ISSN 1070-4272, Russian Journal of Applied Chemistry, 2009, Vol. 82, No. 9, pp. 1682–1685. © Pleiades Publishing, Ltd., 2009.
Original Russian Text © V.P. Yurkinskii, E.G. Firsova, E.V. Gusevskaya, 2009, published in Zhurnal Prikladnoi Khimii, 2009, Vol. 82, No. 9, pp. 1577–1580.

BRIEF COMMUNICATIONS

Electroconductivity of Potassium Iodide Solutions in the System Ethyl Alcohol–Water

V. P. Yurkinskii, E. G. Firsova, and E. V. Gusevskaya

St. Petersburg State Polytechnical University, St. Petersburg, Russia

Received April 13, 2009

Abstract—The electrical conduction of potassium iodide solutions in the ethanol-water system in the temperature range 292–323 K was studied using the conductometric method. Specific and molar electrical conductions of the solutions depending on water and potassium iodide contents were determined.

DOI: 10.1134/S1070427209090304

Solutions of the lowest aliphatic alcohols find increasing application in the modern technological practice [1, 2]. It is known that the physicochemical properties of alcohols essentially depend on the content of water dissolved in them [3–5]. The water content in aqueous-alcohol solutions can be determined by the conductometric method of analysis based on the measurements of the electrical conduction of solutions [6, 7]. There are published data on the electrical conduction of water-organic electrolytes, however the effect of water content on its value has not been adequately studied [5].

To continue studying electrical conduction of alcohol–water systems [8, 9], in the present work we have studied the electrical conduction of potassium iodide solutions in the system ethanol–water as functions of temperature and salt concentration.

EXPERIMENTAL

The experiments were carried out in the temperature range 292–323 K. The electrical conduction of solutions was determined by the conductometric method. The construction of an electrochemical cell and the measurement technique have been described earlier [8]. Chemically-pure grade ethanol was used in the work. Potassium iodide solutions in ethanol-water mixtures were prepared by mixing a KI aqueous solution (0.2 M) with ethanol. To prepare the initial potassium iodide solution, we used a titrant. The concentration of potassium iodide was varied in the range 0.0004–0.0920 M, the water content in the mixtures was from 5 up to 50 vol %.

Using the experimental data, we have determined the specific electrical conduction χ (S cm^{-1}) of the studied solutions and the temperature dependences $\chi = f(T)$, and also the isotherms $\chi = f(c_{KI})$ at various water contents in a water-alcohol solution.

Figure 1 demonstrates a typical example of the $\chi = f(T)$ dependence for various concentrations of potassium iodide solution and a 20 vol % water content. It is seen that χ increases at a constant water content in a solution as KI concentration and temperature increase. The specific electrical conduction also increased as water content in solution increased. Thus, at 320 K and c_{KI} = 0.012 M χ values were 0.0007, 0.0009, and 0.0012 S cm^{-1} for 10, 20, and 40 vol % of H_2O, respectively.

The statistical treatment of the experimental data was carried out using the standard computer program ORIDGIN.

It follows from the examination of the $\chi = f(T)$ dependence (Fig. 1) that for the solutions under study the increase in the specific electrical conduction at increasing temperature is well described by a quadric polynomial: $\chi = A + B_1T + B_2T^2$, where A, B_1, and B_2 are constant coefficients. The values of the coefficients in the polynomials for all studied solutions are given in the table. Confidence intervals R and mean-root-square errors S were also determined.

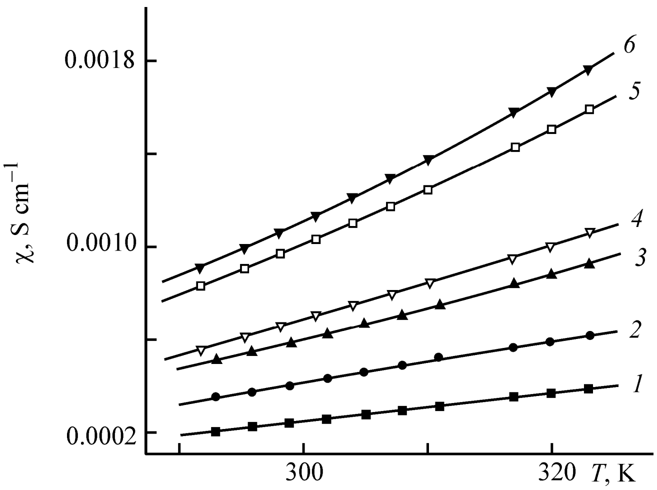

Fig. 1. Dependence of specific electrical conduction χ of potassium iodide solutions in the system ethanol–water (20 vol %) on temperature T at various potassium iodide concentrations. c_{KI}, M: (*1*) 0.004, (*2*) 0.008, (*3*) 0.012, (*4*) 0.016, (*5*) 0.024, and (*6*) 0.028.

