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ARTICLE

Volumetric and viscosity properties of {propyl propanoate (1) + heptane (or octane) (2)} mixtures at several temperatures and correlation with the Jouyban–Acree model

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ABSTRACT

Densities and viscosities of binary liquid mixtures of propyl propanoate + heptane and propyl propanoate + octane at temperatures of 278.15, 283.15, 288.15, 293.15, 298.15, 303.15, 308.15, 313.15, 318.15 and 323.15 K have been measured at atmospheric pressure over the entire range of composition. Using these experimental data, the excess molar volumes and the viscosity deviation have been calculated. The experimental data of density and viscosity at different investigated temperatures were mathematically represented by the Jouyban–Acree model. The mean relative deviation (MRD) was used as an error criterion, and the MRD values for data correlation of density and viscosity at different investigated temperatures are less than 0.03% and 0.50%, respectively. Excess molar volumes and viscosity deviations were correlated with Redlich–Kister equation. The calculated data point out the absence of specific interactions between the molecules of different components, which would be slightly weaker compared to the interactions in the pure components.

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Density; viscosity; excess molar volume; viscosity deviation; propyl propanoate; alcane

1. Introduction

Density and viscosity are two of the most important physicochemical properties which affect mass and heat transfer processes in solutions. So, availability of the related data should be helpful in designing and engineering of such processes. In particular, for the paint and coatings industry, viscosity exerts a marked influence when selecting a suitable solvent, since it influences the wettability, levelling and flowability of the coating. That is, although solvents are a temporary component of the formulations (because they evaporate during curing), they significantly affect the characteristics of their application on the surface of interest and the properties of the resulting coating. As far as specific industrial applications are concerned, propyl propanoate is considered a potential candidate to definitively replace toluene in its use as solvent in the paint and coatings industry [1]. This arises from regulations restricting the use of traditional solvents, such as toluene, because of their high toxicity in humans and animals [2]. Thus, the thermodynamic characterisation of alternative solvents is now an emerging need. Coating manufacturers make specific mention of propyl propanoate because it has great versatility, good solvent activity and adequate volatility, and, unlike toluene, it has not been classified by the EPA (United States Environmental Protection Agency) as hazardous air pollutant. The results obtained were satisfactory, since it was found that the substitution of toluene does not alter significantly the mechanical properties or appearance of the resulting coating [1]. This firm has also obtained favourable results in assessing the possibility of

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Table 1. List of chemicals, source and mass per cent purity.

Chemical name	Source	Purity (%)	Molecular formula
Propyl propanoate	Aldrich	>99.0	$C_6H_{12}O_2$
Heptane	OmniSolv	>99.9	C_7H_{16}
Octane	Fluka	>99.5	C_8H_{18}

including aliphatic hydrocarbons in the mixture of solvents used in coatings for reducing the costs [3].

The present work was undertaken to study volumetric and viscosity properties of the binary liquid mixture of propyl propanoate + heptane and propyl propanoate + octane. Excess molar volumes, V^E, and viscosity deviation, $\Delta\eta$, were calculated from measured data of densities, ρ, and viscosities, η, of the pure solvents and their mixtures. In all cases, positive excess molar volumes were obtained, while the viscosity deviations were always negative. The experimental data of density and viscosity at different investigated temperatures were mathematically represented by the Jouyban–Acree model [4], pointed out by several authors as one of the most accurate models for correlation of physicochemical properties of liquid mixtures [4–9], while excess molar volumes and viscosity deviations were correlated with Redlich–Kister equation [10].

2. Experimental

2.1. *Materials*

The used chemicals are summarised in Table 1. Propyl propanoate, heptane and octane were used without any further treatment.

2.2. *Apparatus and procedures*

The solutions were prepared after weighing using an analytical electronic balance (AND AR-200) with a precision of 1×10^{-4} g.

Densities of the liquids were measured using Anton Paar DMA 5000 densimeter. The instrument was equipped with a thermostating unit, and the temperature was kept constant with uncertainty of 0.01 K at the atmospheric pressure.

