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Research Paper

Volumetric and Viscometric Behaviour of Acrylic Esters with Hexane-2-ol at T= (298.15 And 308.15) K

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Abstract *- Densities and viscosities for the three binary liquid mixtures of methyl acrylate, ethyl acrylate and butyl acrylate with hexane-2-ol at temperatures 298.15 and 308.15 K and at atmospheric pressure were measured over the whole composition range. These values were used to calculate excess molar volumes and deviation in viscosities which were fitted to Redlich-Kister polynomial equation. Recently proposed Jouyban Acree model was also used to correlate the experimental values of density and viscosity. The mixture viscosities were correlated by Grunberg-Nissan, Tamura and Kurata, McAllister's three and four body model equations. The calculated excess molar volume and deviation in viscosity were found to be positive and negative respectively for all the binary liquid mixtures at 298.15 and 308.15 K temperatures.*

Keywords: Binary mixtures, Acrylates, Excess molar volume, Viscosity deviation, densities.

Introduction

Thermodynamic parameters derived are used to understand different kinds of association, molecular packing, molecular motion and various types of intermolecular interactions and their strength influenced by size in pure components and in mixture. These properties are generally convenient parameters for interpreting solvent-solvent, solute-solvent and solute-solute interactions in solution phase. The ultimate goal of the thermodynamics is to explain the excess properties using different interaction parameters. The excess thermodynamic properties of the mixtures correspond to the difference between the actual property and the property if the system behaves ideally. The theoretical values of excess function depend critically on the assumption about the extent of their interaction (strong or weak) and size.

In literature data exists for binary systems of ethyl ethanoate with ethyl acrylate, butyl acrylate, methyl methacrylate and styrene at 298.15 K[1], for volumetric behavior of acrylic esters with alkane-1-ols at 298.15 and 308.15K [2], density and excess molar volume of the binary systems of dimethyl sulfoxide+ ethyl acrylate, butyl acrylate , methyl methacrylate and styrene at 298.15 K[3], volumetric properties of binary systems of dimethyl sulfoxide with Methacrylic acid, vinyl acetate, butyl methacrylate and allyl methacrylate at 298.15 K[4], volumetric properties of toluene with ethyl acrylate , butyl acrylate, methyl methacrylate and styrene at 298.15K[5], thermodynamic properties of methyl methacrylate with alkoxyethanols and 1-alcohols at 298.15 and 308.15 K[6], volumetric properties of ternary system 1,4-dioxane with butyl and ethyl acrylate and its binary at 298.15K[7]. Binary mixtures are an important class of solvents as well as solutions and the behavior of some of their physical properties is still not clear.

Experimental data on the densities and viscosities of binary mixtures containing esters are useful in pharmaceuticals and agricultural chemistry. Acrylic esters are important industrial chemicals used in the large scale preparation of useful polymers. The acrylic esters are also interesting because they contain both a double bond and an ester group. Literature survey reveals that most of research work has been carried out on the binary mixtures of primary alcohols with the aliphatic acrylic esters.

Material and Methods

Chemicals used in the present study were of analytical grade and supplied by S.D. Fine Chemicals Pvt., Mumbai with quoted mass fraction purities: methyl acrylate, MA, (>0.997), ethyl acrylate, EA, (>0.998) and butyl acrylate, BA, (>0.995). Hexane-2-ol was obtained from Aldrich with minimum purity of (>0.998). Prior to use all liquids were stored over 0.4 nm molecular sieves to reduce the water content and were degassed. In addition, all four acrylic esters were distilled before use. The binary mixtures of varying composition were prepared by mass in special air-tight bottles. The solutions of each composition were prepared fresh and all properties were measured the same day. The masses were recorded on a Mettlar one pan balance, which can read up to fifth place of decimal , with an accuracy of ± 0.01 mg. Care was taken to avoid evaporation and contamination during mixing. The estimated uncertainty in mole fraction was $<1\times10^{-4}$.

The densities of the solutions were measured[8] using a single capillary pycnometer made up of borosil glass with a bulb of $8 cm^3$ and capillary with internal diameter of 0.1cm was chosen for present work. An average of triplicate measurement was taken in to account. The reproducibility of density measurement was $\pm 5 x 10^{-5} g/cm^3$.

