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Viscosity Study of Molecular Association in Binary Mixtures of Acetone with Some Aromatic Hydrocarbons at Different Temperatures

دراسة التساند الجزيئي بين الاسيتون وبعض المركبات العطرية وبدرجات حراريه مختلفة بواسطة قياسات اللزوجه

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Abstract

The viscosities η, and refractive indices, n, of binary mixture for acetone +benzene, +toluene, +p-xylene and +mesitylene, cover the whole mole fraction range have been measured at 298.15, 303.15, 308.15, 313.15, and 318.15 K. From the experimental data, the deviations in viscosity, Δη, and deviations in molar refraction, ΔRm, have been calculated. The variation of these parameters with composition and temperature of the mixtures have been discussed in terms of molecular interaction. The effect of the number of the methyl groups in these aromatic hydrocarbons on molecular interactions has been discussed. The free energies ΔG*, enthalpies ΔH*, and entropies ΔS*, of activation of viscous flow have also been obtained using Eyring viscosity equation. The ΔH* values were found independent of temperature.

الخلاصة

تم قياس اللزوجة(η) ومعامل الانكسار (n) وبتراكيز مختلفه للاسيتون مع كل من البنزين و التلوين و البارا زايلين و المستلين , وبدرجات حراره (298,15 و 303,15 و308,15 و313,15 و318,15) كلفن ومن النتائج العمليه لستة عشر مخطط ثنائي التكوين حسب مقدار الانحراف في اللزوجه (ηΔ) , ومقدار الانحراف في الانكسار الضوئي المولي (ΔRm) , وقد نوقشت نتائج الانحراف للتراكيز المختلفه وباختلاف درجات الحراره على ضوء التأثير المتبادل للجزيئات فيما بينها مع زيادة عدد مجاميع المثيل على الحلقة العطريه .

كما نوقشت قيم الطاقه الحره *ΔG والانثالبي *ΔH والانتروبي *ΔS لطاقة جريان المحاليل المدروسه باستعمال معادلة ايرنك. اذ وجد ان قيمة *ΔH لاتتغير بتغير درجات الحراره .

INTRODUCTION

Mixed solvents, rather than single pure liquids, are extensively used in industrial and chemical processes as they provide a wide range of solvents with variable physical properties. The physical property data on mixed solvents are important for theoretical and applied areas of research and are frequently used in many chemical and industrial processes such as design of new processes and process equipment (flow, mass transfer or heat transfer calculations).

Acetone is a versatile compound having a wide range of applications as a solvent in chemical and biological processes (1) It is a highly polar (dipole moment = 2.91 D) (2) and strongly associated aprotic solvent due to polar C=O group in the molecule. In the pure state, acetone molecules associate chains with parallel dipole moments, while neighboring acetone molecules from adjacent chains are oriented with antiparallel dipole moments (3, 4).

The aromatic hydrocarbon molecules (benzene, toluene, *p*-xylene, and mesitylene) possess large quadrupole moments (5) causing an orientational order in these liquids. The binary mixtures

of acetone with aromatic hydrocarbons will be interesting for their applications in the studies of polymer phase diagrams and preferential interaction of polymers in mixed solvents.(6,7)

The aim of the present work is to obtain information's regarding molecular interactions in mixtures of a highly polar liquid with non-polar / weakly polar liquids, and experimental measurements of the viscosities, η□and refractive indices, n of pure acetone, benzene, toluene, *p*-xylene, and mesitylene and those of their binary mixtures, using acetone as common component, at 298.15, 303.15, 308.15, 313.15, and 318.15 K covering the whole composition range expressed by mole fraction, X1 of acetone. The functions such as Δη□and □ΔRm have been calculated and the results have been discussed in terms of molecular interactions of these mixtures. The free energies, ΔG*, enthalpies, ΔH*, and entropies, ΔS*, of activation of viscous flow have also been obtained by using the Eyring viscosity equation.

EXPERIMENTAL

Acetone was (E. Merck, Germany), Benzene, Toluene, p-Xylene, and Mesitylene (BDH purities (mass per cent) > 99.5%, were used as such without further purification.

The mixtures were prepared by mass and were kept in special airtight stoppered glass volumetric flask to avoid evaporation. The weightings were done on a Sartorius BL 210 S electronic balance with a precision of ± 0.1 mg. The densities of the pure liquids and the mixtures were measured with a 10 cm^3 capillary pycnometer. Distilled water was used for calibration. The viscosities of pure liquids and their binary mixtures were measured by using Ubbelohde type suspended level viscometer. The viscometer was calibrated with double distilled water. The viscometer containing the test liquid was allowed to stand for about 15 minutes in a thermostatic water bath so that the thermal fluctuations in the viscometer were minimized. The times of flow were recorded with stopwatch with an accuracy of ± 0.01 second. The viscosity data were reproducible within ±□1×10^{-6} N m^{-2} s.

