Viscosity Behavior of Solutions of Some Potassium Salts in Dimethyl Sulphoxide –Water mixture

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Abstract:

The present work includes a study of viscosity of solutions containing Potassium Chloride and Potassium Bromide in Dimethyl Sulphoxide and water as solvent (containing 60% w/w DMSO).

The study was carried out at six different temperatures. The applicability of Jones- Dole equation has been discussed. Solute –solvent interaction was discussed in terms of ionic size, charge, and shape of solute molecules.

Key words: Viscosity, Potassium Salts, Dimethyl Sulphoxide

Introduction:-

Viscosimetric measurements of electrolyte solutions have been widely used in order to obtain information regarding solute- solvent interaction. Most of these measurements have been concerned with the study of numerous electrolytes in pure solvent [1].

Measurement of the viscosity of electrolytic solutions provides an excellent method of obtaining data on specific ion- solvent interactions. The empirical equation of Jones and Dole [2]

$$\eta_r = \eta/\eta_0 = 1 + A\sqrt{C} + BC \ldots\ldots(1)$$

Where η and η_0 are the solution and solvent viscosities respectively , η_r is the relative viscosity. A and B are empirical coefficients and C is the molar concentration of solution. The effect of dissolved [3-4] ions on the solution viscosity in aqueous solvents, non aqueous and mixed solvents [3], has been interpreted mainly in terms of Jones- Dole equation. The coefficient A is always positive and related to the electrostatic interaction between solute ions while the B coefficient can either be positive or negative depending on the nature of interaction between the solvent molecules and solute ions [3].

Dimethyl sulphoxide (DMSO) is known to posses high selectivity and reported to be a good solvent in petroleum industry, solvent of high density,high boiling point and high polarity are required in the extraction process[4]

In this work ,the viscosity behavior of potassium chloride and potassium bromide in water + Dimethyl sulphoxide mixture containing (>60%) w/w at different temperature have been studied. Mixtures of water and DMSO were reported to exhibit viscosity maximum[4],at DMSO content (>60%) w/w The effect of solvated mono valent ions on the viscosity of H_2O+DMSO was discussed and interpreted.

Material and Methods:
(A) Materials:-

Dimethyl sulphoxide (>99%)) was obtained from fluka AG and left in contact with 5A molecular sieve for

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several days. No further purification was done. potassium Chloride and potassium Bromide, (>99%) were obtained from (BDH) were dried for 24 hours prior to use and stored in a glass desiccators over P_2O_5.

Viscosities were determined using a suspended- level ubbelohde viscometer. The flow times were recorded electronically with an electronic timer of precision $\pm 0.01s$ and the temperature of the bath was controlled to better than $\pm 0.01^oC$. The instrument was calibrated with distilled water. Flow times were reproducible to $0.01s$ [5,6].

(B) Preparation of samples:-

The solvent (water + Dimethyl sulphoxide) mixture was prepared to contain 60% by w/w DMSO .

Stock solutions of KCl and KBr in the solvent mixture were prepared by direct weighting and making dilution accurately using a four place digital balance and a calibrated glass ware to cover the concentration range of study.

Result and Discussion:-

Absolute viscosities (η) in units of centipiose (CP) of solution of the studied salts in DMSO- H_2O mixture as solvent at 20,25,30,35, 40 and 4 5 ^0C are given in Tables(1 and 2) . The data of Tables (1 and 2) are presented also in graphical forms showing liner increase in absolute viscosity as the molar concentration of the solution increased(figures1and2)and the absolute viscosities with rise temperature. Jones- Dole equation can be written in the form.

$$\left[(\eta/\eta_o) - 1) \right]/\sqrt{C} = A + B\sqrt{C} ......(2)$$

The left hand side of equation (2)was calculated (Table1) and plotted versus $\sqrt{C}$ at six different temperature (figures 1 and 2).B coefficients of Jones- Dole equation in units of liter mole^{-1} were calculated and presented in Table(3),Antonio Sacco[4] and S.A.Isa [3] have investigated some binary electrolyte solution; they reported the differences in B values of salts solutions of a certain cation different anions (both are mono valiant) to be independent of cation type .Similar result were obtained for B values of solutions containing the same anion and different cations. . This means the B coefficient is an additive quantity represented by the algebraic sum of cation and anion contribution in B values, i.e.

$$B(salt) = B(cation) + B(Anion)......(3)$$

Gurney [7]and Kaminsky[8] have assumed equal contributions of potassium and chloride ions to the value of B coefficient of potassium chloride aqueous solution at 298K .This assumption is reasonable if we take into consideration the similar ionic mobilities of potassium and chloride ions at the temperature of study.