Viscosity was measured with a microviscosimeter Haake, thermostated with an accuracy of ±0.1 K. The accuracy of reported data was 1×10^{-3} kg·m^3 and 2×10^{-3} mPa for density and viscosity, respectively.

3. Results and discussion

3.1. *Density and viscosity*

The density and viscosity of the pure components are presented and compared with the literature data in Table 2.

Tables 3 and 4 show the densities and viscosities of binary liquid mixtures of propyl propanoate + heptane and propyl propanoate + octane, respectively, at the studied temperatures and at atmospheric pressure, over the entire range of composition. From these results, it is observed that the density of both mixtures increases steadily with the increase in propyl propanoate composition and decreases with temperature. The viscosity of the mixtures increases with increasing propyl propanoate concentration and decreases with temperature.

Table 2. Densities, ρ, and viscosity, η, at different temperatures of propyl propanoate, heptane and octane.

		$\rho \times 10^{-3}$ kg·m^3	$\eta \times 10^{-3}$ Pa·s	$\rho \times 10^{-3}$ kg·m^3	$\eta \times 10^{-3}$ Pa·s	$\rho \times 10^{-3}$ kg·m^3	$\eta \times 10^{-3}$ Pa·s
T K		Propyl propanoate		Heptane		Octane	
278.15	Exp.	0.89675	0.845	0.69616	0.482	0.71458	0.650
	Lit.				0.4904 [11]		0.6651 [11]
283.15	Exp.	0.89150	0.782	0.69218	0.455	0.71059	0.613
	Lit.			0.6923 [11]	0.4618 [11]		0.6207 [11]
288.15	Exp.	0.88624	0.735	0.68797	0.433	0.70659	0.576
	Lit.			0.68828 [12]	0.4358 [11]		0.5810 [11]
293.15	Exp.	0.88096	0.683	0.68375	0.410	0.70257	0.542
	Lit.	0.8817 [11]		0.68375 [13]	0.4122 [11]	0.70256 [11]	0.5452 [11]
298.15	Exp.	0.87568	0.641	0.67951	0.390	0.69854	0.514
	Lit.	0.875 [14]	0.641 [14]	0.67946 [13]	0.3906 [11]	0.69854 [11]	0.5128 [11]
303.15	Exp.	0.87037	0.603	0.67525	0.371	0.69449	0.489
	Lit.			0.67533 [15]	0.3690 [11]	0.69449 [16]	0.4835 [11]
308.15	Exp.	0.86504	0.566	0.67096	0.357	0.69041	0.462
	Lit.			0.67112 [15]	0.3525 [11]	0.69040 [15]	0.4568 [11]
313.15	Exp.	0.85970	0.537	0.66664	0.339		
	Lit.			0.66666 [16]	0.3356 [11]		
318.15	Exp.	0.85433	0.510	0.66229			
	Lit.						
323.15	Exp.	0.84894	0.485	0.65789			
	Lit.						

3.2. *Mathematical model*

The Jouyban–Acree model [4] was used as a mathematical model for correlation of the studied properties, density and viscosity, in solvent mixtures. For this purpose, for each property under investigation, it has been trained with experimental data using a no-intercept regression analysis. The thermodynamic property Q associated with a binary mixture can be correlated by:

$$\ln Q_T = x_1 \ln Q_{1,T} + x_2 \ln Q_{2,T} + \frac{x_1 \cdot x_2}{T} \cdot \sum_{k=0}^{2} J_k \cdot (x_1 - x_2)^k, \tag{1}$$

where Q_i, $Q_{1,T}$ and $Q_{2,T}$ are the properties of the mixture and of the two pure components, respectively, at an absolute temperature T. J_k are adjustable parameters.

