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Determination of Densities of Some R_4NI Salt Solution in Isopropyl Alcohol-DMF Mixtures and Study the Nature of Ionic Interactions from Apparent Molar Volume Data at 313.15K

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Article Info
Volume 82
Page Number: 4091- 4101
Publication Issue:
January-February 2020

Article History
Article Received: *18 May 2019*
Revised: *14 July 2019*
Accepted: *22 December 2019*
Publication: *21 January 2020*

Abstract:
The densities and apparent molar volumes (ϕ_v) of the binary non-aqueous solvent mixtures containing tetra alkyl ammonium iodide (R_4NI) salts have been determined at 313.15K to observe solvent-solute ionic interactions occurred between the constituents of the liquid mixtures. Utilized Masson's equation and plotting graph ϕv vs $\sqrt{c}$ explained the types of molecular interactions involved between solute-solvent molecules. Also, observed the effect of dielectric constant on the thermo-physical properties of solution and change in the slope values (S_v) from positive to negative nature. The changed in estimated volumetric properties of the liquid mixtures indicates the presence of weak as well as strong ion- ion interactions between the components of the mixtures. The penetration of solvent molecules within large void space of tetra alkyl ammonium chain length cation causes such type of molecular interactions occurred. Present investigation reflects specific types of molecular rearrangement that will lead to increase in electrostriction with the presence of ions in the solution mixture.

Keywords: *Apparent molar volume (ϕ_v), Masson's equation, Density (ρ), Dielectric constant (ϵ), Tetra alkyl ammonium iodide (R_4NI) salts, Molecular interactions.*

Introduction

The survey of literature reveals that some scientist[1-3] studied the dependence of ϕ_v of R_4NI salts in pure DMF with concentration at different temperatures. It was found that except for Et_4NI, a negative slope (S_v) was observed for all other higher tetra alkyl ammonium iodide salts. For Et_4NI slope was found to be positive. Some workers[5, 7] examined ionic interactions occurred between the constituents of ions in solutions of tetra alkyl ammonium iodides in pure isopropyl alcohol from apparent molar volume data. The slope of ϕ_v vs $\sqrt{c}$ curves was found to be positive for all these salts. The results were explained with the help of change in the values of dielectric constant (ε) of the solvent media.

Although, the comparison of data in solvents of different dielectric constant indicates that a lower dielectric constant favors a more positive slope (S_v), a systematic study of the effect of ϵ of the non- aqueous media influence on the

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nature of the S_v was still lacking. An attempt was made by Gopal et al[13-14] and Gonzalez et al[3] to study the problem in few aqueous mixtures, namely, Dioxane –Water, Ethanol–Water, and t- Butanol–Water etc. For all these mixtures, a transition in slope (from positive to negative) in ϕv vs $\sqrt{c}$ curves was obtained for higher R_4NI salts, as the dielectric constant (ε) of the solvent systems were enhanced with water adding to non–aqueous component gradually, lower alkyl chain length cation (R_4N^+) showed no transition in the value slope (S_v). It is intended to undertake such an investigation in this paper using non- aqueous – non aqueous type solvent mixtures. Present investigation indicates that, the change in the values of ϵ of the medium, ionic charge density and inter-ionic penetration effect affect the nature of Masson's slope[2]. It seems that it is the combined effect of all the three factors which govern the nature of slope.

Experimental

Tetra alkyl ammonium iodide salts of Merk, Et_4NI, Pr_4NI, Bu_4NI and Pen_4NI (purity ≥ 99%) are used in present work were purified by the Conway et al. method[16]. Isopropyl alcohol and DMF of Qualigen's Glaxo grade (purity ≥ 99.5%) were purified with distilling under reduced pressure. IPPA and DMF were used in the present work after getting the electrical conductance of the final product of the order of 10^{-7} ohm^{-1} cm^{-1} through redistilled process. The purified materials were stored in dark coloured bottles. The Isopropyl alcohol–DMF binary solvent mixtures were prepared using 20, 40, 60, 80% Isopropyl alcohol in DMF (v/v).