The refractive indices of pure liquids and their binary mixture were measured by using a thermostated Abbe refractometer KIKUCHI TOKYO No. 7514 W.S.R. Japan. The refractometer was calibrated by measuring the refractive indices of double distilled water and Toluene at desired temperatures.

The values of refractive index were obtained using sodium D light. The reproducibility of refractive index measurements were within ± 0.0001. The temperature of the test liquids during the measurements was maintained to an accuracy of ± 0.05 K in an electronically controlled thermostatic water bath (MGW LAUDA HANNOVER, Germany). The reliability of experimental measurements of □, η□and, n, were ascertained by comparing the experimental data of pure liquids with the corresponding values, which were available in the literature (8-15) at the studied temperatures Table 1.

RESULTS AND DISCUSSION

The experimental values of viscosity and refractive index of binary mixtures of acetone with benzene, toluene, *p*-xylene, and mesitylene, over the whole composition range expressed by mole fraction, x1 of acetone at different temperatures are listed in Table (3 and 6). The viscosity deviation Δη was obtained from the dynamic viscosity and composition data through□□□□□□□□□□□□

$$\Delta\eta=\eta-(x1\eta1 + x2\eta2) \qquad (1)$$

The mole fraction deviation ΔRm have been calculated using the following relations:

$$\Delta Rm = Rm - (X1Rm1 + x2\ Rm2) \qquad (2)$$

Where x is the mole fraction; subscripts 1 and 2 stand for pure components, Acetone and aromatic hydrocarbons, respectively; Rm is the molar refraction, calculated by using the relation:

$$Rm = [(n^2\text{-}l)/(n^2+2)]\ V \qquad (3)$$

Where V is the molar volume in Table (2), calculated by using the relation

$$V = \frac{x_1 M_1 + x_2 M_2}{\rho} \qquad (4)$$

The values of Δη and ΔRm were fitted to a Redlich- Kister type polynomial equation (18).

$$Y^E = x_1(1 - x_1)\sum_{i=1}^{5} A_i(1\text{-}2x_1)^{i-1} \qquad (5)$$

Where γE is Δη or ΔRm. The values of coefficients, A*i* evaluated by the method of least-squares, with all points weighted equally, together with the corresponding standard deviation, σ (γE) calculated using the relation

$$\sigma(Y^E) = \left[\frac{\Sigma(Y^E_{Expt} - Y^E_{cal})^2}{(m-k)}\right]^{1/2} \qquad (6)$$

Where m is the number of experimental data points and k is the number of coefficients considered (k = 5 in the present calculation), are listed in Table (4). (γEcal) has been obtained from Eq.(5) using the best-fit values of coefficient Ai . The variations of smoothed values of Δη and ΔRm with mole fraction, x_1 of acetone are presented graphically in Figs. (1 and 2). In general the dipole-dipole forces are primarily responsible for the interaction between the component molecules (19,20). The deviations in viscosity, Δη (Fig. 1) are negative for all binary systems (acetone +benzene/toluene/p-xylene/Mesitylene) over the whole composition range at each investigated temperature. The negative Δη values are generally observed by (21-24) for the systems where dispersion or weak dipole-dipole forces. In the systems under study, acetone molecules are highly polar (dipole moment = 2.91 D), and the aromatic hydrocarbon molecules are non-polar having π-electrons on the ring. On mixing, the acetone molecule would induce a small dipole moment in the aromatic hydrocarbon molecule, which might lead to weak dipole-induced dipole interaction between the component molecules, in addition to donor acceptor interaction between π-electrons of benzene ring of the hydrocarbons and the electro negative oxygen of C=O group of Acetone, resulting in negative Δη values.

Negative deviation in Δη values may also be observed due to the difference in the molecular size of the component molecules (25, 26) as in the present mixtures. The magnitude of negative Δη values (Fig. 1) follows the sequence: benzene > toluene > p-xylene> mesitylene. This is also the sequence in the difference in molar volumes of acetone and aromatic hydrocarbons in the present study. For all the mixtures, the Δη values become more negative as the number of methyl groups on the aromatic ring increases moving from benzene to mesitylene.

One concludes that the magnitude of Δη, for the present systems, depends on the number of $-CH_3$ groups in the ring of the aromatic hydrocarbons.

