# CHAPTER IV

# Study of Densities, Viscosities and Ultrasonic Speeds of Binary Mixtures Containing 1, 2 - Dimethoxyethane and Some Alkan-1-ol at 298.15 K

The viscosity deviation ($\Delta\eta$), the excess molar volume ($V^E$), and ultrasonic speed ($u$) have been investigated from the viscosity ($\eta$) and density ($\rho$) measurements of binary liquid mixture of 1,2-dimethoxyethane with methanol, ethanol, propan-1-ol, butan-1-ol, pentan-1-ol, hexan-1-ol and octan-1-ol over the entire range of composition at 298.15 K. The excess volumes are negative over the entire range of composition for all mixtures with the exception of hexan-1-ol and octan-1-ol. The excess isentropic compressibility ($K_S^E$) and viscosity deviation are negative for all mixtures. The magnitudes of negative values of ($V^E$) decrease with the number of carbon atoms of the alkan-1-ol. The trend of increasing $K_S^E$ with the chain length of alkanol is similar to that observed in case of $V^E$. Graphs of $V^E$, $\Delta\eta$, $K_S^E$, $\Delta u$, $L_f^E$, and $Z^E$ against composition are presented as a basis for a qualitative discussion of the results.

**Keywords:** Density; viscosity; excess molar volume; viscosity deviation; isentropic compressibility; alkan-1-ol; 1,2- dimethoxyethane; excess intermolecular free length; excess acoustic impedance, interaction parameters.

## 4.1. Introduction

Grouping of solvents into classes is often based on the nature of the intermolecular forces because the manner whereby solvent molecules are associated with each other brings about a marked effect on the resulting properties. After the introduction of the concept of ionization power of

solvents[1], much work has been devoted to the solvent effects on the rate and equilibrium processes [2]. The determination of density, viscosity, and speeds of sound is a valuable tool to learn about the liquid state [3] because of the close connection between liquid structure and macroscopic properties.

The speed of sound u, isentropic compressibility ($K_S$), viscosity deviation ($\Delta \eta$), and excess molar volumes ($V^E$) are the properties sensitive to different kinds of association in the pure components and in the mixtures. They have been used to investigate the molecular packing, molecular motions, and various types of intermolecular interactions and their strength, influenced by the size, shape, and chemical nature of component molecules [4-6].

Systematic investigations of speeds of sound, isentropic compressibilities, viscosity deviation, and excess molar volumes for binary liquid mixtures of an alkanols with dimethoxyethane have been undertaken. In this paper, we report studies on seven binary mixtures of methanol, ethanol, propan-1-ol, butan-1-ol, pentan-1-ol, hexan-1-ol and octan-1-ol with dimethoxyethane at 298.15 K. The liquids were selected on the basis of their industrial use [7-9].

To the best of our knowledge, the properties of mixtures of this liquid have not been reported earlier.

## 4.2. Experimental

### ***Chemicals***

1, 2- Dimethoxyethane, methanol ethanol propan-1-ol butan-1-ol, pentan-1-ol, hexan-1-ol and octan-1-ol was obtained from Merck and A.R. These were further purified by standard methods [4, 10]. Triply distilled water was used. The purity of the liquids was checked by measuring their densities, viscosities, and sound speeds at 298.15 K, which was in good agreement with the literature values [14-26]. The purity of the solvents were > 99.5 %.

***Apparatus and Procedure***

The speeds of sound ($u$) in pure liquids and in binary mixtures were measured with multi-frequency ultrasonic interferometer supplied by Mittal Enterprise, New Delhi. In the present work, a steel cell fitted with a quartz crystal of 2 MHz [11] - frequency was employed. Densities ($\rho$) were measured with an Ostwald-Sprengel type pycnometer having a bulb volume of 25 $cm^3$ and an internal diameter of the capillary of about 1mm. The pycnometer was calibrated at 298.15 K with triply distilled water and benzene. The pycnometer with the test solution was equilibrated in thermostatic water - bath maintained at $\pm$ 0.01°C of the desired temperature by means of mercury in glass thermo regulator and the temperature was determined with a calibrated thermometer and a Müller bridge [12]. The viscosities were measured by means of a suspended Ubbelohde type viscometer [13] which was calibrated at the desired temperatures with water and methanol. The solutions were prepared by mixing known volumes of pure liquids in airtight, narrow-mouth ground stoppered bottles taking due precautions to minimize the evaporation losses. The masses were determined by using a Mettler electronic analytical balance (AG285, Switzerland) accurate to 0.01mg. The uncertainties in the liquid composition, density, viscosity and speeds of sound measurements were estimated to be $\pm 1 \times 10^{-4}$, $\pm 2 \times 10^{-4}$ g. $cm^{-3}$, $\pm 3 \times 10^{-4}$ mPa.s, and $\pm$ 0.2 m. $s^{-1}$ respectively.

## 4.3. Results and Discussion

The comparison of the experimentally determined densities, viscosities, and sound speeds at 298.15 K of the pure components with the literature values [14-26] have been presented in Table I.

The excess molar volumes ($V^E$) are calculated from density data according to the following equation:

$$V^E = \sum_{i=1}^{2} x_i M_i (1/\rho - 1/\rho_i) \quad (1)$$

where, $M_i$ ,$\rho_i$ and $\rho$ are the molar mass, density of the ith component and density of the mixture respectively.

It has been suggested by Quin *et al.* [27] that relative change of volume in mixing ($\Delta V$), is also a relevant quantity. Its dependence on composition for similar pair of solvents follow similar patterns, while the corresponding dependence for $V^E$ often do not [27]. Therefore, we have also computed $\Delta V$ values from the following equation for the present mixtures.

$$\Delta V = V^E / \sum_{i=1}^{2} x_i V_i \quad (2)$$

The volume fraction ($\Phi_i$) of the *i*th components given as

$$\Phi_i = x_i V_i / \sum_{i=1}^{2} x_i V_i \quad (3)$$

The viscosity deviations ($\Delta\eta$) from linear dependence on mole fraction were calculated by

$$\Delta\eta = \eta - \sum_{i=1}^{2} x_i \eta_i \quad (4)$$

where, $\eta$ is the viscosity of the mixture and $x_i$, and $\eta_i$ is the mole fraction and viscosity of pure component, i respectively.

In Table III, the experimentally determined densities, viscosities, and calculated excess molar volumes and viscosity deviations of the binary mixtures are shown along with the mole fraction of dimethoxyethane $x_1$ at

298.15 K. Experimental results for $V^E$, $\Delta\eta$ and $\Delta V/\Phi_1\Phi_2$ are plotted against $x_1$ in Figs. 1-3.

Isentropic compressibility ($K_S$) and excess isentropic compressibility ($K_S^E$) were calculated from experimental densities, ($\rho$), and speeds of sound $u$, using the following equations:

$$K_S = 1 / u^2 . \rho \tag{5}$$

$$K_S^E = Ks - \sum_{i=1}^{2} x_i K_{S,i} \tag{6}$$

where, $K_{S,i}$ gives the isentropic compressibility for the $i$ th component of the mixture.

The deviations of speed of sound ($\Delta u$) has been calculated as has been common in the literature (Kiyohara, *et al.* 1978; Tamura *et al.* 1983; Aicart *et al.*, 1990) by

$$\Delta u = u - \sum_{i=1}^{2} x_1 u^0_1 \tag{7}$$

For each mixture, the values of $\Delta u$, $K_S^E$, $V^E$, and $\Delta\eta$ were fitted to a Redlich-Kister (1948) polynomial regression of the type

$$F(x) = x_1 x_2 \sum_{i=0}^{m} A_i (1 - 2 x_1)^i \tag{8}$$

where $F(x)$ = $\Delta u$, $K_S^E$, $V^E$, and $\Delta\eta$

The values of coefficients $A_i$ of equation 8 and the corresponding standard deviations $\delta$ obtained by the method of least square, assigning equal weights to each point, are given in table VI. The standard deviations $\delta$ have been defined as

$$\delta = [\Sigma ( Y_{obs} - Y_{cal} )^2 / ( n - m ) ]^{1/2} \qquad (9)$$

where $n$ and $m$ represent the number of experimental points and numbers of coefficients used in equation 8 and 9.

The ultrasonic speeds are given in table V, together with the deviations of speed of sound ($\Delta u$), isentropic compressibility ($K_S$) and excess isentropic compressibility ($K^E_S$) for alkan-1-ol + dimethoxyethane at 298.15 K.

Experimental results for $\Delta u$ and $K_S^E$ are plotted against mole fraction of dimethoxyethane in Figs. 4-5.

We have attempted to explain the physico-chemical behavior of the mixtures in order to know the nature of molecular interactions between the components by various acoustical parameters from the speeds of sound and density data. Various parameters such as specific impedance [31] ($Z$), intermolecular free length [32] ($L_f$), Vander Waal's constant ($b$), molecular radius [32] ($r$), geometrical volume ($B$), molar surface area ($Y$), available volume [33] ($V_a$), molar speed of sound [34] ($R$), collision factor [35] ($S$) and molecular association [36] ($M_A$) has been calculated using the following relations:

$$Z = u\rho \qquad (10)$$

$$b = (M/\rho) - (RT/\rho u^2) \{[1 + (Mu^2/3RT)]^{1/2} - 1\} \qquad (11)$$

$$r = (3b/16\pi N)^{1/3} \qquad (12)$$

$$L_f = K/(u\rho^{1/2}) \qquad (13)$$

$$B = (4/3)\,\pi r^3 \mathrm{N} \tag{14}$$

$$Y = (36\,\pi \mathrm{N} B^2)^{1/3} \tag{15}$$

$$V_a = V - V_0 \tag{16}$$

$$R = Mu^{1/3} / \rho \tag{17}$$

$$S = u\,V / u_\infty B \tag{18}$$

$$M_A = [(u_{mix} / \sum x_i u_i)^2 - 1] \tag{19}$$

where $K$ is a temperature dependent constant (= (93.875 + 0.375 $T$) x $10^{-8}$) [32], $V_0$ is volume at absolute zero, $u_\infty$ is taken as 1600 $ms^{-1}$. These parameters are listed in Table II for the pure components and in Table V for the binary mixtures.

