	1.60	1.33	298.15	1.80	1.73	298.15	2.4	2.20	298.15	2.40	2.47
303.15	1.50	1.47	303.15	1.80	1.78	303.15	2.30	2.32	303.15	2.9	2.94	303.15	3.30	3.29
308.15	2.00	1.92	308.15	2.40	2.34	308.15	3.10	3.06	308.15	3.8	3.88	308.15	4.30	4.34
313.15	2.40	2.49	313.15	3.00	3.06	313.15	4.00	4.00	313.15	4.9	5.07	313.15	5.70	5.66
318.15	3.10	3.19	318.15	3.90	3.95	318.15	5.40	5.18	318.15	6.8	6.56	318.15	7.20	7.31
323.15	4.10	4.06	323.15	5.00	5.06	323.15	6.50	6.65	323.15	8.2	8.42	323.15	9.60	9.35
328.15	5.20	5.11	328.15	6.40	6.42	328.15	8.80	8.46	328.15	10.7	10.70	328.15	11.80	11.86
333.15	6.40	6.39	333.15	8.00	8.08	333.15	10.60	10.67	333.15	13.6	13.49	333.15	14.90	14.93
338.15	7.80	7.93	338.15	10.10	10.01	338.15	13.70	13.37						
343.15	9.90	9.77	343.15	12.40	12.52	343.15	16.50	16.61						

Table 2. Vapor Pressures of LiBr + CHO_2K + H_2O (LiBr/CH_2OK Mass Ratio = 2) System at Various Concentrations and Temperatures

(a) $w = 0.600$			(b) $w = 0.500$			(c) $w = 0.400$			(d) $w = 0.300$			(e) $w = 0.200$		
expt		theory	expt		theory	expt		theory	expt		theory	expt		theoryl
T/K	P/kPa	P/kPa	T/K	P/kPa	P/kPa	T/K	P/kPa	P/kPa	T/K	P/kPa	P/kPa	T/K	P/kPa	P/kPa
293.15	1.30	0.89	293.15	1.30	0.93	293.15	1.40	1.02	293.15	2.00	1.17	293.15	2.00	1.41
298.15	1.70	1.62	298.15	1.70	1.70	298.15	1.70	1.86	298.15	2.30	2.14	298.15	2.40	2.56
303.15	2.30	2.16	303.15	2.30	2.26	303.15	2.30	2.48	303.15	2.90	2.84	303.15	3.40	3.42
308.15	2.80	2.84	308.15	2.80	2.98	308.15	3.10	3.27	308.15	4.00	3.75	308.15	4.40	4.49
313.15	3.80	3.70	313.15	3.80	3.88	313.15	4.10	4.26	313.15	5.10	4.88	318.15	7.60	7.56
318.15	4.80	4.78	318.15	4.80	5.02	323.15	9.00	7.05	323.15	10.60	8.07	318.15	7.60	7.56
323.15	6.30	6.12	323.15	6.30	6.42	318.15	5.40	5.50	318.15	6.80	6.31	323.15	12.10	9.66
328.15	8.10	7.77	328.15	7.60	8.16	328.15	9.00	8.94	328.15	10.60	10.25	328.15	12.10	12.26
333.15	10.00	8.78	333.15	10.00	9.16	333.15	11.70	11.26	333.15	13.60	12.90	333.15	15.30	15.42
338.15	12.30	10.78	338.15	12.50	11.27	338.15	14.90	14.07	338.15					
343.15	15.10	13.20	343.15	14.90	13.83	343.15	17.20	17.45	343.15					

Table 3. Densities of LiBr + CHO_2Na + H_2O (LiBr/CH_2O Mass Ratio = 2) System at Various Concentrations and Temperatures

