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A Study on Density and Viscosity of Binary Solutions of n- Propyl Acetate and IsoPropyl Alcohol at Various Temperatures

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Abstract: *Investigation on Density (ρ) and viscosity (η)of various binary solutions of n-propyl acetate and iso-propyl alcohol have been carried out over a temperature range from 305K to 320K from the data obtained; Excess molar volume (V_m^E) and deviation in viscosities (Δη)were calculated. These data have been interpreted in terms of possible molecular interactions in binary solutions.*

Keywords:*Binary solution, Densities,deviation in viscosity, molecular interaction, viscosity.*

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I. Introduction

Many industrial as well as laboratory process call for the use of solvent mixtures. The preference for the use of solvent mixture is due to certain physical properties of the system. Knowledge of these properties is helpful in synthesis of pharmaceutical, production of biofuel, polymer, paint, design of chemical plant and bimolecular systems [1, 6]. Molecular interaction of binary solution system has great theoretical and practical application in recent developments. Thus study of binary liquid solutions has been attracted by several researchers.Prediction from density and viscosity data has been widely used by various workers to know the nature of interaction like ion- solvent interaction [7] hydrogen bonding, dipole-dipole interaction, and dipole induced dipole interaction which deals with the physical properties of the mixture [8].

Esters are widely used in chemical industries; the interactions between ester and alcohol give useful information for solute-solvent and solvent-solvent interaction. [9-13]. In view of importance for the study of molecular interaction, the present work has been made to interpret the molecular interaction in solution system of n-propyl acetate and iso propyl alcohol. Excess molar volume and deviation in viscosity used to explain intermolecular interaction in the binary system.

II. Experimental

Chemicals used in present investigation were supplied by Loba Company and used without any further purification. The purity of these materials are GC 98% for n –propyl acetate and 99% foriso propyl alcohol. The binary solutions of varying composition (0.05 -0.3 mole fraction)were prepared in air tight bottles and placed in dry place.The density and viscosity measurements of the prepared solutions were conducted on the same day of solution preparation. The weighing was done on electronic balance GC-103 with an accuracy of 0.0001 kg.Densities of solutions were measured using pyknometer.[14]The viscosities of solutions were measured by using Ostwald's viscometer. Electronic digital watch was used to measure flow time of solution. Temperature is monitored in thermometer and regulated in thermostat. All the measurements were performed at least three times and average values were taken as final value.

III. Results And Discussion

3.1 Density and Viscosity

Experimental values of densities (ρ) and viscosities (η) for the binary solutions of n-propyl acetate with isopropyl alcohol at 305K, 310K, 315K and 320K are listed in Table- 1and 2.

Table 1: Densities (ρ) of binary solutions of n- propyl acetate with iso propyl alcohol at T (305 -320) K

Mole fraction	**Densities of binary (in gm/cm^3)**			
X1	**305 K**	**310 K**	**315 K**	**320 K**
0	0.76337	0.76001	0.75721	0.75322
0.05	0.76879	0.7628	0.75939	0.7539
0.1	0.77212	0.7669	0.7616	0.75892
0.15	0.77695	0.7717	0.76653	0.76253
0.2	0.78083	0.77519	0.77103	0.76661
0.25	0.78512	0.77858	0.77423	0.76976
0.3	0.78951	0.78043	0.77462	0.77172

Experimental measured densities for binary system of n-propyl acetate and iso propyl alcohol increase with increasing concentration of n- propyl acetate. Density value gradually decreases with increasing temperature at the same concentration as shown in **Fig 1**.

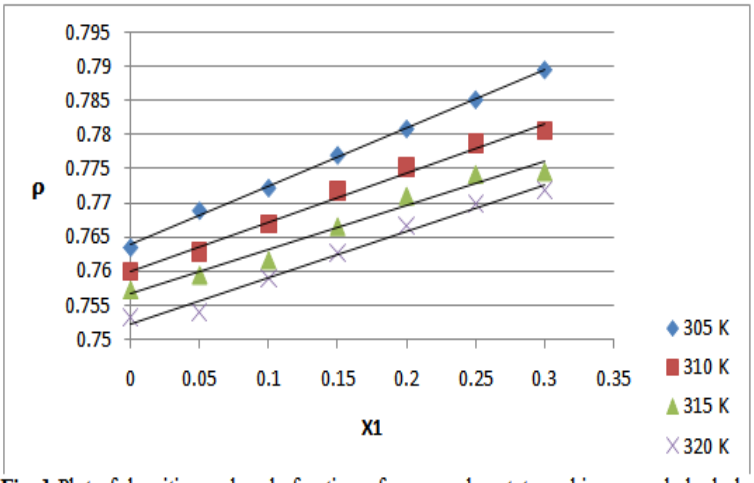

Fig. 1 Plot of densities and mole fraction of n- propyl acetate and iso propyl alcohol