The calculated B value in this study of KCl in DMSO+ H_2O is negative (-5.128 Lmol^{-1}) at 298K which can be considered as an additive quantity of (-2.564Lmol^{-1}) for both potassium and chloride ions. According to equation (3), the cationic and anionic contributions in B coefficient of the solutions investigated in this work are given in Table (3).

The effect of potassium and chloride or bromide ions in destroying the structure of solvent complexes might be due to the relatively small charge density of the solvated ions, thus the orientation effect caused by the electric field of the ions on water-DMSO 60% w/w complexes is weak. On the other hand ,the structural effect is of considerable importance due to a

substantial disortion to the water-DMSO arrangements giving rise to negative B coefficients which may be viewed as a structure breaker to the arrangements of solvent molecules. In conclusion, the order of B values mentioned above of KCl and KBr might be responsible for different participations to the components of η_E, η_o and η_{stro} giving rise to variable magnitude of B coefficients.

Table 1: Absolute viscosity measurements of the KCl solutions in DMSO- H$_2$O mixture.

Temperature	Cone. Mol/l	Absolute Viscosity (cp)	$\sqrt{C}$	$(\eta/\eta_o - 1)/\sqrt{C}$
20 ^{0}C	0.001	2.1302	0.0316	1.2813
	0.003	2.1848	0.0547	1.2278
	0.005	2.2277	0.0707	1.2463
	0.007	2.2466	0.0837	1.1625
	0.01	2.2821	0.1	1.1470
	0.03	2.2995	0.1732	0.7113
	0.05	2.3219	0.2236	0.5997
	0.07	2.3599	0.2646	0.5767
	0.1	2.3966	0.3162	0.5395
25 ^{0}C	0.001	1.8772	0.0316	2.1108
	0.003	1.9237	0.0547	1.7020
	0.005	1.9797	0.0707	1.7666
	0.007	2.0066	0.0837	1.6750
	0.01	2.0194	0.1	1.4750
	0.03	2.0499	0.1732	0.9515
	0.05	2.0795	0.2236	0.8126
	0.07	2.0966	0.2646	0.7233
	0.1	2.1131	0.3162	0.6347
30 ^{0}C	0.001	1.5957	0.0316	3.7373
	0.003	1.7043	0.0547	3.5502
	0.005	1.7307	0.0707	3.0084
	0.007	1.7597	0.0837	2.7844
	0.01	1.7716	0.1	2.4140
	0.03	1.7940	0.1732	1.4844
	0.05	1.8504	0.2236	1.3265
	0.07	1.9472	0.2646	1.3772
	0.1	2.0127	0.3162	1.2976
35 ^{0}C	0.001	1.4481	0.0316	3.2110
	0.003	1.5675	0.0547	3.5155
	0.005	1.6379	0.0707	3.4770
	0.007	1.64414	0.0837	2.9940
	0.01	1.6662	0.1	2.6740
	0.03	1.6806	0.1732	1.6057
	0.05	1.6920	0.2236	1.2835
	0.07	1.7292	0.2646	1.1404
	0.1	1.7489	0.3162	1.0436
40 ^{0}C	0.001	1.3159	0.0316	3.7911
	0.003	1.4147	0.0547	3.7276
	0.005	1.4992	0.0707	3.9009
	0.007	1.5682	0.0837	3.9964
	0.01	1.6172	0.1	3.7620
	0.03	1.7016	0.1732	2.5866
	0.05	1.7151	0.2236	2.0550
	0.07	1.7370	0.2646	1.8069
	0.1	1.7610	0.3162	1.5768
45 ^{0}C	0.001	1.2759	0.0316	7.6740
	0.003	1.2959	0.0547	4.7879
	0.005	1.3117	0.0707	3.9222
	0.007	1.3389	0.0837	3.6296
	0.01	1.3683	0.1	3.3250
	0.03	1.3739	0.1732	1.9509
	0.05	1.3934	0.2236	1.5962
	0.07	1.4143	0.2646	1.4259
	0.1	1.4393	0.3162	1.2700

Table 2: Absolute viscosity measurements of the KBr solutions in DMSO- H_2O mixture.