Furthermore, the Δη values become less negative and tend towards zero as the temperature of the mixtures increases, i.e., with raises in temperature the systems approach towards ideal behavior.

The negative deviations in molar refraction also observed by (22and 24), in this work ΔRm (Fig. 2) show a negative deviation for the binary mixtures (acetone + benzene/toluene/*p*-xylene/Mesitylene),

all binary mixtures over the whole composition range at each investigated temperature. The magnitude of
ΔRm values follow the order: benzene > toluene > *p*-Xylene> Mesitylene.
In general, the negative values ΔRm suggest weak interactions between the component molecules in the mixture. Which agree and support the result of Δη. Farther, the thermodynamics of viscous flow have been investigated by using the Eyring's viscosity equation, (27-29)

$$\eta = \left(\frac{hN}{V}\right) e^{\Delta G^{*}/RT} \qquad (7)$$

Where h is Planck's constant, N is Avogadro number and ΔG* is the free energy of activation of viscous flow. Eq. (7) on combining with
ΔG* = ΔH* □□TΔS* gives the equation

$$R \ln\left(\frac{\eta V}{h N}\right) = \left(\frac{\Delta H^{*}}{T}\right) - \Delta S^{*} \qquad (8)$$

Where ΔH* and ΔS* are the enthalpy and entropy of activation of viscous flow, respectively. The plots of the left hand side of Eq. (8), i.e., Rln (ηV/hN) against 1/T for all the four binary systems at different compositions were found to show a quite linear trend for each composition of the systems under study. This indicates that ΔH* values are almost constant in the investigated temperature range, i.e., ΔH* is independent of temperature. Thus, the values of ΔH* and ΔS* were obtained as the slopes and intercepts of the linear plots of *R*ln(ηV/*h*N) against 1/T using a linear regression procedure.
The values of ΔG*, ΔH*, and ΔS* along with the linear regression coefficient,
(r) are given in Table 4. A close perusal of Table (5) indicates that for all the binary mixtures the values of ΔG* and ΔH* decrease with increase in the mole fraction of acetone in the mixtures. This suggests that the formation of activated species viscous flow appears easy in an aromatic hydrocarbon rich concentration of Acetone in the mixture increases. The values of ΔS* are negative for all the binary mixtures under study and tend to become less negative as the mole fraction of acetone increases in the mixture. The more negative ΔS* values in the aromatic hydrocarbon rich region indicate that during viscous flow there is more structured ness as a result of easy formation of activated species necessary for flow as compared to a acetone rich region where ΔS* values are large. Similar results for ΔH* and ΔS* values have also been observed for dimethylformamide + ethanediol (30) / ethanol (31) and DMSO + *o*-xylene (32) binary systems, wherein the ΔS* values were reported to be large as the amount of the self-associated component (i.e., ethanediol/ethanol) increased in the mixture, as in the Acetone-rich region in the present systems.

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Table 1. Comparison of experimental values of viscosity,□□□ and refractive index, n of pure liquids with the corresponding literature values at different temperatures

□□□□□□□

□□□

Liquid	T/K	□□ (10^{-3} N m^{-2} s) Expt.	Lit.	n Expt.	Lit.
Acetone	298.15	0.3364	0.3310 [a]	1.3595- [a]	1.3588
	303.15	0.3091	-	1.3561	-
	308.15	0.2885	-	1.3490	-
	313.15	0.2592	-	1.3459	-
	318.15	0.2356	-	1.3423	-
Benzene	298.15	0.6025	0.602, 0.6038[c]	1.4980	1.4979[a]
	303.15	0.5632	0.5612[c]	1.4947	1.4948[a]
	308.15	0.5395	0.525[a]	1.4920	1.4918[a]
	313.15	0.4991	-	1.4886	-
	318.15	0.4487	-	1.4857	-
Toluene	298.15	0.5531	0.552[a], 0.554[c]	1.4942	1.4941[a]
	303.15	0.5204	0.520[a]	1.4907	1.4905[a]
	308.15	0.5068	0.496[d]	1.4874	1.4872[a]
	313.15	0.4662	0.470[d]	1.4837	-
	318.15	0.4379	-	1.4810	-
p-Xylene	298.15	0.6110	0.6110 [e]	1.4910	-
	303.15	0.5750	0.5762 [e]	1.4890	-
	308.15	0.5501	0.5470[f]	1.4869	1.4881[g]
	313.15	0.5196	0.5080[h]	1.4850	-
	318.15	0.4912	-	1.4831	-
Mesitylene	298.15	0.6572	0.656[a]	1.4969	1.49684[i]
	303.15	0.6178	0.616[a]	1.4944	1.4945[a]
	308.15	0.5792	0.581[a]	1.4917	1.4918[a]
	313.15	0.5422	-	1.4892	-
	318.15	0.5066	-	1.4866	-

[a] Ref.[8], [b] Ref.[9], [c] Ref.[10], [d] Ref.[10], [e] Ref.[11], [f] Ref.[12], [g] Ref.[13], [h] Ref.[14], [i] Ref.[15].