The correlative capacity of the adjustments made was evaluated using the mean relative deviation (MRD), which is given by:

$$\mathrm{MRD} = \frac{100}{N} \sum_{j}^{N} \frac{\left| Q_j^{\exp} - Q_j^{\mathrm{cal}} \right|}{Q_j^{\exp}}, \tag{2}$$

where N is the number of data points in each set and $Q^{\exp}$ and Q^{calc} are the experimental and calculated property, respectively.

The main advantage of the Jouyban–Acree equation is that it takes into account the influence of temperature, which allows to predict properties at temperatures for which experimental information is not available, and to do this, we must resort to interpolation. Table 5 presents the adjustment coefficients of the Jouyban–Acree equation for all measured properties, as well as the MRD associated with each one.

The properties were correlated perfectly using the Jouyban–Acree model with overall MRD values less than 0.03% for density and 0.50% for viscosity.

Table 3. Densities, ρ, viscosity, η, excess molar volume, V^E, and viscosity deviation, $\Delta\eta$, of binary mixtures of propyl propanoate (x_1) + heptane (x_2) at different temperatures.

x_1	$\rho \times 10^{-3}$ kg·m^3	$V^E \times 10^6$ m^3·mol^{-1}	$\eta \times 10^{-3}$ Pa·s	$\Delta\eta \times 10^{-3}$ Pa·s	$\rho \times 10^{-3}$ kg·m^3	$V^E \times 10^6$ m^3·mol^{-1}	$\eta \times 10^{-3}$ Pa·s	$\Delta\eta \times 10^{-3}$ Pa·s
		T = 278.15 K				T = 283.15 K		
0.1014	0.71369	0.192	0.495	−0.023	0.70941	0.232	0.470	−0.018
0.2016	0.73149	0.349	0.518	−0.037	0.72710	0.388	0.485	−0.036
0.3020	0.74986	0.468	0.533	−0.059	0.74536	0.506	0.500	−0.054
0.4035	0.76911	0.530	0.562	−0.067	0.76449	0.567	0.525	−0.062
0.5007	0.78825	0.531	0.595	−0.068	0.78354	0.561	0.558	−0.061
0.6009	0.80880	0.464	0.635	−0.065	0.80399	0.487	0.593	−0.058
0.7044	0.83062	0.377	0.678	−0.060	0.82579	0.380	0.633	−0.053
0.8016	0.85177	0.266	0.726	−0.047	0.84673	0.280	0.674	−0.044
0.9021	0.87400	0.174	0.783	−0.026	0.86887	0.179	0.723	−0.027
		T = 288.15 K				T = 293.15 K		
0.1014	0.70510	0.235	0.449	−0.015	0.70078	0.237	0.428	−0.009
0.2016	0.72272	0.387	0.462	−0.033	0.71827	0.398	0.442	−0.022