The different values of dielectric constant (ϵ) of the media of the various selected binary liquid mixtures of different % compositions were measured by used of BI-870 dielectric constant meter (absolute accuracy to ± 2%) are given in Table 1. Simply insert the probe in the liquid to be measured, adjust the two controls on the front panel and read the accurately measure in low and high dielectric constant, including mixed liquids and solutions. The dielectric constant (ϵ) of the liquid's sample recorded by measurement the current between the outer and inner cylinders of the probe. With a stable voltage supply and exactly proverbial probe parameters, it is possible to display the dielectric constant directly. Calibration is easy mistreatment the rear panel adjustment with a liquid of proverbial dielectric constant (ϵ).

The solutions of R_4NI salts (R=Et, Pr, Bu, Pen) of molarities 0.02, 0.04, 0.06, 0.08, 0.10, 0.12, 0.14M were prepared in 20% and then 40, 60 % and 80% Isopropyl alcohol in DMF mixtures. The densities, d_0, of the solvent mixtures and solutions, d were measured with the help of Magnetic Float Densitometer[12]. The densities, d_0 of different selected solvent % compositions and d for 0.02 to 0.014 M solutions mixture of each electrolytes, Et_4NI, Pr_4NI,Bu_4NI and Pen_4NI separately, were determined by putting weight 'w' on the float and measuring corresponding hold down current 'I' and then calculated ϕ_v values by using equation 1 and 2 respectively.

$$d_0 = (W + w + f X I)/ V + w/d_{pt}) \quad (1)$$

$$\phi_v = 1000(d_0-d)/cd_0+ M/d_0 \quad (2)$$

Results and Discussion

The densities d_0 of 20, 40, 60, and 80%, DMF in Isopropyl alcohol mixtures were measured by Magnetic Float Densitometer. The weights, corresponding density values (d_0) of these solvent mixtures have been given in Table 2. Densities and apparent molar volumes data are recorded in Table 3 - 6, ϕ_v vs $\sqrt{c}$ curves are then plotted are shown in Fig. 1 - 4 for all the four compositions of DMF – Isopropyl alcohol solution mixtures. These curves are found to be straight line for all the DMF – Isopropyl alcohol compositions and for the entire range of electrolyte concentration selected. The validity of Masson's equation was followed for all these salts and solvent mixtures in the entire selection range (0.02 – 0.14M) of solute concentration.

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Since the inter-ionic force of attraction or repulsion depends on the value of dielectric constant of the solvent media ($F \propto 1/\epsilon$). This inter-ionic force is large when the electrolyte is dissolved in a solvent/solvent mixture of low dielectric constants ($\in$). As the concentration of salt is increased the ions come nearer to each other and the interactions of ions go on increasing. Thus due to strong ionic interactions, ϕ_v increases as the concentration of electrolyte increases, resulting in a positive slope in ϕ_v vs $\sqrt{c}$ curves. Hence, DMF – isopropyl alcohol mixtures showed a positive slopes for all the four salts of tetra alkyl ammonium iodide in 20% ($\in = 21.02$) and 40% ($\in = 25.12$).

As these solvent mixture have, comparatively, low dielectric constant, but as the ϵ of the solvent mixture is increased with the DMF content , that is , studies in 60% $\in = 28.78$ and 80% $\in = 32.98$. DMF – isopropyl alcohol mixture, shows that due to weak interaction of ions / ions – solvent, the ϕ_v decreases with increasing concentration of electrolytes and ϕ_v vs $\sqrt{c}$ curves shows a negative slope for Bu_4NI and Pen_4NI salts. Pr_4NI salt, however, show negative behaviour of slope in higher dielectric constant medium, i.e., in 80% $\in = 32.98$ of the solvent mixture due to relatively smaller size of Pr_4N^+ ion than Bu_4N^+ and Pen_4N^+ ions. The charge density of Et_4N^+ is higher than Pr_4N^+ and Bu_4N^+ ions. This increases the ionic interaction between the ions in the solvent which seems to reduce the effect of dielectric constant on interaction and so only 80% $\in = 32.98$. DMF – isopropyl alcohol mixture gives a negative slope Et_4N^+ ion is the smallest of all the other three ions ($Et_4N^+ < Pr_4N^+ < Bu_4N^+ < Pen_4N^+$). So in this case the charge density of the ion is largest and there is strongest ionic interaction. Thus Et_4NI shows only positive slope in all the four composition of solvent mixture (the charge density effect seems to dominate the dielectric constant effect on interaction in this case).