The dynamic viscosities were measured using an Ubbelhode suspended level viscometer calibrated with conductivity water [8]. An electronic digital stop watch with readability of ± 0.01 s was used for the flow time measurements. At least three repetitions of each data reproducible to ± 0.05 s were obtained and the results were averaged. Since all flow times were greater than 300 s and capillary radius (0.1 mm) was far less than its length (50 to 60) mm, the kinetic energy and end corrections, respectively, were found to be negligible. The uncertainties in dynamic viscosities are of the order of ± 0.003 mPa.s. [8]. A comparison of measured values of pure components with the literature values as presented in Table 1 shows a good agreement.

Results and Discussion

Twenty one density and viscosity measurements were performed with repetitions for each binary liquid system namely methyl acrylate (1) + hexane-2-ol (2), ethyl acrylate (1) + hexane-2-ol (2) and butyl acrylate (1) + hexane-2-ol (2) over the entire mole fraction range ($0 < x < 1$), at temperatures 298.15 and 308.15 K and at atmospheric pressure. Experimental values of densities (ρ), viscosities (η), excess molar volumes (V^E) and deviations in viscosities ($\Delta\eta$) of these mixtures at 298.15 and 308.15 K are listed as a function of mole fraction in Table 2.

The excess molar volumes V^E of the solutions of molar compositions x were calculated from the densities of the pure liquids and their mixtures according to the following equation

$$V^E / cm^3.mol^{-1} = [x_1M_1+x_2M_2]/\rho_{12} - [(x_1M_1/\rho_1)+(x_2M_2/\rho_2)] \quad (1)$$

where ρ_{12} is the density of the mixture and x_1, M_1, ρ_1, and x_2, M_2, ρ_2 are the mole fraction, the molecular weight, and the density of pure components 1and 2, respectively. The first term on the right hand side of above Equation (1) represents the actual molar volume V of the solution and the second represents the molar volume it would occupy if the mixture behaved ideally. In general, while these two molar volumes are similar in size (usually larger than $100 cm^3.mol^{-1}$) their difference is usually smaller by two to three orders of magnitude and thus may carry a significantly larger error.

The viscosity deviations ($\Delta\eta$) were calculated using equation

$$\Delta\eta / mPa.s = \eta12 - x1\eta 1 - x2\eta2 \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where η_{12} is the viscosity of the mixture and x_1, x_2 and η_1, η_2 are the mole fraction and the viscosity of pure components 1and 2 respectively [9].

The excess molar volumes and deviations in viscosity were fitted to Redlich Kister equation of the type

$$Y = x1x2 \sum_{i}^{n} a_i (x_1 - x_2)^i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where Y is either V^E, or $\Delta\eta$ and n is the degree of polynomial. Coefficient a_i was obtained by fitting eqn 3 to experimental results using a least-squares regression method. In each case, the optimum number of coefficients is ascertained from an examination of the variation in standard deviation (σ).

σ was calculated using the relation

$$\sigma (Y) = \left[\frac{\sum (Y_{exp\,t} - Y_{calc})^2}{N - n} \right]^{1/2} \ldots\ldots\ldots\ldots\ldots (4)$$

Where N is the number of data points and n is the number of coefficients [10]. The calculated values of the coefficients a_i along with the standard deviations (σ) are given in Table 3.

Several relations have been proposed to evaluate the dynamic viscosity (η) of liquid mixtures and these are classified according to the number of adjustable parameters used to account for the deviation from some average. An attempt has been made to check the suitability of the equation for experimental data fits by taking into account the number of empirical adjustable coefficients. The equations of Grunberg-Nissan, Tamura and Kurata have one adjustable parameter. Grunberg-Nissan provided the following empirical equation containing one adjustable parameter. The expression is

$$\ln \eta_{12} = x_1 \ln \eta_1 + x_2 \ln \eta_2 + x_1x_2G_{12} \quad (5)$$

where G_{12} is a parameter proportional to the interchange energy.

Tamura and Kurata developed expression for viscosity of binary mixtures

$$\eta = x_1\phi_1 \eta_1 + x_2\phi_2 \eta_2 + 2(x_1x_2\phi_1\phi_2)^{1/2}T_{12} \quad (6)$$

where T_{12} is the interaction parameter , ϕ_1 and ϕ_2 are the volume fractions.

