Journal of Kerbala University , Vol. 8 No.1 Scientific . 2010

A study some physical properties for ternary system of hexane with some alcohols at different temperatures.

دراسة بعض الخواص الفيزيائية للنظام الثلاثي للهسكان مع بعض الكحولات عند درجات حرارية مختلفة .

Prof. Dr. Ahlam Mohammed Farhan, Ass. Prof. Dr. Eman Talib Kareem
College of Science for Women , College of Science
University of Baghdad University of Karbala
Ins. Dr. Ahmed Najem Abd
College of Veterinary medicine , University of Diyala

Abstract:-

This reasearch concerned with study the densities, ρ, refractive indices, n_D, and viscosities, η, over the range of temperatures 298.15, 308.15, 318.15, and 328.15 K for ternary mixtures cyclohexane+1-pentanol+ n-hexane, and cyclohexane+3-hexanol +n-hexane. From experimental data of densities, refractive indices, and viscosities, the excess molar volumes, V^E , excess refractive indices, n^E , and excess viscosities, η^E , were calculated for ternary mixtures. The excess function results for these mixtures were observed the ternary mixtures in this study are not ideal, show a positive or a negative deviation from ideality depending on molecular interactions in these mixtures. Flory theory was adopted to predict the excess molar volumes V^E for the ternary mixtures. The theoretical results of excess molar volumes exert good agreement in sign and magnitude with the experimental excess molar volumes for these mixtures. The mixing rules equation were used to predict theoretical refractive index, we found good agreement between them for ternary mixtures in this study. In this study Heric-coursey equation was used to calculate the excess viscosities for ternary mixtures studied here. The theoretical results of excess viscosity exert good agreement with the experimental results of excess viscosity for these mixtures.

الخلاصة :-

تم في هذه الدراسة قياس الكثافة ومعامل الانكسار واللزوجة على مدى اربع درجات حرارية للمخاليط ثلاثية المكون والتي تتضمن الهكسان الحلقي + 1- بنتانول + ن- هكسان والهكسان الحلقي + 3- هكسانول + ن- هكسان. ومن النتائج العملية لقياس الكثافة ومعامل الانكسار واللزوجة تم حساب الحجوم المولارية الفائضة V^E , معامل الانكسار الفائض n^E , واللزوجة الفائضة η^E للمخاليط الثلاثية ومن نتائج الخواص الفائضة في هذه المخاليط أتضح أن جميع المخاليط في هذه الدراسة غير مثالية (nonideal) وتظهر انحرافاً موجباً وسالباً عن المثالية أعتماداًعلى التأثيرات الجزيئية (molecular interactions) بين مكونات هذه المخاليط
تم تطبيق نظرية فلوري لحساب الحجوم المولارية الفائضة للمخاليط الثلاثية المكون وقد أظهرت القيم النظرية للحجوم المولارية الفائضة تطابقاً عالياً مع الحجوم المولارية الفائضة المحسوبة عملياً لهذه المخاليط في الاشارة والقيمة . طبقت معادلات الخلط (mixing rules) لحساب معامل الانكسار نظرياً وقد وجد تطابقاً كبير على مدى الكسر المولي . معادلة (Heric – Coursey) تم استخدامها لحساب اللزوجة الفائضة وأظهرت النتائج تطابقاً جيداً بين القيم النظرية والعملية للمخاليط المدروسة

Introduction:-

Over the last decades simple liquids and non-electrolyte solvent mixtures have been characterized on the basis of their thermo-physical properties[1]. The experimental study and proper interpretation of the thermo-physical properties of pure liquids and mixed solvents play a key role in solution chemistry; physical properties and correlation methods may be regard and as the raw material for chemical design[2]. Acknowledge of chemical and physical properties of pure liquids and their mixtures is important both academically and industrially. Many industrial processes use mixtures of solvents and knowledge of the subject area is critical to the efficient utilization-

preparation development and economic design of appropriate equipment for these processes are only possible if the chemical and physical properties of the solvent or substances to be processed are known[3] .