(a) $w = 0.500$			(b) $w = 0.400$			(a) $w = 0.300$			(b) $w = 0.200$		
expt		theory	expt		theory	expt		theory	expt		theory
T/K	ρ/kg·m^{-3}	ρ/kg·m^{-3}	T/K	ρ/kg·m^{-3}	ρ/kg·m^{-3}	T/K	ρ/kg·m^{-3}	ρ/kg·m^{-3}	T/K	ρ/kg·m^{-3}	ρ/kg·m^{-3}
			293.15	1369.00	1363.90	293.15	1246.00	1208.34	293.15	1164.00	1190.51
			298.15	1368.00	1344.98	298.15	1244.00	1220.94	298.15	1162.00	1141.77
303.15	1448.00	1430.01	303.15	1365.00	1355.32	303.15	1242.00	1231.04	303.15	1161.00	1151.62
308.15	1444.00	1437.96	308.15	1362.00	1363.09	308.15	1239.00	1238.64	308.15	1161.00	1159.05
313.15	1444.00	1443.27	313.15	1358.00	1368.29	313.15	1238.00	1243.75	313.15	1159.00	1164.06
318.15	1444.00	1445.93	318.15	1358.00	1370.92	318.15	1236.00	1246.37	318.15	1158.00	1166.65
323.15	1438.00	1445.96	323.15	1357.00	1371.00	323.15	1233.00	1246.49	323.15	1149.00	11166.83
328.15	1433.00	1443.34	328.15	1353.00	1368.49	328.15	1226.00	1244.12	328.15	1148.00	11164.58
333.15	1432.00	1438.07	333.15	1352.00	1363.42	333.15	1224.00	1239.26	333.15	1148.00	1159.91
338.15	1428.00	1430.17	338.15	1351.00	1355.78	338.15	1224.00	1231.90	338.15	1146.00	1152.82
343.15	1428.00	1419.62	343.15	1348.00	1345.57	343.15	1223.00	1222.05	343.15	1144.00	1143.31

Table 4. Densities of LiBr + CHO_2K + H_2O (LiBr/CH_2OK Mass Ratio = 2) System at Various Concentrations and Temperatures

(a) $w = 0.500$			(b) $w = 0.400$			(a) $w = 0.300$			(b) $w = 0.200$		
expt		theory	expt		theory	expt		theory	expt		theory
T/K	ρ/kg·m^{-3}	ρ/kg·m^{-3}	T/K	ρ/kg·m^{-3}	ρ/kg·m^{-3}	T/K	ρ/kg·m^{-3}	ρ/kg·m^{-3}	T/K	ρ/kg·m^{-3}	ρ/kg·m^{-3}
293.15	1557.00	1549.32	293.15	1363.00	1361.53	293.15	1238.00	1234.75	293.15	1163.00	1168.97
298.15	1553.00	1549.87	298.15	1360.00	1360.78	298.15	1237.00	1232.65	298.15	1162.00	1165.48
303.15	1551.00	1549.76	303.15	1355.00	1359.74	303.15	1235.00	1230.62	303.15	1162.00	1162.41
308.15	1548.00	1548.98	308.15	1351.00	1358.42	308.15	1231.00	1228.67	308.15	1160.00	1159.75
313.15	1547.00	1547.56	313.15	1349.00	1356.81	313.15	1229.00	1226.79	313.15	1157.00	1157.50
318.15	1542.00	1545.47	318.15	1349.00	1354.92	318.15	1228.00	1224.98	318.15	1157.00	1155.65
323.15	1536.00	1542.72	323.15	1347.00	1352.74	323.15	1227.00	1223.24	323.15	1155.00	1154.22
328.15	1535.00	1539.32	328.15	1346.00	1350.28	328.15	1226.00	1221.57	328.15	1154.00	1153.20
333.15	1533.00	1535.26	333.15	1343.00	1347.53	333.15	1225.00	1219.98	333.15	1151.00	1152.59
338.15	1532.00	1530.53	338.15	1340.00	1344.50	338.15	1225.00	1218.46	338.15	1149.00	1152.39
343.15	1530.00	1525.15	343.15	1339.00	1341.19	343.15	1224.00	1217.00	343.15	1149.00	1152.60

heating, a vacuum pump (TELSTAR 2P-3), a pressure controller (DIVATRONIC DT 1), the accuracy of which is ±0.1 kPa, and a stirrer.