McAllister's multibody interaction model was widely used to correlate kinematic viscosity (υ) data. The two parameter McAllister equation based on Eyring's theory of absolute reaction rates, taken into account interactions of both like and unlike molecules by a two dimensional three body model. The three body model was defined by

$$\ln \nu = x_1^3 \ln \nu_1 + x_2^3 \ln \nu_2 + 3 x_1^2 x_2 \ln Z_{12} + 3 x_1 x_2^2 \ln Z_{21} - \ln [x_1+(x_2M_2/M_1)] + 3 x_1^2 x_2 \ln[(2/3)+(M_2/3M_1)] + 3x_1x_2^2 \ln[(1/3)+(2M_2/3M_1)] + x_2^3 \ln(M_2/M_1) \quad (7)$$

Similarly the four body model was defined by

$$\ln \nu = x_1^4 \ln \nu_1 + 4x_1^3x_2 \ln Z_{1112} + 6 x_1^2x_2^2 \ln Z_{1122} + 4 x_1x_2^3 \ln Z_{2221} + x_2^4 \ln \nu_2 - \ln [x_1+x_2 (M_2/M_1)] + 4 x_1^3x_2 \ln [(3+M_2/M_1)/4] + 6 x_1^2 2x_2^2 \ln[1+M_2/M_1)/2] + 4 x_1x_2^3 \ln [(1+ 3M_2/M_1)/4] + x_2^4 \ln (M_2/M_1) \ldots\ldots\ldots\ldots (8)$$

Where Z_{12}, Z_{21}, Z_{1112}, Z_{1122} and Z_{2221} are model parameters and M_i and ν_i are the molecular mass and kinematic viscosity of pure component i.

To perform a numerical comparison of the correlating capability of above Eq (5 to 8) we have calculated the standard percentage deviation (σ %) using the relation

$\sigma\% = [1/(\eta_{expt} – k) \times \sum(100(\eta_{expt} – \eta_{cal})/\eta_{expt})^2]^{1/2}$ …………..(9)

where k represents the number of numerical coefficients in the respective equations.

The terms G_{12}, T_{12}, Z_{12}, Z_{21}, Z_{1112}, Z_{1122} and Z_{2221} in the above Eq 5, 6, 7 and 8 have been considered as adjustable parameters and were estimated by a non-linear regression analysis based on a least-squares method. These are presented with their standard percentage deviation (σ %) in Table 4. The Equation 5 is particularly selected because the characteristic constant parameter G_{12} allows for the positive and negative deviations from the additivity rule [11].

Recently Jouyban and Acree proposed a model for correlating the density and viscosity of liquid mixtures at various temperatures. The proposed equation is

$\ln y_{mT} = f_1 \ln y_{1T} + f_2 \ln y_{2T} + f_1 f_2 \sum[A_j (f_1 - f_2)^j / T]$ ……………..(10)

where y_{mT}, y_{1T} and y_{2T} is density or viscosity of the mixture and solvents 1 and 2 at temperature T, respectively, $f_1$and f_2 are the volume fractions of solvents in case of density, and mole fraction in case of viscosity, and Aj are the model constants. The correlating ability of the Jouyban - Acree model was tested by calculating the average percentage deviation (APD) between the experimental and calculated density and viscosity as

$APD = (100/N) \sum[(|y_{expt} - y_{cal}|)/y_{expt})]$ ……………………(11)

Where N is the number of data points in each set. The optimum numbers of constants Aj, in each case, were determined from the examination of the average percentage deviation value. The constants Aj calculated from the least square analysis are presented in Table 5 along with the average percentage deviation (APD). The proposed model provides reasonably accurate calculations for the density and viscosity of binary liquid mixtures at various temperatures and the model could be used in data modeling [12, 13].

A graphical comparison of the dependence of excess molar volume, V^E, on acrylic esters at 298.15 and 308.15K for the binary mixtures of each acrylic ester with hexane-2-ol is given in Figure 1 and 2. A systematic decrease in V^E is noted with the rise in the carbon chain length of acrylic esters from methyl acrylate to butyl acrylate at both temperatures in all the binary mixtures. The observed positive excess molar volumes in the present investigation may be discussed in terms of several effects. Excess molar volumes can be considered as arising from three types of interactions between the component molecules; namely physical, chemical and geometrical type of molecular interactions. Positive values of excess molar volumes can be visualized as being due to a closer approach of unlike molecules having significantly different molecular size. Due to presence of nonpolar molecule like acrylic esters, H-bonding in alcohol molecule breaks and system shows weak intermolecular interactions. Longer the chain length of acrylic esters, weaker will be interaction between liquid components .Positive values of excess molar volumes shows that volume expansion is taking place causing rupture of H-bonds in self associated alcohols.