Temperature	Cone. Mol/l	Absolute Viscosity (cp)	$\sqrt{C}$	$(\eta/\eta_o - 1)/\sqrt{C}$
20 ^{0}C	0.001	2.1892	0.0316	2.1934
	0.003	2.3466	0.0547	2.0402
	0.005	2.4814	0.0707	1.7250
	0.007	2.6241	0.0837	3.6141
	0.01	2.7649	0.1	3.5050
	0.03	2.9136	0.1732	2.4428
	0.05	2.9880	0.2236	2.0550
	0.07	3.0202	0.2646	1.7959
	0.1	3.0719	0.3162	1.5828
25 ^{0}C	0.001	1.8335	0.0316	1.3259
	0.003	1.9689	0.0547	2.1728
	0.005	1.9974	0.0707	1.9093
	0.007	2.0902	0.0837	2.2425
	0.01	2.1178	0.1	2.0340
	0.03	2.1584	0.1732	1.3077
	0.05	2.2258	0.2236	1.1843
	0.07	2.2494	0.2646	1.0514
	0.1	2.759	0.3162	0.9272
30 ^{0}C	0.001	1.5029	0.0316	1.1682
	0.003	1.5240	0.0547	1.2395
	0.005	1.5383	0.0707	1.1018
	0.007	1.5532	0.0837	1.0562
	0.01	1.5816	0.1	1.0830
	0.03	1.5986	0.1732	0.6939
	0.05	1.6226	0.2236	0.6126
	0.07	1.6466	0.2646	0.5812
	0.1	1.6709	0.3162	0.5402
35 ^{0}C	0.001	1.4667	0.0316	3.6591
	0.003	1.5445	0.0547	3.1957
	0.005	1.5715	0.0707	2.7630
	0.007	1.6308	0.0837	2.8727
	0.01	1.7084	0.1	2.9950
	0.03	1.8033	0.1732	2.1460
	0.05	1.8416	0.2236	1.7933
	0.07	1.8659	0.2646	1.5846
	0.1	1.8860	0.3162	1.3757
40 ^{0}C	0.001	1.2465	0.0316	1.9227
	0.003	1.2745	0.0547	1.5447
	0.005	1.3035	0.0707	1.5459
	0.007	1.3249	0.0837	1.5232
	0.01	1.3463	0.1	1.4570
	0.03	1.3566	0.1732	0.8920
	0.05	1.3787	0.2236	0.7750
	0.07	1.4097	0.2646	0.7543
	0.1	1.4479	0.3162	0.7343
45 ^{0}C	0.001	1.0749	0.0316	1.4778
	0.003	1.1500	0.0547	2.1901
	0.005	1.2146	0.0707	2.5861
	0.007	1.2859	0.0837	3.0131
	0.01	1.3138	0.1	2.7930
	0.03	1.3368	0.1732	1.7419
	0.05	1.3602	0.2236	1.4516
	0.07	1.38245	0.2646	1.3084
	0.1	1.4061	0.3162	1.1676

Table 3:-B-coefficients of viscosity of the studied salts and their cations and anions