The excess functions of acoustic impedance $Z$ and intermolecular free length $L_f$ were calculated using the following equations:

$$L^E_f = L_f - \sum_{i=1}^{2} x_i L_{fi} \tag{20}$$

$$Z^E = Z - \sum_{i=1}^{2} x_i Z_i \tag{21}$$

The observed values of $L_f^E$ and $Z^E$ with mole fraction of $x_1$ for all systems studied at 298.15 K are depicted in Figs. 6 and 7, respectively. The values of $L_f^E$ and $Z^E$ were fitted to polynomial similar to that given by equation 8. Parameters $A_i$ along with standard deviations $\delta$ is give in Table VI.

The several models (equations) have been put forward to correlate the viscosity of binary liquid mixtures in terms of pure–components data. Some of them are discussed as under:

(i) Grunberg and Nissan [42] suggested a logarithmic relation between the viscosity of liquid mixture and that of its pure components,

$$\eta = \exp (x_1 \ln \eta_1 + x_2 \ln \eta_2 + x_1 x_2 G_{12}) \qquad (22)$$

where $G_{12}$ is a constant, regarded as a measure of the strength of molecular interactions between the mixing components.

(ii) Tamura and Kurata[43] developed the following equation for the viscosity of binary liquid mixtures:

$$\eta = x_1 \Phi_1 \eta_1 + x_2 \Phi_2 \eta_2 + 2 (x_1 x_2 \Phi_1 \Phi_2)^{1/2} T_{12} \qquad (23)$$

where $\Phi_1$ and $\Phi_2$ are the volume fractions of components 1 and 2, and $T_{12}$ and adjustable parameter.

(iii) Hind *et al.*[44] suggested the following equation for the viscosity of the binary liquid mixtures:

$$\eta = x_1^2 \eta_1 + x_2^2 \eta_2 + 2 x_1 x_2 \eta_1 \eta_2 H_{12} \qquad (24)$$

Table III records the calculated results, showing that all the models (equations) are in good agreements with the experimental data.

As can be seen from Fig. I that $V^E$ is negative for all alkan-1-ol mixtures with the exception of hexan-1-ol and octan-1-ol over the entire range of composition. The magnitude of the negative values of $V^E$ decreases with increasing chain length of the alkan-1-ol in dimethoxyethane. The values of $V^E$ at first decreases to minimum value and then increases for $C_1$- $C_5$ alkan-1-ol over the entire range of compositions while the values of $V^E$ is positive for $C_6$ and $C_8$ alkan-1-ol. Such behavior is the result of contribution from several contraction and expansion processes which proceed simultaneously when alkan-1-ol – dimethoxyethane molecules are formed. The following effects can

be considered: (a) disruption of liquid order on mixing and unfavorable interactions between unlike molecules producing a positive contribution of $V^E$; (b) contraction due to free volume difference of unlike molecules, and (c) possible association through hydrogen bond –OH....O- formation between alkan-1-ol and dimethoxyethane producing a negative contribution to $V^E$. The large positive $V^E$ observed in the case of ROH + $C_6H_{12}$ [37] and $R_2NH$ + $C_6H_{12}$ [38] mixtures, as a result of disruption of the self-association of alkan-1-ol and amine by the addition of inert hydrocarbon molecules. Thus, the observed negative values of $V^E$ can be accounted only considering predominance of an energetically favored [39, 40] cross bonding –OH....O-, bond over the rupture of -OH...OH- bonds present in pure alkan-1-ol.

The plots of $\Delta V/\Phi_1\Phi_2$ against $x_1$ are shown in Fig 3. When a given dimethoxyethane is mixed with a series of alkan-1-ols, the value of $\Delta V/\Phi_1\Phi_2$ increases regularly with the number of carbon atoms in alkan-1-ol. The values of $\sum {}^{n}{}_{i=1} A_i$ and $\sum {}^{n}{}_{i=1} A_i (-1)^i$ of equation (8) represent the limiting values of excess partial molar volumes of $V_i^{E,\infty}$ of both dimethoxyethane and alkan-1-ol equivalent to $V_1^{E,\infty}$ and $V_2^{E,\infty}$.The limiting values of excess partial molar volumes(EPMV)[39] of dimethoxyethane $V_1^{E,\infty}$ vary from -1.976 $cm^3$ $mol^{-1}$ to 0.657 $cm^3.mol^{-1}$ in methanol to octan-1-ol and alkanols these values are in the range from -3.712 $cm^3$. $mol^{-1}$ to -0.247 in dimethoxyethane. The negative contribution to EPMV for both dimethoxyethane alkan-1-ol in the present mixtures clearly suggests specific interaction between the components and the free volume effect when a mixture is formed [39].

The values of $\Delta\ \eta$ (fig.2) are negative which regularly increase as the size or viscosity of the alkan-1-ol is increased. It is known that the strength of the molecular hydrogen bonding is not only factor influencing the viscosity deviations in liquid mixtures [39, 41]. The molecular size and shape of the components and average degree of association of the mixture are equally important factors. The negative values of $\Delta\ \eta$ indicate that the average degree of cross- association of mixtures gradually decreases as the chain length of

alkan-1-ol is increased [38, 39]. Thus, larger the chain length of alkan-1-ol, the greater is the decrease in the average degree of association, as result more negative deviations in viscosity versus mole fraction curve are observed.

The values of (Fig.4) $K_S^E$ are negative and the magnitude of negative values decrease with increasing number of carbon atoms of alkan-1-ol, attain a minimum value and then increase regularly over the whole composition range for all the mixtures. The overall behavior of $K_S^E$ is similar for $\Delta u$ but of opposite sign. Also, the behavior of $V^E$ seems to be consistent with minimum values of $K_S^E$ and a maximum value of $\Delta u$ for all the mixture studied. The negative value of $K_S^E$ mean that the mixture is less compressible, suggesting that there may be strong intermolecular hydrogen bonding with alkan-1-ol. However, $V^E$ is positive for hexan-1-ol and octan-1-ol, although $K_S^E$ is negative and $\Delta u$ (Fig.5) is likewise positive for all the mixtures, indicating that when the mixtures are created "excess free volumes" increase and is higher in mixtures containing hexan-1-ol and octan-1-ol. Again the effect is that while going from methanol to octan-1-ol, interstitial accommodation becomes less important, that the molecule of the two components can not accommodate easily [37, 40]. This additional rigidity is a good reason for the positive value of $V^E$ and $\Delta u$ [40].

The variations of $V_a$, $Z$, $L_f$, $R$ and $M_A$ for binary mixtures with $x_1$ are given in Table IV. It is seen from table IV that $Z$ increase with mole fraction of $x_1$ attains a maximum value and thereafter decreases for alkan-1-ol containing 1- 4 carbon atoms, while, for alkan-1-ol with 5 - 8 carbon atoms shows the decreasing trend with $x_1$. The values of $R$ increase for $C_1$ - $C_4$ alkan-1-ol and decrease regularly for $C_5$ - $C_8$ alkan-1-ol with $x_1$. $K_S$ and $L_f$ decrease to attain minimum value and then increase for $C_1$ - $C_4$, while these parameters increase regularly for $C_5$ –$C_6$ over the entire rang of composition. Sound speed increase up to certain mole fraction of $x_1$ for $C_1$ - $C_4$ alkan-1-ol, thereafter showing a continuous decrease for the system, whereas sound speed decrease regularly for $C_5$ –$C_6$ over the entire rang of composition. The increase in $u$ and the corresponding decrease in $K_S$ and $L_f$ suggest significant interaction between

alkan-1-ol and dimethoxyethane molecule. However, because of formation of strong hydrogen bond between alkan-1-ol and dimethoxyethane leads to cause contraction in the volume in mixing formation, which in turns increasing the magnitude of $V_a$.

The values of $R$ increase for mixture containing $C_1$, $C_2$, $C_3$ and $C_4$ in alkan-1-ol, and decreases for $C_5$, $C_6$ and $C_8$ alkan-1-ol. Similarly, the large positive deviations in $M_A$ for alkan-1-ol + dimethoxyethane systems and these deviations decrease from methanol to octan-1-ol. Thus, it is concluded that the intermolecular hydrogen bonding or average degree of association decreases as the chain length of alkan-1-ol increases in the mixtures.

The trend reported in Fig. 6 and 7 can be interpreted in terms of molecular interactions of the solution components. Fig.6 and 7 shows that $L_f^E$ is negative while $Z^E$ is positive for all the binary mixtures over the entire rang of compositions. Positive and negative deviations in these functions from rectilinear dependence on composition for the present system are indicative of interactions between unlike molecules. The observed very large negative values of $L_f^E$ can be accounted only considering the predominance of the formation of – OH...O- bonds over rupture of –OH...OH- hydrogen bonds present in pure alkan-1-ol. The magnitude of negative values of $L_f^E$ decreases as the number of carbon atoms in the alkan-1-ol increase. The observed large negative values of $L_f^E$ over the entire range of compositions for all the binary mixtures supports the conclusions drawn from the $V^E$ and $K_S^E$ values.