0.3020	0.74084	0.513	0.476	−0.048	0.73630	0.523	0.457	−0.036
0.4035	0.75987	0.574	0.495	−0.060	0.75531	0.569	0.478	−0.042
0.5007	0.77880	0.572	0.523	−0.061	0.77405	0.582	0.502	−0.044
0.6009	0.79914	0.498	0.556	−0.059	0.79428	0.508	0.529	−0.044
0.7044	0.82089	0.378	0.593	−0.053	0.81594	0.383	0.562	−0.040
0.8016	0.84168	0.285	0.630	−0.045	0.83661	0.291	0.596	−0.032
0.9021	0.86371	0.183	0.676	−0.030	0.85854	0.185	0.636	−0.020
		T = 298.15 K				T = 303.15 K		
0.1014	0.69643	0.243	0.404	−0.011	0.69206	0.248	0.386	−0.009
0.2016	0.71381	0.407	0.419	−0.022	0.70932	0.418	0.396	−0.022
0.3020	0.73173	0.535	0.434	−0.032	0.72715	0.546	0.411	−0.031
0.4035	0.75064	0.581	0.452	−0.039	0.74595	0.592	0.430	−0.035
0.5007	0.76928	0.594	0.475	−0.040	0.76447	0.610	0.450	−0.038
0.6009	0.78940	0.519	0.503	−0.038	0.78450	0.530	0.475	−0.035
0.7044	0.81083	0.413	0.532	−0.034	0.80580	0.426	0.502	−0.033
0.8016	0.83153	0.297	0.565	−0.026	0.82642	0.304	0.530	−0.027
0.9021	0.85335	0.190	0.600	−0.016	0.84815	0.193	0.562	−0.018
		T = 308.15 K				T = 313.15 K		
0.1014	0.68766	0.253	0.367	−0.011	0.68323	0.259	0.353	−0.007
0.2016	0.70481	0.428	0.377	−0.022	0.70028	0.436	0.363	−0.016
0.3020	0.72253	0.558	0.392	−0.028	0.71789	0.570	0.376	−0.023
0.4035	0.74123	0.605	0.407	−0.035	0.73649	0.617	0.390	−0.029
0.5007	0.75966	0.620	0.424	−0.037	0.75481	0.634	0.405	−0.033
0.6009	0.77957	0.543	0.447	−0.035	0.77462	0.555	0.425	−0.033
0.7044	0.80080	0.430	0.473	−0.032	0.79575	0.440	0.448	−0.030
0.8016	0.82129	0.311	0.499	−0.026	0.81614	0.318	0.472	−0.026
0.9021	0.84292	0.196	0.534	−0.012	0.83767	0.201	0.502	−0.015
		T = 318.15 K				T = 323.15 K		
0.1014	0.67876	0.267	0.338	−0.006	0.67427	0.269	0.322	−0.009
0.2016	0.69570	0.449	0.348	−0.015	0.69110	0.456	0.332	−0.016
0.3020	0.71321	0.585	0.358	−0.023	0.70851	0.595	0.342	−0.023
0.4035	0.73174	0.625	0.372	−0.029	0.72690	0.644	0.355	−0.028
0.5007	0.74993	0.649	0.389	−0.030	0.74502	0.662	0.371	−0.029
0.6009	0.76964	0.568	0.408	−0.028	0.76463	0.580	0.390	−0.027
0.7044	0.79067	0.449	0.430	−0.026	0.78557	0.457	0.411	−0.023
0.8016	0.81096	0.326	0.454	−0.019	0.80575	0.334	0.433	−0.018
0.9021	0.83240	0.204	0.484	−0.009	0.82710	0.209	0.458	−0.010

