Conductivity of Alkali Metal Bromides and Chlorides in Water–Ethanol Mixed Solvent

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***Abstract* – The conductivity of bromide and chloride of sodium and potassium were determined in pure water and ethanol-water mixed solvent media containing 10, 20, 30, 40, 50, and 60 volume percent of ethanol at room temperature. The results showed sharp increase in the conductivity with increasing electrolyte concentration and decrease in the conductivity of electrolyte with increase in the amount of ethanol.**

***Keywords*: Conductivity, solvent, ethanol, alkali metals Bromide, Chloride**

I. INTRODUCTION

Conductivity measurements provide important information on ion-ion solvent interactions. Studies on electrolytic conductance in mixed solvents can provide useful information and sensitive indications of ion-solvent, ion-ion interactions and solvent structure.

One of the important methods in studying the ion-pair formation in both aqueous and non-aqueous solutions is the measurement of electrical conductivity of dilute solutions.

Although water is a poor conductor of electricity, the presence of ionic species in solution increases its conductance considerably. The conductance of such solution depends on the concentration and nature of ions present. Their conductance behavior as a function of concentration is different for strong and weak electrolytes.

To carry a current a solution must contain charged particles or ions. Most conductivity measurements are made in aqueous solutions, and the ions responsible for the conductivity come from electrolyte dissolved in the water.

Mixed solvent system containing one salt has been considered pseudo binary solution consisting of mixed solvent and salts. This view makes it difficult to model mixed solvent systems because the standard chemical potentials of ions are functions of solvent composition [1].

Ethanol (C_2H_5OH) is an alcohol mainly found in alcoholic beverages as pure organic solvent and as alcohol.

Water and ethanol molecules are mixable. Water-ethanol mixed at different temperatures exhibit a wide range of dielectric constant, viscosity, density, and a high degree of hydrogen bonding effects. Appropriate measurement provides useful indication of solvent-solvent interaction and solvent structure (Zumdahl, 2009). Mixed solvents of water-ethanol can be prepared by adding known amount of ethanol to water in volume ratio or mass ratio. Different percentage compositions of ethanol in water, like 10%, 20%, 30% etc can be prepared by making known volume of ethanol in water (10% ethanol = 10cm^3 ethanol + 90 cm^3 water). Conductance measurement of 1:1 electrolytes mixed solvent is widely available [3]. The behavior of electrolytes in mixed solvent systems provide a vast field of research and the literature survey show an exclusive area for the research of nature of compounds in mixed solvents [4].

Conductometric analysis is one of the reliable and useful techniques used for determination and electrolytes nature in a solvent.

Dielectric constant of the medium plays a very important role concerning the behavior of electrolytes in solution. [5] studied the conductance of chloroamine-T and bromoamine-T as a function of temperature at different compositions of water-methanol and water-ethanol.

Molar conductance has been analyzed by Debye Huckel-Onsager theory of conductivity. The study of variation in molar conductance with temperature and solvent composition provides information about ionic mobility and solvent viscosity, hydrogen bonding, capability, dialectical constant and its specific interaction with ions [5]. In order to analyze ion-solvent interactions, great interest has been paid to the behaviour of solutions of electrolytes in pure solvents and in binary solvent mixtures [6]. [7] carried out conductance studied on the drugs parvan spas, parvodex and tramacip in ethanol-water mixture at 25^{0}C in absence and presence of additive viz. electrolytes – fructose and sucrose. The data obtained was evaluated in terms of specific conductance, equivalent conductance and limiting molar conductance.

Conductivity measurements are widely used in industries. Some important applications are Interface detection, Leak detection, Desalination, In the pharmaceutical and beverage and food industries, piping and vessels are periodically cleaned and sanitized in a procedure called clean in place (CIP) and Water treatment

This study is to investigate the conductance of bromides and chlorides of sodium and potassium in water and water-ethanol mixed solvents at room temperature.

II. MATERIAL AND METHODS

Potassium chloride (KCl), sodium chloride (NaCl), Potassium bromide (KBr) and sodium bromide (NaBr) were obtained from Poole Company England.

The two solvents used were ethanol and water-ethanol obtained from BDH limited, Poole England. Analar grade ethanol of 99.5% with conductivity 1.31 was used without further purification. Distilled water with conductivity 3.75 was obtained from the laboratory.

All glass wares were washed with detergent and water and left to dry before use. Exactly 0.6g each of NaBr, NaCl, KBr and KCl were mixed in different percentages of water and ethanol solutions as in Table 1. They were all mixed with each of the salts to 100ml at temperature of 25.4^0C.