Table 2 . Values of the density **ρ** (g / cm³), and molar volume **V**(cm³ / mol) and mole fraction x_1 of acetone for the binary mixtures at different temperatures.

				acetone+	benzene					
	298.15	298.15	303.15	303.15	308.15	308.15	313.15	313.15	318.18	318.18
x1	**ρ**	V	**ρ**	V	**ρ**	V	**ρ**	V	**ρ**	V
0	0.8791	88.7271	0.8646	90.2078	0.8606	90.6333	0.8563	91.0831	0.8510	91.6471
0.0868	0.8707	87.5834	0.8607	96.5278	0.8529	89.4151	0.8490	89.8259	0.8440	90.3526
0.1584	0.8638	86.6233	0.8566	94.644	0.8465	88.3922	0.8429	88.7707	0.8382	89.2674
0.2392	0.85611	85.5214	0.8432	92.5230	0.8394	87.2210	0.8361	87.5632	0.8317	88.0253
0.3284	0.84754	84.2814	0.8406	90.1849	0.8315	85.9032	0.8286	86.2059	0.8245	86.6314
0.4247	0.83828	82.914	0.8378	87.6655	0.8230	84.4523	0.8204	84.7127	0.8167	85.098
0.5271	0.8284	81.4271	0.8283	84.9921	0.8139	82.8773	0.8118	83.0927	0.8085	83.4359
0.6345	0.8181	79.8289	0.8158	82.1942	0.8044	81.1859	0.8027	81.3558	0.7998	81.6558
0.7549	0.80655	77.9885	0.8057	79.0650	0.7937	79.2426	0.7926	79.3615	0.7901	79.6127
0.8772	0.79480	76.0643	0.7957	75.8945	0.7829	77.2146	0.7822	77.2827	0.7802	77.4858
1	0.793	73.1399	0.7719	74.4544	0.7721	75.1198	0.7719	75.1392	0.7703	75.2953
				acetone+	toluene					
0	0.8716	105.5530	0.8667	106.1497	0.8610	106.8462	0.8583	107.1886	0.8549	107.6149
0.102	0.8635	102.5171	0.79105	111.9170	0.8519	103.9144	0.8494	104.2190	0.8462	104.6143
0.1836	0.857	100.047	0.7916	108.3328	0.8447	101.5231	0.8424	101.7978	0.8393	102.1702
0.2731	0.8501	97.2959	0.7922	104.407	0.8367	98.8522	0.834	99.0950	0.8317	99.4416
0.3688	0.8426	94.3029	0.7928	100.217	0.8282	95.9393	0.8264	96.1494	0.8237	96.4681
0.4687	0.8347	91.1210	0.7935	95.8500	0.8193	92.8348	0.8178	93.0107	0.8152	93.3028
0.5712	0.8267	87.7934	0.7942	91.3772	0.8102	89.5774	0.8089	89.7213	0.8065	89.9849
0.6748	0.8185	84.3636	0.7949	86.8645	0.8010	86.2110	0.7999	86.3220	0.7978	86.5579
0.7864	0.8097	80.5918	0.7957	82.0124	0.7911	82.4957	0.7903	82.5740	0.7883	82.7814
0.8952	0.8012	76.8351	0.7965	77.2910	0.7814	78.7837	0.7809	78.8311	0.7791	79.012
1	0.79	73.1399	0.779	74.4544	0.7721	75.1198	0.7719	75.1392	0.7703	75.2953
				acetone+	p-xylene					
0	0.8654	122.4867	0.8503	124.6618	0.8336	127.1593	0.8268	128.2051	0.8199	129.2840
0.1163	0.8569	117.1761	0.7891	127.2401	0.8264	121.5062	0.8204	122.3992	0.8141	123.3434
0.2067	0.8504	112.9756	0.789	121.6699	0.8208	117.0431	0.8154	117.8225	0.8096	118.6680
0.3034	0.8434	108.4101	0.7901	115.7188	0.8149	112.2006	0.8101	112.8654	0.8048	113.6072
0.4038	0.8361	103.5891	0.7906	109.5480	0.8087	107.0992	0.8046	107.6489	0.7998	108.2896
0.5057	0.8287	98.6096	0.7912	103.2932	0.802	101.8410	0.7990	102.2820	0.7948	102.825
0.607	0.8214	93.570	0.7917	97.0835	0.7962	96.5300	0.7934	96.8707	0.7897	97.3220
0.7064	0.8142	88.5381	0.7922	90.9982	0.7901	91.2393	0.7880	91.4871	0.7848	91.8543
0.8103	0.8067	83.1817	0.7927	84.6459	0.7837	85.6200	0.7823	85.7787	0.7797	86.0659
0.9083	0.7996	78.0372	0.7932	78.6621	0.7777	80.2345	0.7769	80.3181	0.7748	80.534
1	0.793	73.1399	0.779	74.4544	0.7721	75.1198	0.7719	75.1392	0.7703	75.2953
				acetone+	mesitelyne					
0	0.8618	139.2402	0.8564	140.1214	0.8525	140.7624	0.8470	141.6631	0.8416	142.5753
0.1051	0.8545	132.7937	0.8482	133.7842	0.8440	134.4515	0.8391	135.2333	0.8341	136.0456
0.2058	0.84765	126.5139	0.8404	127.5957	0.8359	128.2856	0.8316	128.9567	0.8269	129.6787
0.3071	0.84068	120.0922	0.832	121.2584	0.8278	121.9615	0.8239	122.5255	0.8197	123.1607
0.4042	0.8340	113.8360	0.8251	115.0629	0.82	115.78	0.8166	116.2492	0.8128	116.8041
0.5018	0.8272	107.4457	0.8175	108.7240	0.8121	109.4482	0.8093	109.826	0.8058	110.303
0.6024	0.8203	100.7495	0.8097	102.0675	0.8040	102.7923	0.8017	103.0833	0.7986	103.4860
0.7074	0.8131	93.6388	0.8016	94.9817	0.7956	95.7004	0.7938	95.9090	0.7911	96.2375
0.8031	0.8065	87.0469	0.7942	88.3962	0.7879	89.1041	0.7867	89.2434	0.7843	89.5108
0.9049	0.7995	79.9157	0.7863	81.2556	0.7797	81.9455	0.7790	82.0180	0.7770	82.2260
1	0.7932	73.1399	0.779	74.4544	0.7721	75.11980	0.7719	75.1392	0.770	75.2953