3.3. *Calculations*

Values of the excess molar volume, V^E, listed in Tables 3 and 4 were calculated from the experimental data according to the equation:

$$V^E = \frac{1}{\rho} \cdot \sum_{i=1}^{2} x_i \cdot M_i - \sum_{i=1}^{2} \frac{x_i \cdot M_i}{\rho_i}, \tag{3}$$

Table 4. Densities, ρ, viscosity, η, excess molar volume, V^E, and viscosity deviation, $\Delta\eta$, of binary mixtures of propyl propanoate (x_1) + heptane (x_2) at different temperatures.

x_1	$\rho \times 10^{-3}$ kg·m^3	$V^E \times 10^6$ m^3·mol^{-1}	$\eta \times 10^{-3}$ Pa·s	$\Delta\eta \times 10^{-3}$ Pa·s	$\rho \times 10^{-3}$ kg·m^3	$V^E \times 10^6$ m^3·mol^{-1}	$\eta \times 10^{-3}$ Pa·s	$\Delta\eta \times 10^{-3}$ Pa·s
T = 278.15 K					T = 283.15 K			
0.1015	0.72854	0.283	0.657	−0.013	0.72445	0.286	0.613	−0.017
0.1994	0.74301	0.447	0.659	−0.028	0.73880	0.456	0.613	−0.033
0.2983	0.75849	0.550	0.659	−0.046	0.75417	0.559	0.612	−0.049
0.4048	0.77579	0.669	0.667	−0.063	0.77134	0.681	0.624	−0.058
0.5000	0.79244	0.672	0.680	−0.067	0.78788	0.683	0.636	−0.062
0.5980	0.81058	0.624	0.697	−0.068	0.80589	0.635	0.650	−0.062
0.7006	0.83077	0.514	0.723	−0.062	0.82594	0.524	0.674	−0.056
0.7992	0.85123	0.383	0.758	−0.047	0.84627	0.390	0.702	−0.045
0.9087	0.87534	0.199	0.808	−0.023	0.87024	0.200	0.744	−0.027
		T = 288.15 K				T = 293.15 K		
0.1015	0.72033	0.293	0.576	−0.016	0.71621	0.296	0.542	−0.014
0.1994	0.73458	0.464	0.578	−0.028	0.73034	0.473	0.545	−0.024
0.2983	0.74983	0.571	0.577	−0.045	0.74547	0.583	0.546	−0.035
0.4048	0.76687	0.695	0.585	−0.056	0.76238	0.710	0.554	−0.045
0.5000	0.78329	0.698	0.595	−0.060	0.77868	0.714	0.561	−0.050
0.5980	0.80118	0.649	0.609	−0.060	0.79645	0.662	0.573	−0.051
0.7006	0.82112	0.531	0.631	−0.054	0.81630	0.535	0.592	−0.046
0.7992	0.84129	0.399	0.658	−0.043	0.83629	0.408	0.615	−0.038
0.9087	0.86512	0.203	0.700	−0.024	0.85999	0.204	0.651	−0.022
		T = 298.15 K				T = 303.15 K		
0.1015	0.71206	0.304	0.512	−0.015	0.70790	0.309	0.484	−0.016
0.1994	0.72609	0.482	0.514	−0.025	0.72181	0.493	0.485	−0.026
0.2983	0.74110	0.596	0.517	−0.033	0.73670	0.611	0.487	−0.034
0.4048	0.75789	0.723	0.523	−0.043	0.75336	0.741	0.494	−0.042
0.5000	0.77406	0.730	0.530	−0.047	0.76942	0.746	0.501	−0.044
0.5980	0.79171	0.677	0.541	−0.047	0.78694	0.693	0.512	−0.044
0.7006	0.81144	0.545	0.559	−0.041	0.80656	0.555	0.526	−0.041
0.7992	0.83129	0.417	0.583	−0.031	0.82626	0.427	0.546	−0.033
0.9087	0.85484	0.209	0.617	−0.015	0.84968	0.210	0.576	−0.020
		T = 308.15 K				T = 313.15 K		
0.1015	0.70371	0.315	0.462	−0.010	0.69951	0.321	0.432	−0.009
0.1994	0.71751	0.502	0.461	−0.020	0.71319	0.514	0.434	−0.017
0.2983	0.73229	0.622	0.463	−0.029	0.72785	0.637	0.437	−0.023
0.4048	0.74882	0.755	0.470	−0.034	0.74425	0.774	0.443	−0.031
0.5000	0.76475	0.763	0.476	−0.038	0.76007	0.781	0.449	−0.035
0.5980	0.78216	0.707	0.485	−0.038	0.77735	0.724	0.457	−0.036
0.7006	0.80165	0.565	0.500	−0.034	0.79672	0.578	0.471	−0.032
0.7992	0.82121	0.436	0.516	−0.028	0.81614	0.447	0.488	−0.026
0.9087	0.84449	0.213	0.544	−0.016	0.83928	0.218	0.516	−0.014
		T = 318.15 K				T = 323.15 K		
0.1015	0.69527	0.329	0.414	−0.009	0.69102	0.335	0.395	−0.009
0.1994	0.70884	0.526	0.416	−0.016	0.70447	0.539	0.395	−0.017
0.2983	0.72338	0.653	0.417	−0.023	0.71890	0.668	0.398	−0.023
0.4048	0.73966	0.790	0.422	−0.030	0.73504	0.810	0.405	−0.027
0.5000	0.75536	0.798	0.428	−0.034	0.75062	0.819	0.409	−0.031
0.5980	0.77252	0.741	0.436	−0.034	0.76766	0.759	0.417	−0.030
0.7006	0.79175	0.593	0.449	−0.030	0.78675	0.609	0.429	−0.027
0.7992	0.81104	0.459	0.466	−0.024	0.80592	0.470	0.444	−0.021
0.9087	0.83405	0.221	0.491	−0.014	0.82880	0.224	0.467	−0.012

where M_i and ρ_i are the molar mass and density of pure components, respectively, and ρ is the density of the mixture.

