International Journal of ChemTech Research
CODEN(USA): IJCRGG ISSN : 0974-4290
Vol. 3, No.3, pp 1265-1268, July-Sept 2011

Volumetric properties of Potassium chromate(K_2CrO_4) and Potassium dichromate ($K_2Cr_2O_7$) in 15%(W/V)Sucrose-Aqueous solution at 303.15K.

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Abstract : The experimental data of densities in temperature at 303.15K have been obtained for potassium chromate (K_2CrO_4) and potassium dichromate ($K_2Cr_2O_7$) in sucrose-aqueous solution measured as a function of their concentration. Experimental data of density evaluates the values of Apparent molar volume (ϕ_v), limiting apparent molar volume (ϕ_V^0), experimental slope (S_V^*), molar volume (V) and excess molar volume (V^E). The results were interpreted in the light of ion–ion and ion–solvent interactions and of structural effects of the solutes in solutions.
Keywords: Density, Molar volume, Excess molar volume.

Introduction

Sucrose solution plays important role in the biological and food industries. Sucrose has been the subject of structural and theoretical investigations for long time and research is still lively [1-3]. Density is an example of an intensive property, a property in which the value is solely dependent upon the identity of the material, and not the amount present. Since intensive properties are an inherent characteristic of the material they can be used to identify the material. Density data are required many chemical engineering calculations involving fluid flow, heat and mass transfer[4-5]. The densities of potassium chromate (K_2CrO_4) and potassium dichromate ($K_2Cr_2O_7$) is studied in binary organo-aqueous solvent of sucrose-water.Potassium chromate and potassium dichromate is widely used in day today life. Potassium chromate is used in chemical analysis[6], in making pigments for paints and inks[7], as a fungicide[8], and to make other chromium compounds and potassium dichromate is used in cleaning[9], leather industries, photography[10] and for construction purpose[11]. This Study is done to investigate the interaction of both potassium compounds with sucrose solution because of biological importance of sucrose. Data of densities of potassium chromate and potassium dichromate in sucrose-aqueous solution are scarce. The data of densities is used to analyses of Apparent molar volume (ϕ_v), limiting apparent molar volume (ϕ_V^0), experimental slope (S^{*}_{V}), molar volume (V) and excess molar volume (V^E).

Experimental

A stock solution of 0.10M of each of potassium chromate and potassium dichromate are prepared in 15% (w/v) Sucrose-Aqueous solvent by direct weighing. Mass dilution technique used for preparation of other concentrations. The concentration of the solutions involved in the experiment was taken in range from 0.01M to 0.10M. Mass dilution technique was applied to prepare the solution of different concentration; ranges from 0.01 M to 0.10 M. Densities of solutions of both the potassium chromate and potassium dichromate in sucrose-aqueous solvent are determined using 10 cm^3 double armed pycnometer at temperatures 303.15 K. The pycnometer was calibrated at these temperatures with distilled water and benzene. The estimated accuracy of density measurement of solution was 0.00003 g cm^{-3}.

Results and discussion

Densities of potassium chromate (K_2CrO_4) and potassium dichromate ($K_2Cr_2O_7$) are determined using equation[12],

$\rho/\rho_1 = W/W_1$ (1)

Where,

W and W_1 are weight of potassium chromate or potassium dichromate solutions and weight of sucrose-aqueous solution respectively. ρ is density of potassium chromate or potassium dichromate solutions and ρ_1 is density of sucrose-aqueous solution . Densities of potassium chromate and potassium dichromate solutions, determined as a function of their concentration at 303.15K temperature in 15 % (w/v) sucrose-aqueous solution. The densities of solute were obtained as an intercept of plot between concentration and density of solutions (using Microsoft Excel). The data is reported in Table -1.

Apparent molar volume, ϕ_v, is calculated by following the equation[13],

$\phi_v = (\rho_1-\rho)/c\rho\rho_1 + M/\rho$ (2)

Where,

c is Morality of the solution, M is Molar mass of the solute,ρ andρ_1 Density of solution and solute. The result of ϕ_v of both potassium chromate and potassium dichromate are reported in Table- 2.The apparent molar volume at infinite dilution ϕ^0_V were calculated by the method of least square and fit to plot of ϕ_v vs $c^{1/2}$ in accordance with the Masson's [13]empirical relation ,

$\phi_v = \phi^0_V + S^{*}_{V}\, c^{1/2}$ (3)

Where, S^{*}_{V} is experimental slope. The slope is calculated by the extrapolation of the plots to zero concentration (using Microsoft excel). The positive and less negative values of experimental slope are generally associated with the solutes showing an overall hydrophilic character as in the present investigation. The values of apparent molar volume are reported in Table-2.