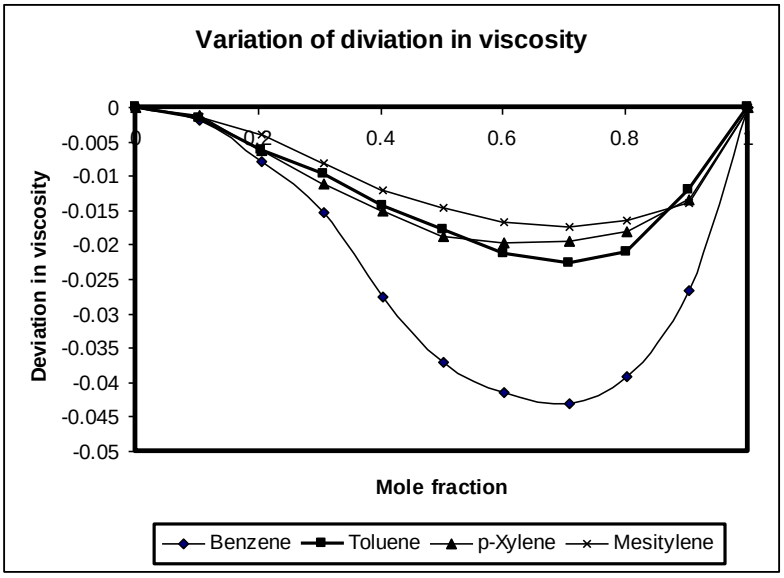

Fig. 1. Variation of deviation in viscosity, η , with mole fraction, x1 of acetone for the binary mixtures at 298.15 K. Points show experimental values and curves show smoothed values using Eq. (5).