The values of viscosity deviations, $\Delta\eta$, for the binary mixtures shown in Tables 3 and 4, were calculated using the equation:

Table 5. Parameters of Jouyban–Acree equation and mean relative deviation for density and viscosity.

	$\rho \times 10^{-3}$ kg · m^{-3}	$\eta \times 10^{-3}$ Pa · s
	Propyl propanoate + heptane	
J_0	−3.36450	−70.158
J_1	0.70992	0.641
J_2	0.31361	15.337
MRD	0.02%	0.50%
	Propyl propanoate + octane	
J_0	−12.33570	−95.124
J_1	−0.27231	−15.405
J_2	0.31002	17.664
MRD	0.03%	0.30%

Table 6. Coefficients, a_i, for excess molar volume of the binary systems at all temperatures.

K	a_0 cm^3 · mol^{-1}	a_1 cm^3 · mol^{-1}	a_0 cm^3 · mol^{-1}	a_1 cm^3 · mol^{-1}
	Propyl propanoate + heptane		Propyl propanoate + octane	
278.15	2.043	−0.396	2.636	−0.342
283.15	2.172	−0.573	2.683	−0.345
288.15	2.201	−0.572	2.738	−0.359
293.15	2.229	−0.575	2.789	−0.375
298.15	2.293	−0.549	2.849	−0.383
303.15	2.346	−0.557	2.912	−0.402
308.15	2.392	−0.582	2.970	−0.407
313.15	2.445	−0.588	3.041	−0.416
318.15	2.499	−0.609	3.112	−0.428
323.15	2.552	−0.613	3.188	−0.428

Table 7. Coefficients, a_i, for viscosity deviation of the binary systems at all temperatures.

T K	a_0 mPa · s	a_1 mPa · s	a_0 mPa · s	a_1 mPa · s
278.15	−0.275	−0.029	−0.264	−0.086
283.15	−0.250	–	−0.253	−0.054
288.15	−0.245	−0.057	−0.240	−0.065
293.15	−0.177	−0.049	−0.202	−0.068
298.15	−0.157	−0.023	−0.186	−0.033
303.15	−0.149	−0.029	−0.184	−0.032
308.15	−0.145	−0.020	−0.153	−0.036
313.15	−0.128	−0.051	−0.139	−0.045
318.15	−0.114	–	−0.134	−0.040
323.15	−0.112	–	−0.124	−0.023

Table 8. Comparison between measured experimental data of V^E (×10^{-6} m^3·mol^{-1}) against published literature values at a molar fraction $x_1 = 0.5$.

	This work	Lorenzana [17]	MDR	Ortega [18]	MDR	Ortega [19]	MDR
			Propyl propanoate + heptane				
298.15 K	0.573	0.541	5.7	0.555	3.2	-	-
318.15 K	0.598	-	-	-	-	0.600	0.3
			Propyl propanoate + octane				
298.15 K	0.712	0.673	5.4	-	-	-	-

$$\Delta\eta = \eta - \sum_{i=1}^{2} x_i \cdot \eta_i, \tag{4}$$

V^E and $\Delta\eta$ at each temperature were satisfactorily correlated with Redlich–Kister equation [10], using the adjustable coefficients, a_i, listed in Tables 6 and 7.

Experimental data of V^E for the binary systems studied were previously published by other authors [17–19]. Table 8 shows the comparison between our data and the literature, from the calculation of the MRD for an equimolar fraction. In each case, the V^E at $x_1 = 0.5$ was calculated from the Redlich–Kister equation.