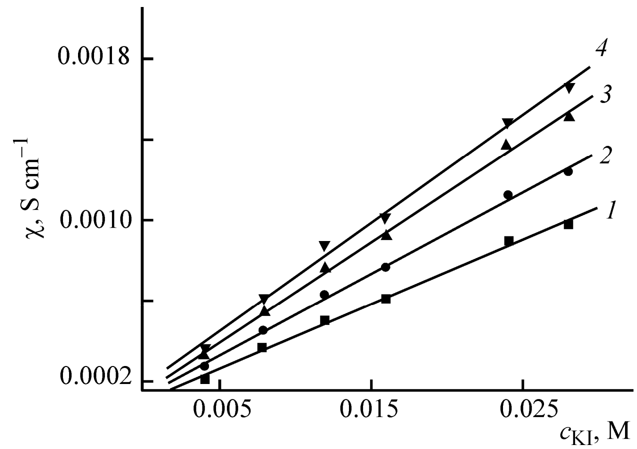

Fig. 2. Dependence of specific electrical conduction χ of potassium iodide solutions in the ethanol–water system (20 vol %) on the concentration of potassium iodide c_{KI} at various temperatures. *T*, K: (*1*) 295, (*2*) 305, (*3*) 315, and (*4*) 320.

Using the data of Table 1, we have constructed isothermal dependences of specific electrical conduction on potassium iodide concentration at various water contents in the solutions under study. An example of the typical $\chi = f(c_{KI})$ dependence at the water content of 20 vol % in solution is given in Fig. 2. It was found that for all solutions under study the isotherms of specific electrical conduction are linear

Table 1. Values of coefficients for potassium iodide solutions in ethanol–water mixtures of various composition

$c(H_2O)$, vol %	c_{KJ}, M	A	$B_1 \times 10^6$	$B_2 \times 10^8$	R	$S \times 10^6$
5	0.0004	0.00010	–0.91	0.22	0.997	0.267
	0.0008	0.00017	–1.62	0.41	0.997	0.496
	0.0012	0.00041	–3.34	0.72	0.998	0.529
	0.0016	0.00039	–3.31	0. 76	0.998	0.601
	0.0018	0.00042	–3.84	0. 92	0.996	1.175
7	0.0008	0.00103	–7.27	1.33	0.998	0.378
	0.0020	0.00181	–13.15	2.49	0.998	1.059
	0.0032	0.00093	–7.997	1.78	0.998	1.004
	0.0044	0.00254	–19.31	3.84	0.993	4.102
	0.0060	0.00071	–8.05	2.17	0.998	1.300
10	0.0020	–0.00027	0.621	0. 224	0.993	1.950
	0.0040	–0.00165	8.084	–0.627	0.995	3.288
	0.0060	0.00089	–9.196	2.40	0.997	3.221
	0.0080	–0.00143	4.348	0.537	0.999	1.708
	0.0100	–0.00580	32.58	–3.94	0.998	3.36
	0.0120	–0.00948	55.35	–7.34	0.997	6.345

Table 1. (Contd.)

$c(H_2O)$, vol %	c_{KJ}, M	A	$B_1 \times 10^6$	$B_2 \times 10^8$	R	$S \times 10^6$
20	0.0040	–0.00113	3.105	0.48	0.999	1.678
	0.0080	–0.00531	28.64	–3.20	0.999	2.469
	0.0120	0.00145	–18.96	5.36	0.999	2.806
	0.0160	–0.00358	12.72	4.96	0.999	4.321
	0.0240	0.00473	–47.29	11.61	0.999	4.312
	0.0280	0.00999	–84.01	18.10	0.999	2.063
40	0.0120	0.00593	–51.147	11.37	0.999	5.327
	0.0240	0.00771	–75.60	18.10	0.999	8.255
	0.0360	–0.00948	24.47	4.54	0.999	13.895
	0.0480	–0.02570	116.09	–7.37	0.997	38.118
	0.0600	–0.02580	108.24	–4.10	0.999	27.204
	0.0720	–0.03951	184.29	–13.71	0.999	26.16
50	0.0160	0.00652	–68.496	17.10	0.999	5.409
	0.0320	0.01929	–170.00	37.50	0.999	13.368
	0.0480	0.04049	–330.63	68.43	0.999	23.330
	0.0640	0.05646	–456.97	93.78	0.999	21.505
	0.0800	0.07118	–571.49	1.16	0.998	61.273
	0.09200	0.08985	–706.42	1.41	0.999	52.578

and can be expressed by the equation $\chi = A + Bc$, where c is the KI concentration (M) and A and B are constant coefficients.