A sample solution was initially prepared to the desired absorbent concentration and placed in the vessel with an approximate volume of 250 cm^3. The entire apparatus was

Table 5. Viscosities of LiBr + CHO_2Na + H_2O (LiBr/CH_2ONa Mass Ratio = 2) System at Various Concentrations and Temperatures

(a) $w = 0.300$			(b) $w = 0.200$		
expt		theory	expt		theory
T/K	η/mPa s	η/mPa s	T/K	η/mPa s	η/mPa s
298.15	2.52	1.50	298.15	1.48	2.54
303.15	2.25	1.35	303.15	1.38	2.29
308.15	2.05	1.22	308.15	1.22	2.07
313.15	1.98	1.11	313.15	1.11	1.88
318.15	1.75	1.01	318.15	1.01	1.72
323.15	1.59	0.93	323.15	0.92	1.58
328.15	1.47	0.85	328.15	0.83	1.45
333.15	1.32	0.79	333.15	0.79	1.34
338.15	1.18	0.73	338.15	0.73	1.24

then evacuated to a proper degree of pressure which is a little higher than the approximate vapor pressure of each sample. This sample solution was then heated and stirred well with a magnetic stirrer to prevent superheating. After thermal equilibrium was reached, the temperature of the sample solution and the corresponding pressure were measured.

The calibration of the apparatus was carried out measuring with the apparatus the vapor pressure of pure water and comparing the values obtained with the vapor pressure of pure water in bibliography.[4]

Density and Viscosity. The temperature was controlled within ±0.01 K with a constant-temperature bath and was measured by a thermistor thermometer for both density and viscosity measurements. The density measurements were carried out by using a set of hydrometers capable of reading up to 0.001 $kg \cdot m^{-3}$, and the possible measuring interval of one hydrometer was 0.1 in specific gravity. A suitable hydrometer was then selected and immersed in the sample solution. After the solution temperature reached a desired point, the specific gravity value was read from the meniscus of the solution with the hydrometer. The measured specific gravity values were simply converted to the density values with the density data of water.[4] Hydrometers are calibrated based upon the specific gravity of water at 288.15 K.

The viscosities were measured by using a well-calibrated Ubbelohdetype viscometers which have different capillary diameters. A suitable viscometer was clamped in the constant-temperature bath, and the temperature was adjusted at a desired point. After thermal equilibration, the efflux time of the solution was measured three times by stopwatch for every experimental run. The reproducibility of efflux time measurement was within ±0.1%. The viscosity values were calculated by the following equation:

$$\eta = tK\rho \tag{1}$$

where η is the absolute viscosity, t is the efflux time, K is the given constant of each viscometer for the calculation of kinematic viscosity (tK), and ρ is the density value at the same condition.The calibration of viscometer was made according to the standar specifications of the norm ASTM D446.

The standard uncertainty and reproducibility of measurements was found to be ±0.1%.

Results and Discussion

All measured properties for the lithium bromide + sodium formate + water (LiBr/CHO_2Na mass ratio =2) and lithium bromide + potassium formate + water (LiBr/CHO_2K mass ratio =2) system are listed in Tables 1−6.

The vapor pressures were measured at various concentrations in the range of temperature from (293.15 to 343.15) K. The experimental values are listed in Tables 1 and 2, and correlated with the following Antoine-type equation,[4] which expresses vapor pressure as a function of temperature and concentration:

$$\log (P/\mathrm{kPa}) = \sum_{i=0}^{3}[A_i + \{1000B_i/(T/K - 43.15)\}](100w)^i \tag{2}$$

where P is the vapor pressure, T is the absolute temperature, and w is the mass fraction of absorbent. The parameters A_i and B_i were determined by the least-squares method, and the results are listed in Tables 7 and 8. The experimental and calculated results were plotted in Figures 1 and 2. These figures shows that the log P versus 1000/(T/K − 43.15) relation at a given concentration is linear over the pressure and temperature ranges considered.

The average deviation from experimental basis is calculated from the difference, in absolute value (ABS), between the experimental pressure and the predicted by the Antoine-type equation, according to the following formula:

$$\mathrm{Av.Dev.}(\%) = \frac{\sum_{i=1}^{m} \mathrm{ABS}\left(\frac{Y^{\mathrm{exp}}_{\mathrm{M}^{2+}} - Y^{\mathrm{theor}}_{\mathrm{M}^{2+}}}{Y^{\mathrm{exp}}_{\mathrm{M}^{2+}}}\right) \times 100}{m} \tag{3}$$

The average absolute deviations of the calculated values from the experimental data were 1.64% for the system (water + lithium bromide + sodium formate) and 3.98% for the other system.