Table 2: Viscosities (η) of binary solutions of n- propyl acetate with iso propyl alcohol at T (305 -320) K

Molefraction	**Viscosities of binary η(m.Pa.s)**			
X1	**305 K**	**310 K**	**315 K**	**320 K**
0	1.9056	1.8146	1.7304	1.6528
0.05	1.3723	1.1882	1.1138	0.9943
0.1	1.1851	1.1335	1.0477	0.9578
0.15	1.1219	1.0178	0.9412	0.8583
0.2	1.0209	0.9254	0.8591	0.8019
0.25	0.8837	0.8144	0.7746	0.7439
0.3	0.7989	0.7631	0.7398	0.6932

Viscosities for binary system of n-propyl acetate and iso propyl alcohol decrease with increasing temperature and increasing concentration of n-propyl acetate as shown in **Fig 2**.

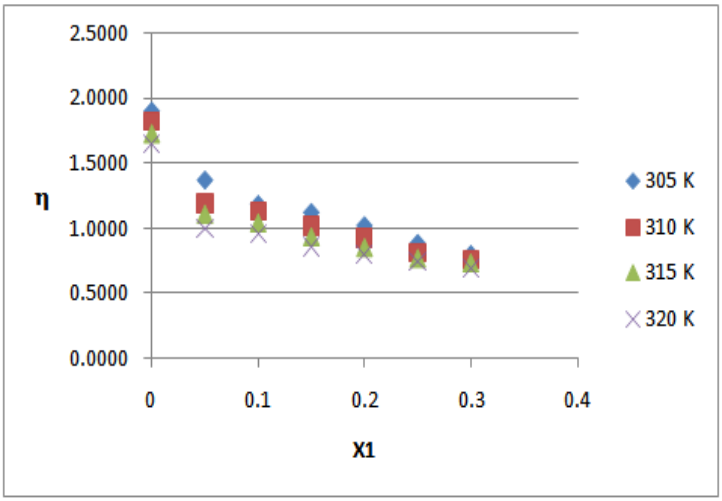

Fig.2 Plot of viscosity and mole fraction of n-propyl acetate and iso propyl alcohol

Excess Molar Volume

Density values have been used to calculate excess molar volume (V_m^E) for binary solution using the following equation (1).

V_m^E (cm^3/ mol) = (X1 M1 + X2M2)/ρ12 - (X1M1 / ρ1 + X2M2/ρ2) ---------- (1)

Where ρ12 is density of binary solution of n- propyl acetate and iso propyl alcohol; X1, M1, ρ1 and X2,M2, ρ2 are the mole fraction, molecular weight and density of pure compound 1 and 2 respectively. Excess molar volume for binary solution of n-propyl acetate and iso propyl alcohol at 305K, 310K, 315K and 310K are listed in Table-3.

Table 3: Excess molar volume (V_m^E) of binary solutions of n- propyl acetate with iso propyl alcohol at T (305 - 320) K

Mole fraction	**Excess molar volume of binary (in cm^3/mol)**			
X1	**305 K**	**310 K**	**315 K**	**320 K**
0	0.0000	0.0000	0.0000	0.0000
0.05	0.4111	1.0454	1.4110	2.0065
0.1	0.8488	1.4147	1.9973	2.2950
0.15	1.1010	1.6815	2.2610	2.7147
0.2	1.4326	2.0700	2.5460	3.0575
0.25	1.6950	2.4492	2.9580	3.4868
0.3	1.9218	2.9916	3.6894	4.0416

In present work excess molar volume is positive for whole range of composition and temperature shown in **Fig. 4**.It may be due to repulsive force of steric hindrance of ester molecule and declustering of alcohol in presence of ester.[15,16] The dispersion force in binary system may leads to the positive value of excess molar volume. As the temperature increase force of dispersion also increase which significantly governs to increase value of excess molar volume. [17, 18]