Volume changes arising due to addition of a second component to alkanols result from several effects. Main volume effects accompanying addition of acrylates to alkanols results from changes of free volume, interstitial accommodation of acrylates within hydrogen bonded structure of alkanols, disruption of alkanols structure and so-called condensation effect due to restricted rotation motion of alkanols molecules. Positive V^E values may be attributed to predominance of declustering of alkanols in presence of acrylates.

A graphical comparison of the dependence of deviation in viscosity, Δη, on acrylic esters at 298.15 and 308.15K for the binary mixtures of each acrylic ester with hexane-2-ol is given in Fig. 3 and 4. Negative values of Δη over whole composition range suggests that, viscosities of associates formed between unlike molecules are relatively less than those of pure components, which is exhibited by decreased values of viscosity with mole fraction. This decrease in viscosity attributed to breaking of dipolar association of alcohol into small dipoles. Weak types of dipole- induced dipole type of interactions are not sufficient to produce bulky or less mobile entities in system and hence decreased trend of viscosity is observed in the present binary liquid mixture of acrylics esters with the branched alcohol.

Viscosity deviations may be explained in terms of relative strength of molecular interactions between like and unlike molecules. The sign and magnitude of δη depends on the combined effect of factors like molecular size and shape of the components in addition to operating, the values of viscosity deviation are found to be negative, whereas the existence of specific interactions between the mixing components of the various binary systems tends to make intermolecular forces. Tamura and Kurata model used to explain viscosity gives T_{12} interaction parameter and it found to be positive supporting existing of weak interactions.

Conclusion

The overall positive magnitude of excess molar volumes for the systems acrylates with the hexane-2-ol is the result of the breaking and dislocation of the ester's dipole-dipole association. The free volume difference and interstitial accommodation of smaller molecules are chief factors for negative excess molar volumes. In higher alcohols, geometrical fitting of one into other is negligibly small; therefore association decreases with increase in chain length of alcohols.

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Table 1: Densities (*ρ*) and Viscosities (*η*) for Pure Liquids at T= (298.15 and 308.15) K.

Property	**T=298.15K**		**T=308.15K**	
	Expt.	**Lit.**	**Expt**	**Lit.**
Hexane-2-ol				
ρ(g.m^{-3})	0.81082	---	0.80172	---
η(mPa.s)	4.101	---	2.920	---
Methyl Acrylate				
ρ(g.m^{-3})	0.94751	0.94750[14]	0.93561	0.93770[15]
η(mPa.s)	0.449	0.449[14]	0.390	0.384[16]
Ethyl Acrylate				
ρ(g.m^{-3})	0.91632	0.91593[15]	0.90400	0.90460[16]
η(mPa.s)	0.518	0.530[15]	0.456	0.455[14]
Butyl Acrylate				
ρ(g.m^{-3})	0.89399	0.89395[15]	0.88546	0.88460[16]
η(mPa.s)	0.787	0.838[15]	0.684	0.684[15]

Table 2: Densities (ρ), Viscosities (η), Excess molar volumes (V^E) and Deviations In Viscosity (Δη) for binary liquid mixture of Acrylic Esters (1) + Hexane-2-ol (2) at T= (298.15 and 308.15) K.