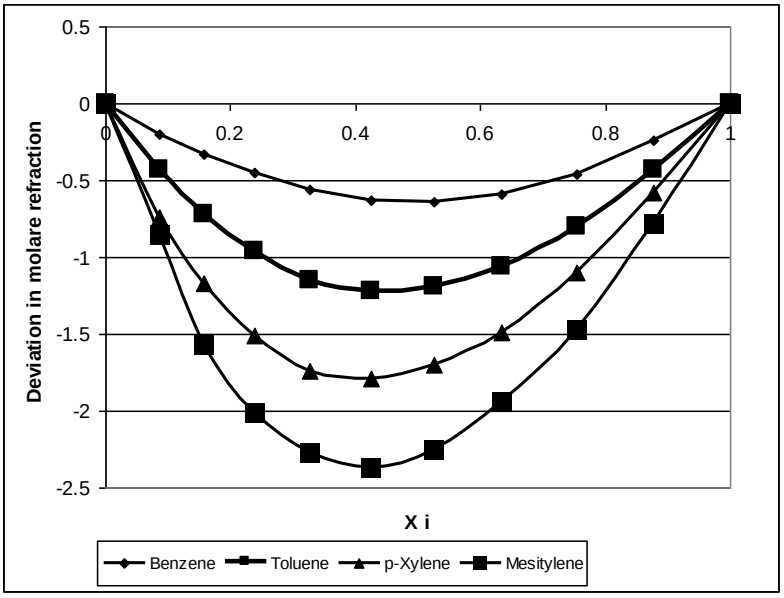

Fig. 2. Variation of deviation in molar refraction, Rm with mole fraction, x1 of acetone for the binary mixtures at 298.15 K. Points show experimental values and curves show smoothed values using Eq. (5).

Table 3. Values of viscosities, (10^{-3} N m $^{-2}$ s) as function of Mole fraction, x_1 of Acetone for the binary mixtures at different temperature

	Temperature / K			
X1	298.15	303.15	308.15	313.15
	Acetone+ Benzene			
0.0868	0.5774	0.5382	0.5145	0.4741
0.1584	0.5526	0.5132	0.4895	0.4491
0.2392	0.5271	0.4882	0.4645	0.4241
0.3284	0.4875	0.4632	0.4305	0.3991
0.4247	0.4476	0.4285	0.3965	0.3741
0.5271	0.4071	0.3938	0.3625	0.3441
0.6345	0.3828	0.3690	0.3475	0.3441
0.7549	0.3576	0.3491	0.3225	0.3141
0.8772	0.3325	0.3391	0.3125	0.2891
	Acetone+ Toluene			
0.102	0.5301	0.4971	0.4832	0.4462
0.1836	0.5070	0.4738	0.4599	0.4262
0.2731	0.4842	0.4505	0.4366	0.4062
0.3688	0.4616	0.4272	0.4069	0.3754
0.4687	0.4381	0.4039	0.3621	0.3442
0.5712	0.4124	0.3767	0.3338	0.3132
0.6748	0.3861	0.3495	0.3170	0.2888
0.7864	0.3605	0.3223	0.3003	0.2768
0.8952	0.3371	0.3160	0.2904	0.2647
	Acetone+ p-Xylene			
0.1163	0.5795	0.5460	0.523	0.4916
0.2067	0.5480	0.5170	0.4961	0.4636
0.3034	0.5165	0.4880	0.4691	0.4356
0.4038	0.4850	0.4575	0.4215	0.4049
0.5057	0.4535	0.4270	0.3818	0.3742
0.6070	0.4220	0.3965	0.3414	0.3435
0.7064	0.3920	0.3675	0.3113	0.3155
0.8103	0.3620	0.3385	0.3011	0.2899
0.9084	0.3482	0.3153	0.3691	0.2696
	Acetone+ Mesitylene			
0.1051	0.6222	0.5838	0.5472	0.5112
0.2058	0.5872	0.5498	0.5152	0.4802
0.3071	0.5522	0.5016	0.4832	0.4492
0.4042	0.5154	0.4809	0.4503	0.4170
0.5018	0.4786	0.4460	0.4174	0.3848
0.6024	0.4418	0.4111	0.3845	0.3526
0.7074	0.4068	0.3771	0.3525	0.3216
0.8031	0.3718	0.3431	0.3205	0.2906
0.9049	0.3468	0.3191	0.2969	0.2658

Table 4. Coefficients, A_i of Eq. (5) and standard deviations $\sigma(Y^E)$ for the Binary mixtures at different temperatures.