It may be noted from the ϕ_v data of Table 3 - 6 and slope S_v data of Table 7 that the slope is positive for Et_4NI in 20, 40, 60, and 80% DMF with isopropyl alcohol mixtures. ϕ_v increases with increase in salt concentration of Pr_4NI for 20, 40 and 60% DMF while Bu_4NI and Pen_4NI salts show only at 20 and 40% DMF in Isopropyl alcohol mixtures as shown in Table 3-4. Although it appears that the slope S_v diminished with increase in the values dielectric constant of the solvent mixture. Table 6 reflected that the slope (S_v) is negative for Pr_4NI salt solution of 80% DMF + 20% isopropyl alcohol mixture i.e. apparent molar volume (ϕ_v) decreases with increase of concentration in these cases. It noted that the slope become lowered as the DMF content is increased gradually in the mixture that is as the dielectric constant is increased.

For these electrolytes Pr_4NI, Bu_4NI and Pen_4NI, the slope is actually positive when the values of ϵ of the solvent media is low and it goes on decreasing and becomes negative at higher dielectric constant of solvent media. But this does not happened with Et_4NI. The slope is positive for this salts in all the selected solvent mixtures and remains positive for all compositions, the slope decreases from lower tetra alkyl chain length (Et_4NI) to higher tetra alkyl chain length (Pen_4NI) in a given solution system, this may be explained as; The relative volume (size) of the tetra alkyl ammonium salt increases as we go from Et_4NI to Pen_4NI, the larger the size of the ion, smaller will be the charge density and hence weaker will be the interactions. The slope would thus go on decreasing and it would even be negative if the dielectric constant of the medium is high. In addition to above two factors, there may be a third possible cause of the negative slope which may also be kept in consideration.

In order to explain the behavior of the larger R_4NI salts in non–aqueous solutions, it has been suggested that the negative slope would occur if the solute's ionic size is relatively greater as than to that of the solvent molecules and if the interpenetration of the ions takes place. The larger of the R_4N^+ ions would be quit voluminous in comparison to the solvent molecules which would be accommodated inside the void spaces formed by the R_4N^+ ions when they come in contact at appropriate concentration besides interpenetration of R_4N^+ ions would occur at higher concentration. Thus cation–cation and cation-anion penetration theory suggested by some workers may be used to explain the negative slope of ϕ_v vs $\sqrt{c}$ curves of these salts in non–aqueous solvents of high dielectric constants.

The inter-ionic penetration at higher concentration and ion solvent penetration in dilute solutions of the larger R_4NI salts appear to occur in all these solvents. It was suggested that inter ionic penetration occurs at the higher concentration as R_4N^+ ions are large and hollow structure. The higher the concentration, the larger inter–ionic penetration and hence the smaller the resultant molar volume of the R_4NI salts in solution. That is why the value of ϕ_v decreases with increase the concentration and consequently, a negative slope is obtained.

Conclusion

Summarizing the outcome of the investigation of our study on the ionic charge density affects the ionic interaction, higher the charge density, stronger will be the interaction and the chances of getting positive slope in ϕ_v vs $\sqrt{c}$ curves are increased. The charge density affects the interaction of the extent that even the high dielectric constant effect is over powered and the slopes comes out to be positive instead of negative slope. The effect of dielectric constant of the medium has been, clearly, seen in the present investigation. The low dielectric constant leads to the stronger ionic interaction and the high dielectric constant leads to the weaker ionic interaction in the liquid mixtures. The inter–ionic accommodation, which may occur at higher concentration, is also responsible in controlling the nature of the slope.

Acknowledgements

The author thanks to the Head of the Chemistry Department, Lucknow University for providing the research facility in the Department.

Supplementary Data

Supplementary data associated with this article are available in the electronic from at http://www.e-journal.in/CST2014_3(01) 87-92_ SupplData.pdf.