	***T*=298.15K**				***T*=308.15K**			
X1	**ρ (g.cm^{-3})**	**η (mPa.s)**	**V^E (cm^{3}mol^{-1})**	**Δη (mPa.s)**	**ρ (g.cm^{-3})**	**η (mPa.s)**	**V^E (cm^{3}mol^{-1})**	**Δη (mPa.s)**
	MA (1) + Hexane-2-ol (2)							
0	0.81082	4.101	0	0	0.80172	2.920	0	0
0.0551	0.81564	3.631	0.105	-0.269	0.80657	2.614	0.086	-0.167
0.1000	0.81995	3.287	0.150	-0.449	0.81083	2.387	0.128	-0.280
0.1554	0.82532	2.908	0.220	-0.625	0.81619	2.136	0.183	-0.391
0.1998	0.82978	2.636	0.272	-0.735	0.82065	1.953	0.222	-0.462
0.2554	0.8356	2.331	0.325	-0.837	0.82646	1.746	0.263	-0.528
0.2999	0.84046	2.112	0.359	-0.893	0.83128	1.596	0.290	-0.565
0.3554	0.84677	1.868	0.393	-0.935	0.83754	1.428	0.316	-0.593
0.3999	0.85205	1.693	0.412	-0.948	0.84276	1.305	0.330	-0.603
0.4555	0.85891	1.497	0.427	-0.940	0.84953	1.167	0.341	-0.601
0.4999	0.86458	1.357	0.438	-0.918	0.85520	1.067	0.340	-0.588
0.5554	0.87211	1.200	0.426	-0.872	0.86248	0.954	0.341	-0.560
0.5999	0.87837	1.088	0.414	-0.822	0.86861	0.872	0.332	-0.530
0.6551	0.88646	0.963	0.390	-0.746	0.87651	0.781	0.313	-0.482
0.7000	0.89335	0.872	0.363	-0.673	0.88322	0.713	0.292	-0.436
0.7551	0.90219	0.772	0.320	-0.572	0.89181	0.638	0.259	-0.371
0.7998	0.90971	0.699	0.278	-0.481	0.89910	0.583	0.226	-0.313
0.8555	0.91950	0.618	0.216	-0.359	0.90856	0.522	0.178	-0.234
0.8999	0.92769	0.560	0.158	-0.254	0.91646	0.477	0.133	-0.166
0.9555	0.93814	0.495	0.106	-0.116	0.92665	0.426	0.085	-0.076
1	0.94751	0.449	0	0	0.93561	0.390	0	0

	EA (1) + Hexane-2-ol (2)							
0	0.81082	4.101	0	0	0.80172	2.920	0	0
0.0551	0.81550	3.659	0.060	-0.244	0.80638	2.636	0.042	-0.148
0.1000	0.81936	3.336	0.108	-0.408	0.81021	2.426	0.078	-0.248
0.1554	0.82428	2.973	0.159	-0.571	0.81507	2.188	0.115	-0.349
0.1998	0.82829	2.712	0.194	-0.673	0.81903	2.015	0.141	-0.413
0.2554	0.83343	2.417	0.231	-0.769	0.82409	1.817	0.167	-0.474
0.2999	0.83762	2.205	0.255	-0.822	0.82821	1.673	0.185	-0.508
0.3554	0.84299	1.965	0.278	-0.862	0.83347	1.509	0.202	-0.535
0.3999	0.84739	1.793	0.291	-0.876	0.83776	1.389	0.211	-0.545
0.4555	0.85300	1.598	0.301	-0.871	0.84324	1.253	0.218	-0.545
0.4999	0.85758	1.458	0.305	-0.852	0.84768	1.154	0.222	-0.534
0.5554	0.86349	1.299	0.299	-0.811	0.85342	1.040	0.216	-0.510
0.5999	0.86828	1.185	0.290	-0.766	0.85805	0.958	0.210	-0.484
0.6551	0.87443	1.056	0.272	-0.696	0.86398	0.864	0.197	-0.441
0.7000	0.87943	0.964	0.252	-0.630	0.86880	0.797	0.182	-0.400
0.7551	0.88590	0.859	0.221	-0.535	0.87502	0.718	0.159	-0.341
0.7998	0.89119	0.783	0.190	-0.452	0.88009	0.661	0.136	-0.288
0.8555	0.89796	0.698	0.145	-0.337	0.88655	0.596	0.103	-0.216
0.8999	0.90348	0.637	0.103	-0.240	0.89182	0.549	0.072	-0.154
0.9555	0.91066	0.568	0.034	-0.110	0.89865	0.495	0.018	-0.071
1	0.91632	0.518	0	0	0.90400	0.456	0	0
	BA (1) + Hexane-2-ol (2)							
0	0.81082	4.101	0	0	0.80172	2.920	0	0
0.0551	0.81587	3.742	0.025	-0.175	0.80683	2.694	0.020	-0.102
0.1000	0.81987	3.477	0.042	-0.293	0.81089	2.526	0.032	-0.171
0.1554	0.82482	3.172	0.062	-0.413	0.81591	2.330	0.046	-0.242
0.1998	0.82875	2.948	0.075	-0.490	0.81988	2.185	0.056	-0.289
0.2554	0.83359	2.690	0.089	-0.565	0.82478	2.015	0.067	-0.334
0.2999	0.83745	2.499	0.098	-0.608	0.82867	1.889	0.074	-0.360
0.3554	0.84221	2.280	0.107	-0.643	0.83348	1.743	0.080	-0.382
0.3999	0.84597	2.119	0.113	-0.657	0.83728	1.634	0.084	-0.392
0.4555	0.85062	1.934	0.116	-0.658	0.84196	1.508	0.087	-0.394
0.4999	0.85434	1.796	0.117	-0.648	0.84571	1.413	0.087	-0.389
0.5554	0.85892	1.639	0.116	-0.621	0.85032	1.304	0.086	-0.374
0.5999	0.86253	1.523	0.113	-0.590	0.85395	1.222	0.084	-0.356
0.6551	0.86703	1.390	0.106	-0.539	0.85847	1.128	0.079	-0.327
0.7000	0.87060	1.291	0.099	-0.490	0.86205	1.057	0.074	-0.298
0.7551	0.87501	1.178	0.088	-0.420	0.86648	0.957	0.065	-0.256
0.7998	0.87853	1.095	0.076	-0.355	0.87000	0.914	0.057	-0.217
0.8555	0.88286	0.999	0.059	-0.267	0.87434	0.844	0.044	-0.164
0.8999	0.88631	0.928	0.044	-0.191	0.87779	0.791	0.033	-0.117
0.9555	0.89057	0.847	0.024	-0.088	0.88205	0.729	0.018	-0.054
1	0.89399	0.787	0	0	0.88546	0.684	0	0