Studies on excess function of ternary liquid mixtures are considerable importance in understanding the nature of molecular. Interactions that determined by intermolecular forces (hydrogen bonding, charge transfer complex, Vander weal forces, etc.)[4]. In this work, the densities, dynamic, viscosities, and refractive indices of ternary mixtures of cyclohexane have been measured at over rang temperature (298.15 , 308.15 , 318.15 , and 328.15)K and atmospheric pressure over the full composition range.

Experimental part :-

(a)Materials:-

The chemical materials that was used in this research with its degree of purity and the name of the supplying company as shown in Table (1).

Table (1): The chemical materials that used with their degree of purity and name of supplier.

Chemical material	Degree of purity	Name of supplier
Cyclohexane	99.9%	BDH
n-hexane	99.9%	BDH
1-pentanol	99.5%	Fluka
3-hexanol	99.9%	Fluka

(b)Mixtures preparation :-

The solvent was kept on activated molecular sieves type 4A° for 24 hours then filtered before use, Doubly distilled water was used as the standard liquid with conductivity less than 1×10^{-6} $S.m^{-1}$.

Mixture were prepared by mass using (sartorins) balance with an accuracy of 1 ± 10^{-4} covering the whole composition range mixture were kept in air tight stoppered bottle to prevent any contamination. The possible error in mole fraction is estimated to be less than $\pm 1 \times 10^{-4}$.

(c)The measurements :-

Densities of pure liquids and their mixtures were determined using digital densimeter (Anton paur DMA 60/602), the density values were reproducible to within 1×10^{-5} $g.cm^{-3}$. The experimental technique has been described previously[5].

The refractive indices were measured with an Abbe refract meter (Tafesa) with a precision of the reading of ± 0.0002. Both apparatuses were connected to aschott-Gerate 1150, circulating water bath with proportional temperature control and an automatic drift correction system that kept the samples at the desired temperatures with an accuracy of ± 0.01 K.

On the hand, the viscosity of pure liquids and Ternary liquid mixtures were measured using connon-ubbeloude semi Micro viscometer thermo stated with digital water bath (Kottemaun). The flow times were determined electronically with an electric timer precision ± 0.05 sec. .

Results:-

The experimental results for the pure components are reported in table(2) together with literature values for comparison purposes.

The experimental data of densities ρ , viscosities η , refractive indices n_D , and excess molar volumes V^E , of Ternary mixtures (cyclohexane + 1-pentanol + n-hexane) and (cyclohexane + 3-hexanol + n-hexane) are shown in table (2) . The excess molar volumes for ternary mixtures were calculated from the relation [6] .

$$V^E_{123}\ /(cm^3.mol^{-1})=[\frac{x_1M_1+x_2M_2+x_3M_3}{\rho_m}]-[x_1\frac{M_1}{\rho_1}+x_2\frac{M_2}{\rho_2}+x_3\frac{M_3}{\rho_3}]\quad\text{.....(1)}$$

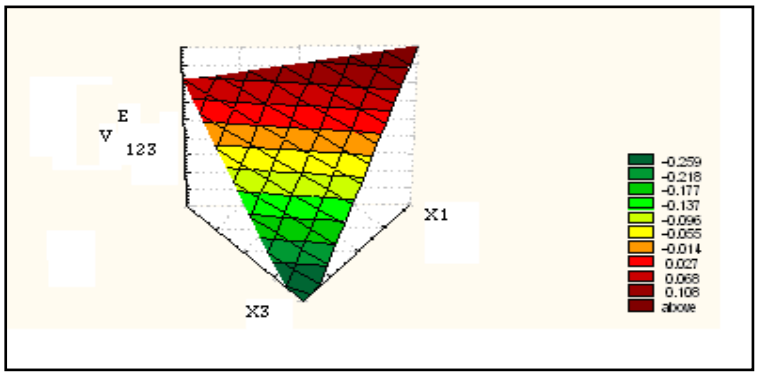
Where $x_{(1,2,3)}$, $M_{(1,2,3)}$ and $\rho_{(1,2,3)}$ are respectively the mole fraction, molar mass and density of component

(1,2,3). ρ_m is the density mixture. The obtained results of V^E_{123} are plotted as a function of the mol fraction x_1,x_2 and x_3 for the three components at four temperatures in figures (1,2) .