Densities and viscosities were measured in the temperature range of (293.15 to 343.15) K and in the concentration range of 20.0 to 50.0 mass %. The measured density values

Table 6. Viscosities of LiBr + CHO_2K + H_2O (LiBr/CH_2OK Mass Ratio = 2) System at Various Concentrations and Temperatures

(a) $w = 0.400$			(b) $w = 0.300$			(e) $w = 0.200$		
expt		theory	expt		theory	expt		theory
T/K	η/mPa s	η/mPa s	T/K	η/mPa s	η/mPa s	T/K	η/mPa s	η/mPa s
298.15			298.15	1.52	1.53	298.15	1.25	1.24
303.15			303.15	1.40	1.39	303.15	1.14	1.13
308.15	1.38	1.53	308.15	1.29	1.26	308.15	1.04	1.03
313.15	1.26	1.39	313.15	1.11	1.15	313.15	0.95	0.95
318.15	1.15	1.27	318.15	1.02	1.05	318.15	0.88	0.92
323.15	1.08	1.16	323.15	0.94	0.97	323.15	0.81	0.80
328.15	1.00	1.07	328.15	0.90	0.90	328.15	0.75	0.74
333.15	0.91	0.98	333.15	0.86	0.83	333.15	0.70	0.69

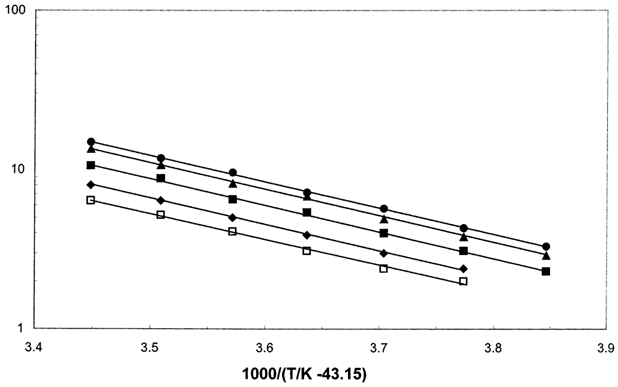

Figure 1. Vapor pressures of the (H_2O + LiBr + CHO_2Na) system (LiBr: CHO_2Na = 2:1 mass ratio): ● ($w_T = 0.20$); ▲ ($w_T = 0.30$); ■ ($w_T = 0.40$); ◆ ($w_T = 0.50$); ($w_T = 0.60$); — (calculated).

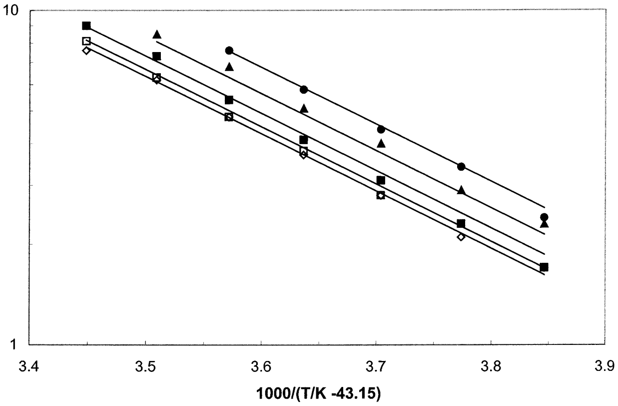

Figure 2. Vapor pressures of the (H_2O+LiBr+CHO_2K) system (LiBr: CHO_2K = 2:1 mass ratio): ● ($w_T = 0.20$); ▲ ($w_T = 0.30$); ■ ($w_T = 0.40$); ♦ ($w_T = 0.50$); ($w_T = 0.60$); — (calculated).

Table 7. Values of A_i, B_i, and AAD for Least-Squares Representation by eq 2 for the System (Water + Lithium Bromide + Sodium Formate)

n	A_n	B_n	n	A_n	B_n
0	6.61	−1.64	3	-6.44×10^{-1}	2.03
1	2.05	1.74×10^{-1}	4	2.94×10^{-5}	4.41×10^{-6}
2	−3.81	−1.39			

Table 8. Values of A_i, B_i, and AAD for Least-Squares Representation by eq 2 for the System (Water + Lithium Bromide + Potassium Formate)

n	A_n	B_n	n	A_n	B_n
0	7.13	−1.69	2	6.02×10^{-5}	1.00×10^{-5}
1	-9.31×10^{-3}	-9.30×10^{-4}			

were listed in Tables 3 and 4 and were regressed by the following equation:

$$\rho/\mathrm{kgm}^{-3} = \sum_{i=0}^{3}[(a_i + b_iT + c_iT^2)(100w)^i] \qquad (4)$$

where ρ is the density of the solution, T is the absolute temperature in K, w is the mass fraction of absorbent, and a_i, b_i, and c_i are the regression coefficients of eq 4. These coefficients were determined by a least-squares method and the results were listed in Tables 9 and 10. Figures 3 and 4 shows the experimental and the calculated results of the density measurement.