Table 3: Adjustable parameters of Eq 3 and 4 for the Mathematical Representation of Excess Functions for binary liquid mixture of Acrylic esters (1) + Hexane-2-ol (2) at T= (298.15 and 308.15) K.

Property	T/K	a_0	a_1	a_2	a_3	a_4	σ
	MA (1) + Hexane-2-ol (2)						
V^E(cm^{3}mol^{-1})	298.15	1.7784	-0.0737	-0.9478	0.2985	1.7371	0.01130
	308.15	1.3758	0.1471	-0.6979	-0.0833	1.5031	0.02948
Δη(mPa.s)	298.15	-3.6731	1.3072	-0.3491	0.0626	-0.0211	0.00022
	308.15	-2.3532	0.7662	-0.1820	0.0267	-0.0162	0.00044
	EA (1) + Hexane-2-ol (2)						
V^E(cm^{3}mol^{-1})	298.15	1.1943	0.0657	0.2958	-0.2558	-0.6457	0.00512
	308.15	0.8609	0.0677	0.3194	-0.2700	-0.7119	0.00536
Δη(mPa.s)	298.15	-3.4090	1.1296	-0.2905	0.0697	-0.0112	0.00033
	308.15	-2.1388	0.6417	-0.1314	0.0271	-0.0281	0.00025
	BA (1) + Hexane-2-ol (2)						
V^E(cm^{3}mol^{-1})	298.15	0.4700	-0.0204	-0.0431	0.0687	0.1149	0.00134
	308.15	0.3506	-0.0072	-0.0552	0.0295	0.1409	0.00110
Δη(mPa.s)	298.15	-2.5912	0.6964	-0.1479	0.0273	0.0014	0.00026
	308.15	-1.5649	0.3745	-0.0106	-0.0015	-0.0674	0.00185

Table 4: Adjustable parameters of Eq 5,6,7,8 and 9 for Mathematical Representation of Excess Functions for binary liquid mixture of Acrylic esters (1) + Hexane-2-ol (2) at T= (298.15 and 308.15) K.

T/K	G_{12}	σ	T_{12}	σ	Z_{12}	Z_{21}	σ	Z_{1112}	Z_{1122}	Z_{2221}	σ
	MA (1) + Hexane-2-ol (2)										
298.15	-0.001	0.027	0.118	13.795	1.066	2.338	0.032	0.869	1.445	2.833	0.607
308.15	-0.002	0.047	0.265	10.068	0.875	1.799	0.055	0.726	1.148	2.144	2.136
	EA (1) + Hexane-2-ol (2)										
298.15	-0.001	0.029	0.451	8.840	1.180	2.452	0.025	0.981	1.686	2.937	0.934
308.15	-0.001	0.029	0.52	6.125	0.979	1.896	0.037	0.828	1.353	2.229	1.475
	BA (1) + Hexane-2-ol (2)										
298.15	-0.001	0.016	1.244	2.482	1.573	2.818	0.016	1.360	2.342	3.260	1.512
308.15	-0.003	0.122	1.090	1.578	1.290	2.167	0.124	1.134	1.859	2.466	2.149

Table 5: Adjustable parameters of Equation 10 and 11 for the Mathematical Representation of Excess Functions for binary liquid mixture of Acrylic esters (1) + Hexane-2-ol (2) at T= (298.15 and 308.15) K.