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Table 1−Estimated values of dielectric constant of DMF in Isopropyl alcohol mixtures used as a solvent at 313.15K

S.N.	Composition of mixtures (v/v)	Dielectric constant (ε)
1	0% DMF in Isopropyl alcohol	17.9
2	20% DMF in Isopropyl alcohol	21.02
3	40% DMF in Isopropyl alcohol	25.12
4	60% DMF in Isopropyl alcohol	28.78
5	80% DMF in Isopropyl alcohol	32.98
6	100% DMF in Isopropyl alcohol	36.70

Table 2−Estimated values of densities and corresponding hold-down currents for various composition of DMF in Isopropyl alcohol (v/v)

S.N.	Solvent mixture (v/v)	Weight (w) kg × 10^{-3}	Current (I) Amp×10^{-3}	Density (d_0) kg/m^{-3}
1.	0% DMF in isopropyl alcohol	5.100	210	785.82
2.	20% DMF in isopropyl alcohol	5.150	240	814.24
3.	40% DMF in isopropyl alcohol	5.200	285	845.00
4.	60% DMF in isopropyl alcohol	5.250	315	877.26
5.	80% DMF in isopropyl alcohol	5.300	340	907.82
6.	100% DMF in isopropyl alcohol	5.400	380	947.60

Table 3−Estimated values of d and ϕ_v of 20% DMF in Isopropyl alcohol (v/v) for Et_4NI, Pr_4NI, Bu_4NI and Pen_4NI salt at 313.15K

S.N.	M Mole dm^{-3}	w Kg×10^{-3}	I Amp×10^{-3}	d Kg×m^{-3}	$\sqrt{C}$ mole^{½} dm$^{-3/2}$	ϕ_v dm^3mole^{-1}
For Et_4NI Salt						
1.	0.02	20.0	476	1079.00	0.1402	176.40
2.	0.04	20.1	442	1079.74	0.2000	187.52
3.	0.06	20.2	391	1080.98	0.2404	195.97
4.	0.08	20.3	341	1081.94	0.2802	200.00
5.	0.10	20.4	300	1182.00	0.3200	201.89
6.	0.12	20.5	243	1182.84	0.3550	203.72
7.	0.14	20.6	186	1183.08	0.3720	205.75
For Pr_4NI Salt						
1.	0.02	20.0	469	1078.86	0.1402	229.94
2.	0.04	20.1	438	1079.30	0.2000	236.83
3.	0.06	20.2	393	1079.66	0.2404	243.04
4.	0.08	20.3	337	1080.62	0.2802	248.45
5.	0.10	20.4	280	1081.20	0.3200	251.86
6.	0.12	20.5	223	1081.88	0.3550	254.14
7.	0.14	20.6	165	1082.24	0.3720	255.89
For Bu_4NI Salt						
1.	0.02	20.0	454	1078.52	0.1402	290.13
2.	0.04	20.1	416	1078.96	0.2000	293.67
3.	0.06	20.2	365	1079.08	0.2404	293.49
4.	0.08	20.3	311	1079.54	0.2802	301.53
5.	0.10	20.4	254	1079.94	0.3200	303.85

6.	0.12	20.5	198	1080.12	0.3550	305.26
7.	0.14	20.6	141	1080.84	0.3720	306.39
For Pen_4NI Salt						
1.	0.02	20.0	446	1078.42	0.1402	344.47
2.	0.04	20.1	403	1078.70	0.2000	346.76
3.	0.06	20.2	348	1079.16	0.2404	347.67
4.	0.08	20.3	302	1079.64	0.2802	349.05
5.	0.10	20.4	254	1080.00	0.3200	351.40
6.	0.12	20.5	197	1080.26	0.3550	353.93
7.	0.14	20.6	140	1080.68	0.3720	354.14

Table 4−Estimated values of d and ϕ_v of 40% DMF in Isopropyl alcohol (v/v) for Et_4NI, Pr_4NI, Bu_4NI and Pen_4NI salt at 313.15K