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**Table I. Comparison of Experimental Densities ($\rho$), Viscosities ($\eta$), and Ultrasonic Speeds ($u$) of Pure Liquids with Literature Values at 298.15 K**

| | $\rho$ x $10^{-3}$ ($kg.m^{-3}$) | | $\eta$ x $10^{3}$ (Pa.s) | | $u$ ($m.s^{-1}$) | |
|---|---|---|---|---|---|---|
| Liquids | Observed | Literature | Observed | Literature | Observed | Literature |
| Dimethoxyethane | 0.86109 | 0.86109[a] | 0.41735 | 0.4089[a] | 1146 | - |
| | | 0.86126[b] | | 0.417[b] | | |
| Methanol | 0.78664 | 0.78656[c,d] | 0.54230 | 0.5422[c,d] | 1105.1 | 1103.0[e] |
| Ethanol | 0.78514 | 0.7851[f] | 1.08805 | 1.088[f] | 1143.00 | 1145.00[g] |
| Propan-1-ol | 0.79958 | 0.79954[h] | 2.00401 | 2.004[i] | 1207.2 | 1206.5[h] |
| Butan-1-ol | 0.80589 | 0.8057[i] | 2.56041 | 2.5600[i] | 1240.6 | 1240.00[k] |
| | | 0.80581[j] | | | | |
| Pentan-1-ol | 0.81098 | 0.81108[j] | 3.5100 | 3.510[l] | 1280.9 | 1280.00[m] |
| Hexan-1-ol | 0.81515 | 0.81515[j] | 4.59002 | 4.590[l] | 1329.01 | 1328.00[m] |
| Octan-1-ol | 0.82158 | 0.82162[j] | 7.36502 | 7.363[l] | 1349.69 | - |

[a]Ref. from (14)
[b]Ref. from (15)
[c]Ref. from (16)
[d]Ref. from (17)
[e]Ref. from (18)
[f]Ref. from (19)
[g]Ref. from (20)
[h]Ref. from (21)
[i]Ref. from (22)
[j]Ref. from (23)
[k]Ref. from (24)
[l]Ref.. from (25)
[m]Ref. from (26)

**Table II. Vander Wall's Constant ($b$), Molecular Radius ($r$), Geometrical Volume ($B$), Collision Factor ($S$), Molar Speed of Sound ($R$), Available Volume ($V_a$) , Intermolecular Free Length ($L_f$), Molar Volume at Absolute Zero ($V_0$) , Molar Surface Area ($Y$) and Specific Acoustic Impedance ($Z$) of the Pure Component at 298.15 K[a].**

| Component | $b \times 10^6$ | $r \times 10^{10}$ | $B \times 10^5$ | $S$ | $R \times 10^4$ | $V_a \times 10^5$ | $L_f \times 10^{11}$ | $V_0 \times 10^5$ | $Y \times 10^{-4}$ | $Z \times 10^{-3}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| Dimethoxyethane | 408.80 | 3.4339 | 10.2200 | 0.73 | 10.9520 | 2.9697 | 6.1163 | 7.4961 | 89.2868 | 986.81 |
| Methanol | 87.51 | 2.0542 | 2.1879 | 1.29 | 4.2110 | 1.2598 | 6.6359 | 2.8132 | 31.9525 | 869.33 |
| Ethanol | 160.06 | 2.5120 | 4.0087 | 1.05 | 6.1351 | 1.6796 | 6.4221 | 4.1881 | 47.8434 | 897.42 |
| Propan-1-ol | 250.66 | 2.9173 | 6.2667 | 0.91 | 8.0034 | 1.8453 | 6.0252 | 5.6711 | 64.4435 | 965.25 |
| Butan-1-ol | 352.40 | 3.2681 | 8.8101 | 0.81 | 9.8826 | 2.0659 | 5.8402 | 7.1314 | 80.8737 | 999.79 |
| Pentan-1-ol | 471.07 | 3.6001 | 11.7770 | 0.7388 | 11.8030 | 2.1675 | 5.6383 | 8.7005 | 98.1393 | 1038.93 |
| Hexan-1-ol | 609.05 | 3.9219 | 15.2260 | 0.6838 | 13.782 | 2.1231 | 5.4206 | 10.4120 | 116.469 | 1083.34 |
| Octan-1-ol | 885.91 | 4.4437 | 20.2148 | 0.6037 | 17.5180 | 2.4798 | 5.3166 | 13.3710 | 149.5235 | 1108.88 |

[a]Units: $b$, $m^3$; $r$, m; $B$, $m^3.mol^{-1}$; $R$, $m^3.mol^{-1}(m.s^{-1})^{1/3}$; $V$a, $m^3.mol^{-1}$; $L_f$, m; $V_0$ , $m^3.mol^{-1}$; $Y$, m; $Z$, $kg.m^{-2}.s^{-1}$.

## Table III. Densities ($\rho$), Viscosities ($\eta$), Excess Molar Volumes ($V^E$) and Viscosity Deviation ($\Delta\eta$) of Binary Mixtures of Alkan-1-ol + Dimethoxyethane at 298.15 K

| Mole fraction dimethoxyethane ($x_1$) | $\rho$ x $10^{-3}$ / (kg.m$^{-3}$) | $\eta$ x $10^3$ / (Pa .s) | $V^E$ x $10^6$ / (m$^3$.mol$^{-1}$) | $\Delta\eta$ x $10^3$/ (Pa. s) | $G_{12}$ | $T_{12}$ | $H_{12}$ |
|---|---|---|---|---|---|---|---|
| **Dimethoxyethane (1) + Methanol (2)** | | | | | | | |
| 0.03801 | 0.79586 | 0.53330 | -0.12812 | -0.00425 | -0.19 | 0.53 | 0.42 |
| 0.08163 | 0.80449 | 0.52517 | -0.22902 | -0.00693 | -0.14 | 0.53 | 0.43 |
| 0.13223 | 0.81293 | 0.51416 | -0.32332 | -0.01162 | -0.16 | 0.53 | 0.43 |
| 0.19160 | 0.82100 | 0.49464 | -0.39883 | -0.02372 | -0.27 | 0.50 | 0.40 |
| 0.26228 | 0.82869 | 0.47898 | -0.45146 | -0.03055 | -0.29 | 0.50 | 0.40 |
| 0.34780 | 0.83613 | 0.46275 | -0.48571 | -0.03609 | -0.30 | 0.49 | 0.40 |
| 0.45342 | 0.84333 | 0.44963 | -0.49705 | -0.03602 | -0.28 | 0.49 | 0.41 |
| 0.58713 | 0.85006 | 0.43554 | -0.45728 | -0.03340 | -0.27 | 0.48 | 0.41 |
| 0.76190 | 0.85611 | 0.42091 | -0.32321 | -0.02619 | -0.30 | 0.47 | 0.41 |
| **Dimethoxyethane (1) + Ethanol (2)** | | | | | | | |
| 0.05375 | 0.79345 | 0.95653 | -0.10196 | -0.09547 | -1.52 | 0.15 | -0.19 |
| 0.11332 | 0.80184 | 0.83287 | -0.20722 | -0.17918 | -1.58 | 0.16 | -0.18 |
| 0.17972 | 0.81000 | 0.73694 | -0.29103 | -0.23057 | -1.47 | 0.22 | -0.03 |
| 0.25418 | 0.81796 | 0.66302 | -0.35335 | -0.25455 | -1.33 | 0.28 | 0.08 |
| 0.33828 | 0.82584 | 0.59309 | -0.40212 | -0.26808 | -1.26 | 0.32 | 0.15 |
| 0.43401 | 0.83347 | 0.54438 | -0.42056 | -0.25258 | -1.13 | 0.37 | 0.24 |
| 0.54397 | 0.84069 | 0.49260 | -0.38624 | -0.23061 | -1.09 | 0.35 | 0.29 |
| 0.67157 | 0.84764 | 0.48596 | -0.30521 | -0.17867 | -1.00 | 0.42 | 0.35 |
| 0.82146 | 0.85446 | 0.43557 | -0.18330 | -0.10153 | -0.60 | 0.46 | 0.41 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Dimethoxyethane (1) + Propan-1-ol (2)** | | | | | | | |
| 0.06899 | 0.80622 | 1.58778 | -0.08502 | -0.30677 | -1.94 | -0.71 | -1.18 |
| 0.14290 | 0.81310 | 1.26383 | -0.18806 | -0.51344 | -1.93 | -0.52 | -0.89 |
| 0.22228 | 0.81979 | 1.05609 | -0.26921 | -0.59524 | -1.69 | -0.23 | -0.51 |
| 0.30776 | 0.82638 | 0.85909 | -0.33408 | -0.65661 | -1.71 | -0.10 | -0.33 |
| 0.40008 | 0.83284 | 0.73033 | -0.38005 | -0.63889 | -1.59 | 0.05 | -0.12 |
| 0.50008 | 0.83881 | 0.62692 | -0.36754 | -0.58363 | -1.51 | 0.18 | 0.04 |
| 0.60877 | 0.84451 | 0.55279 | -0.31360 | -0.48531 | -1.34 | 0.22 | 0.19 |
| 0.72734 | 0.85010 | 0.49451 | -0.23385 | -0.35546 | -1.30 | 0.38 | 0.31 |
| 0.85718 | 0.85568 | 0.44820 | -0.13636 | -0.19576 | -1.25 | 0.46 | 0.41 |
| **Dimethoxyethane (1) + Butan-1-ol (2)** | | | | | | | |
| 0.08373 | 1.95471 | 0.81174 | -0.07405 | -0.42626 | -1.54 | -1.07 | -1.29 |
| 0.17055 | 1.47925 | 0.81790 | -0.17725 | -0.71566 | -1.69 | -0.86 | -1.04 |
| 0.26062 | 1.17608 | 0.82398 | -0.26435 | -0.82581 | -1.58 | -0.52 | -0.65 |
| 0.35413 | 0.94635 | 0.82991 | -0.32640 | -0.85514 | -1.54 | -0.28 | -0.38 |
| 0.45129 | 0.78829 | 0.83548 | -0.33958 | -0.80498 | -1.40 | -0.06 | -0.14 |
| 0.55231 | 0.66624 | 0.84080 | -0.31505 | -0.71054 | -1.39 | 0.11 | 0.05 |
| 0.65743 | 0.57968 | 0.84593 | -0.25828 | -0.57182 | -1.30 | -0.26 | 0.22 |
| 0.76689 | 0.51034 | 0.85098 | -0.18305 | -0.40658 | -1.24 | 0.38 | 0.35 |
| 0.88098 | 0.45425 | 0.85607 | -0.10057 | -0.21817 | -1.25 | 0.49 | 0.45 |
| **Dimethoxyethane (1) + Pentan-1-ol (2)** | | | | | | | |
| 0.09803 | 2.33524 | 0.81608 | -0.03298 | -0.87159 | -2.25 | -3.06 | -2.97 |
| 0.19649 | 1.78027 | 0.82102 | -0.05195 | -1.12206 | -1.65 | -1.66 | -1.59 |
| 0.29538 | 1.29472 | 0.82604 | -0.07405 | -1.30177 | -1.77 | -1.22 | -1.16 |
| 0.39471 | 1.02430 | 0.83108 | -0.09056 | -1.26500 | -1.64 | -0.72 | -0.68 |
| 0.49447 | 0.84837 | 0.83614 | -0.10150 | -1.13241 | -1.47 | -0.33 | -0.30 |
| 0.59468 | 0.70069 | 0.84119 | -0.01031 | -0.97017 | -1.43 | -0.07 | -0.05 |
| 0.69534 | 0.60360 | 0.84616 | -0.08825 | -0.75596 | -1.32 | 0.16 | 0.18 |
| 0.79644 | 0.53516 | 0.85111 | -0.06298 | -0.51173 | -1.14 | 0.37 | 0.39 |
| 0.89799 | 0.46331 | 0.85611 | -0.03595 | -0.26952 | -1.23 | 0.49 | 0.49 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Dimethoxyethane (1) + Hexan-1-ol (2)** | | | | | | | |
| 0.11188 | 2.87624 | 0.81968 | -0.02380 | -1.24694 | -2.00 | -4.42 | -3.77 |
| 0.22085 | 2.02794 | 0.82378 | 0.02367 | -1.64055 | -1.67 | -2.71 | -2.26 |
| 0.32702 | 1.49193 | 0.82762 | 0.11350 | -1.73354 | -1.54 | -1.76 | -1.43 |
| 0.43049 | 1.15234 | 0.83172 | 0.16873 | -1.64139 | -1.43 | -1.07 | -0.84 |
| 0.53136 | 0.90280 | 0.83643 | 0.14501 | -1.47003 | -1.41 | -0.62 | -0.45 |
| 0.62973 | 0.75442 | 0.84154 | 0.07501 | -1.20794 | -1.27 | -0.22 | -0.09 |
| 0.72570 | 0.63293 | 0.84667 | 0.01325 | -0.92898 | -1.21 | 0.08 | 0.17 |
| 0.81934 | 0.53902 | 0.85163 | -0.01705 | -0.63216 | -1.20 | 0.30 | 0.37 |
| 0.91075 | 0.46894 | 0.85643 | -0.02008 | -0.32082 | -1.20 | 0.49 | 0.53 |
| **Dimethoxyethane (1) + Octan-1-ol (2)** | | | | | | | |
| 0.13835 | 0.82519 | 4.22191 | 0.03222 | -2.18190 | -1.34 | -7.49 | -5.26 |
| 0.26539 | 0.82857 | 2.82370 | 0.10805 | -2.69748 | -1.01 | -4.48 | -3.03 |
| 0.38246 | 0.83197 | 1.92189 | 0.17832 | -2.78592 | -1.04 | -3.07 | -2.01 |
| 0.49067 | 0.83560 | 1.40179 | 0.21171 | -2.55422 | -1.00 | -1.99 | -1.22 |
| 0.59101 | 0.83946 | 1.08887 | 0.21332 | -2.17001 | -0.89 | -1.17 | -0.60 |
| 0.68430 | 0.84357 | 0.85225 | 0.18340 | -1.75848 | -0.89 | -0.60 | -0.18 |
| 0.77126 | 0.84780 | 0.67451 | 0.14361 | -1.33205 | -1.00 | -0.18 | 0.12 |
| 0.85251 | 0.85654 | 0.56606 | 0.10205 | -0.87600 | -0.94 | 0.21 | 0.41 |
| 0.92860 | 0.85661 | 0.47891 | 0.04550 | -0.43450 | -1.02 | 0.49 | 0.61 |

