Solubility and Density of Potassium Iodide in Binary Ethanol−Water Solvent Mixture at (298.15, 303.15, 308.15, and 313.15) K

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The solubility of potassium iodide in ethanol + water binary solvent was measured over the entire composition range from 0 to 1 weight fraction of ethanol at (298.15, 303.15, 308.15, and 313.15) K. The densities of the saturated solutions are also reported. Equations are given for the solubility and density of the saturated solutions as functions of mole fraction of ethanol and temperature.

Introduction

The precipitation of inorganic salts from aqueous solutions by addition of alcohols as cosolvents has several advantages over the standard crystallization technique,[1−3] such as, for example, high yield and purity of the products, operation at ambient temperatures, and fitness for systems where the temperature has little effect on the solubility.[4]

Solubility data are generally available for many salts in aqueous systems.[5−7] Solubilities of potassium iodide in water−ethanol mixed solvent for a few compositions are available in Stephan and Stephan.[6] However there are no data available for solubility of potassium iodide in water−ethanol for the complete binary water−ethanol composition range. Therefore, we have undertaken systematic measurements of solubilities and densities of potassium iodide in ethanol−water binary solvent over the entire composition range from 0 to 1 mass fraction of ethanol at (298.15, 303.15, 308.15, and 313.15) K.

Experimental Section

Material. In all experiments, triple distilled water was used. Ethanol was supplied by the Jiangyin Huaxi International Trade Co. (China) of purity > 99.9 %. Potassium iodide (KI) was supplied by Qualigens Chemicals (India) of purity > 99.8 %.

Apparatus and Procedure. Binary (ethanol + water) mixtures were prepared by weight on an electronic balance (Shimadzu, Auxzzo) with an uncertainty of ± 0.1 mg. An excess amount of KI was added to the binary solvents in a specially designed 100 mL doublewall flask. Water was circulated at constant temperature between the outer and inner walls of the flask. The temperature of the circulating water was controlled by a thermostat to within (± 0.1) K. The solution was constantly stirred using a magnetic stirrer. After attaining equilibrium, the stirrer was turned off to let the solution settle for 1 h. Then the supernatant liquid was taken in a weighing bottle. The weight of this sample was taken, and the sample was kept in an oven at 343 K until the whole solvent was evaporated and the residue was completely dry. This was confirmed by weighing twice or thrice until constant weight was obtained after keeping the sample in an oven for another half an hour every time. From the weight of solute (residue) and weight of solution, the solubility has been calculated. Each experimental value of solubility is an average of at least three different measurements, and the uncertainty of the experimental solubility value is ± 0.0001 g/100 g.

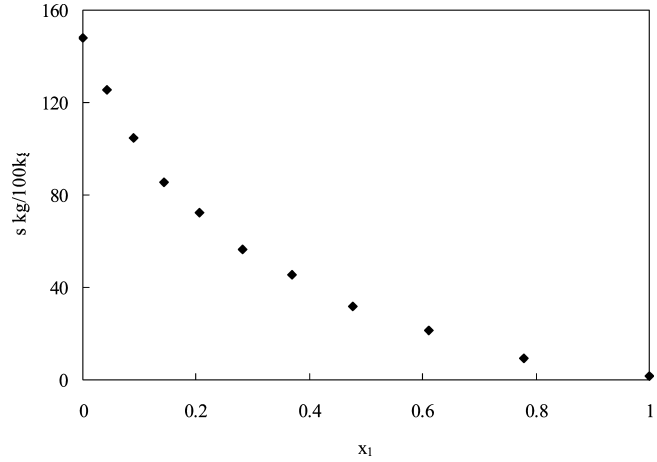

Figure 1. Solubility (*s*) vs mole fraction (*x*) of ethanol at 298.15 K.

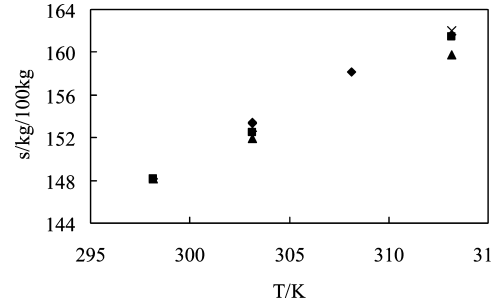

Figure 2. Solubility of KI in water as a function of temperature: ◆, this study; ▲, ref 5; ■, ref 7; ×, ref 8.

Densities were determined using a 15 cm^3 bicapillary pycnometer as described earlier.[9,10] The pycnometer was calibrated using water with conductivity of $5 \cdot 10^{-6}$ $S \cdot cm^{-1}$ and a density[11] of 0.99705 $g \cdot cm^{-3}$ at 298.15 K. The pycnometer filled with air bubble free experimental liquids was kept in a transparent walled water bath (maintained constant to ± 0.01 K) for (10 to 15) min to attain thermal equilibrium. The positions of the liquid levels in the two arms were recorded with the help of a traveling microscope, which could read to 0.01 mm. The estimated uncertainty of the density measurements of the solvent and