The average absolute deviations of the calculated values from the experimental data were 0.13% for the system (water + lithium bromide + sodium formate) and 0.25% for the other system.

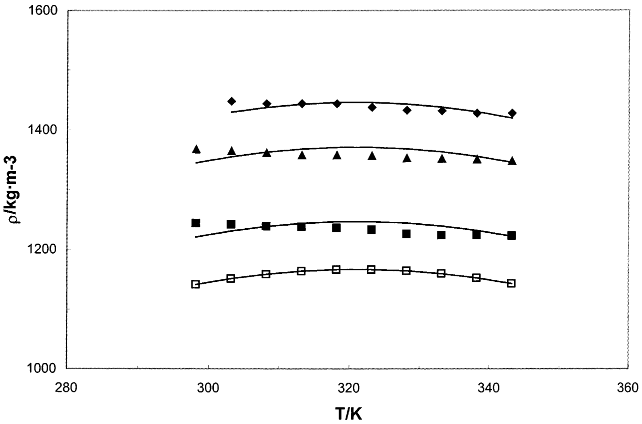

Figure 3. Densities of the (H_2O + LiBr + CHO_2Na) system (LiBr: CHO_2Na = 2:1 mass ratio) at various mass fractions: □ ($w_T = 0.20$); ■ ($w_T = 0.30$); ▲ ($w_T = 0.40$); ■ ($w_T = 0.50$); — (calculated).

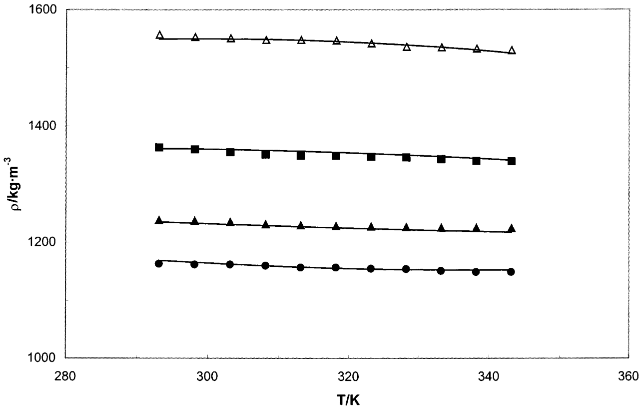

Figure 4. Densities of the (H_2O + LiBr + CHO_2K) system (LiBr: CHO_2K =2:1 mass ratio) at various mass fractions: ● ($w_T = 0.20$); ▲ ($w_T = 0.30$); ■ ($w_T = 0.40$); △ ($w_T = 0.50$); — (calculated).

Table 9. Values of a_i, b_i, and c_i for Least-Squares Representation by eq 4 for the System (Water + Lithium Bromide + Sodium Formate)

n	A_n	B_n	C_n
0	-3.17×10^{2}	2.92×10^{1}	-4.55×10^{-2}
1	-5.93×10^{1}	9.30×10^{-2}	-1.43×10^{-4}
2	1.65	1.18×10^{-5}	-1.33×10^{-7}
3	-1.59×10^{-2}	7.37×10^{-8}	1.00×10^{-9}

Table 10. Values of a_i, b_i, and c_i for Least-Squares Representation by eq 4 for the System (Water + Lithium Bromide + Potassium Formate)

n	A_n	B_n	C_n
0	3.41×10^{3}	-1.35×10^{1}	2.07×10^{-2}
1	-6.91×10^{1}	3.79×10^{-1}	-5.91×10^{-4}
2	1.66×10^{-1}	9.85×10^{-4}	-1.74×10^{-6}
3	4.27×10^{-3}	-4.56×10^{-7}	1.00×10^{-9}

The measured viscosities were also listed in Tables 5 and 6, and all the values were regressed by the following equation:

$$\log(\eta/\mathrm{mPas}) = \sum_{i=0}^{4}[(a_i + b_i/T + c_i/T^2)(100w)^i] \qquad (5)$$

where η is the viscosity of the solution, T is the absolute temperature in K, a_i, b_i, and c_i is the regression coefficients, and w is the absorbent concentration in mass fraction. The regression coefficients were determined by a least-squares method and listed in Tables 11 and 12. The experimental