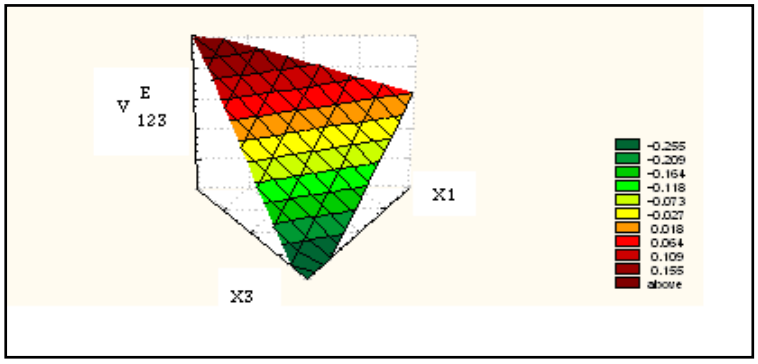
Table (2) Experimental values of the densities (ρ) and excess molar volumes (V^E_{123}) for ternary mixtures at four temperatures.

x_1 Cyclohexane + x_2 1- Pentanol + x_3 n- Hexane									
x_1	x_2	ρ ($g.cm^{-3}$) 298.15k	ρ ($g.cm^{-3}$) 298.15k	ρ ($g.cm^{-3}$) 318.15k	ρ ($g.cm^{-3}$) 298.15k	V^E_{123} ($cm^3.mol^{-1}$) 298.15k	V^E_{123} ($cm^3.mol^{-1}$) 308.15k	V^E_{123} ($cm^3.mol^{-1}$) 318.15k	V^E_{123} ($cm^3.mol^{-1}$) 328.15k
0.0195	0.4463	0.83555	0.81427	0.80300	0.77906	0.0976	0.0750	0.0808	0.0755
0.0321	0.4411	0.83187	0.81072	0.79952	0.77768	0.1054	0.0710	0.0933	0.0859
0.0998	0.3920	0.80945	0.78751	0.77824	0.76127	0.0569	0.1394	0.0552	0.0494
0.1513	0.3700	0.79583	0.77376	0.76541	0.75262	0.0258	0.1518	0.0309	0.0202
0.1867	0.3394	0.78408	0.76291	0.75422	0.73713	0.0030	0.0024	0.0115	-0.0018
0.2715	0.3145	0.76509	0.74420	0.73645	0.72905	-0.0486	-0.0378	-0.0326	-0.0465
0.3623	0.2933	0.74652	0.72602	0.71922	0.73059	-0.0857	-0.0737	-0.0800	-0.0890
0.3877	0.2839	0.74084	0.72048	0.71396	0.72853	-0.0784	-0.0725	-0.0842	-0.0903
0.4349	0.2451	0.72756	0.70728	0.70127	0.70075	-0.1032	-0.1019	-0.1061	-0.1714
0.4678	0.2360	0.72119	0.70101	0.69523	0.70081	-0.1185	-0.1112	-0.1055	-0.1187
0.4984	0.2273	0.71533	0.69526	0.68965	0.70116	-0.1312	-0.1218	-0.1026	-0.1159
0.5162	0.2184	0.71135	0.69136	0.68586	0.69670	-0.1277	-0.1221	-0.0940	-0.1118
0.5595	0.1879	0.70082	0.68088	0.67583	0.67410	-0.1571	-0.1458	-0.1192	-0.1274
0.6330	0.1194	0.68129	0.66160	0.65728	0.61378	-0.1873	-0.2089	-0.1800	-0.1639
0.6722	0.0833	0.67149	0.65167	0.64782	0.58272	-0.2302	-0.2185	-0.2085	-0.1920
0.7015	0.0574	0.66436	0.64453	0.64096	0.56119	-0.2413	-0.2165	-0.2102	-0.1866
0.7293	0.0297	0.65743	0.63760	0.63423	0.53790	-0.2689	-0.2383	-0.2224	-0.1961
0.7479	0.0201	0.65384	0.63412	0.63083	0.62752	-0.2609	-0.2382	-0.2137	-0.1963
0.7520	0.0165	0.65268	0.63314	0.62990	0.62666	-0.2199	-0.2329	-0.2108	-0.1857

