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Research Article

An Intermolecular interaction in binary liquid mixture of Ethyl Aceto Acetate with o, m, p - Xylene: An Volumetric and Viscometric study

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Abstract:

The density and viscosity in binary mixture of Ethyl Aceto Acetate with o, m, p - xylene have been measured over the whole composition range at 303.15K. From these data some of excess viscosity and excess molar volume of *o, m, p* - xylene in Ethyl Aceto Acetate were calculated using the value of density and viscosity. The results are interpreted in term of molecular interaction between the components of the mixture. It has been observed that molecular interaction existing in the system is highly disturbed by the polar Ethyl Aceto Acetate molecule and depressive type interaction are existing in the system

Keywords: Molar Volume, Viscosity, Density, Binary mixture, Molecular interaction.

Introduction

Density and viscosity data for liquid mixtures are important from practical and theoretical points of view. Experimental measurements of these properties for binary mixtures have gained much importance in many chemical industries and engineering disciplines (Yang, 2009). Experimental liquid viscosities of pure hydrocarbons and their mixtures are needed for the design of chemical processes where heat and mass transfer and fluid mechanics are important. Prediction of the liquid behavior of hydrocarbon mixture viscosities is not yet possible within the experimental uncertainty. Therefore, experimental measurements are needed to understand the fundamental behavior of this property and then to develop new models (Rathnam, 2008). Alkanes are important series of homologous, nonpolar, and organic solvents. They have often been used in the study of solute dynamics because their physicochemical properties as a function of chain length are well-known (Gurung, 2006). They are also employed in a large range of chemical processes (Dominguez, 1998). The physicochemical properties play an important role in the understanding of several industrial processes, Properties such as viscosity or surface tension are required in many empirical equations for different operations such as mass and heat transfer processes. For example, it is necessary to know the mass transfer coefficient to design gas-liquid contactors. To determine the equations that modelize the mass transfer process requires knowledge of the density, viscosity, and surface tension of the liquid phase (Palafologou, 1996).

Viscosities and excess molar volumes of binary mixtures of diethyl benzene and methyl cyclohexane with octan-2-ol at 303.15 K are only reported. To the best of our knowledge, the properties of the binary mixtures of Ethyl Aceto Acetate with o, m, p - xylene have not been reported earlier. The excess molar volume and viscosity deviations are properties sensitive to different kinds of association in the pure components and in the mixtures. These properties have been used to investigate the molecular packing. Molecular motions and various types of intermolecular interactions and their strengths, but these properties are influenced by the size, shape, and chemical nature of the component molecules, in view of this significance, it was thought worthwhile to study the binary mixtures of Ethyl aceto acetate with o-, m-, and p-xylene in order to understand the interactions between these components. In the present paper, we report density and viscosity data for the binary mixtures of Ethyl Aceto Acetate with o, m, p - xylene. This work will also provide a test of various semi empirical equations to correlate viscosity of binary mixtures. These data are discussed to study the nature of behaviors between the components of the mixtures, the study of which will have great relevance in chemical process engineering.

Experimental

Material

The chemicals used in the present work were high purity laboratory reagent grade samples of Ethyl aceto acetatae, o- xylene, m-xylene and p- xylene were purchased from Merck Chem. Ltd India. All chemicals were stored over sodium hydroxide pellets for several days and fractionally distilled twice (Perrin, 1988). All chemicals was purified by the method described by Zhao et al

(Zhao, 2000) ethyl acetate was dried over K_2CO_3, filtered and distilled were discarded. All the chemicals were stored in dark bottles over freshly activated molecular sieve to minimize absorption of moisture. The purity of the solvent was ascertained by comparing the measured density, dynamic viscosities and sound velocity of the pure component at 303.15K. as shown in Table 1. The reported experimental values of density (ρ) and viscosity (η) conform closely to their corresponding literature values,

Measurements

Three binary system viz. Ethyl aceto acetatae+ o- xylene, Ethyl aceto acetatae+ m-xylene and Ethyl aceto acetatae + p- xylene were studied. Each sample mixture was prepared, on mass basis, by mixing the calculated volume of liquid components in specially designed glass stopper bottles. All binary mixture was prepared by weight covering the entire mole fraction range. The components of binary mixtures were injected by means of syringe in to the glass vials of sealed with rubber stopper in order to check evaporation losses during sample preparation. The mass measurements were carried out using an single pan analytical balance (Model K-15 Deluxe, K Roy Instruments Pvt. Ltd.) with an accuracy of $\pm 0.00001\times10^{-3}$ kg as described elsewhere(Yadava, 1994; Singh, 1988) . The possible error in the mole fraction was estimated to be less than $1x10^{-4}$. Five samples were prepared for one system, and their density and sound velocity were measured on the same day.

