Density, speed of sound and viscosity of binary mixtures of {diethyl malonate (DEM) + ethanol} at different temperatures and atmospheric pressure

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Key words: *Excess properties, diethyl malonate, ethanol.*

Introduction

Thermodynamics properties of binary and multicomponent liquid mixtures are required in many chemical engineering calculations involving fluid flow, heat and mass transfer. Their derived properties can provide valuable information about molecular interactions and structural effects. As a continuation of our studies on excess properties of binary liquid mixtures containing alcohols, in this study we report density, speed of sound and viscosity data of binary mixtures of diethyl malonate (DEM) + ethanol, in the whole composition range, at the temperatures of 288.15 293.15, 298.15, 303.15 and 308.15 K and atmospheric pressure. The experimental results have been used to calculate the excess molar volume (V_m^E), the isentropic compressibility deviation ($\Delta\kappa$) and the viscosity deviation ($\Delta\eta$). The results were correlated using a Redlich-Kister equation.

Results and Discussion

Diethyl malonate (Sigma-Aldrich, purity > 0.997 mole fraction), ethanol (Merck, purity > 0.999 mole fraction) were used without further purification. The densities and speed of sounds data were measured using a commercial densimeter and speed of sound analyzer manufactured by Anton Paar (Model DSA 5000), whereas the viscosities data were measured by using a viscosimeter Stabinger (Model SVM 3000/ G2) manufactured by Anton Paar.
Excess molar volume (V_m^E), isentropic compressibility deviation ($\Delta\kappa$) and viscosity deviation ($\Delta\eta$) were calculated using the following relations:

$$V_m^E = x_1 M_1\left(\frac{1}{\rho}-\frac{1}{\rho_1}\right)+x_2 M_2\left(\frac{1}{\rho}-\frac{1}{\rho_2}\right), \quad (1)$$

$$\Delta\kappa = \kappa - x_1\kappa_1 - x_2\kappa_2, \quad (2)$$

$$\Delta\eta = \eta - x_1\eta_1 - x_2\eta_2, \quad (3)$$

where ρ, κ, η are the density, isentropic compressibility and viscosity of the mixture, respectively; and x_1, M_1, ρ_1, κ_1 and η_1, and x_2, M_2, ρ_2, κ_2 and η_2, are the mole fraction, molar mass, density, isentropic compressibility and viscosity of pure components 1 and 2, respectively.
All of the excess properties were fitted to the Redlich-Kister polynomial equation [1]:

$$Y_m^E = x_1(1-x_1)\sum_{j=0}^{j=n} A_j(1-2x_1)^j, \quad (4)$$

where $Y = V_m^E$, $\Delta\kappa$ or $\Delta\eta$, and x_1 is the mole fraction of DEM. A_j are the adjustable parameters.

The A_j were fitted by a least-square method, and the standard deviation is given by:

$$\sigma = \left[\sum (V_{exp}^E - V_{teo}^E)^2/(N-n)\right]^{1/2}, \quad (5)$$

where *N* is the number of experimental data and *n* is the number of fitted parameters.
For the present system, the values of excess molar volume are negative at low concentration region of DEM and positive ah higher mole fractions (S shaped curve). Isentropic compressibility deviation data is negative over the entire range of composition, becoming more negative when temperature increases. Viscosity deviation was negative over the entire composition range and it becomes less negative when temperature increases.

Conclusions

Values of excess properties depend on molecular interactions and structural effects among different molecules in the binary solution. The interactions are highly dependent on size and shape of molecules. The results obtained for the binary system DEM + ethanol suggest that dispersion forces should prevail over chemical and structural effects.

Agradecimentos

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[1] Redlich, O.; Kister, T. *Ind. Eng. Chemistry*, **1948**, *40*, 345.