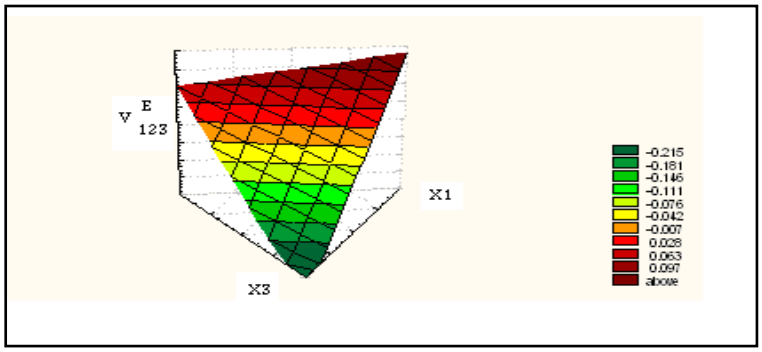
x_1 Cyclohexane + x_2 3- Hexanol + x_3 n- Hexane									
x_1	x_2	ρ ($g.cm^{-3}$) 298.15k	ρ ($g.cm^{-3}$) 298.15k	ρ ($g.cm^{-3}$) 318.15k	ρ ($g.cm^{-3}$) 298.15k	V^E_{123} ($cm^3.mol^{-1}$) 298.15k	V^E_{123} ($cm^3.mol^{-1}$) 308.15k	V^E_{123} ($cm^3.mol^{-1}$) 318.15k	V^E_{123} ($cm^3.mol^{-1}$) 328.15k
0.0235	0.3845	0.83296	0.81570	0.80713	0.78927	-0.0310	-0.0486	-0.0418	-0.0698
0.0851	0.3751	0.81900	0.80178	0.79384	0.77747	-0.0082	-0.0196	-0.0175	-0.0533
0.1463	0.3564	0.80417	0.78683	0.77945	0.76449	-0.0431	-0.0534	-0.0504	-0.0736
0.1785	0.3277	0.79300	0.77521	0.76817	0.75424	-0.0701	-0.0742	-0.0737	-0.0947
0.2311	0.3068	0.77997	0.76199	0.75543	0.74271	-0.1009	-0.0982	-0.1014	-0.1173
0.3097	0.2999	0.76596	0.74782	0.74189	0.73047	-0.1952	-0.1333	-0.1410	-0.1457
0.3316	0.2901	0.76017	0.74238	0.73660	0.72569	-0.1395	-0.1424	-0.1460	-0.1543
0.3623	0.2667	0.75102	0.73106	0.72740	0.71737	-0.1571	0.1635	-0.1554	-0.1775
0.3978	0.3434	0.75928	0.74264	0.73722	0.72667	-0.1704	-0.1717	-0.1704	-0.1949
0.4160	0.2213	0.73456	0.71604	0.71095	0.70226	-0.1855	-0.1831	-0.1931	-0.2107
0.4300	0.2187	0.73192	0.71343	0.70843	0.69998	-0.1825	-0.1804	-0.1890	-0.2098
0.4529	0.1990	0.72504	0.70633	0.70142	0.69491	-0.1910	-0.1901	-0.1837	-0.4597
0.4909	0.1821	0.71648	0.69772	0.69308	0.68586	-0.2112	-0.2056	-0.2026	-0.2176
0.5516	0.1267	0.69845	0.67922	0.67494	0.66900	-0.2643	-0.2574	-0.2438	-0.2414
0.6320	0.0693	0.67790	0.65852	0.65469	0.65027	-0.3011	-0.3283	-0.3080	-0.3048
0.7614	0.0539	0.65887	0.63990	0.63675	0.63378	-0.3641	-0.3834	-0.3666	-0.3600
0.7801	0.0416	0.65459	0.63555	0.63242	0.62963	-0.3739	-0.3883	-0.3548	-0.3246
0.8881	0.0091	0.63667	0.61765	0.61504	0.61362	-0.4425	-0.4262	-0.3953	-0.3887
0.9015	0.0079	0.63486	0.61584	0.61324	0.61198	-0.4327	-0.4042	-0.3623	-0.3643