Salt	B(salt)	B(cation)	B(anion)	Temperature
KCl	-3.085	-1.5425	-1.5425	20 ^{0}C
	-5.128	-2.5640	-2.5640	25 ^{0}C
	-8.991	-4.4955	-4.4955	30 ^{0}C
	-9.744	-4.8720	-4.8720	35 ^{0}C
	-9.535	-4.7670	-4.7670	40 ^{0}C
	-12.85	-6.4260	-6.4260	45 ^{0}C
KBr				
	-9.263	-4.6315	-4.6315	20 ^{0}C
	-4.629	-2.3115	-2.3115	25 ^{0}C
	-3.405	-1.7025	-1.7025	30 ^{0}C
	-7.552	-3.7760	-3.7760	35 ^{0}C
	-4.170	-2.0850	-2.0850	40 ^{0}C
	-4.043	-2.0215	-2.0215	45 ^{0}C
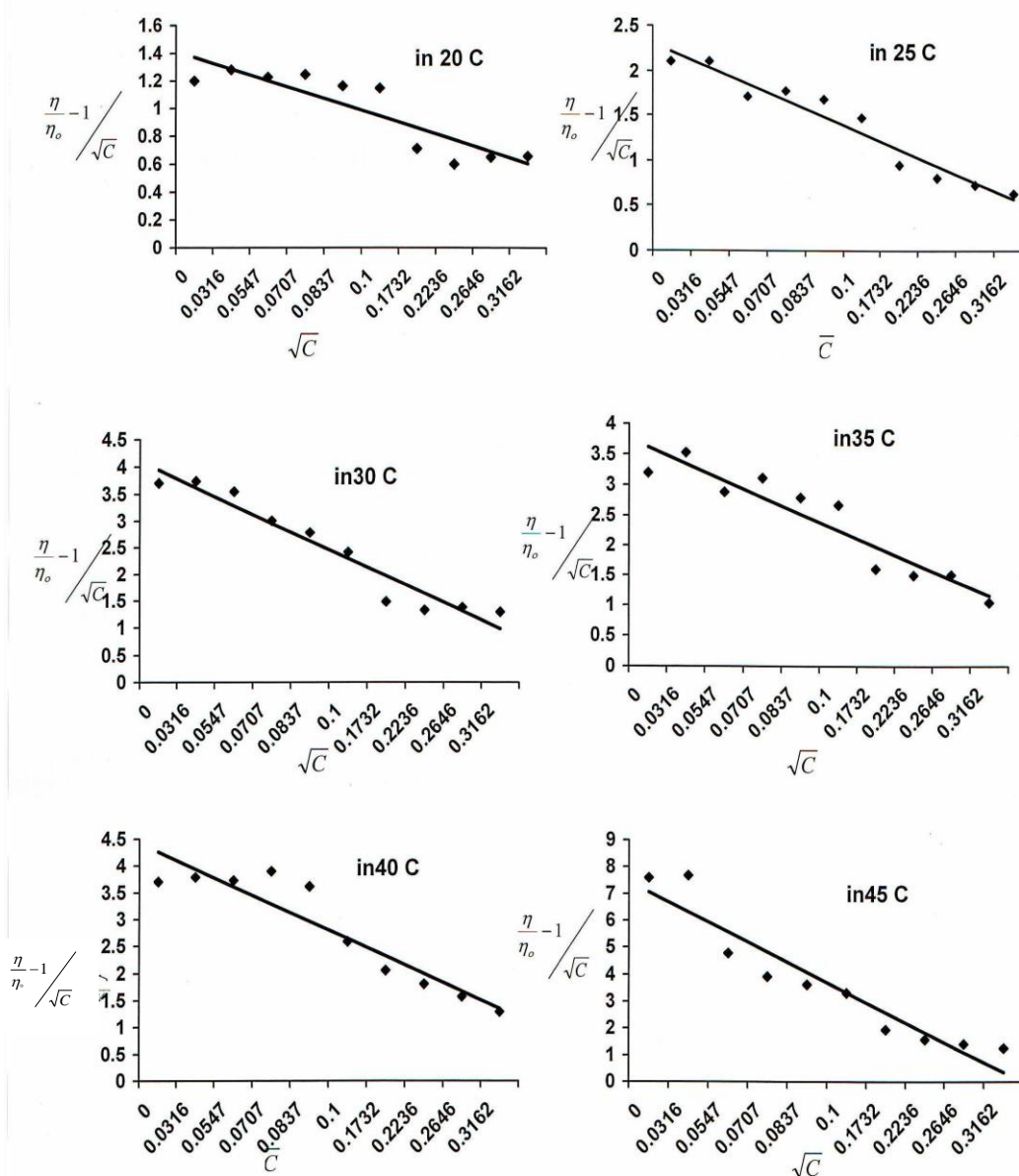
Fig (1) Plots of $\dfrac{\frac{\eta}{\eta_\circ} - 1}{\sqrt{C}}$ versus $\sqrt{C}$ at different temperature (20-45) C^0 for KCl solution in DMSO Mixture