**Table IV. Molar Surface Area ($Y$), Available Volume ($V_a$), Molar Speed of Sound ($R$), Intermolecular Free Length ($L_f$), Specific Acoustic Impedance ($Z$) and Molecular Association ($M_A$) for Dimethoxyethane + Alkan-1-ol at 298.15 K[b].**

| Mole fraction dimethoxyethane ($x_1$) | $Y$x10$^{-4}$ | $V_a$x10$^5$ | $R$x10$^4$ | $L_f$x10$^{11}$ | $Z$ x 10$^{-3}$ | $M_A$ |
|---|---|---|---|---|---|---|
| **Dimethoxyethane (1) + Methanol (2)** | | | | | | |
| 0.03801 | 34.4475 | 1.2776 | 4.4758 | 6.4809 | 895.32 | 0.0333 |
| 0.08163 | 37.1067 | 1.3244 | 4.4771 | 6.3805 | 914.33 | 0.0513 |
| 0.13223 | 40.1295 | 1.3884 | 5.1121 | 6.2983 | 931.10 | 0.0637 |
| 0.19160 | 43.6884 | 1.4652 | 5.5156 | 6.2196 | 947.56 | 0.0754 |
| 0.26228 | 47.9714 | 1.5526 | 6.0013 | 6.1302 | 965.87 | 0.0892 |
| 0.34780 | 53.1515 | 1.6626 | 6.5914 | 6.0577 | 982.64 | 0.1005 |
| 0.45342 | 59.4927 | 1.8058 | 7.3193 | 5.9891 | 997.31 | 0.1076 |
| 0.58713 | 67.1440 | 2.0393 | 8.2235 | 5.9751 | 1003.62 | 0.0934 |
| 0.76190 | 76.8182 | 2.3910 | 9.3919 | 6.0046 | 1002.26 | 0.0615 |
| **Dimethoxyethane (1) + Ethanol (2)** | | | | | | |
| 0.05375 | 50.3715 | 1.6939 | 6.4073 | 6.3162 | 917.27 | 0.0227 |
| 0.11332 | 53.15902 | 1.7228 | 6.7045 | 6.2235 | 935.85 | 0.0420 |
| 0.17972 | 56.2273 | 1.7641 | 7.0366 | 6.1427 | 952.97 | 0.0585 |
| 0.25418 | 59.6246 | 1.8175 | 7.4084 | 6.0707 | 968.99 | 0.0728 |
| 0.33828 | 63.3785 | 1.8892 | 7.8248 | 6.0115 | 983.24 | 0.0831 |
| 0.43401 | 67.5684 | 1.9849 | 8.2976 | 6.9671 | 995.12 | 0.0887 |
| 0.54397 | 72.1029 | 2.1332 | 8.8280 | 5.9598 | 1000.65 | 0.0813 |
| 0.67157 | 77.0303 | 2.3500 | 9.4276 | 5.9935 | 999.12 | 0.0597 |
| 0.82146 | 82.6206 | 2.6332 | 10.1220 | 6.0536 | 993.17 | 0.0297 |
| **Dimethoxyethane (1) + Propan-1-ol (2)** | | | | | | |
| 0.06899 | 64.4435 | 1.8418 | 8.2349 | 5.9480 | 981.86 | 0.0249 |
| 0.14290 | 68.9964 | 1.8647 | 8.4693 | 5.8967 | 994.62 | 0.0418 |
| 0.22228 | 71.0693 | 1.9132 | 8.7128 | 5.8682 | 1003.56 | 0.0519 |
| 0.30776 | 73.6110 | 1.9742 | 8.9745 | 5.8477 | 1011.12 | 0.0601 |
| 0.40008 | 75.9859 | 2.0641 | 9.2481 | 5.8488 | 1014.87 | 0.0616 |
| 0.50008 | 78.3789 | 2.1896 | 9.5385 | 5.8752 | 1013.93 | 0.0554 |
| 0.60877 | 80.9728 | 2.3313 | 9.8574 | 5.9076 | 1011.78 | 0.0487 |
| 0.72734 | 83.6540 | 2.5035 | 10.1970 | 5.9560 | 1006.87 | 0.0377 |
| 0.85718 | 86.4611 | 2.7092 | 10.5630 | 6.0207 | 999.32 | 0.0229 |
| **Dimethoxyethane (1) + Butan-1-ol (2)** | | | | | | |
| 0.08373 | 82.1228 | 2.0675 | 9.9983 | 5.8025 | 1009.93 | 0.0187 |
| 0.17055 | 83.2467 | 2.0887 | 10.0600 | 5.7797 | 1017.74 | 0.0327 |
| 0.26062 | 84.2948 | 2.1265 | 10.2130 | 5.7696 | 1023.31 | 0.0432 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 0.35413 | 85.2220 | 2.1896 | 10.3170 | 5.7784 | 1025.43 | 0.0478 |
| 0.45129 | 85.8884 | 2.2952 | 10.4110 | 5.8193 | 1021.63 | 0.0420 |
| 0.55231 | 87.8740 | 2.3809 | 10.5250 | 5.8434 | 1020.65 | 0.0435 |
| 0.65743 | 87.5132 | 2.5041 | 10.6310 | 5.8953 | 1014.74 | 0.0362 |
| 0.76689 | 88.1474 | 2.6449 | 10.7370 | 5.9593 | 1006.83 | 0.02600 |
| 0.88098 | 88.7735 | 2.7959 | 10.8460 | 6.0296 | 998.07 | 0.0150 |
| | | | **Dimethoxyethane (1) + Pentan-1-ol (2)** | | | |
| 0.09803 | 96.8126 | 2.1971 | 11.739 | 5.6458 | 1040.72 | 0.0120 |
| 0.19649 | 97.0753 | 2.2411 | 11.671 | 5.6633 | 1040.63 | 0.0210 |
| 0.29538 | 96.4263 | 2.2912 | 11.598 | 5.6855 | 1039.75 | 0.0287 |
| 0.39471 | 95.6851 | 2.3546 | 11.520 | 5.71729 | 1037.11 | 0.0333 |
| 0.49447 | 94.8675 | 2.4252 | 11.438 | 5.7551 | 1033.43 | 0.0362 |
| 0.59468 | 93.9897 | 2.5052 | 11.354 | 5.8009 | 1028.36 | 0.0367 |
| 0.69534 | 92.8737 | 2.6157 | 11.256 | 5.8708 | 1019.12 | 0.0294 |
| 0.79644 | 91.6993 | 2.7315 | 11.156 | 5.9475 | 1008.91 | 0.0205 |
| 0.89799 | 90.4884 | 2.8514 | 11.054 | 6.0307 | 997.91 | 0.0101 |
| | | | **Dimethoxyethane (1) + Hexan-1-ol (2)** | | | |
| 0.11188 | 113.6368 | 2.1946 | 13.475 | 5.4651 | 1077.51 | 0.0092 |
| 0.22085 | 110.8524 | 2.2737 | 13.181 | 5.5173 | 1069.97 | 0.0160 |
| 0.32702 | 108.1650 | 2.3515 | 12.898 | 5.5724 | 1061.86 | 0.0220 |
| 0.43049 | 105.5134 | 2.4260 | 12.619 | 5.6284 | 1053.90 | 0.0272 |
| 0.53136 | 102.7412 | 2.5134 | 12.330 | 5.6950 | 1044.52 | 0.0278 |
| 0.62973 | 113.1924 | 2.6171 | 12.035 | 5.7764 | 1032.94 | 0.0227 |
| 0.72570 | 97.0530 | 2.7545 | 11.747 | 5.8593 | 1021.43 | 0.0171 |
| 0.81934 | 94.3526 | 2.8062 | 11.471 | 5.9441 | 1009.79 | 0.0113 |
| 0.91075 | 91.6936 | 2.9001 | 11.203 | 6.0368 | 997.09 | 0.0033 |
| | | | **Dimethoxyethane (1) + Octan-1-ol (2)** | | | |
| 0.13835 | 140.7708 | 2.6141 | 16.588 | 5.4113 | 1091.87 | 0.0025 |
| 0.26539 | 133.0807 | 2.6952 | 15.757 | 5.4914 | 1078.14 | 0.0086 |
| 0.38246 | 126.0652 | 2.7580 | 14.996 | 5.5690 | 1065.30 | 0.0137 |
| 0.49067 | 119.5644 | 2.8140 | 14.288 | 5.6485 | 1052.59 | 0.0160 |
| 0.59101 | 113.5542 | 2.8580 | 13.631 | 5.7266 | 1040.64 | 0.0169 |
| 0.68430 | 107.8685 | 2.9071 | 13.013 | 5.8130 | 1027.68 | 0.0132 |
| 0.77126 | 102.6326 | 2.9420 | 12.439 | 5.8960 | 1015.74 | 0.0092 |
| 0.85251 | 97.2707 | 2.9896 | 11.834 | 5.9782 | 1006.93 | -0.0008 |
| 0.92860 | 93.2787 | 2.9831 | 11.406 | 6.0567 | 993.92 | -0.0004 |

