Excess Molar Volumes and Viscosities of the Ternary System n-Butylamine + 1,4-Dioxane + Acetonitrile at 25°C

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Densities and viscosities for the n-butylamine + 1,4-dioxane + acetonitrile system were determined at 25°C and molar excess volumes and excess viscosities were calculated. Of the different expressions existing in the literature that predict these excess properties for ternary mixtures from data for the binary mixtures, the empirical correlation of Singh et al. is the best for this system.

KEY WORDS: Densities; viscosities; n-butylamine + 1,4-dioxane + acetonitrile system; excess molar properties; ternary system.

1. Introduction

In the chemical literature, properties of binary systems are relatively abundant but properties of ternary systems are scarce. It is the aim of this work to determine the excess molar volumes $V^E$ and excess viscosities $\eta^E$ for the $n$-butylamine(1) + 1,4-dioxane(2) + acetonitrile(3) ternary system at 25°C and to compare the results with the prediction of some empirical correlations that assume interactions that in a ternary mixture are close to those in the corresponding binary mixtures.

2. Experimental

The methods used in our laboratory have been described previously. Densities were determined with a digital densimeter (Anton Parr, model DMA 45). A thermostatically controlled bath (con-
stant to ±0.01°C) was used and temperatures were read from calibrated
thermometers. The densimeter was calibrated using air and doubly dis-
tilled water with an error of ±0.1 kg·m⁻³.

Viscosities were determined with a Cannon-Fenske viscosimeter
calibrated with doubly distilled water and benzene. Kinetic energy cor-
rections were applied. The estimated error was ±0.005 mPa·s.

2.1. Materials and Solutions

n-Butylamine (Fluka, puriss.)(3) was dried over potassium
hydroxide for three days, refluxed for 2 h., distilled and the middle frac-
tion collected. 1,4-Dioxane (Baker, puriss.) was distilled over sodium
metallic under reduced pressure and the middle colorless fraction col-
clected. Acetonitrile (Carlo Erba puriss.) was distilled over phosphorous
pentoxide and the middle colorless fraction collected. Mixtures were
prepared by mixing weighed amounts of the pure liquids. Caution was
taken to prevent evaporation.

3. Results and Discussion

The experimental results for the pure liquids are reported in Table I, together with literature values for comparison.

Densities and viscosities of the binary mixtures can be calculated
from known experimental data,⁴,⁵,⁶,⁷ at any mole fraction with

\[ P = x_i P_i + x_j P_j + x_i x_j \sum_{k=0}^{n} a_k (x_i - x_j)^k \]  

where \( P_i \) and \( P_j \) are the properties of the pure components and \( x_i \) and \( x_j \)
are the mole fractions of components \( i \) and \( j \) (\( i < j \)). Table II shows the
values of the coefficients \( a_k \) as well as their standard deviations cal-
culated by the method of least squares.

The excess function of a binary system can be represented by a
Redlich-Kister equation of the form

\[ X^E = x_i x_j \sum_{k=0}^{n} a_k (x_i - x_j)^k \]  

where \( x^E \) represents \( V^E \) or \( \eta^E \), and \( a_k \) are the polynomial coefficients.
The method of least squares was used to determine the coefficients. In
each case, the optimum number of coefficients was ascertained from an
examination of the variation of the standard error of estimate with \( n \)