T/K	A1	A2	A3	A4	A5	$\sigma(Y^E)$
		Acetone + Benzene				
Δη (10^{-3} N m^{-2} s)						
298.15	-0.9256	0.1924	0.0048	0.1562	-0.3194	0.0008
303.15	-0.8062	0.2019	0.0096	0.0037	-0.0775	0.0010
308.15	-0.6948	0.1815	-0.0570	-0.0601	0.1165	0.0018
313.15	-0.5875	0.1520	-0.1323	-0.0182	0.2794	0.0006
318.15	-0.5147	0.1627	-0.0903	-0.0633	0.2269	0.0005
ΔRm(10^{-6} m^3 mol^{-1})						
298.15	-0.8282	-0.2746	-0.2318	0.0756	0.2526	0.0013
303.15	-0.8503	-0.2799	-0.1535	0.0596	0.0919	0.0012
308.15	-0.8688	-0.2966	-0.2512	0.1462	0.2567	0.0006
313.15	-0.8988	-0.2727	-0.2354	0.0912	0.2306	0.0009
318.15	-0.9353	-0.2668	-0.2908	0.0961	0.2605	0.0010
		Acetone + Toluene				
Δη (10^{-3} N m^{-2} s)						
298.15	-1.0161	0.3176	-0.0325	0.3248	-0.2879	0.0010
303.15	-0.9003	0.2585	0.0325	0.2703	-0.2659	0.0026
308.15	-0.8125	0.1678	0.1792	0.2561	-0.3441	0.0009
313.15	-0.7156	0.1189	0.1695	0.2114	-0.2609	0.0016
318.15	-0.6360	0.0829	0.0613	0.1282	0.0365	0.0011
ΔRm(10^{-6} m^3 mol^{-1})						
298.15	-0.7675	-0.2238	0.0102	0.2485	0.1355	0.0006
303.15	-0.8166	-0.2177	0.0372	0.2208	0.2361	0.0009
308.15	-0.8530	-0.2038	0.0261	0.2509	0.3522	0.0020
313.15	-0.8878	-0.2069	-0.0563	0.2738	0.5316	0.0010
318.15	-0.9372	-0.2585	0.0874	0.3603	0.3911	0.0009
		Acetone + *p*-Xylene				
Δη (10^{-3} N m^{-2} s)						
298.15	-1.1564	0.4481	-0.1650	0.1959	-0.1650	0.0010
303.15	-1.0692	0.4059	-0.1485	0.2228	-0.1202	0.0013
308.15	-1.0004	0.3933	-0.1582	0.1273	0.0566	0.0014
313.15	-0.9458	0.3709	-0.2124	0.1980	0.2036	0.0011
318.15	-0.8896	0.3652	-0.2685	0.1484	0.3158	0.0006
ΔRm(10^{-6} m^3 mol^{-1})						
298.15	-0.7227	-0.1483	-0.0356	0.2203	-0.1052	0.0015
303.15	-0.7377	-0.2016	0.0420	0.2599	-0.1294	0.0020
308.15	-0.7499	-0.2191	-0.0300	0.2909	-0.0497	0.0007

313.15	-0.7617	-0.2083	-0.1996	0.2737	0.1604	0.0009
318.15	-0.7893	-0.2556	-0.2574	0.4011	0.3007	0.0008

Table 5. The values of free energy, ΔG^*, enthalpy, ΔH^* and entropy, ΔS^* of activation of viscous flow along with the linear regression coefficient, r as function of mole fraction, x1 of Acetone for the binary mixture .

X1	ΔG*(kJ/mol.) (at 298.15 K)	Δ H* (kJ/ mol)	ΔS* (J/mol. K)	r
	BENZENE+ACETONE			
0	12.1450	11.4630	-2.94	0.970
0.0868	11.9787	12.1830	-0.05	0.970