Density

Densities of pure liquids and their binary mixtures were determined by using a double-arm pycnometer (Redlich, 1948). With a bulb of 25 cm^3 and a capillary of an internal diameter of about 1 mm is used to measure the densities (ρ) of pure liquids and binary mixtures. The pycnometer is calibrated by using conductivity water (having specific conductance less than 1×10^6 ohm^{-1}) with 0.9970 and 0.9940 gem as its densities at T = 303.15 K, respectively. The pycnometer filled with air bubbles free liquids is kept in thermostate water bath (MSI Goyal Scientific, Meerut, India) controlled with a thermal equilibrium. The precision of the density measurements was estimated to be ±0.0002 g cm^3. The observed values of densities of pure Ethyl aceto acetatae, o- xylene, m-xylene and p- xylene at 303.15K were 1.0240, 0.8751, 0.8521 and 0.5704 Kg. m^{-3} which compares well with corresponding literature values of respectively.

Viscosity

Using Ostwald's viscometer (Bingham, 1922). Viscosities were measured at the desired temperature. It was calibrated using water and benzene. The flow time has been measured after the attainment of bath temperature by each mixture. The flow measurements were made with an electronic stopwatch with a precision of 0.01 s. The viscosities □, were obtained from the following relation:

□□□□□□□□□□□□□ = **k · □ · t** **(1)**

Where k, □ and t, are viscometric constant, density of liquid and time of efflux for a constant volume of liquid respectively. For all pure compounds and mixtures, 3-5 measurements wereperformed and the average of these values was used in all calculations. The values are accurate to ±0.002 CP.

Table. 1. Viscosities (η) and Densities of pure organic liquids At 303.15 K

	Literature value		This work	
Liquids	Viscosity $\eta \times 10^2$ (poise)	Density $\rho \times 10^{-3}$ (Kgm^{-3})	Viscosity $\eta \times 10^2$ (poise)	Density $\rho \times 10^{-3}$ (Kgm^{-3})
Ethyle Aceto Acetate	1.7165	1.0240	1.5897	1.0134
o- Xylene	0.693	0.8715	0.6891	0.8752
m- Xylene	0.557	0.8533	0.5790	0.8589
p- Xylene	0.556	0.8521	0.5704	0.8546

Result and discussion

The experimental data on density (***ρ***) and viscosity (η) for binary mixtures of Ethyl aceto acetate with o-, m- and p-Xylene at 303.15K were determined. From the measured values of density, molar volume (V_m) was calculated using the relation

$$V_m = (x_1M_1 + x_2M_2) / \rho \quad (2)$$

Where x_1, x_2 and M_1, M_2 are the molefraction and molecular weights of the components 1 and 2 respectively.

Viscosity data for binary liquid mixture at 303.15 k as a function of reported in table 1 besides the value of excess viscosity (η^E) obtained from equation 3.As it is evident from the table there is an appreciable negative deviation (Inglese , 1980). From rectilinear dependence of viscositiy on mole fraction for the mixture containing non polar solute and Ethyl Aceto Acetate as solvent. The values of excess viscosity (η^E) and excess molar volume (V^E) are plotted against the mole fraction of Ethyl aceto acetate and are shown in figures 1 and 2 respectively.

In the terms of intermolecular forces, it seems that so far as non polar solute Ethyl Aceto Acetate binary liquid mixture are concerned the force between unlike Pairs of molecule are more than the forces between like pair molecules (Sastry, 1996; Nagata,1977; Dai,1985). And that is why the mixture is less fluid i.e. more viscous However non polar aromatic solute, polar solvent mixture of a certain composition are less fluid i.e. more viscous as compared to the solute Ethyl aceto acetate mixture of the same composition because of enhanced intermolecular forces between pair of molecules.
This enhancement could be due to Ethyl Aceto Acetate. The Excess viscosity of mixing η^E, given by