[b]**Units:** $R$, $m^3.mol^{-1}(m.s^{-1})^{1/3}$; $V$a, $m^3.mol^{-1}$; $L_f$, m; $Y$, m; $Z$, $kg.m^{-2}.s^{-1}$

**Table V. Speeds of Sound ($u$), Isentropic Compressibility ($K_S$), Excess Isentropic Compressibility ($K_S^E$), Deviation of Speed of Sound ($\Delta u$), Excess Intermolecular Free Length ($L_f^E$) and Excess Acoustic Impedance ($Z^E$), of Alkan-1-ol + Dimethoxyethane at 298.15 K[c].**

| Mole fraction dimethoxyethane ($x_1$) | $u$ | $K_S$ x$10^{10}$ | $K_S^E$x$10^{10}$ | $\Delta u$ | $L_f^E$x$10^{11}$ | $Z^E$x$10^{-3}$ |
|---|---|---|---|---|---|---|
| **Dimethoxyethane (1) + Methanol (2)** | | | | | | |
| 0.03801 | 1124.97 | 9.9285 | -4.21 | 18.2962 | -1.3525 | 21.5246 |
| 0.08163 | 1136.53 | 9.6231 | -6.58 | 28.0730 | -2.1299 | 35.4101 |
| 0.13223 | 1145.36 | 9.3769 | -8.25 | 34.8344 | -2.6889 | 46.2356 |
| 0.19160 | 1154.15 | 9.1439 | -9.65 | 41.1974 | -3.1674 | 55.7208 |
| 0.26228 | 1164.54 | 8.8982 | -10.00 | 48.6980 | -3.6942 | 65.7274 |
| 0.34780 | 1174.22 | 8.6742 | -11.90 | 54.8819 | -3.9748 | 72.4505 |
| 0.45342 | 1182.59 | 8.4788 | -12.20 | 58.9342 | -4.1120 | 74.7122 |
| 0.58713 | 1180.65 | 8.4393 | -10.50 | 51.5281 | -3.5573 | 65.2940 |
| 0.76190 | 1170.71 | 8.5226 | -6.93 | 34.4435 | -2.3542 | 43.4620 |
| **Dimethoxyethane (1) + Ethanol (2)** | | | | | | |
| 0.05375 | 1156.05 | 9.4303 | -2.70 | 12.8888 | -0.8946 | 15.0453 |
| 0.11332 | 1167.13 | 9.1553 | -4.91 | 23.7900 | -1.6395 | 28.3003 |
| 0.17972 | 1176.51 | 8.9191 | -6.67 | 32.9708 | -2.2444 | 39.4848 |
| 0.25418 | 1184.64 | 8.7116 | -8.07 | 40.8775 | -2.7367 | 48.8489 |
| 0.33828 | 1190.59 | 8.5424 | -9.00 | 46.5752 | -3.0715 | 55.5812 |
| 0.43401 | 1193.95 | 8.4166 | -9.39 | 49.6480 | -3.2228 | 58.9039 |
| 0.54397 | 1190.27 | 8.3960 | -8.60 | 45.6381 | -2.9595 | 54.6545 |
| 0.67157 | 1178.71 | 8.4913 | -6.49 | 33.6953 | -2.2323 | 41.6684 |
| 0.82146 | 1162.34 | 8.6624 | -3.42 | 16.8756 | -1.1730 | 22.3197 |
| **Dimethoxyethane (1) + Propan-1-ol (2)** | | | | | | |
| 0.06899 | 1217.86 | 8.3628 | -2.37 | 14.8822 | -0.8349 | 15.1226 |
| 0.14290 | 1223.25 | 8.2191 | -4.00 | 24.7955 | -1.4152 | 26.2891 |
| 0.22228 | 1224.17 | 8.1398 | -5.00 | 30.5735 | -1.7725 | 30.5576 |
| 0.30776 | 1223.55 | 8.0831 | -5.79 | 35.1849 | -2.0554 | 39.2147 |
| 0.40008 | 1218.57 | 8.0861 | -6.00 | 35.8549 | -2.1285 | 41.0243 |
| 0.50008 | 1208.77 | 8.1592 | -5.53 | 32.1749 | -1.9556 | 37.8683 |
| 0.60877 | 1198.07 | 8.2496 | -4.91 | 28.1267 | -1.7306 | 33.4249 |
| 0.72734 | 1184.41 | 8.3855 | -3.86 | 21.7232 | -1.3546 | 25.9686 |
| 0.85718 | 1167.87 | 8.5684 | -2.87 | 13.1294 | -0.8259 | 15.5892 |
| **Dimethoxyethane (1) + Butan-1-ol (2)** | | | | | | |
| 0.08373 | 1244.15 | 7.9586 | -1.69 | 11.4709 | -0.6082 | 11.1968 |
| 0.17055 | 1244.33 | 7.8964 | -2.99 | 19.8640 | -1.0759 | 20.1237 |
| 0.26062 | 1241.91 | 7.8687 | -3.97 | 25.9647 | -1.4250 | 26.9029 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 0.35413 | 1235.59 | 7.8926 | -4.46 | 28.4907 | -1.5958 | 30.2366 |
| 0.45129 | 1222.81 | 8.2447 | -4.60 | 24.9020 | -1.4550 | 27.6977 |
| 0.55231 | 1213.90 | 8.0713 | -4.097 | 25.5485 | -1.4929 | 28.0290 |
| 0.65743 | 1199.56 | 8.2153 | -3.60 | 21.1529 | -1.2642 | 23.4834 |
| 0.76689 | 1183.14 | 8.3947 | -2.66 | 15.0878 | -0.9264 | 16.9942 |
| 0.88098 | 1165.88 | 8.5937 | -1.56 | 8.6207 | -0.5384 | 9.7151 |
| **Dimethoxyethane (1) + Pentan-1-ol (2)** | | | | | | |
| 0.09803 | 1275.27 | 7.5347 | -1.10 | 7.5942 | -0.3836 | 6.8993 |
| 0.19649 | 1267.49 | 7.5815 | -1.94 | 13.0965 | -0.6892 | 11.9411 |
| 0.29538 | 1258.72 | 7.6408 | -2.66 | 17.6668 | -0.9399 | 16.2152 |
| 0.39471 | 1247.91 | 7.7267 | -3.12 | 20.2564 | -1.0967 | 18.7523 |
| 0.49447 | 1235.95 | 7.8292 | -3.42 | 21.7540 | -1.1956 | 20.2718 |
| 0.59468 | 1222.51 | 7.9543 | -3.50 | 21.8323 | -1.2166 | 20.4247 |
| 0.69534 | 1204.41 | 8.1470 | -2.91 | 17.3114 | -0.9987 | 16.4311 |
| 0.79644 | 1185.41 | 8.3613 | -2.11 | 11.9498 | -0.7150 | 11.4905 |
| 0.89799 | 1165.63 | 8.5970 | -1.10 | 5.8689 | -0.3684 | 5.7832 |
| **Dimethoxyethane (1) + Hexan-1-ol (2)** | | | | | | |
| 0.11188 | 1314.55 | 7.0600 | -0.99 | 6.0152 | -0.3334 | 4.9698 |
| 0.22085 | 1298.86 | 7.1955 | -1.69 | 10.2678 | -0.5695 | 7.9487 |
| 0.32702 | 1283.03 | 7.3400 | -2.28 | 13.8679 | -0.7571 | 10.0872 |
| 0.43049 | 1267.13 | 7.4882 | -2.74 | 16.9040 | -0.9169 | 12.1152 |
| 0.53136 | 1248.78 | 7.6665 | -2.87 | 17.0142 | -0.9523 | 12.4722 |
| 0.62973 | 1227.44 | 7.8872 | -2.53 | 13.6769 | -0.8230 | 10.3878 |
| 0.72570 | 1206.41 | 8.1152 | -2.07 | 10.2104 | -0.6617 | 8.1418 |
| 0.81934 | 1185.72 | 8.3519 | -1.48 | 6.6574 | -0.4652 | 5.5409 |
| 0.91075 | 1164.24 | 8.6143 | -0.90 | 1.9064 | -0.1741 | 1.6647 |
| **Dimethoxyethane (1) + Octan-1-ol (2)** | | | | | | |
| 0.13835 | 1349.69 | 6.9216 | -0.59 | 1.6705 | -0.1594 | -0.1216 |
| 0.26539 | 1323.18 | 7.1281 | -1.27 | 5.5773 | -0.3743 | 1.6562 |
| 0.38246 | 1301.21 | 7.3311 | -1.77 | 8.6633 | -0.5345 | 3.1069 |
| 0.49067 | 1280.45 | 7.5419 | -2.00 | 9.9346 | -0.6049 | 3.6061 |
| 0.59101 | 1259.68 | 7.7518 | -2.07 | 10.3428 | -0.6263 | 3.9046 |
| 0.68430 | 1239.65 | 7.9874 | -1.73 | 7.9451 | -0.5084 | 2.3325 |
| 0.77126 | 1218.25 | 8.2173 | -1.31 | 5.4979 | -0.3738 | 1.0077 |
| 0.85251 | 1198.09 | 8.4479 | -0.76 | -0.4622 | -0.2015 | 2.1159 |
| 0.92860 | 1175.58 | 8.6713 | -0.17 | -0.2535 | -0.0250 | -1.6058 |