S.N.	M Mole dm^{-3}	w $Kg\times10^{-3}$	I $Amp\times10^{-3}$	d $Kg\times m^{-3}$	$\sqrt{C}$ $mole^{1/2}\ dm^{-3/2}$	ϕ_v dm^3mole^{-1}
For Et_4NI Salt						
1.	0.02	19.3	326	1068.90	0.1402	178.44
2.	0.04	19.4	300	1069.22	0.2000	186.04
3.	0.06	19.5	265	1069.66	0.2404	191.13
4.	0.08	19.6	219	1070.04	0.2802	196.00
5.	0.10	19.7	162	1070.42	0.3200	200.78
6.	0.12	19.8	105	1070.98	0.3550	203.96
7.	0.14	19.9	048	1071.12	0.3720	206.30
For Pr_4NI Salt						
1.	0.02	19.3	310	1067.78	0.1402	240.05
2.	0.04	19.4	274	1068.20	0.2000	245.13
3.	0.06	19.5	232	1068.56	0.2404	248.51
4.	0.08	19.6	181	1069.20	0.2802	252.11
5.	0.10	19.7	125	1069.86	0.3200	255.11
6.	0.12	19.8	112	1070.22	0.3550	257.26
7.	0.14	19.9	068	1070.86	0.3720	258.59
For Bu_4NI Salt						
1.	0.02	19.3	295	1067.68	0.1402	300.01
2.	0.04	19.4	252	1067.94	0.2000	302.50
3.	0.06	19.5	205	1068.24	0.2404	304.19
4.	0.08	19.6	153	1068.82	0.2802	306.10
5.	0.10	19.7	099	1069.10	0.3200	307.59
6.	0.12	19.8	042	1069.68	0.3550	309.00
7.	0.14	19.85	013	1070.00	0.3720	310.09
For Pen_4NI Salt						
1.	0.02	19.3	463	1067.36	0.1402	352.74
2.	0.04	19.4	418	1067.64	0.2000	353.36
3.	0.06	19.5	371	1068.22	0.2404	354.13
4.	0.08	19.6	324	1068.62	0.2802	354.51
5.	0.10	19.7	271	1068.98	0.3200	355.76
6.	0.12	19.8	222	1069.32	0.3550	356.02
7.	0.14	19.6	166	1069.78	0.3720	357.06

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Table 5−Estimated values of d and ϕ_v of 60% DMF in Isopropyl alcohol (v/v) for Et_4NI, Pr_4NI, Bu_4NI and Pen_4NI salt at 313.15K

S.N.	M Mole dm^{-3}	w Kg×10^{-3}	I Amp×10^{-3}	d Kg×m^{-3}	$\sqrt{C}$ $mole^{1/2}$ $dm^{-3/2}$	ϕ_v dm^3mole^{-1}
For Et_4NI Salt						
1.	0.02	18.0	512	1057.00	0.1402	179.72
2.	0.04	18.1	494	1057.78	0.2000	184.20
3.	0.06	18.2	467	1058.38	0.2404	188.24
4.	0.08	18.3	436	1058.90	0.2802	191.13
5.	0.10	18.4	398	1059.22	0.3200	194.05
6.	0.12	18.5	359	1059.66	0.3550	196.15
7.	0.14	18.6	300	1060.10	0.3720	199.10
For Pr_4NI Salt						
1.	0.02	18.0	481	1056.38	0.1402	254.77
2.	0.04	18.1	439	1056.94	0.2000	256.24
3.	0.06	18.2	392	1057.10	0.2404	258.15
4.	0.08	18.3	340	1057.48	0.2802	260.18
5.	0.10	18.4	281	1057.98	0.3200	260.22
6.	0.12	18.5	233	1058.12	0.3550	260.63
7.	0.14	18.6	176	1058.82	0.3720	263.76
For Bu_4NI Salt						
1.	0.02	18.0	467	1056.10	0.1402	315.29
2.	0.04	18.1	417	1056.60	0.2000	314.17
3.	0.06	18.2	369	1056.98	0.2404	313.14
4.	0.08	18.3	324	1057.26	0.2802	312.13
5.	0.10	18.4	281	1057.64	0.3200	311.13
6.	0.12	18.5	237	1057.92	0.3550	310.12
7.	0.14	18.6	180	1058.32	0.3720	311.80
For Pen_4NI Salt						
1.	0.02	18.0	466	1056.08	0.1402	364.65
2.	0.04	18.1	422	1056.58	0.2000	360.58
3.	0.06	18.2	385	1056.76	0.2404	357.23
4.	0.08	18.3	50	1057.20	0.2802	355.11
5.	0.10	18.4	324	1057.80	0.3200	352.31
6.	0.12	18.5	299	1058.42	0.3550	350.30
7.	0.14	18.6	272	1059.08	0.3720	349.11