$$\eta^E = \eta_{ideal} - \eta_{mix.} \quad (3)$$

Where $\eta_{ideal} = \eta_1 X_1 + \eta_2 X_2$

Refers to the deviation from the rectilinear dependence of viscosity on molar proportion for the mixtures. The study of Viscosity n also supports the behavior as in case of viscosity. The mean values of η are given in table 2 a perusal of viscosity for a binary of particular composition shows that viscosity increases with the rise in mole fraction of first name components. This quite expected in view of the enhanced tendency for the formation of collision complex at higher mole fraction The sign of excess viscosity (η^E) clearly indicates the presence of intermolecular interaction in binary system studied. A negative excess function is indication of the strong interaction between the components (Rattan.1989; Fort, 1966).
Experimental results for mixture of Ethyl Aceto Acetate with o- xylene, m-xylene.p-xylene at 303.15 K all given in the table 3. Perusal table 3 show that excess molar volume all negative from binary mixtures the for mixture of Ethyl Aceto Acetate with o-xylene, m-xylene and p-xylene all are found negative values. As data for excess molar volume for the system in present are not available in literature (Solimo,1975; Bilkis,1996; Rattan,1993; Poupko,1955).The negative values for binary mixtures of for mixture of Ethyl Aceto Acetate with o- xylene, m-xylene and P-xylene confirm above view and shows that the molecular interaction are strong in the system. However when binary mixture are prepared between for mixture of Ethyl Aceto Acetate with o- xylene, m-xylene and p-xylene. With polarization pi electron diopole - dipole interaction and hydrogen bond for mixture of Ethyl Aceto Acetate with o- xylene, m-xylene and p-xylene. Also continue excess molar volume at appear the true fraction cannot fully dominant the exess molar volume for mixture of Ethyl Aceto Acetate with o-xylene, m-xylene and p-xylene. Sharma et.al, (Sharma, 2022). Have suggested that hydrogen bonding present in these system give rise for stronger complex.

Table. 2. Values of mole fraction (X_1), viscocities (η), densities (ρ), and molar volume (V_{mix}) of binary liquid mixture of Ethyle aceto acetate with hydrocarbons at 303.15 K.

S.N0.	Mole Fraction (x_1)	Density (ρ) Kgm^{-3}	Viscosity $\eta \times 10^2$ (poise)	Molar Volume $V_{mix} \times 10^6$ (m^3mole^{-1})
Ethyle aceto acetate +*o*- Xyelene				
1	0.0000	0.8752	0.6891	121.309
2	0.0844	0.8886	0.7355	121.756
3	0.1717	0.9034	0.7839	122.078
4	0.2629	0.9142	0.8299	123.027
5	0.3564	0.9285	0.8801	123.546
6	0.4496	0.9397	0.9283	124.451
7	0.5549	0.9546	0.9813	125.152
8	0.6636	0.9698	1.0228	125.884
9	0.7829	0.9865	1.3170	126.645
10	0.8847	0.9989	1.3669	127.516
11	1.0000	1.0134	1.5897	128.419
Ethyle aceto acetate +*m*- Xyelene				
1	0.0000	0.8589	0.5790	123.611

2	0.0844	0.8740	0.6417	123.775
3	0.1717	0.8896	0.7110	124.204
4	0.2629	0.9036	0.7841	124.491
5	0.3564	0.9176	0.8575	125.081
6	0.4496	0.9326	0.9187	125.406
7	0.5549	0.9487	0.9960	126.054
8	0.6636	0.9659	1.0048	126.350
9	0.7829	0.9796	1.1138	127.168
10	0.8847	0.9947	1.2014	127.680
11	1.0000	1.0134	1.5897	128.419
Ethyle aceto acetate +*p*- Xyelene				
1	0.0000	0.8546	0.5704	124.233
2	0.0844	0.8697	0.6269	124.435
3	0.1717	0.8845	0.6789	124.749
4	0.2629	0.8989	0.7320	125.188
5	0.3564	0.9158	0.7824	125.340
6	0.4496	0.9289	0.8432	126.094
7	0.5549	0.9473	0.9042	126.200
8	0.6636	0.9640	0.9652	126.614
9	0.7829	0.9795	1.0330	127.295
10	0.8847	0.9976	1.3318	127.518
11	1.0000	0.8546	1.5897	128.419

Table. 3. Values of mole fraction (X_1), densities (ρ), excess viscosities (η^E), and excess molar volume (V^E) of binary liquid mixture of Ethyle aceto acetate with hydrocarbons at 303.15 K.