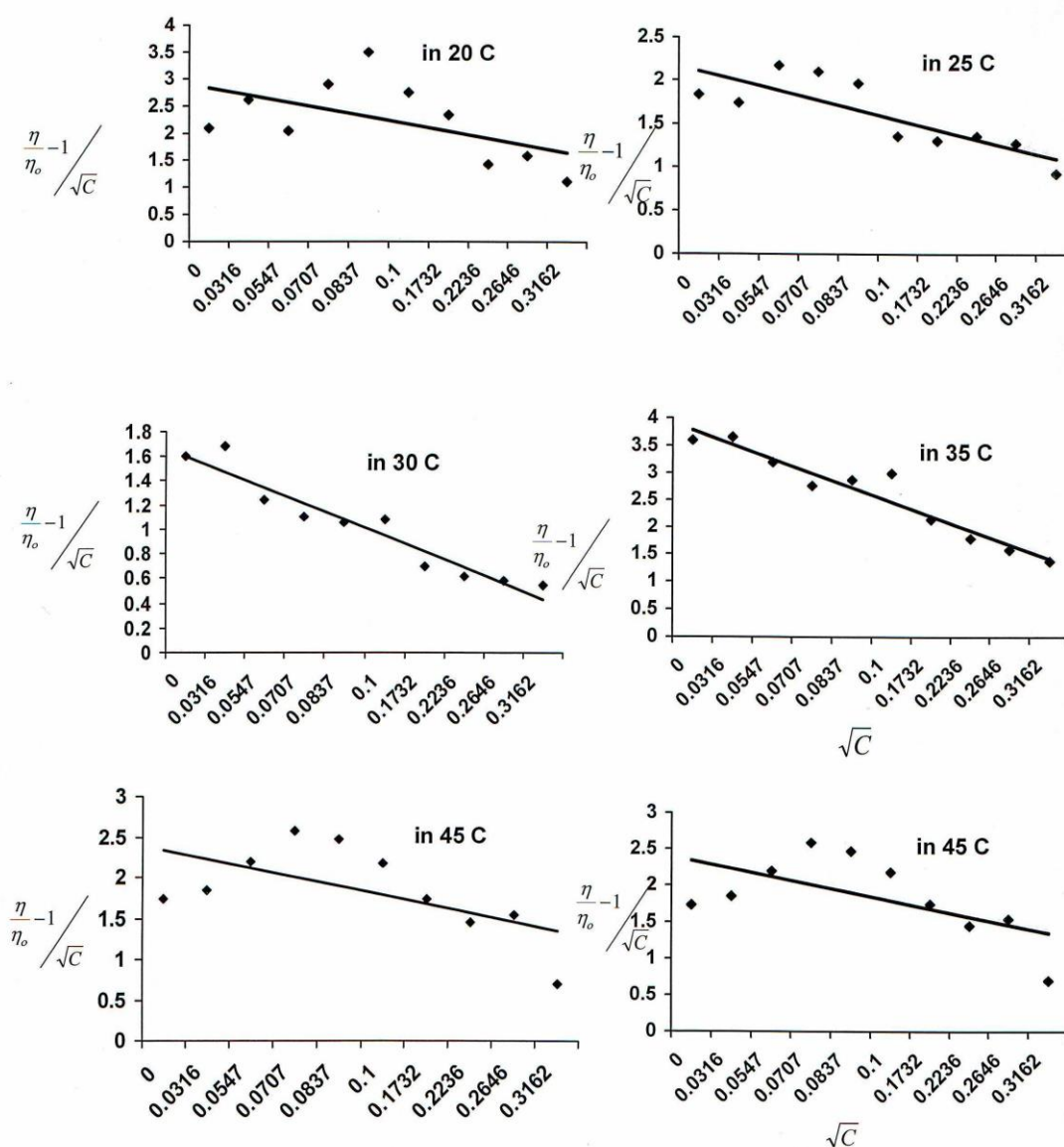
Fig (2) Plots of $\dfrac{\frac{\eta}{\eta_o}-1}{\sqrt{C}}$ **versus** $\sqrt{C}$ **at different temperature (20-45) C° for KBr solution in DMSO Mixture**

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سلوك لزوجة محاليل بعض املاح البوتاسيوم في مزيج من داي مثيل سلفوكسايد و الماء

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الخلاصة:ـ

يتضمن البحث دراسة لزوجة محاليل تحتوي على املاح كلوريد البوتاسيوم وبروميد البوتاسيوم في مزيج من الماء وداي مثيل سلفوكسايد 60% وزنا داي مثيل سلفوكسايد.وقد اجريت الدراسة بست درجات حرارية مختلفة ونوقشت امكانية في ضوء معادلة جونز ـ دول حيث اخذ بنظر الاعتبار الحجم الايوني والشحنة وشكل جزيئات المذاب.