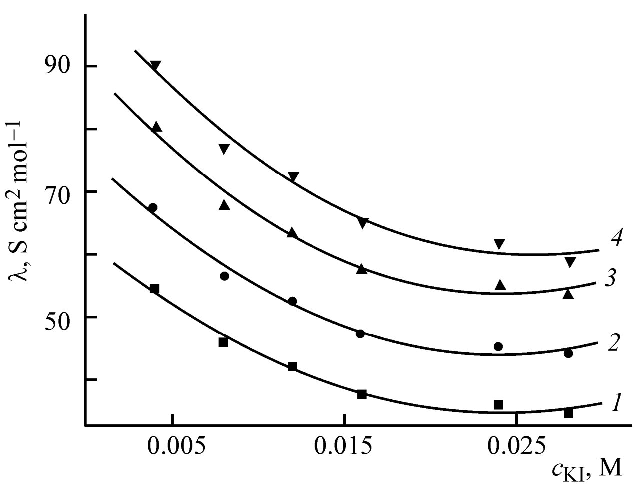

Fig. 3. Dependence of molar electrical conduction λ of potassium iodide solutions in the ethanol-water system (20 vol %) on the concentration of potassium iodide c_{KI} at various temperatures. T, K: (*1*) 295, (*2*) 305, (*3*) 315, and (*4*) 320.

Using specific electrical conduction values, we have calculated the molar electrical conduction of potassium iodide solutions λ and the values λ_0 of the molar electrical conduction at infinite dilution. An examination of the molar electrical conduction isotherms (Fig. 3) has shown that at a constant water contents in aqueous-alcoholic solutions λ decreases with increasing potassium iodide concentration as is the case with analogous aqueous solutions [10], λ being adequately described by a quadric polynomial.

To ascertain the applicability of Kohlrausch's equation to the studied aqueous-alcohol solutions, the $\lambda = f(\sqrt{c})$ dependence was investigated. It has appeared that the $\lambda = f(\sqrt{c})$ dependences are nonlinear that points to inapplicability of Kohlrausch's law to the studied aqueous-alcohol solutions.

As the water concentration increases the molar electrical conduction of potassium iodide solutions in the ethanol–water system at the infinite dilution increases and is described by a composite function of a cubic polynomial. Thus, at 295 K the equation for the $\lambda_0 = f[c(H_2O)]$ is:

$$\lambda_0 = 43.5376 + 2.42017c(H_2O) - 0.10299c^2(H_2O) + 0.00144c^3(H_2O).$$

The confidence interval is 0.996 and the mean-root-square error is 1.481.

CONCLUSIONS

(1) It was found that the specific electrical conduction of the investigated solutions increases with increasing temperature, the $\chi = f(T)$ dependence being described by a quadric polynomial. As the potassium iodide concentration and the water content in the ethanol–water system increase the specific electrical conduction decreases. The $\chi = f(c_{KI})$ isotherms found at various water content in solutions are linear.

(2) The molar electrical conduction of the investigated solutions was calculated. It was found that the molar electrical conduction of solutions decreases as the concentration of potassium iodide in the ethanol-water system increases at a constant water content. The $\chi = f(c_{KI})$ isotherms are described by a quadric polynomial.

(3) Values of the molar electrical conduction of solutions λ_0 at infinite dilution were determined. As water concentration in solutions increases λ_0 increases. The $\lambda_0 = c(H_2O)$ dependence is described satisfactorily by a cubic polynomial.

REFERENCES

1. Tomilov, A.P., *Elektrokhim.,* 2000, vol. 36, no. 2, pp. 115–116.
2. Makarov, V.V., Petrykin, V.E., Emel'yanov, V.V., et al., *Avtomob. Promyshlennost'*, 2005, no. 8, pp. 24–26.
3. Petrov, A.A., Bal'yan, H.V., and Troshchenko, A.T., *Organicheskaya khimiya* (Organic Chemistry), St. Petersburg: Ivan Fedorov, 2002.
4. Hasanshin, T.S., *TFTs* (Thermal-Physical Center), Moscow: Inst. Vysokikh Temperatur Akad. Nauk, 1991, no. 2 (88), pp. 3–71.
5. Janz, G.J. and Tomkins, R.P.T., *Nonaqueous Electrolytes: Handbook*, New York: Acad. Press, 1972.
6. Hudyakova, T.A. and Kreshkov, A.P., *Konduktometricheskii metod analiza* (Conductometric Method of Analysis), Moscow: Vysshaya shkola, 1975.
7. Grilikhes, M.S. and Filanovskii, B.K., *Kontaktnaya konduktometriya: Teoriya i praktika metoda* (Contact Conductometry: Theory and Practice of the Method), Leningrad: Khimiya, 1980.
8. Yurkinskii, V.P., Firsova, E.G., Chechulina, O.V., and Soboleva, A.M., *Zh. Prikl. Khim.*, 2008, vol. 81, no. 9, pp. 1474–1478.
9. Yurkinskii, V.P., Khorosheva, O.M., and Firsova, E.G., Abstract of Papers, *Materialy XII Vserossiiskoi konferentsii po problemam nauki i vysshei shkoly "Fundamental'nye issledovaniya v tekhnicheskikh universitetakh"* (Proc. XII All-Russian Conf. on Problems of Science and Highest School "Fundamental Studies in Technical Universities"), St. Petersburg: Izd. Polytehnicheskogo Universiteta, 2008, pp. 160–161.
10. Skorchelletti, V.V., *Teoreticheskaya elektrokhimiya* (Theoretical Electrochemistry), Leningrad: Khimiya, 1974.