S. N0.	Mole Fraction (x_1)	Density (ρ) $K.gm^{-3}$	Excess Viscosity $\eta^E x\ 10^2$ (poise)	Excess Molar Volume $V^E\ x\ 10^6$ (m^3mole^{-1})
Ethyle aceto acetate +*o*- Xyelene				
1	0.0000	0.8752	0.0000	0.000
2	0.0844	0.8886	-0.0296	-0.0930
3	0.1717	0.9034	-0.0598	-0.1100
4	0.2629	0.9142	-0.0759	-0.1310
5	0.3564	0.9285	-0.0929	-0.1570
6	0.4496	0.9397	-0.1157	-0.1840
7	0.5549	0.9546	-0.0907	-0.1620
8	0.6636	0.9698	-0.0764	-0.1446
9	0.7829	0.9865	0.0577	-0.1130
10	0.8847	0.9989	-0.0289	-0.0983
11	1.0000	1.0134	0.0000	0.000
Ethyle aceto acetate +*m*- Xyelene				
1	0.0000	0.8589	0.0000	0.000
2	0.0844	0.8740	-0.0261	-0.125
3	0.1717	0.8896	-0.0598	-0.144
4	0.2629	0.9036	-0.0770	-0.161
5	0.3564	0.9176	-0.0963	-0.186
6	0.4496	0.9326	-0.1150	-0.206
7	0.5549	0.9487	-0.0946	-0.187
8	0.6636	0.9659	-0.0743	-0.164
9	0.7829	0.9796	-0.0541	-0.148
10	0.8847	0.9947	-0.0216	0.119
11	1.0000	1.0134	0.0000	0.000
Ethyle aceto acetate +*p*- Xyelene				
1	0.0000	0.8546	0.0000	0.000
2	0.0844	0.8697	-0.0307	-0.156
3	0.1717	0.8845	-0.0688	-0.186
4	0.2629	0.8989	-0.0989	-0.215
5	0.3564	0.9158	-0.1144	-0.237
6	0.4496	0.9289	-0.0932	-0.262
7	0.5549	0.9473	-0.0735	-0.226
8	0.6636	0.9640	-0.0506	-0.195
9	0.7829	0.9795	-0.0323	-0.175
10	0.8847	0.9976	-0.0138	-0.152
11	1.0000	0.0134	0.0000	0.000