[c]**Units:** $u$, $m.s^{-1}$; $\Delta u$, $m.s^{-1}$; $K_S$, $Pa^{-1}$; $K_S^E$, $Pa^{-1}$; $L_f^E$, m; $Z^E$, $kg.m^{-2}.s^{-1}$

**Table VI. Coefficients $A_i$ and Standard Deviations $\delta$ of Equation 9**

| Property | $A_0$ | $A_1$ | $A_2$ | $A_3$ | $A_4$ | $A_5$ | $A_6$ | $A_7$ | $A_8$ | δ |
|---|---|---|---|---|---|---|---|---|---|---|
| Methanol + Dimethoxyethane | | | | | | | | | | |
| $V^E \times 10^6$ | -1.956 | 0.449 | -0.390 | 0.528 | -0.388 | – | – | – | – | 0.0024 |
| $\Delta\eta \times 10^3$ | -0.144 | 0.059 | -0.019 | -0.190 | – | – | – | – | – | 0.0014 |
| $K_S^E \times 10^{10}$ | -47.937 | 21.331 | 39.145 | -18.40 | -126.76 | – | – | – | – | 0.2464 |
| $\Delta u$ | 235.519 | -45.468 | -322.76 | -1063.34 | -260.68 | 3259.1 | 4608.7 | 1434.3 | – | 0.1301 |
| $L_f^E \times 10^{11}$ | -16.482 | 2.1103 | 22.777 | 136.979 | 98.226 | -372.37 | -647.91 | -262.7 | – | 0.0153 |
| $Z^E \times 10^{-3}$ | 295.243 | -77.098 | -209.46 | -1129.34 | -860.403 | 3162.676 | 5783.967 | 2319.944 | – | 0.2056 |
| Ethanol + Dimethoxyethane | | | | | | | | | | |
| $V^E \times 10^6$ | -1.607 | 0.573 | – | – | – | – | – | – | – | 0.0040 |
| $\Delta\eta \times 10^3$ | -0.964 | 0.534 | -0.383 | 0.322 | – | – | – | – | – | 0.0031 |
| $K_S^E \times 10^{10}$ | -36.227 | 15.798 | 12.910 | 5.635 | -19.998 | -5.537 | – | – | – | 0.2270 |
| $\Delta u$ | 194.293 | -91.509 | -292.27 | -189.27 | 1723.622 | 3038.8 | -1427.4 | -6145.6 | - 3348.006 | 0.0000 |
| $L_f^E \times 10^{11}$ | -12.455 | 5.228 | 4.961 | 2.118 | -7.052 | -2.678 | – | – | – | 0.0086 |
| $Z^E \times 10^{-3}$ | 230.604 | -96.115 | -236.63 | -135.170 | 1345.448 | 2283.854 | -1106. 59 | -4648.881 | -2549.200 | 0.0000 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Propan-1-ol + Dimethoxyethane | | | | | | | | | | |
| $V^E x10^6$ | -1.471 | 0.589 | 0.514 | -0.643 | -0.363 | – | – | – | – | 0.0042 |
| $\Delta\eta x10^3$ | -2.337 | 1.470 | -0.661 | 0.553 | -0.699 | – | – | – | – | 0.0077 |
| $K_S^E x10^{10}$ | -22.370 | 9.399 | -6.909 | – | – | – | – | – | – | 0.0749 |
| $\Delta u$ | 130.795 | -67.347 | 46.093 | – | – | – | – | – | – | 0.5327 |
| $L_f^E x10^{11}$ | -7.925 | 3.434 | -2.311 | – | – | – | – | – | – | 0.0277 |
| $Z^E x10^{-3}$ | 153.228 | -58.115 | 24.886 | – | – | – | – | – | – | 1.2561 |
| Butan-1-ol + Dimethoxyethane | | | | | | | | | | |
| $V^E x10^6$ | -1.333 | 0.509 | 0.516 | -0.718 | – | – | – | – | – | 0.0014 |
| $\Delta\eta x10^3$ | -3.057 | 1.990 | -1.165 | 0.307 | – | – | – | – | – | 0.0071 |
| $K_S^E x10^{10}$ | -17.627 | 6.622 | -1.008 | -3.808 | – | – | – | – | – | 0.0512 |
| $\Delta u$ | 104.719 | -45.406 | 19.464 | – | – | – | – | – | – | 0.9838 |
| $L_f^E x10^{11}$ | -6.093 | 1.999 | -0.809 | – | – | – | – | – | – | 0.0462 |
| $Z^E x10^{-3}$ | 116.359 | -39.769 | – | – | – | – | – | – | – | 0.8529 |
| Pentan-1-ol + Dimethoxyethane | | | | | | | | | | |
| $V^E x10^6$ | -0.412 | -0.104 | 0.230 | 0.147 | -0.275 | – | – | – | – | 0.0012 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| $\Delta\eta x10^3$ | -4.525 | 3.022 | -1.958 | 2.009 | -1.430 | – | – | – | – | 0.0047 |
| $K_s^E x10^{10}$ | -13.801 | -2.331 | 2.910 | 4.500 | – | – | – | – | – | 0.0516 |
| $\Delta u$ | 88.0307 | 9.570 | -34.038 | -76.843 | 20.514 | 64.932 | – | – | – | 0.2959 |
| $L_f^E x10^{11}$ | -4.867 | -0.996 | 1.743 | 4.263 | -1.156 | -3.643 | – | – | – | 0.0166 |
| $Z^E x10^{-3}$ | 82.250 | 12.876 | -32.269 | -75.784 | 21.197 | 65.793 | – | – | – | 0.3007 |
| Hexan-1-ol + Dimethoxyethane | | | | | | | | | | |
| $V^E x10^6$ | 0.641 | -0.769 | -2.730 | 3.163 | 3.181 | -4.787 | -1.738 | 2.807 | – | 0.0001 |
| $\Delta\eta x10^3$ | -6.124 | 4.050 | -1.906 | 1.041 | -2.788 | 2.218 | – | – | – | 0.0058 |
| $K_s^E x10^{10}$ | -11.258 | -0.814 | 4.333 | 2.135 | – | – | – | – | – | 0.0534 |
| $\Delta u$ | 69.327 | -14.800 | -120.52 | 33.426 | 320.557 | -63.831 | -303.36 | – | – | 0.1081 |
| $L_f^E x10^{11}$ | -3.719 | -0.175 | 1.459 | 1.091 | – | – | – | – | – | 0.0223 |
| $Z^E x10^{-3}$ | 48.459 | -0.962 | -19.123 | -21.867 | – | – | – | – | – | 0.3704 |
| Octan-1-ol + Dimethoxyethane | | | | | | | | | | |
| $V^E x10^6$ | 0.848 | 0.249 | -0.643 | 0.203 | – | - | – | – | – | 0.0028 |
| $\Delta\eta x10^3$ | -10.093 | 6.774 | -2.750 | -4.447 | -1.898 | 13.91 | -1.00 | -2.58 | -5.43 | 0.0000 |
| $K_s^E x10^{10}$ | -8.116 | -2.152 | 3.142 | 3.386 | 4.636 | – | – | – | – | 0.0342 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| $\Delta u$ | 42.138 | 13.239 | -59.921 | -39.344 | – | – | – | – | – | 0.7769 |
| $L_f^E \times 10^{11}$ | -2.487 | -0.829 | 2.156 | 1.478 | – | – | – | – | – | 0.0151 |
| $Z^E \times 10^{-3}$ | 15.580 | 0.675 | -32.338 | – | – | – | – | – | – | 0.5284 |

**Units: $V^E$, $m^3.mol^{-1}$; $\Delta\eta$, Pa.s; $K_S^E$, $Pa^{-1}$; $\Delta u$, $m.s^{-1}$; $L_f^E$, m; $Z^E$, $kg.m^{-2}.s^{-1}$**