A conductivity metre (Pye Unican PW #9509) with Conductivity dip type probe electrode with cell constant $1.00cm^{-1}$ was used for the measurements.

Table 1. Percentage of Ethanol with Water for NaCl, NaBr, KCl and KBr

Ethanol %	0	10	20	30	40	50	60	70	80	90	100
Water %	100	90	80	70	60	50	40	30	20	10	0

III. RESULTS AND DISCUSSION

The results of conductivity measurements are shown in Tables 2-5 while comparisons in conductivities of the salts are presented in Figs. 1-4.

Table 2. Conductivity of Sodium Chloride in Ethanol-Water Mixed Solvent

Ethanol (ml)	Water (ml)	Observed conductivity (μScm^{-1})	Conductivity (Scm^{-1})	Specific conductivity (Sm^{-1})	Equivalent conductivity (Scm^{-2})
-	100	41.0	4.1×10^{-2}	4.1×10^{-2}	410
10	90	38.5	3.85×10^{-2}	3.85×10^{-2}	385
20	80	32.4	3.24×10^{-2}	3.24×10^{-2}	324
30	70	30.1	3.01×10^{-2}	3.01×10^{-2}	301
40	60	28.4	3.84×10^{-2}	3.84×10^{-2}	284
50	50	24.9	2.46×10^{-2}	2.46×10^{-2}	246
60	40	21.7	2.17×10^{-2}	2.17×10^{-2}	217
70	30	19.9	1.99×10^{-2}	1.99×10^{-2}	199
80	20	17.9	1.79×10^{-2}	1.79×10^{-2}	179
90	10	14.8	1.48×10^{-2}	1.48×10^{-2}	148
100	-	3.3	3.3×10^{-3}	3.3×10^{-3}	033

Table 3. Conductivity of Potassium Chloride in Water-Ethanol Mixed Solvent

Ethanol (ml)	Water (ml)	Observed conductivity (μScm^{-1})	Conductivity in (Scm^{-1})	Specific conductivity (Sm^{-1})	Equivalent conductivity (Scm^{-2}) 1000/c
-	100	45.6	4.56×10^{-2}	4.56×10^{-2}	456.00
10	90	41.5	4.15×10^{-2}	4.15×10^{-2}	415.00
20	80	37.8	3.78×10^{-2}	3.78×10^{-2}	378.00
30	70	33.8	3.38×10^{-2}	3.38×10^{-2}	338.00
40	60	31.4	3.14×10^{-2}	3.14×10^{-2}	314.00
50	50	28.7	2.87×10^{-2}	2.87×10^{-2}	287.00
60	40	26.3	2.63×10^{-2}	2.63×10^{-2}	263.00
70	30	20.4	2.04×10^{-2}	2.04×10^{-2}	204.00
80	20	18.3	1.83×10^{-2}	1.83×10^{-2}	183.00
90	10	10.3	1.03×10^{-2}	1.03×10^{-2}	103.00
100	-	2.3	2.3×10^{-3}	2.3×10^{-3}	012.00

Table 4. Conductivity of Sodium Bromide in Ethanol-Water Mixed Solvent

Ethanol (ml)	Water (ml)	Observed conductivity (μScm^{-1})	Conductivity (Scm^{-1})	Specific conductivity (Sm^{-1})	Equivalent conductivity (Scm^{-2})
-	100	35.4	3.54 x 10^{-2}	3.54 x 10^{-2}	354
10	90	34.1	3.41 x 10^{-2}	3.41 x 10^{-2}	341
20	80	21.1	2.11x 10^{-2}	2.11x 10^{-2}	211
30	70	16.5	1.65x 10^{-2}	1.65x 10^{-2}	165
40	60	15.6	1.56 x 10^{-2}	1.56 x 10^{-2}	156
50	50	13.3	1.33x 10^{-2}	1.33x 10^{-2}	133
60	40	12.8	1.28x 10^{-2}	1.28x 10^{-2}	128
70	30	12.6	1.26x 10^{-2}	1.26x 10^{-2}	126
80	20	11.4	1.14x 10^{-2}	1.14x 10^{-2}	114
90	10	10.3	1.03x 10^{-2}	1.03x 10^{-2}	103
100	-	1	1.0 x 10^{-3}	1.0 x 10^{-3}	10