Table 6−Estimated values of d and ϕ_v of 80% DMF in Isopropyl alcohol (v/v) for Et_4NI, Pr_4NI, Bu_4NI and Pen_4NI salt at 313.15K

S.N.	M Mole dm^{-3}	w Kg×10^{-3}	I Amp×10^{-3}	d Kg×m^{-3}	$\sqrt{C}$ $mole^{1/2}$ $dm^{-3/2}$	ϕ_v dm^3mole^{-1}
For Et_4NI Salt						
1.	0.02	17.0	536	1046.06	0.1402	181.43
2.	0.04	17.1	522	1046.58	0.2000	184.08
3.	0.06	17.2	505	1047.20	0.2404	185.97
4.	0.08	17.3	483	1047.46	0.2802	187.95
5.	0.10	17.4	459	1048.12	0.3200	189.47

6.	0.12	17.5	438	1048.86	0.3550	198.06
7.	0.14	17.6	413	1049.24	0.3720	191.98
For Pr_4NI Salt						
1.	0.02	17.0	506	1045.50	0.1402	256.20
2.	0.04	17.1	471	1045.96	0.2000	255.20
3.	0.06	17.2	439	1046.42	0.2404	253.96
4.	0.08	17.3	408	1046.98	0.2802	253.10
5.	0.10	17.4	379	1047.54	0.3200	252.28
6.	0.12	17.5	348	1048.10	0.3550	252.09
7.	0.14	17.6	323	1048.72	0.3720	251.07
For Bu_4NI Salt						
1.	0.02	17.0	495	1045.28	0.1402	315.80
2.	0.04	17.1	452	1045.54	0.2000	312.40
3.	0.06	17.2	414	1046.14	0.2404	310.16
4.	0.08	17.3	376	1046.48	0.2802	309.03
5.	0.10	17.4	346	1046.88	0.3200	306.98
6.	0.12	17.5	313	1047.32	0.3550	306.04
7.	0.14	17.6	283	1047.92	0.3720	305.00
For Pen_4NI Salt						
1.	0.02	17.0	493	1045.24	0.1402	365.98
2.	0.04	17.1	457	1045.66	0.2000	359.24
3.	0.06	17.2	432	1046.32	0.2404	353.97
4.	0.08	17.3	413	1046.78	0.2802	350.05
5.	0.10	17.4	403	1047.02	0.3200	346.14
6.	0.12	17.5	397	1047.92	0.3550	342.96
7.	0.14	17.6	396	1048.44	0.3720	340.07

Table 7−Slope (S_v) values for some tetra alkyl ammonium iodides in different % composition of DMF with Isopropyl alcohol mixtures

S.N.	% Composition of DMF in Isopropyl alcohol (v/v)	Dielectric Constant (ϵ)	S_v -values ($dm^{9/2}$ $mole^{-3/2} \times 10^{-3}$) in different % composition of DMF in Isopropyl alcohol			
			Pen_4NI	Pen_4NI	Pen_4NI	Pen_4NI
1.	20% DMF	21.02	122.26	122.14	82.70	41.82
2.	40% DMF	25.12	115.79	82.24	40.04	-22.33
3.	60% DMF	28.78	73.69	43.87	-19.11	-420.15
4.	80% DMF	32.98	43.58	18.36	-68.21	-110.22

Table Captions

Table 1−Estimated values of dielectric constant of DMF in Isopropyl alcohol mixtures used as a solvent at 313.15K

Table 2−Estimated values of densities and corresponding hold-down currents for various composition of DMF in Isopropyl alcohol (v/v)

Table 3−Estimated values of d and ϕ_v of 20% DMF in Isopropyl alcohol (v/v) for Et_4NI, Pr_4NI, Bu_4NI and Pen_4NI salt at 313.15K

Table 4−Estimated values of d and ϕ_v of 40% DMF in Isopropyl alcohol (v/v) for Et_4NI, Pr_4NI, Bu_4NI and Pen_4NI salt at 313.15K