It can be observed in Figures 1 and 2 (and in Tables 3 and 4) that the excess molar volume values are positive at all measured temperatures and over the entire composition range, which indicates a positive deviation from ideal behaviour of both systems during the mixing process. The

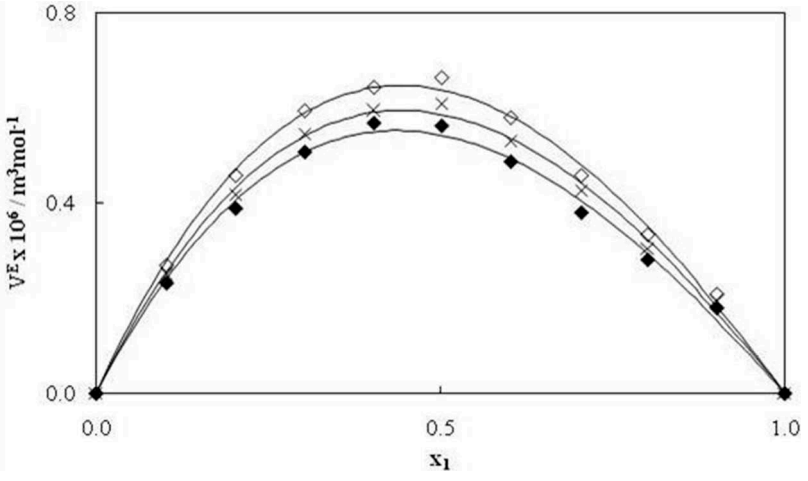

Figure 1. Plot of the excess molar volumes, V^E, of propyl propanoate + heptane binary mixtures against the molar fraction of propyl propanoate, x_1, in the mixture at (♦) 283.15 K, (×) 303.15 K and (◊) 323.15 K. The solid line represents the fit with Redlich–Kister equation.

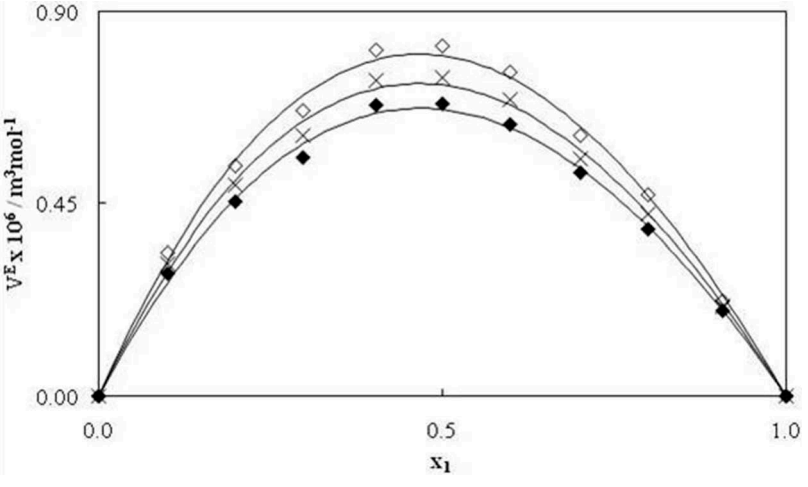

Figure 2. Plot of the excess molar volumes, V^E, of propyl propanoate + octane binary mixtures against the molar fraction of propyl propanoate, x_1, in the mixture at (♦) 283.15 K, (×) 303.15 K and (◊) 323.15 K. The solid line represents the fit with Redlich–Kister equation.