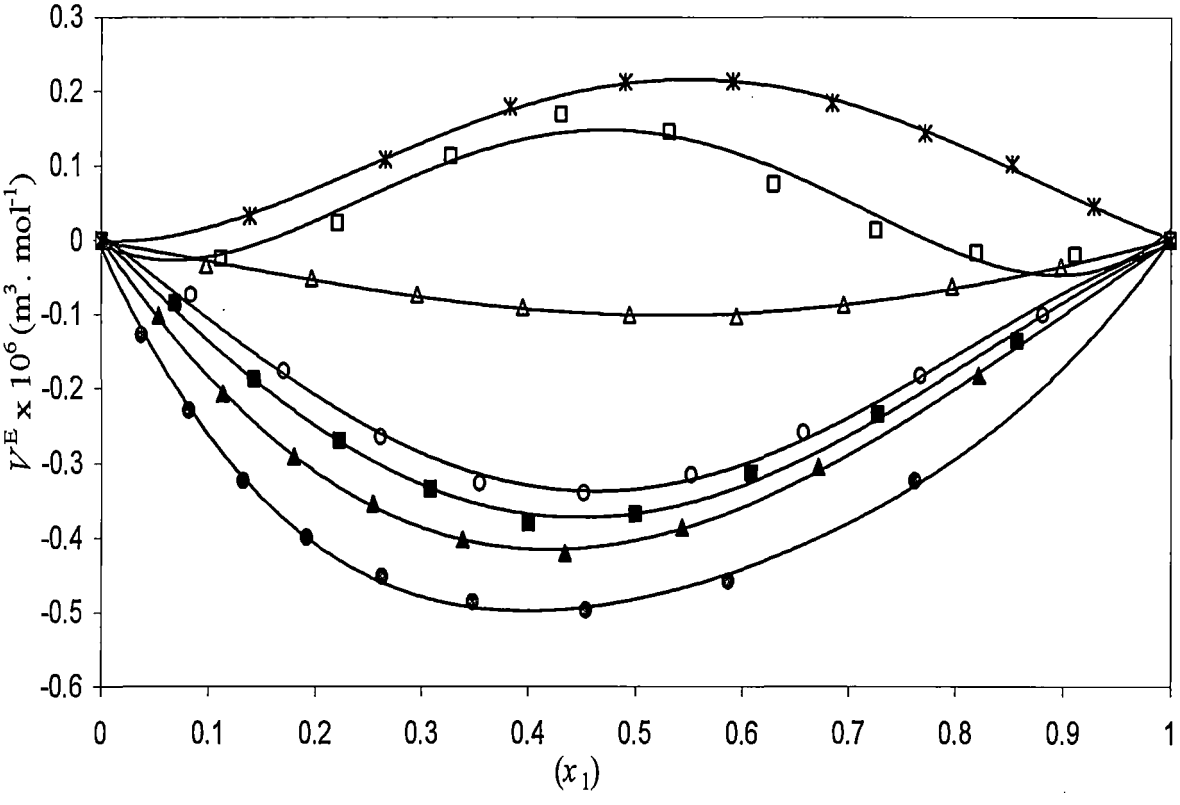


**Fig.1.**The plots of excess molar volumes ($V^E$) *versus* mole fraction of dimethoxyethane ($x_1$) at 298.15 K for binary mixtures of dimethoxyethane with methanol(●), ethanol(▲), propan-1-ol (■), butan-1-ol (0), pentan-1-ol (Δ), hexan-1-ol (□) and octan-1-ol (ж)

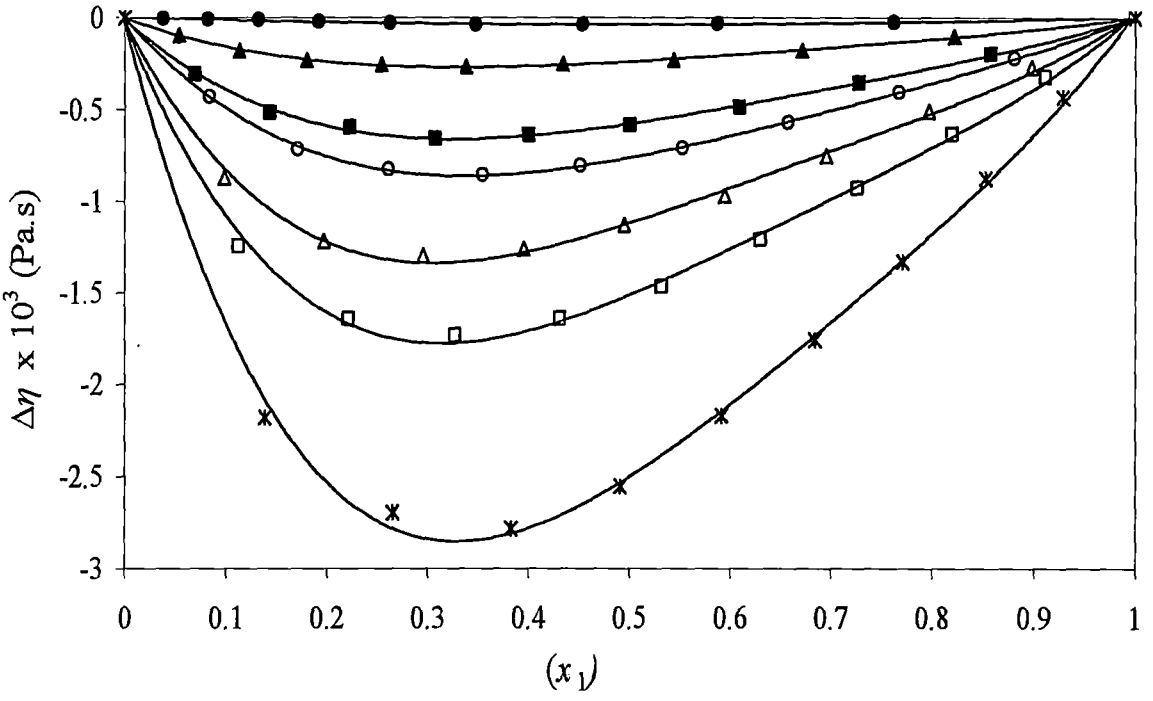


**Fig.2**.The plots of $\Delta\eta$ *versus* mole fraction of dimethoxyethane ($x_1$) at 298.15 K for binary mixtures of dimethoxyethane with methanol (•), ethanol (▲), propan-1-ol (■), butan-1-ol (○), pentan-1-ol (Δ), hexan-1-ol (□) and octan-1-ol (ж).

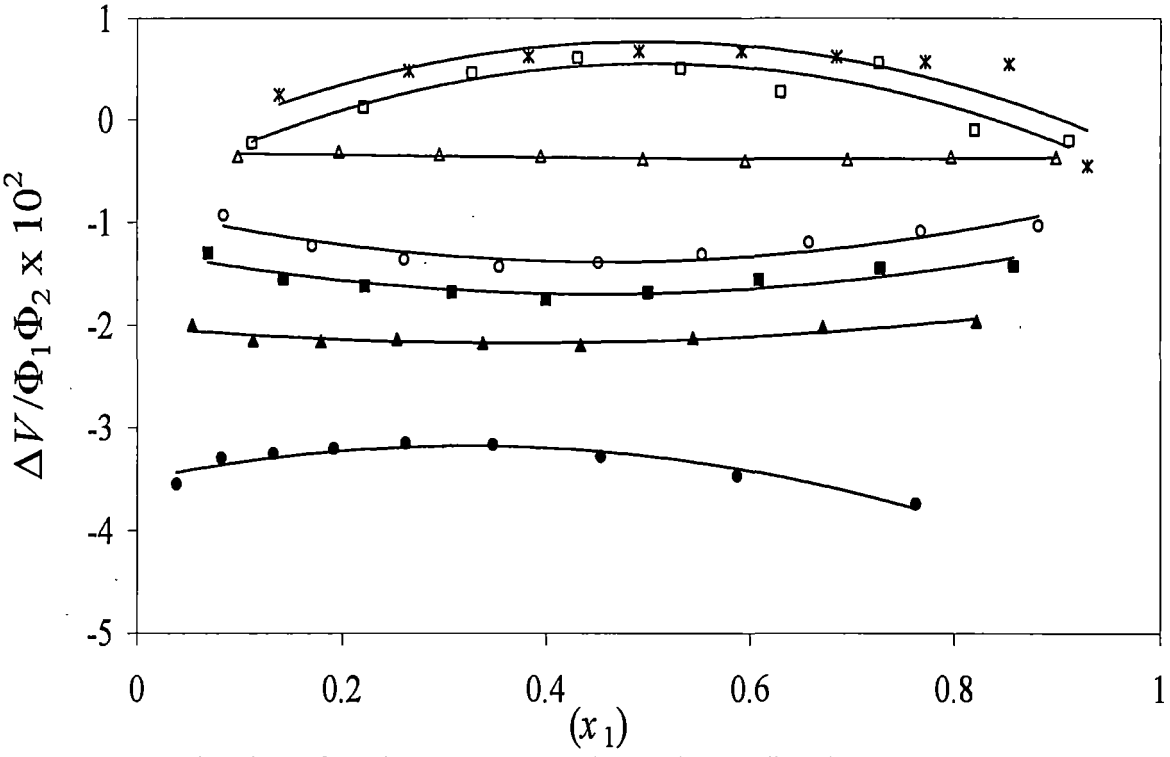


**Fig.3**. The plots of $\Delta V/\Phi_1\Phi_2$ *versus* mole fraction of dimethoxyethane ($x_1$) at 298.15 K for binary mixtures of dimethoxyethane with methanol (•), ethanol (▲), propan-1-ol (■), butan-1-ol (○), pentan-1-ol (Δ), hexan-1-ol (□) and octan-1-ol (ж)

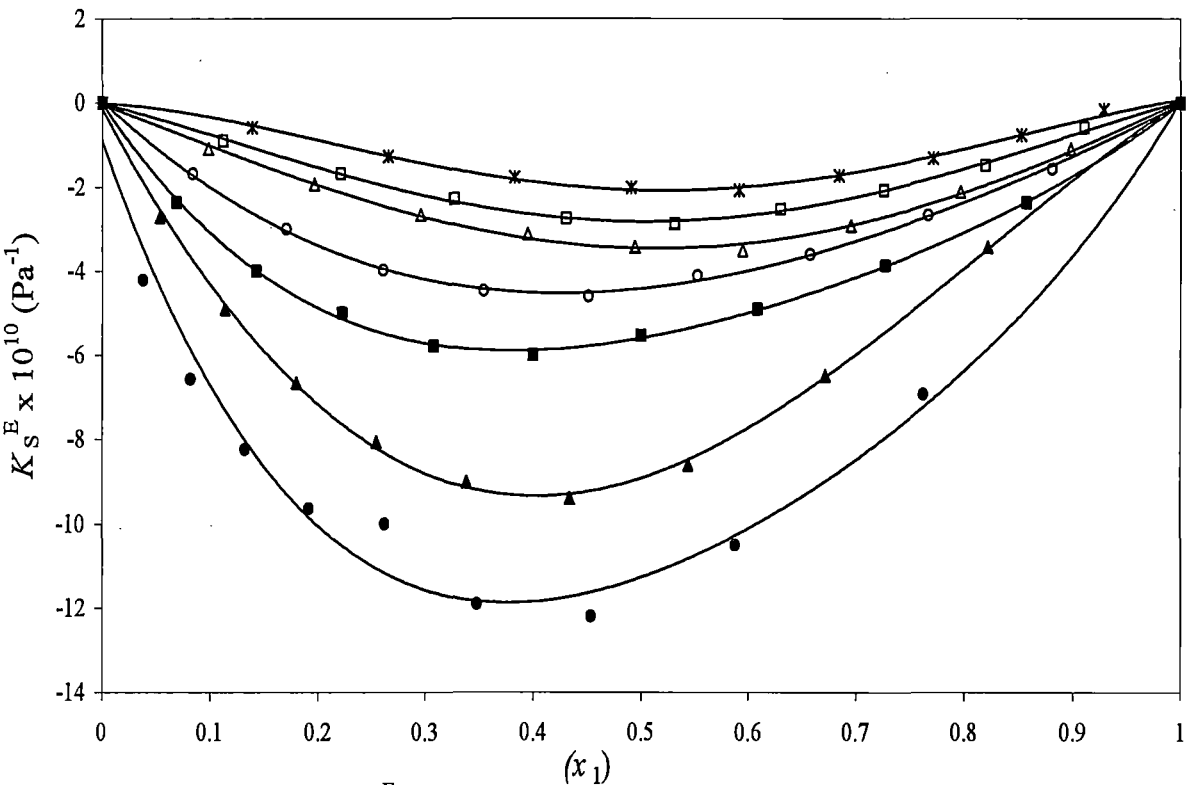


**Fig.4**.The plots of $K_S^E$ *versus* mole fraction of dimethoxyethane ($x_1$) at 298.15 K for binary mixtures of dimethoxyethane with methanol (•), ethanol (▲), propan-1-ol (■), butan-1-ol (○), pentan-1-ol (Δ), hexan-1-ol (□) and octan-1-ol (ж)

