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Excess volume, excess viscosity and excess gibb's free energy of activation of mixture of 1-propyl alcohol, benzene, ethyl alcohol and methyl alcohol at some temperatures

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Abstract

Densities and viscosities of quaternary liquid mixture of 1-propyl alcohol with ethyl alcohol and methyl alcohol and benzene of equal volumes of the components have been measured at 308.15, 313.15, 318.15, 323.15, and 328.15, K. From the experimental density and viscosity, the values of Excess volume (V^E), Excess viscosity (μ^E) and Excess Gibb's free energy of activation of flow (ΔG^E) have been determined. On the basis of the values of interaction parameters and various excess properties, the nature of molecular interactions between the components of mixtures has been explained.

Keywords: liquids, mixture, Excess volume, Excess viscosity, Gibb's free energy, molecular interactions

Introduction

Over the years alcohols have found various applications ^{[14],[15]} and commercial use in medical and other fields, for example *n*-propyl alcohol (PA) is very effective against a broad spectrum of microorganisms including bacteria, fungi and viruses such as HIV, hepatitis-B, and respirator syncytial viruses. Also *n*-propyl alcohol is in use as the safest antiseptic compound for topical use and is feedstock in the manufacture of insecticides. Therefore it seemed important to examine the excess properties of 1-propyl alcohol with ethyl and methyl alcohols and benzene. Excess properties investigations of solutions containing amounts of interacting molecules help detect the formation and composition of complexes in them. A survey of the literature shows that a few workers have tried to investigate some binary systems taking amines as one of the constituent components in the binary mixtures. Though the information in this field is steadily being enlarged by a number of workers, the nature of complex formation in binary mixtures is still far from clear. With this in view, the present investigation is aimed at studying the excess properties of quaternary mixtures of 1-propyl alcohol with ethyl and methyl alcohols and benzene, which may provide useful information about the formation of complex in the mixture.

Materials and Method

Pure samples of 1-propyl alcohol, ethyl and methyl alcohols and benzene were obtained from Microbiology Department, AR Grade and used without further purification. The liquids were mixed in the required proportions of 1:1:1 by volume and kept in well-stoppered bottles to ensure good thermal equilibrium.

The viscosities and densities of the pure liquids and their mixtures were measured by using Oswald's Viscometer and Pycnometer respectively. The viscometer was kept for 10 -15 minutes in the thermostatically controlled water-bath ^[6], to achieve constant temperature. The measurements of flow time of the solution between the two points on the viscometer were performed at least three times for each solution and the average results were noted. All liquids making up a mixture were of equal proportion by volume. The volumes mass of the of the particular liquids samples at different temperatures studied were noted. Then the densities of the liquids and liquid mixtures at different temperatures were calculated using the relation, density = mass/volume.

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The average of three readings of time of flow of each liquid or mixture at different temperatures was used in determining the corresponding viscosity.

The excess function is a measure of deviation from the ideal behaviour of the mixture, and found to be highly sensitive towards molecular interactions between the component molecules of liquid mixtures. The sign and magnitude of these excess functions from ideal depends on the strength of interaction between unlike molecules^[7].

The excess viscosity (μ^E) of the given quaternary liquid mixture was calculated from the observed viscosity of mixture and that of its pure components using following equation^{[1],[2]},

$$\mu^E = \mu - (x_1\mu_1 + x_2\mu_2 + x_3\mu_3 + \dots + x_n\mu_n) \quad (1)$$

where μ is viscosity of quaternary mixture, $\mu_1, \mu_2, \mu_3, \dots, \mu_n$ are the viscosities of pure components respectively and $x_1, x_2, x_3, \dots, x_n$ are the mole fractions of components of quaternary liquid mixtures respectively.

The excess volume (V^E) of quaternary mixture can be evaluated from the volume of mixture (V) and that of pure components ($V_1, V_2, V_3, \dots, V_n$)

V^E can be determined using the following equation^[12],

$$V^E = V - (x_1V_1 + x_2V_2 + x_3V_3 + \dots + x_nV_n) \quad (2)$$

The volume V of the quaternary liquid mixture can be calculated from the measured density (ρ) of the mixture using following equation,

$$V = (x_1V_1 + x_2V_2 + x_3V_3 + \dots + x_nV_n) / \rho \quad (3)$$

The excess Gibb's free energy of flow (ΔG^E) for the quaternary liquid mixture was computed from the Eyring equation,

$$\Delta G^E = RT (\ln \mu V - x_1 \ln \mu_1 V_1 - x_2 \ln \mu_2 V_2 - x_3 \ln \mu_3 V_3 - \dots - x_n \ln \mu_n V_n) \quad (4)$$

Results and Discussion

The values of excess volume (V^E), excess viscosity (μ^E), and excess Gibb's free energy of activation of flow (ΔG^E), as a function of temperature of 1-propyl alcohol with ethyl and methyl alcohols and benzene mixtures are presented in Table 1

Table 1: Excess volume (V^E), excess viscosity (μ^E), and excess Gibb's free energy of activation of flow (ΔG^E), at certain temperatures

Temperature (K) ± 0.01	Excess viscosity (μ^E) (10^{-4} Pa.sec)	Excess volume (V^E) ± 0.005	Excess Gibb's free energy of activation (ΔG^E)
308.15	0.058	-0.758	115.77
313.15	0.053	-0.715	122.39
318.15	0.049	-0.687	127.43
323.15	0.046	-0.665	131.22
328.15	0.042	-0.662	134.26

Table 1 show that the values of μ^E are positive over entire experimental temperatures. The positive of μ^E suggest that dispersion types^[11] of forces are predominant in these mixtures. Alcohols are associate liquids; they can interact with each other and with water molecules. For water-alcohol mixtures, the hydrogen bonding between water and alcohol molecules is much more predominant than for water-water, and alcohol-alcohol molecule pairs.^{[1],[13]}

Table 1 also shows the V^E of the mixture at various temperatures T . The increase in temperature results in decrease in V^E of the mixture. The excess volumes are negative over entire experimental temperatures, indicating chemical or specific interactions which can result in decrease in volume due to some molecular interactions. The hydrogen of the -OH group on alcohol is polar as it is in the water molecule. Also, in solvents such as alcohol, which can take part in hydrogen bond formation, the self-association of alcohols may be increased in favour of hydrogen - bonded forms between solute and solvent.^{[11],[9]} ...

The values of ΔG^E for the above mixture against T are shown in Table 1. The positive values of ΔG^E may be due to the size effect of the mixing components.^{[9],[10]} ΔG^E may be considered, a reliable measure to detect the presence of interaction between the molecule, positive values of ΔG^E can be seen in quaternary mixture where specific interactions (hydrogen bonding) between the molecules are dominant. For a strong hydrogen bond donor mixing cosolvents-specific donor-acceptor interactions may probably produce stable stoichiometric complexes which

are formed in competition with the simultaneous disruption of the structures of both the pure solvents^{[2],[11],[13]}. This behavior has been attributed to the fact that the O-H bond moment of these aggregates is increased through mutual induction. Consequently, taking into account all these assumptions, we could attribute the observed deviations from ideality to all these effects.

Conclusion

Excess volume (V^E), excess viscosity (μ^E), and excess Gibb's free energy of activation of flow (ΔG^E) of the mixture, indicate some molecular interactions. Since alcohols are associate liquids, they can interact with each other and with benzene molecules. Viscosity, volume, Gibb's free energy of activation of flow parameters were affected from these interactions. The excess values of these components means a deviation from ideal.

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