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Table 1. Solubility s and Density ρ of Potassium Iodide for Various Mole Fractions x of Ethanol at (298.15, 303.15, 308.15, and 313.15) K

			s	ρ
T/K	w	x	(kg/100 kg)·10^{-3}	kg·m^{-3}·10^{-3}
298.15	0.0	0.0000	0.1481	1.7169
	0.1	0.0417	0.1256	1.6163
	0.2	0.0891	0.1049	1.5153
	0.3	0.1436	0.0855	1.4226
	0.4	0.2069	0.0725	1.3262
	0.5	0.2813	0.0565	1.2398
	0.6	0.3698	0.0453	1.1471
	0.7	0.4772	0.0318	1.0572
	0.8	0.6100	0.0215	0.9735
	0.9	0.7790	0.0094	0.8763
	1.0	1.0000	0.0018	0.8021
303.15	0.0	0.0000	0.1534	1.7271
	0.1	0.0417	0.1296	1.6268
	0.2	0.0891	0.1103	1.5297
	0.3	0.1436	0.0910	1.4298
	0.4	0.2069	0.0755	1.3315
	0.5	0.2813	0.0604	1.2444
	0.6	0.3698	0.0473	1.1534
	0.7	0.4772	0.0342	1.0600
	0.8	0.6100	0.0022	0.9833
	0.9	0.7790	0.0108	0.8832
	1.0	1.0000	0.0022	0.7984
308.15	0.0	0.0000	0.0158	1.7338
	0.1	0.0417	0.1333	1.6383
	0.2	0.0891	0.1135	1.5383
	0.3	0.1436	0.0954	1.4399
	0.4	0.2069	0.0787	1.3428
	0.5	0.2813	0.0632	1.2508
	0.6	0.3698	0.0493	1.1600
	0.7	0.4772	0.0359	1.0660
	0.8	0.6100	0.0245	0.9902
	0.9	0.7790	0.0118	0.8904
	0.1	1.0000	0.0016	0.7928
313.15	0.0	0.0000	0.0162	1.7404
	0.1	0.0417	0.0139	1.6439
	0.2	0.0891	0.0120	1.5472
	0.3	0.1436	0.0994	1.4575
	0.4	0.2069	0.0820	1.3557
	0.5	0.2813	0.0660	1.2603
	0.6	0.3698	0.0514	1.1795
	0.7	0.4772	0.0379	1.0678
	0.8	0.6100	0.0258	0.9950
	0.9	0.779	0.0128	0.9040
	1.0	1.0000	0.0031	0.7928

Table 2. Coefficients of Model Equation 1

a·10^{-2}	b	c	d	e	f	g·10^{2}	h·10^{5}
−2.336	−1.674	0.910	0.135	−1.238	22.989	−7.530	8.230

Table 3. Coefficients of Model Equation 3

a_1	b_1	c_1	d_1	e_1	f_1·10^{2}	g_1·10^{5}
3.518	−2.470	3.410	−2.826	0.954	−1.32	2.41

binary mixtures was 0.1 kg·m^{-3}. At least three to four measurements were made which had an average deviation of ± 0.1 kg·m^{-3}.

Results and Discussion

The solubility and density of the saturated solutions for potassium iodide + water + ethanol at (298.15, 303.15, 308.15, and 313.15) K are given in Table 1. The solubility data at 298.15 K are presented in Figure 1.

Figure 2 shows a comparison of our experimental values of solubility of potassium iodide in pure water with literature values.[5,7,8] It can be seen from the figure that our experimental values agree well with literature values. The solubility of the potassium iodide solution appreciably decreases with increasing mole fraction (x) of ethanol, whereas there is little increase in solubility with an increase of temperature (T). The solubility data are correlated with the mole fraction (x) of ethanol and temperature by eq 1[4,12−15]

$$\log s = A + BT \tag{1}$$

with

$$A = a + bx + cx^2 + dx^3 + ex^4$$

$$B = f + gT + hT^2$$

The standard error of estimate (σ) is calculated using eq 2

$$\sigma = \left[\sum (y_{\text{exp}} - y_{\text{calc}})^2/(N - n)\right]^{1/2} \tag{2}$$

where y_{exp} is the experimental solubility and y_{cal} is the calculated solubility. N is the number of data points, and n is the number of coefficients. The standard error has been found to be ± 0.0311 kg/100 kg. Values of coefficients of eq 1 are presented in Table 2.

The density results are correlated with composition and temperature according to eq 3[6,14,16] with a standard error of estimate ± 0.0059 kg·m^{-3}.

$$\rho = C + DT \tag{3}$$

where C and D are given by

$$C = a_1 + b_1x + c_1x^2 + d_1x^3 + e_1x^4$$

$$D = f_1 + g_1x$$

Coefficients of eq 3 are presented in Table 3.

Conclusions

This paper reports experimental data for the solubility and density of potassium iodide in ethanol + water mixed solvent from (298.15 to 313.15) K. The simple method for measuring solubility and density was found to be very precise. The data of solubility and density were correlated with mole fraction of ethanol (x) and temperature by polynomial equations. For all systems, the calculated values of solubility and density are in good agreement with experimental values.

Nomenclature

s	solubility, kg of KI/100 kg of solvent
w	weight fraction of ethanol
ρ	density of solution, kg·m^{-3}
σ	standard error
T	temperature, K
a, b, c, d, e, f, g, h	coefficients of eq 1

a_1, b_1, c_1, d_1, f_1, g_1 coefficients of eq 2

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