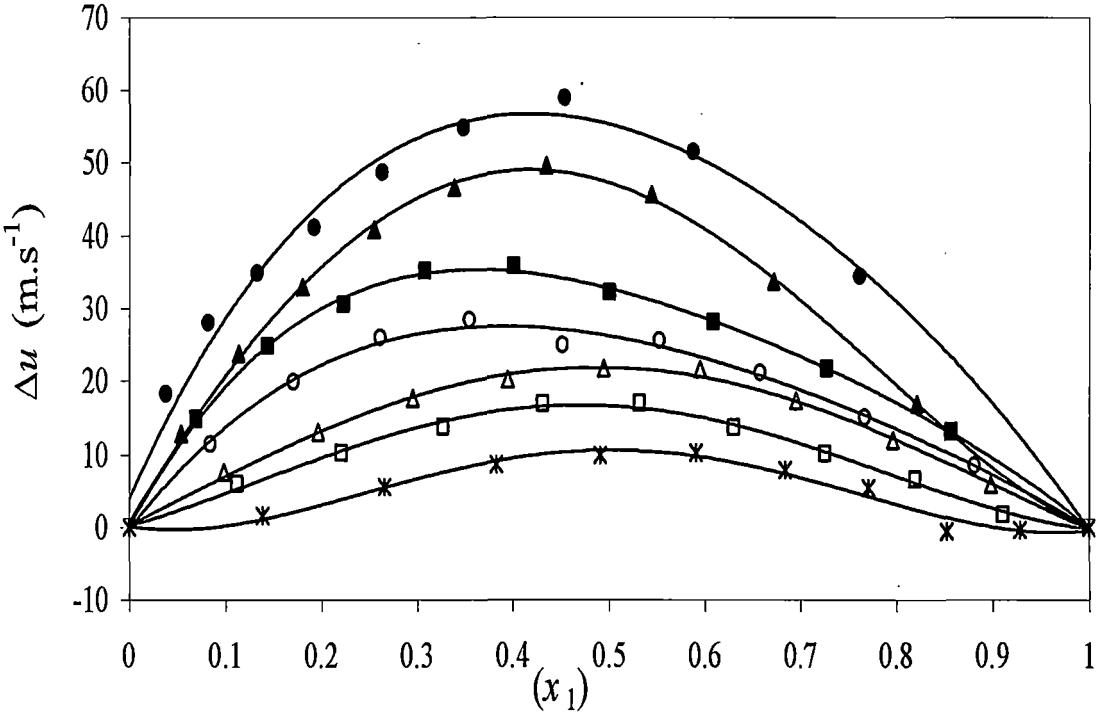


Fig.5.The plots of $\Delta u$ *versus* mole fraction of dimethoxyethane ($x_1$) at 298.15 K for binary mixtures of dimethoxyethane with methanol (•), ethanol (▲), propan-1-ol (■), butan-1-ol (○), pentan-1-ol (Δ), hexan-1-ol (□) and octan-1-ol (ж)

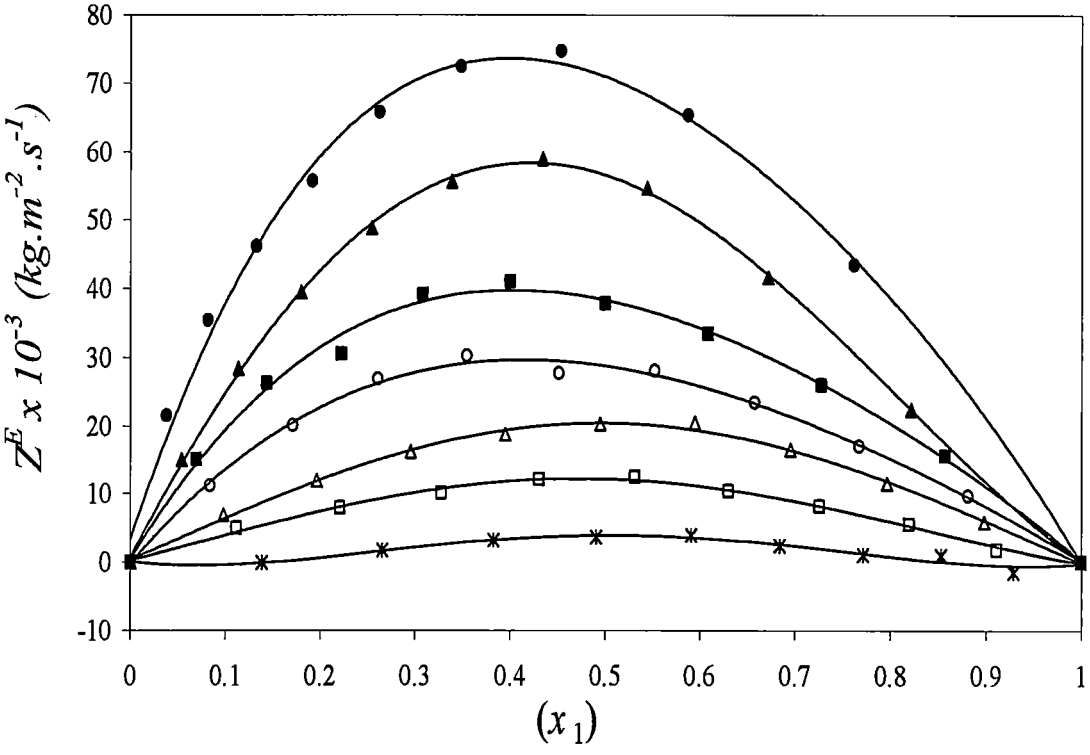


**Fig.6.** The plots of $Z^E$ *versus* mole fraction of dimethoxyethane ($x_1$) at 298.15 K for binary mixtures of dimethoxyethane with methanol (●), ethanol (▲), propan-1-ol (■),butan-1-ol (○),pentan-1-ol (Δ), hexan-1-ol (□) and octan-1-ol (ж).

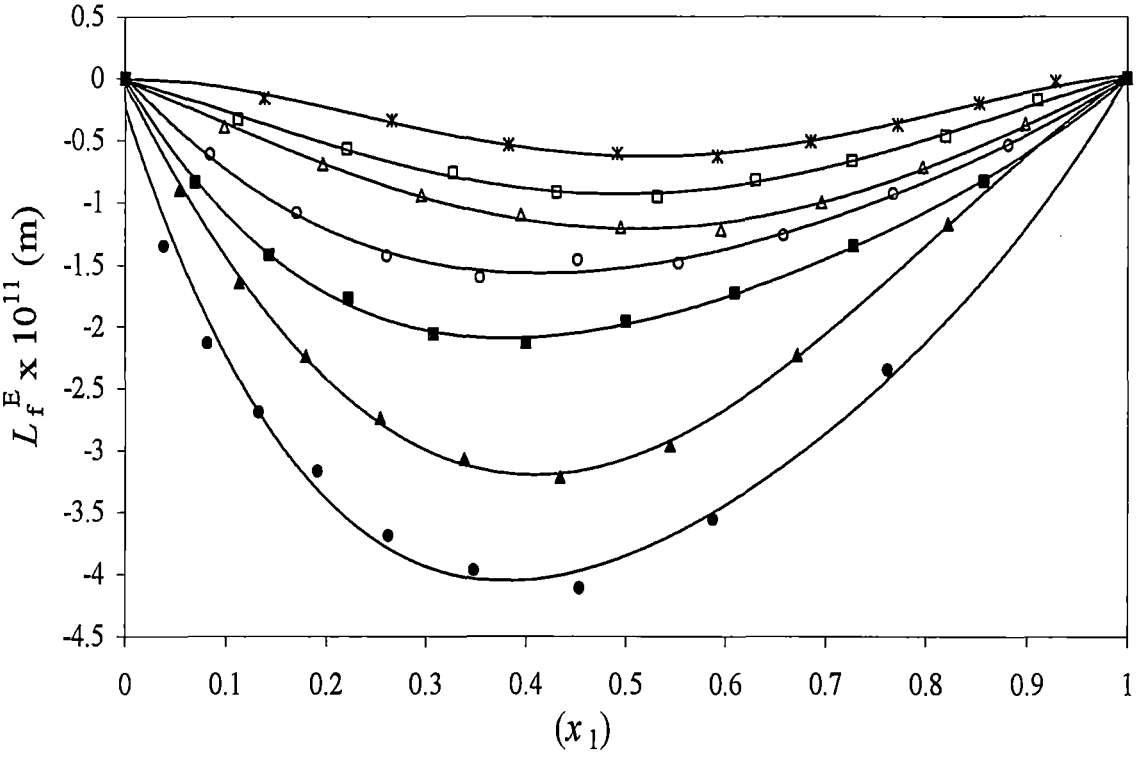


**Fig.7**. The plots of $L_f^E$ *versus* mole fraction of dimethoxyethane ($x_1$) at 298.15 K for binary mixtures of dimethoxyethane with methanol (●), ethanol (▲), propan-1-ol (■), butan-1-ol (○), pentan-1-ol (Δ), hexan-1-ol (□) and octan-1-ol (ж)