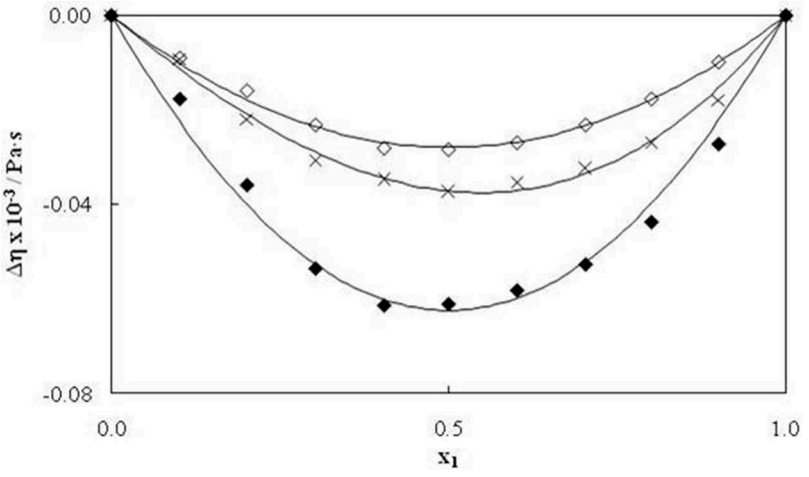

Figure 3. Plot of the viscosities deviation, $\Delta\eta$, of propyl propanoate + heptane binary mixtures against the molar fraction of propyl propanoate, x_1, in the mixture at (♦) 283.15 K, (×) 303.15 K and (◊) 323.15 K. The solid line represents the fit with Redlich–Kister equation.

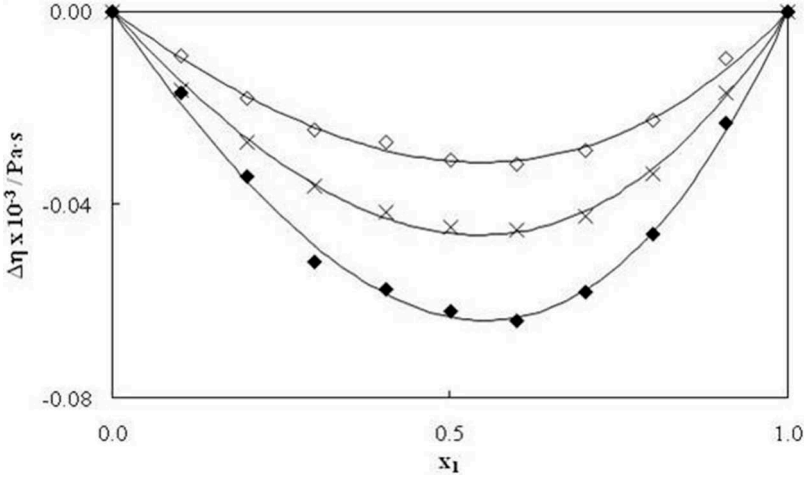

Figure 4. Plot of the viscosities deviation, $\Delta\eta$, of propyl propanoate + octane binary mixtures against the molar fraction of propyl propanoate, x_1, in the mixture at (♦) 283.15 K, (×) 303.15 K and (◊) 323.15 K. The solid line represents the fit with Redlich–Kister equation.

positive values of V^E indicate that the interactions between the same molecules are stronger than the interactions between unlike molecules. The maximum value of the excess molar volume is observed near the equimolar composition.

The values of the viscosity deviation, given in Tables 3 and 4, were represented in Figures 3 and 4, showing negative and small values in the whole composition range and all temperatures.

Positive data of the excess molar volume and small negative values of viscosity deviation indicate the lack of specific interactions between unlike molecules [20–24].

4. Conclusion

As a conclusion, density and viscosity data of propyl propanoate + heptane and propyl propanoate + octane mixtures are reported at temperatures between 283.15 and 323.15 K, and the Jouyban–Acree model constants of the data are computed. From these constants, it is possible to predict the density and viscosity data in all solvent compositions of propylene glycol + water at various temperatures using the interpolation technique. The experimental measurements of density and viscosity provide some information regarding the state of interactions in solution. The investigated binary liquid mixtures formed by propyl propanoate and heptane or octane mixture reveal values of excess molar volume and viscosity deviations characteristic for binary systems with absence of specific molecular interactions where interactions between unlike molecules are a little weaker than the interactions between the same molecules.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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