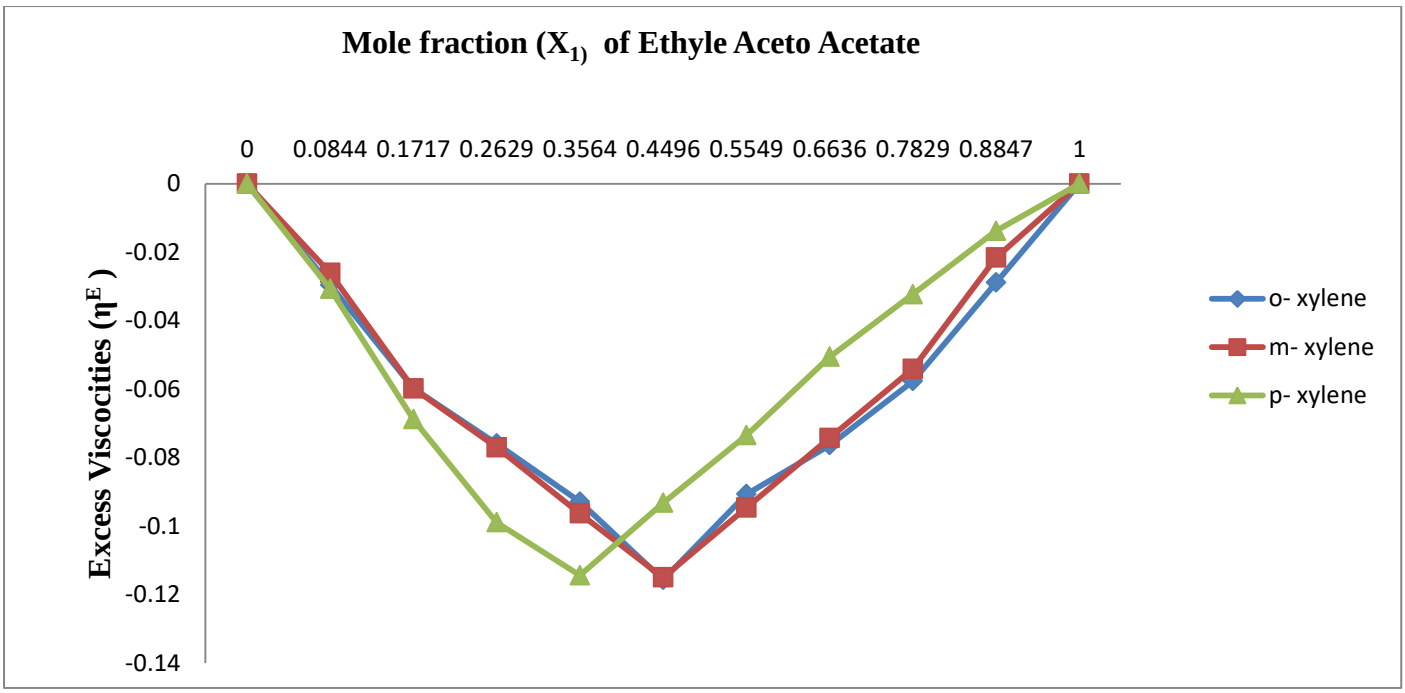

Fig. 1. Plots of Excess viscocities with mole fraction X_1 for the binary mixture of ethyl aceto acetate with o-xylene, m-xylene, and p-xylene

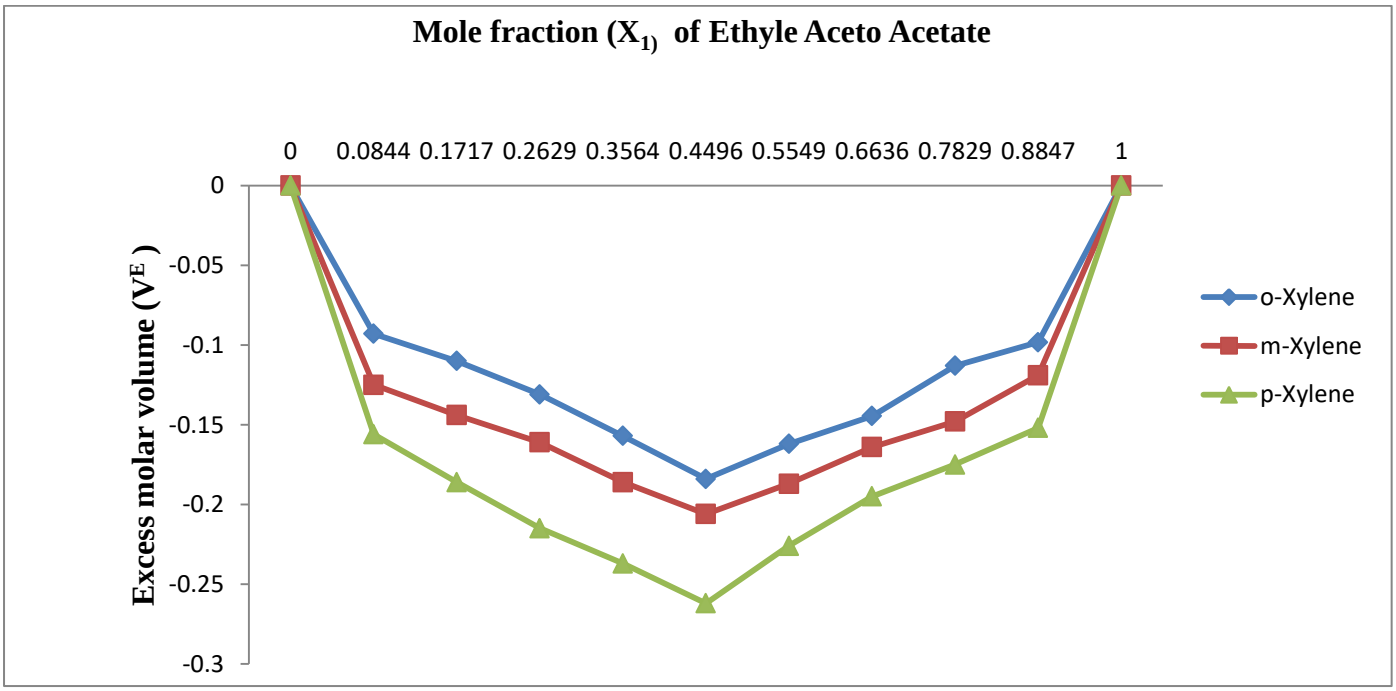

Fig. 2. Plots of Excess molar volume with mole fraction X_1 for the binary mixture of ethyl aceto acetate with o-xylene, m-xylene, and p-xylene

Conclusion

The density and viscosity are measured and related excess parameters were calculated from the measured data. The existence of molecular interactions in solute-solvent is favoured in the system. Hence it is concluded that there exist a molecular interaction between Ethyl aceto acetate and o, m, p-Xylene due to dipole - dipole interaction and hydrogen bonding.

Conflict of Interest:

The authors declare that they have no conflict of interest

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