Property	a_0	a_1	a_2	a_3	a_4	σ	APD
	MA (1) + Hexane-2-ol (2)						
ρ(g.cm^{-3})	-52.6004	20.5928	114.2616	-223.2918	-348.7572	12.7315	3.7944
η(mPa.s)	6.4597	26.0236	-110.6110	-22.4278	121.2688	3.4706	0.8388
	EA (1) + Hexane-2-ol (2)						
ρ(g.cm^{-3})	-5.3554	-0.4984	-0.8524	0.7226	1.8238	1.8929	0.0235
η(mPa.s)	38.1570	-21.2861	-105.9921	211.3677	325.2454	8.5732	3.7922
	BA (1) + Hexane-2-ol (2)						
ρ(g.cm^{-3})	4.5025	-0.4116	0.1366	-0.0885	-0.2505	0.3233	0.0144
η(mPa.s)	-0.7703	-0.0666	2.8808	-0.6024	-3.2680	1.9212	0.0305

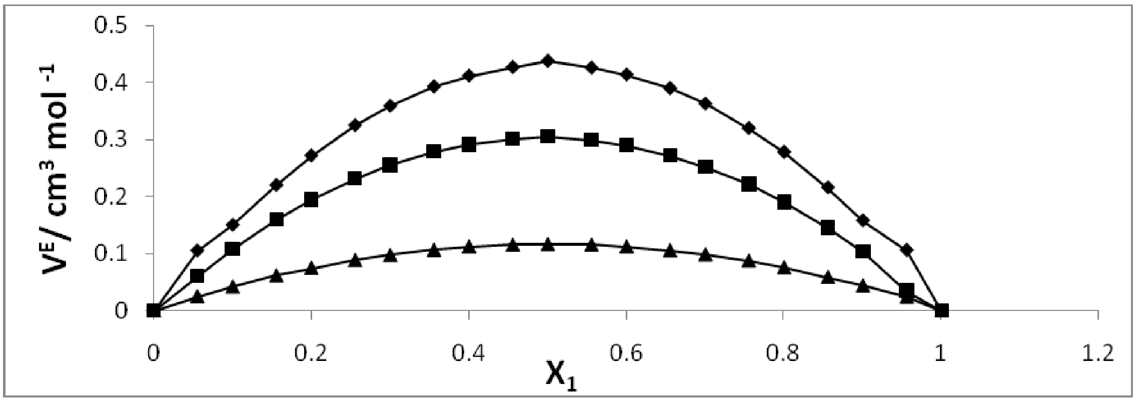

Figure 1: Variation of excess molar volumes with acrylic ester mole fraction for binary mixtures of Acrylic esters (1) + Hexane-2-ol (2) at 298.15 K:♦, Methyl acrylate; ■,Ethyl acrylate;▲, Butyl acrylate.