Table 5. Conductivity of Potassium Bromide in Ethanol-Water Mixed Solvent

Ethanol (ml)	Water (ml)	Observed conductivity (μScm^{-1})	Conductivity (Scm^{-1})	Specific conductivity (Sm^{-1})	Equivalent conductivity (Scm^{-2}) 1000/c
-	100	49.9	4.99 x 10^{-2}	4.99 x 10^{-2}	499
10	90	37.6	3.76 x 10^{-2}	3.76 x 10^{-2}	376
20	80	32.6	3.26 x 10^{-2}	3.26 x 10^{-2}	326
30	70	27.6	2.76 x 10^{-2}	2.76 x 10^{-2}	276
40	60	20.7	2.07 x 10^{-2}	2.07 x 10^{-2}	207
50	50	17.9	1.79 x 10^{-2}	1.79 x 10^{-2}	179
60	40	16.6	1.66 x 10^{-2}	1.66 x 10^{-2}	166
70	30	14.7	1.47 x 10^{-2}	1.47 x 10^{-2}	147
80	20	12.7	1.27 x 10^{-2}	1.27 x 10^{-2}	127
90	10	11.3	1.13 x 10^{-2}	1.13 x 10^{-2}	133
100	-	1.9	1.9 x 10^{-3}	1.9 x 10^{-3}	19