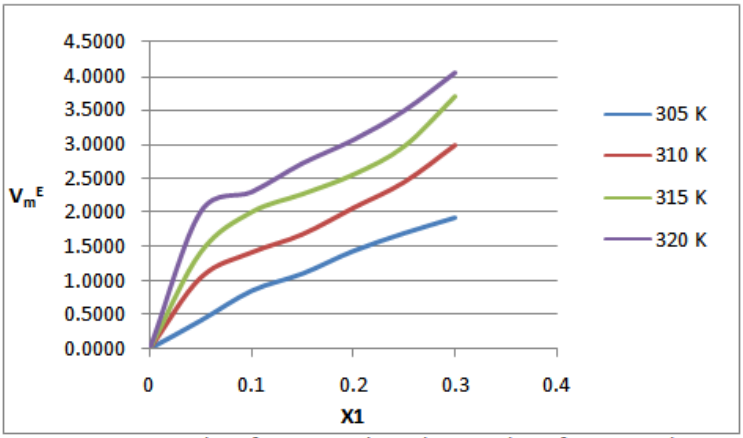

Fig. 3Plot of excess molar volume and X1 for n propyl acetate and isopropyl alcoholDeviation in viscosity

The deviation in viscosity (Δη)is calculated using following relation given in equation (2)

$\Delta\eta$ (m.Pa.s) = η_{12} - (X1 η1 + X2 η2) ----------(2)

Where η_{12} is viscosity of binary solution; X1, η_1 and X2, η_2 are the mole fraction and viscosities of pure component 1 and 2 respectively.Deviation in viscosity (Δη) at 305K, 310K, 315K and 320 K for the binary mixture of n- propyl acetate and iso propyl alcohol is listed in Table 4.

Table 4: Deviation in viscosity (Δη) of binary solutions of n- propyl acetate with iso propyl alcohol at T (305 - 320) K

Mole Fraction	**Deviation in viscosity Δη (m.Pa.s)**			
X 1	**305 K**	**310 K**	**315 K**	**320 K**
0	0.0000	0.0000	0.0000	0.0000
0.05	-0.4652	-0.5628	-0.5571	-0.6027
0.1	-0.5843	-0.5538	-0.5635	-0.5835
0.15	-0.5795	-0.6059	-0.6105	-0.6271
0.2	-0.6123	-0.6347	-0.6331	-0.6278
0.25	-0.6815	-0.6821	-0.6579	-0.6299
0.3	-0.6982	-0.6697	-0.6332	-0.6249

Δηobtainednegative in entire range of composition and becomes more negative with increasing temperature shown in **Fig 4**.The negative value of deviation in viscosity revels the Association of molecules in binary mixture is less than that of pure components [19]. Negativedeviation in viscosity may also due to breaking of dipolar combination of alcohol in presence of esters.

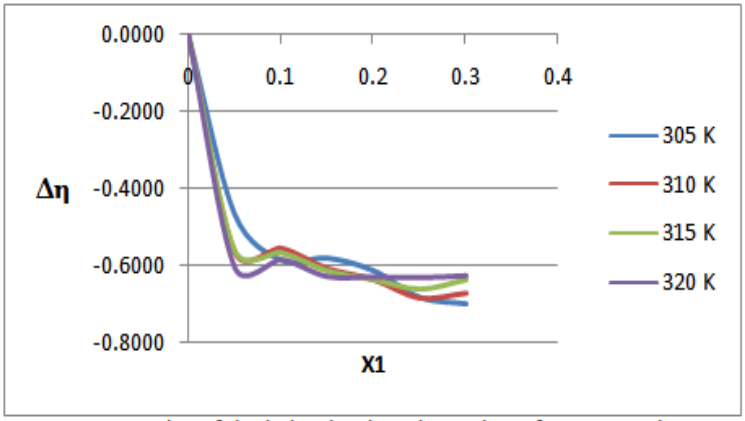

Fig. 4 Plot of deviation in viscosity and X1 for n- propyl acetate and iso propyl alcohol

Apparent Molar Volume

The apparent molar volume VΦ1 and VΦ2 of the binary system of n- propyl acetate and iso propyl alcohol were calculated by using equation (3) and (4) respectively.

VΦ1 = (X2M2/X1)*(ρ2-ρ12)/ (ρ2ρ12) + M1/ρ12 -------- **(**3)

VΦ2 = (X1M1/X2)*(ρ1-ρ12)/ (ρ1ρ12) + M2/ρ12 -------- **(**4)

Apparent molar volume for n-propyl acetate (VΦ1) and iso propyl alcohol (VΦ2) are listed in Table 5 and graph is plotted against mole fraction shown in Fig 5 and Fig 6.