Table 5−Estimated values of d and ϕ_v of 60% DMF in Isopropyl alcohol (v/v) for Et_4NI, Pr_4NI, Bu_4NI and Pen_4NI salt at 313.15K

Table 6−Estimated values of d and ϕ_v of 80% DMF in Isopropyl alcohol (v/v) for Et_4NI, Pr_4NI, Bu_4NI and Pen_4NI salt at 313.15K

Table 7−Slope (S_v) values for some tetra alkyl ammonium iodides in different % composition of DMF with Isopropyl alcohol mixtures

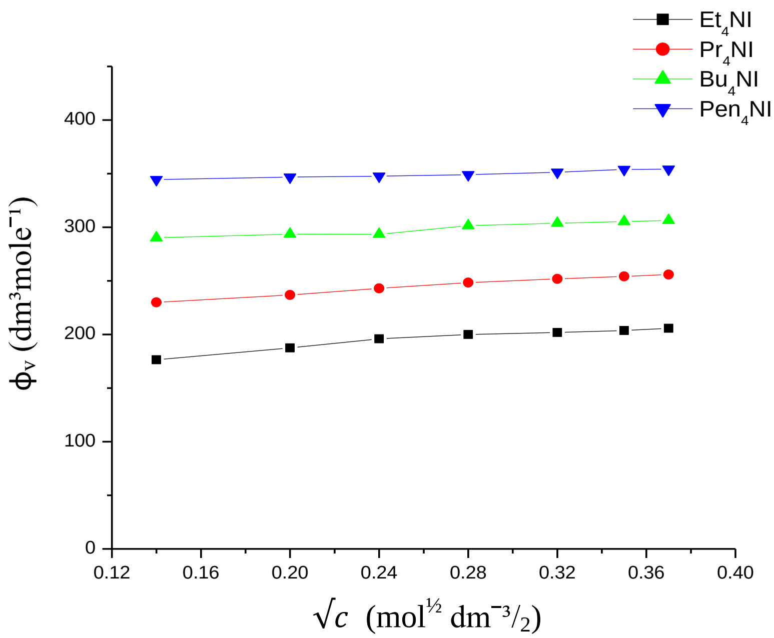

Fig. 1−Graph between ϕ_v and $\sqrt{c}$ for different electrolyte Solution in 20% DMF in Isopropyl alcohol mixtures

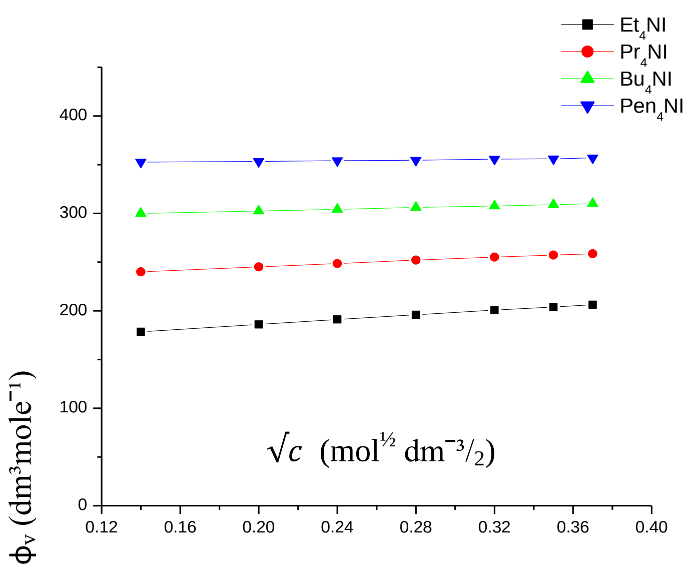

Fig. 2−Graph between ϕ_v and $\sqrt{c}$ for different electrolyte Solution in 40% DMF in Isopropyl alcohol mixtures