0.1584	11.8416	11.9130	-0.54	0.989
0.2392	11.6869	11.3580	-1.84	0.991
0.3284	11.5161	11.2300	-1.63	0.996
0.4247	11.3316	10.9250	-1.94	0.997
0.5271	11.1356	10.3740	-2.96	0.999
0.6345	10.9299	9.85700	-3.75	0.998
0.7549	10.6993	9.51900	-3.84	0.999
0.8772	10.4651	9.24900	-3.67	0.999
1	10.2300	8.22600	-3.53	0.998
	TOLUENE + ACETONE			
0	12.3710	11.1770	-13.72	0.971
0.1020	12.1509	10.2370	-11.07	0.987
0.1836	11.9749	9.21100	-8.07	0.994
0.2731	11.7819	8.60700	-6.55	0.996
0.3688	11.5754	7.77400	-4.37	0.998
0.4687	11.3600	7.61800	-4.47	0.998
0.5712	11.1389	7.55500	-4.99	0.997
0.6748	10.9154	7.47800	-5.61	0.998
0.7864	10.6747	7.52700	-6.66	0.997
0.8952	10.4400	7.07900	-6.05	0.996
1	10.2300	8.22600	-3.53	0.998
	P- XYLENE + ACETONE			
0	13.2520	11.4300	-17.7	0.997
0.1163	12.9005	10.2920	-14.34	0.999
0.2067	12.6273	9.01100	-10.33	0.998
0.3034	12.3351	7.81200	-6.77	0.999
0.4038	12.0317	7.12100	-4.92	0.999
0.5057	11.7237	6.61300	-3.68	0.999
0.6070	11.4176	5.80900	-1.48	0.999
0.7064	11.1172	5.59900	-1.33	0.999
0.8103	10.8032	5.45100	-1.46	0.999
0.9084	10.5068	6.83700	-3.36	0.999
1	10.2300	8.22600	-3.53	0.998
	MESITELENE + ACETONE			
0	13.4670	12.4800	-13.02	0.999
0.1051	13.1267	11.8750	-11.25	0.999
0.2058	12.8008	10.6590	-7.66	0.999
0.3071	12.4729	10.0560	-6.18	0.999
0.4042	12.1586	9.46700	-4.62	0.999
0.5018	11.8426	9.20000	-4.11	0.999
0.6024	11.5170	8.82700	-3.19	0.999
0.7074	11.1771	8.77800	-3.27	0.998
0.8031	10.8673	8.61600	-3.70	0.999
0.9049	10.5378	8.49100	-4.54	0.998
1	10.2300	8.22600	-3.53	0.998

Table 6. Values of refractive indices, n as function of mole fraction x_1 of acetone for the binary mixtures at different temperatures

X1	298.15	303.15	308.15	313.15	318.15
		Acetone + Benzene			
0.0862	1.4860	1.4827	1.4796	1.4762	1.4733
0.1578	1.4761	1.4728	1.4694	1.4660	1.4630
0.2386	1.4649	1.4616	1.4578	1.4545	1.4514

0.3278	1.4526	1.4492	1.4451	1.4418	1.4386
0.4241	1.4392	1.4350	1.4313	1.4280	1.4248
0.5265	1.4250	1.4217	1.4167	1.4134	1.4101
0.6339	1.4102	1.4068	1.4013	1.3981	1.3947
0.7543	1.3935	1.3901	1.3841	1.3809	1.3775
0.8766	1.3765	1.3732	1.3666	1.3630	1.3599

Acetone + Toluene

0.1014	1.4805	1.4770	1.4733	1.4697	1.4669
0.183	1.4695	1.4660	1.4620	1.4584	1.4556
0.2725	1.4574	1.4540	1.4496	1.4461	1.4432
0.3682	1.4446	1.4411	1.4364	1.4329	1.4299
0.4681	1.4311	1.4276	1.4226	1.4191	1.4160
0.5706	1.4173	1.4138	1.4084	1.4050	1.4018
0.6742	1.4033	1.3999	1.3940	1.3907	1.3874
0.7858	1.3883	1.3849	1.3786	1.3754	1.3720
0.8946	1.3736	1.3702	1.3635	1.3604	1.3569

Acetone + *p*-Xylene

0.1157	1.4757	1.4736	1.4709	1.4689	1.4668
0.2061	1.4638	1.4616	1.4584	1.4563	1.4540
0.3028	1.4511	1.4487	1.4451	1.4428	1.4404
0.4032	1.4379	1.4354	1.4312	1.4289	1.4263
0.5051	1.4245	1.4218	1.4172	1.4147	1.4119
0.6064	1.4112	1.4084	1.4032	1.4006	1.3977
0.7058	1.3981	1.3951	1.3895	1.3868	1.3837
0.8097	1.3845	1.3813	1.3752	1.3723	1.3690
0.9078	1.3716	1.3683	1.3617	1.3587	1.3552

Acetone+ Mesitylene

0.1045	. 1.4825	1.4799	1.4767	1.4742	1.4715
0.2052	1.4687	1.4660	1.4624	1.4597	1.4569
0.3065	1.4547	1.4520	1.4479	1.4452	1.4423
0.4036	1.4414	1.4385	1.4341	1.4313	1.4283
0.5012	1.4280	1.4250	1.4201	1.4173	1.4142
0.6018	1.4142	1.4111	1.4058	1.4029	1.3996
0.7068	1.3997	1.3966	1.3908	1.3879	1.3846
0.8025	1.3866	1.3834	1.3771	1.3742	1.3707
0.9043	1.3726	1.3693	1.3626	1.3596	1.3561