Table 5: Apparent molar volume (VΦ1) and (VΦ2) of binary solutions of n- propyl acetate with iso propyl alcohol at T (305 -320) K

	V Φ 1 (cm^3/ mol)				**V Φ 2 (cm^3/ mol)**			
X 1	**305 K**	**310 K**	**315 K**	**320 K**	**305 K**	**310 K**	**315 K**	**320 K**
0	133.6180	134.2088	134.7050	135.4186	78.5988	78.9463	79.2382	79.6580
0.05	125.3296	138.0158	145.3272	157.2373	78.8642	79.5318	79.9167	80.5435
0.1	125.5946	131.2542	137.0798	140.0566	79.3745	80.0033	80.6506	80.9814
0.15	124.4467	128.3170	132.1801	135.2049	79.7267	80.4096	81.0914	81.6252
0.2	124.2700	127.4567	129.8370	132.3944	80.2222	81.0188	81.6139	82.2533
0.25	123.8866	126.9037	128.9387	131.0538	80.6913	81.6970	82.3754	83.0804
0.3	123.5127	127.0789	129.4047	130.5787	81.1768	82.7052	83.7019	84.2051

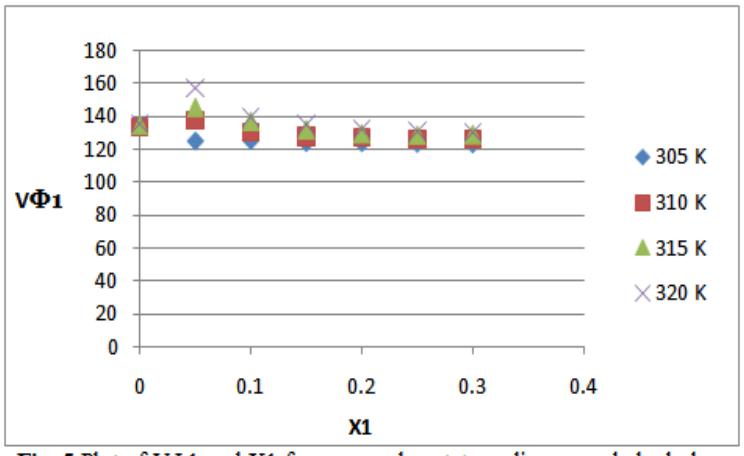

Fig. 5 Plot of VΦ1 and X1 for n-propyl acetate andiso propyl alcohol

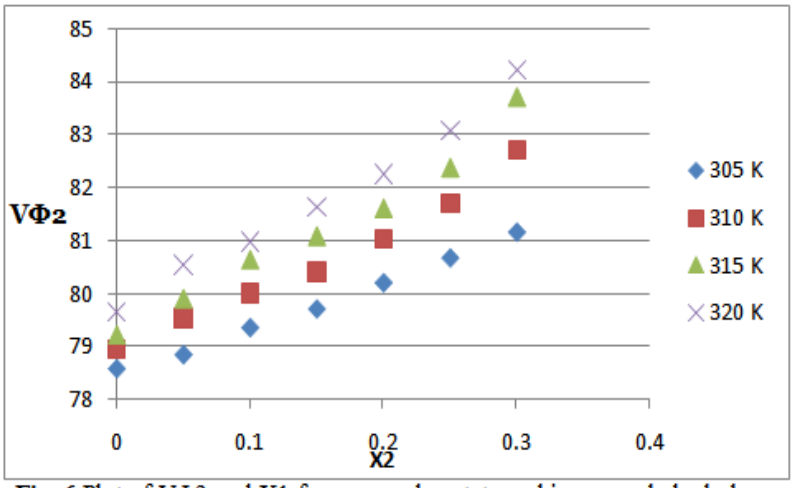

Fig. 6 Plot of VΦ2 and X1 for n propyl acetate and iso propyl alcohol

IV. Conclusion

In the present work study of binary system of n- propyl acetate and iso propyl alcohol, densities and viscosities measurements were carried out at 305K, 310K, 315K and 310K. Experimental values of density obtained are used to evaluate excess molar volume of the solution. Positive values of excess molar volume show declustering of alcohol in presence of ester. The negative value of deviation in viscosity again reveals the breaking of dipolar association of iso propyl alcohol.

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