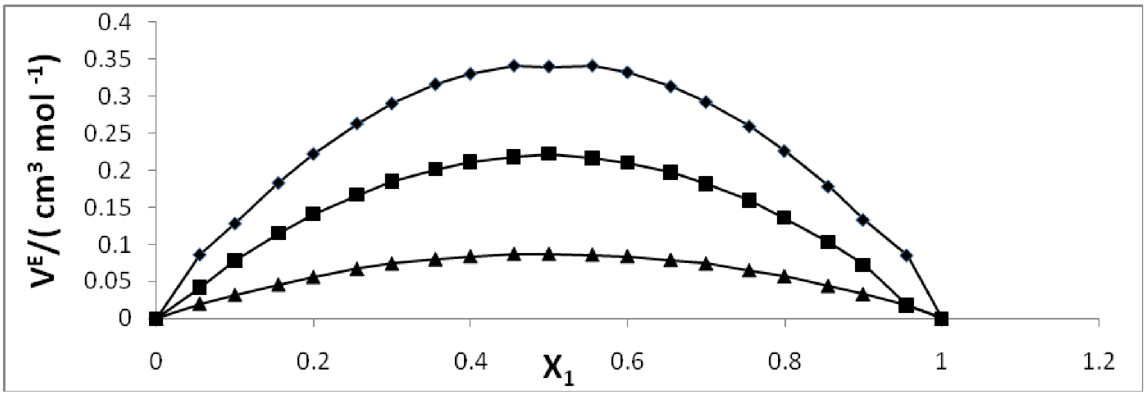

Figure 2: Variation of excess molar volumes with acrylic ester mole fraction for binary mixtures of Acrylic esters (1) + Hexane-2-ol (2) at 308.15 K: ♦, Methyl acrylate, ■,Ethyl acrylate,▲, Butyl acrylate.

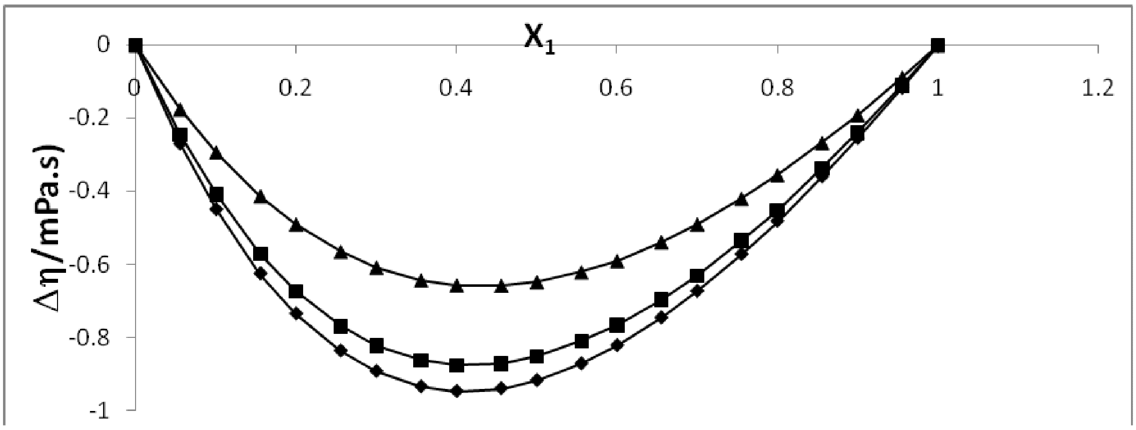

Figure 3: Variation of deviation in viscosity with acrylic ester mole fraction for binary mixtures of Acrylic esters (1) + Hexane-2-ol (2) at 298.15 K: ♦, Methyl acrylate, ■,Ethyl acrylate,▲, Butyl acrylate.

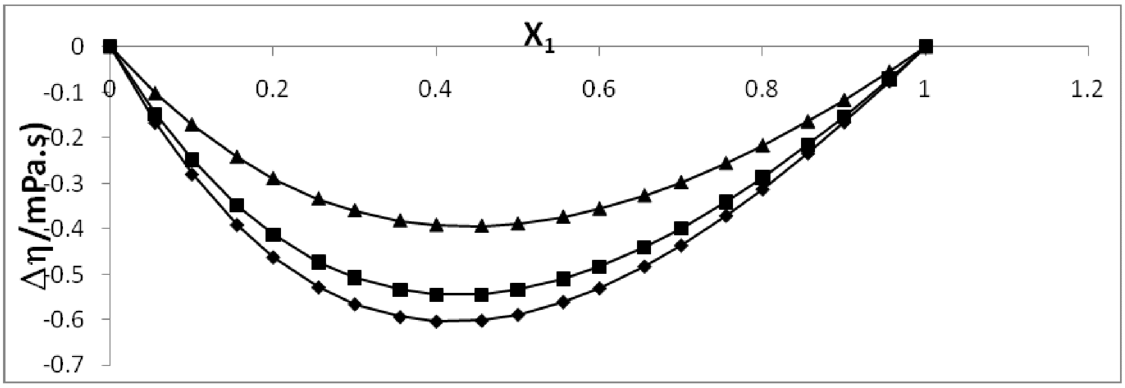

Figure 4: Variation of deviation in viscosity with acrylic ester mole fraction for binary mixtures of Acrylic esters (1) + Hexane-2-ol (2) at 308.15 K: ♦, Methyl acrylate,■, Ethyl acrylate,▲, Butyl acrylate.