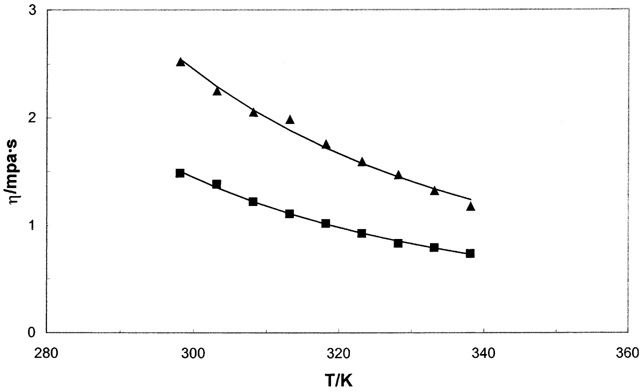

Figure 5. Viscosities of the (H_2O + LiBr + CHO_2Na) system (LiBr: CHO_2Na = 2:1 mass ratio) at various mass fractions: ● (w_T = 0.20); ▲ (w_T = 0.30); — (calculated).

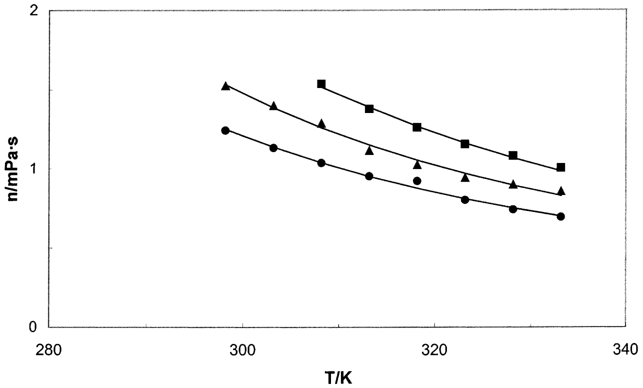

Figure 6. Viscosities of the (H_2O + LiBr + CHO_2K) system (LiBr: CHO_2K = 2:1 mass ratio) at various mass fractions: ● (w_T = 0.20); ▲ (w_T = 0.30); ■ (w_T = 0.40); — (calculated).

Table 11. Values of a_i, b_i, and c_i for Least-Squares Representation by eq 5 for the System (Water + Lithium Bromide + Sodium Formate)

n	A_n	B_n	C_n
0	−1.94	1.59 × 10^{2}	1.01 × 10^{5}
1	2.53 × 10^{-2}	−1.04	9.93 × 10^{1}
2	−1.06 × 10^{-5}	9.04 × 10^{-5}	0.96
3	−1.88 × 10^{-8}	2.21 × 10^{-6}	8.45 × 10^{-4}

Table 12. Values of a_i, b_i, and c_i for Least-Squares Representation by eq 5 for the System (Water + Lithium Bromide + Potassium Formate)

n	A_n	B_n	C_n
0	−1.21	1.09	1.01 × 10^{5}
1	2.30 × 10^{-3}	2.96	9.92 × 10^{1}
2	−1.03 × 10^{-5}	8.40 × 10^{-5}	0.99
3	−1.88 × 10^{-8}	3.94 × 10^{-6}	7.95 × 10^{-4}

and calculated viscosity values were plotted in Figures 5 and 6 as a function of temperature at a fixed concentration.

The average absolute deviations of the calculated values from the experimental data were 0.11% for the system (water + lithium bromide + sodium formate) and 0.03% for the other system.

Conclusions

As an alternative working fluid for the air-cooled absorption chiller, the water + lithium bromide + sodium formate system (LiBr/CHO_2Na mass ratio = 2) and the water + lithium bromide + sodium formate system (LiBr/CHO_2K mass ratio = 2) were selected, and three physical properties (vapor pressure, density and viscosity), necessary for the design of new absorption cooling machines, were measured at various absorbent concentrations and temperatures.

The data for each property were correlated with a proper regression equation, and the calculated results show good agreement with the measured result. The measured data sets and the correlation results can be used to give the required thermodynamic data for the detailed system design, but several other properties such as heat of mixing and heat capacity should be measured in order to evaluate the performance characteristic of the working fluid.

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