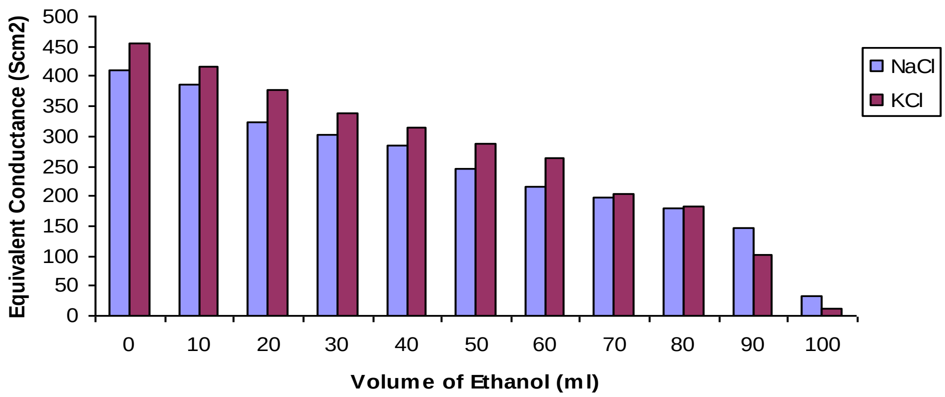

FIG. 1 Conductivities of NaCl and KCl in Water-Ethanol mixed Solvent

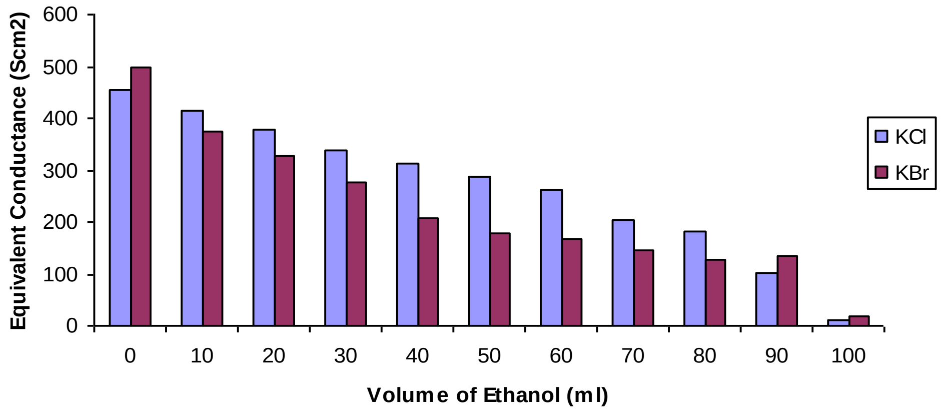

FIG.2 Conductivities of KCl and KBr in Water-Ethanol mixed Solvent

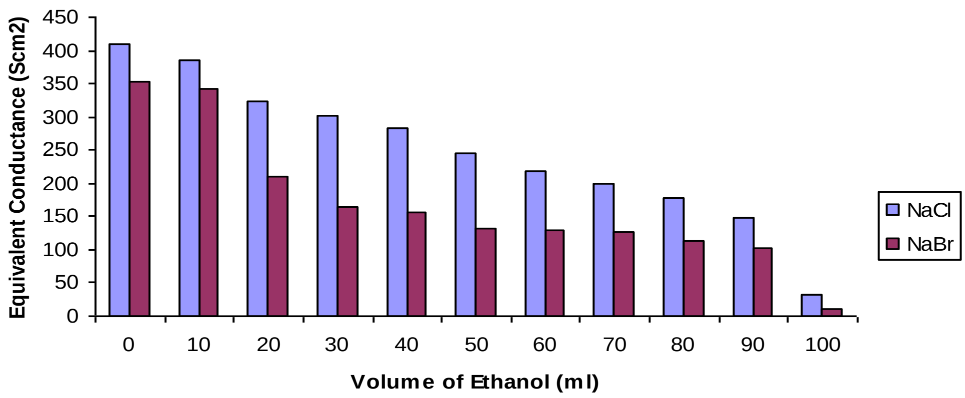

FIG.3 Conductivities of NaCl and NaBr in Water-Ethanol Mixed Solvents

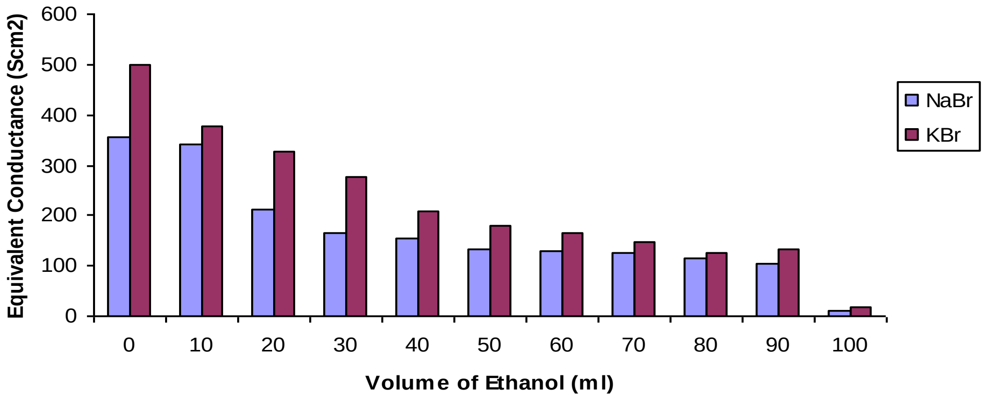

FIG.4 Conductivities of NaBr and KBr in Water-Ethanol Mixed Solvents

It was found that the conductivity of distilled water was 3.5µS/cm and exposure to air increased the conductivity of the distilled water. The electrical conductivity of distilled water should not be more than 10µS/cm [9].

In the solution of 0% ethanol and 100% distilled water all the salts dissolved completely but as the percentage of ethanol increased the solubility of the salts decreased considerably. Thus the conductivity of the salts decreased with increase in the volume of ethanol used. The results of both potassium salts showed the chlorides higher than the bromides up to 80% ethanol. Similar trend was observed between the chlorides of both metals. These observations could be attributed to similarity in reactivity of the salts. The conductivity of the salts generally followed the trend: KCl > NaCl (Fig. 1), KCl > KBr (Fig. 2), NaCl > NaBr (Fig. 3), KBr > NaBr (Fig. 4).

IV. CONCLUSION AND RECOMMENDATION

The result of this study showed that conductivity of the solution decreases with increase in ethanol showing that addition of ethanol will reduce the conductivity of the solution. Also solvents with low conductivity reduce the conductivity of an aqueous solution. It is recommended that further research should be made on the conductivity of other strong electrolytes in mixed solvent media.

REFERENCES

[1] Biswas, P. K., Lahiri, S. C. and Dey, J. B. P. (1993). Solvational Behaviour of some substituted Benzoic Acids in Ethanol-Water mixtures at 298.15K Indian Chemical Soc. 70, 125.

[2] Zumdahl, S. (1997). Chemistry Textbook. Boston Houghton Mifflin Company. 4th ed. p. 133-145.

[3] Kouissi, M. and Bouanz, J. (2010). Properties of aqueous PotassiumIodide solutions *Chem. Eng. Data* 55, 320.

[4] Bay, G. C., Singh, N. M. and Singh, N. R. J. (2001). Thermodynamic studies ofIon Association of Halides and perchlorate in Methanol solutions. *Indian Chem. Soc*. 78, 294-297.

[5] Bhattacharyya, A., Maandal, A. K., Lahiri, S. C. (2003). Conductance of Chloroamines-T and Bromoamines-T and ion-solvent interaction. *Electrochemica Acta* 25 (5) 559-561.

[6] Pattan, S. K. and Tochigi, A. (2006). Determination of Electrolytes nature in a solvent. *J. Chem. Eng. Data*. 47, 1388.

[7] Syal, V. K. Thakur, S. K., Chauhan, S. and Sharma, P. (2005). Ultrasonic Velocity studies of drug parvon-spas in mixed alcohol-water solvent Systems at 298.15K. *International J. Thermophys*. 26,807-826.

[8] Bhattarai, A and Raut, J. (2011). Conductometric studies of potassium Bromide to pure water and ethanol – water mixed solvent media. *Journal of Alpine chemistry*, 2 44.