Table - 1. Densities,ρ, of potassium chromate and potassium dichromate in 5%(w/v)sucrose-aqueous solution at 303.15K.

Concentration ($mol.L^{-1}$)C	Density of K_2CrO_4 ($Kg.m^{-1}$)ρ	Density of $K_2Cr_2O_7$ ($Kg.m^{-1}$)ρ
0.0100	1.0210	1.0599
0.0200	1.0129	1.0609
0.0300	1.0138	1.0623
0.0400	1.0144	1.0637
0.0500	1.0152	1.0647
0.0600	1.0166	1.0661
0.0700	1.0175	1.0675
0.0800	1.0184	1.0686
0.0900	1.0231	1.0696
0.1000	1.0308	1.0703

Table-2. Apparent molar volume ϕ_v, apparent molar volume infinite dilution, ϕ_V^0 and experimental slope, S_V^* of potassium chromate and potassium dichromate in 15%(w/v) sucrose-aqueous solution at 303.15K.

Concentration (mol.L[-1])C	Apparent molar volume ϕ_v of K_2CrO_4	Apparent molar volume at infinite dilution, ϕ_V^0 of K_2CrO_4	Experimental slope s_V^* of K_2CrO_4	Apparent molar volume ϕ_v of $K_2Cr_2O_7$	Apparent molar volume at infinite dilution, ϕ_V^0 of $K_2Cr_2O_7$	Experimental slope s_V^* of $K_2Cr_2O_7$
0.0100	190.6925	192.4647	-30.1844	163.4759	198.0047	852.6717
0.0200	192.2895			221.0757		
0.0300	191.8352			240.2461		
0.0400	191.5876			249.8312		
0.0500	191.3521			255.5999		
0.0600	191.0221			259.4309		
0.0700	190.8129			262.1672		
0.0800	190.6140			264.2306		
0.0900	189.6713			265.8353		
0.1000	188.1685			267.1236		

The molar volumes of solutions are derived from the following expression[14],

$$V = (X_1M_1+X_2M_2) /\rho \qquad (4)$$

Where, X_1 and X_2 are Mole fraction of mixed solvent and Mole fraction of solute. M_1 and M_2 Molecular weight of solvent and Molecular weight of solute ρ is density of solution respectively. The data of molar volume of solution is reported in **Table-3**. The molar volume of 15% (w/v) sucrose solution is 22.2116. The molar volume of potassium chromate (K_2CrO_4) and potassium dichromate($K_2Cr_2O_7$)are 191.7135 and 277.8691 respectively.

Knowledge of the excess molar volume is of important property in design and storage and handling facilities of mixtures .The excess molar volume (V^E) for these solutions are obtained by the given expression[15],

$$V^E= V - (X_1V_1 + X_2 V_2) \qquad (5)$$

Where, V, V_1 and V_2 are the molar volume of solution, mixed solvent and solute respectively. Negative excess molar volume arises due to increased interaction between the unlike molecules. The data of both the compounds are reported in **Table -4.**

Table-3. Molar volume of potassium chromate and potassium dichromate in 15% (w/v) sucrose-aqueous solution at 303.15K.

Concentration (mol.L[-1])C	Molar volume V of K_2CrO_4	Molar volume V of $K_2Cr_2O_7$
0.0100	22.2683	22.7432
0.0200	22.4577	22.7618
0.0300	22.4491	22.7805
0.0400	22.4472	22.7991
0.0500	22.4409	22.8178
0.0600	22.4214	22.8364
0.0700	22.4131	22.8551
0.0800	22.4048	22.8738
0.0900	22.3134	22.8926
0.1000	22.1583	22.9115

Table-4.Excess molar volume of potassium chromate and potassium dichromate in 15%(w/v) sucrose-aqueous solution at 303.15k.

Concentration $(mol.L^{-1})C$	Excess molar volume V^E of K_2CrO_4	Excess molar volume V^E of $K_2Cr_2O_7$
0.0100	-0.4674	-0.0012
0.0200	-0.2894	-0.0025
0.0300	-0.3093	-0.0038
0.0400	-0.3225	-0.0052
0.0500	-0.3401	-0.0066
0.0600	-0.3709	-0.0081
0.0700	-0.3907	-0.0096
0.0800	-0.4104	-0.0112
0.0900	-0.5128	-0.0127
0.1000	-0.6786	-0.0143

Conclusion

The data of densities increases as function of concentration .The positive value of ϕ_v for indicate greater solute-solvent interactions. The values of ϕ^0_v are large and positive for potassium chromate (K2CrO4) and potassium dichromate ($K_2Cr_2O_7$) in 15% (w/v) sucrose solution, suggesting the presence of strong solute – solvent interaction. The experimental slope of potassium dichromate is positive showing ion-ion interaction then potassium chromate for this concentration range.

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