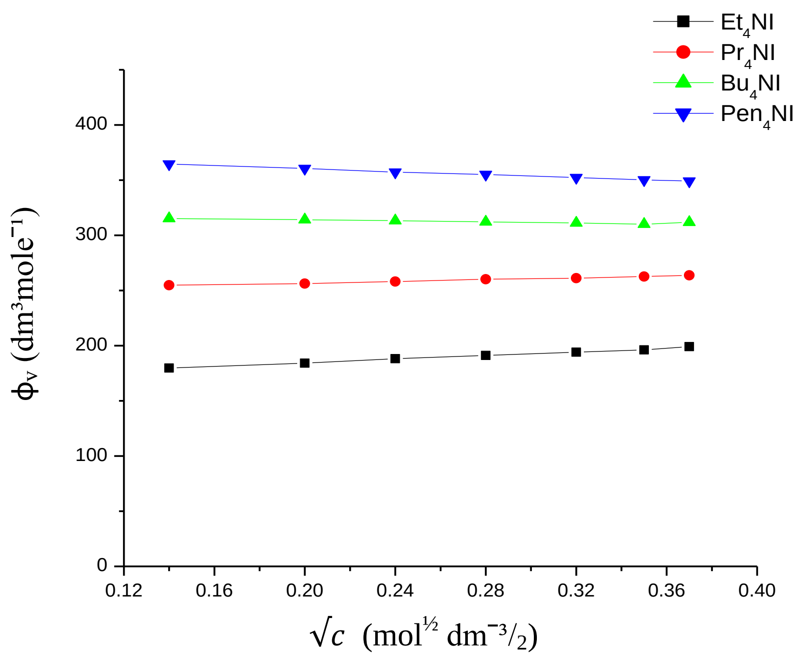

Fig. 3−Graph between ϕ_v and $\sqrt{c}$ for different electrolyte Solution in 60% DMF in Isopropyl alcohol mixtures

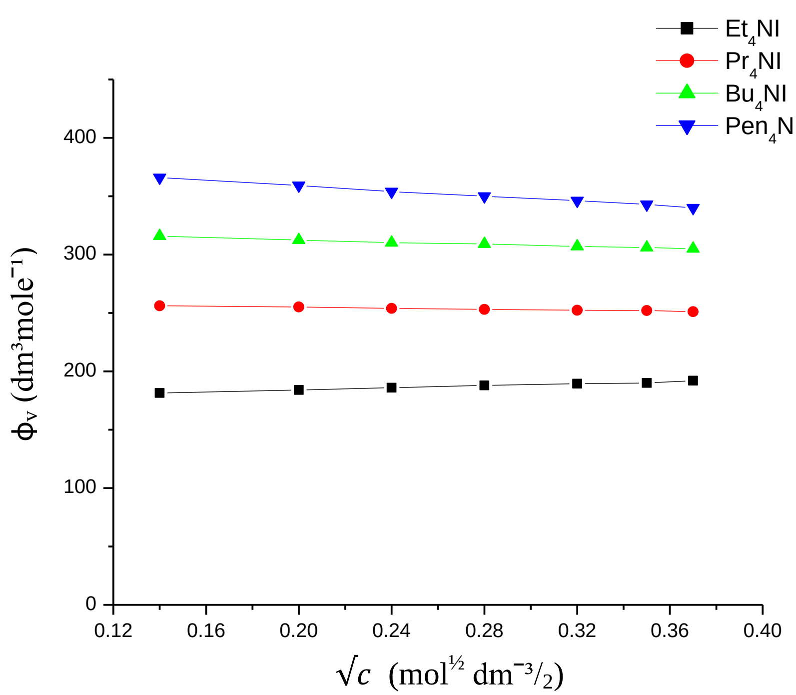

Fig. 4−Graph between ϕ_v and $\sqrt{c}$ for different electrolyte Solution in 80% DMF in Isopropyl alcohol mixtures

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Figure Captions

Fig. 1−Graph between ϕ_v and $\sqrt{c}$ for different electrolyte Solution in 20% DMF in Isopropyl alcohol mixtures

Fig. 2−Graph between ϕ_v and $\sqrt{c}$ for different electrolyte Solution in 40% DMF in Isopropyl alcohol mixtures

Fig. 3−Graph between ϕ_v and $\sqrt{c}$ for different electrolyte Solution in 60% DMF in Isopropyl alcohol mixtures

Fig. 4−Graph between ϕ_v and $\sqrt{c}$ for different electrolyte Solution in 80% DMF in Isopropyl alcohol mixtures