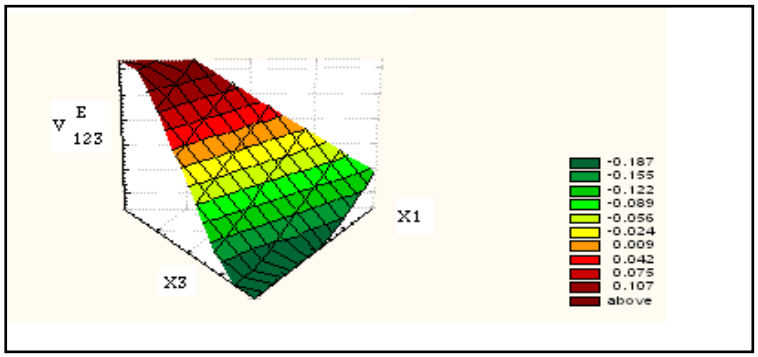
(a)



(b)

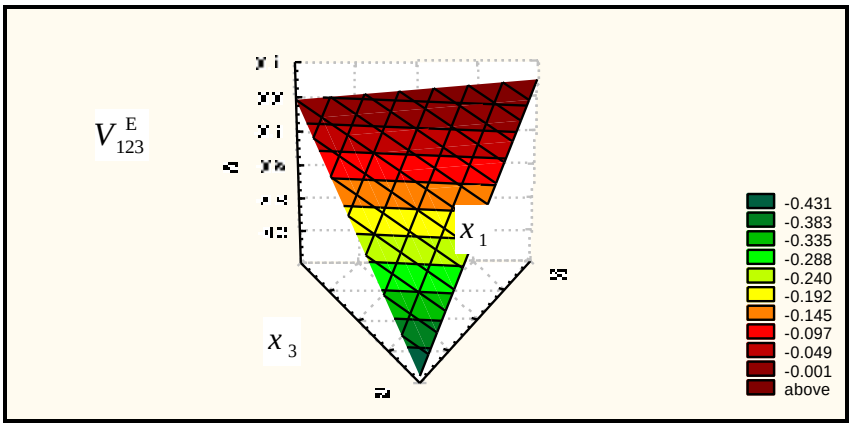


(c)

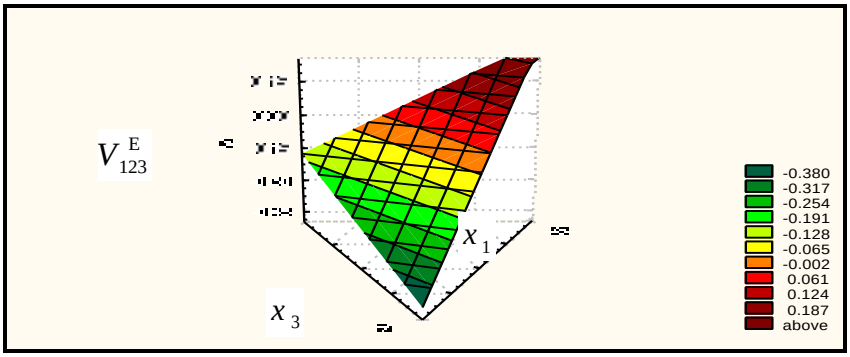


(d)

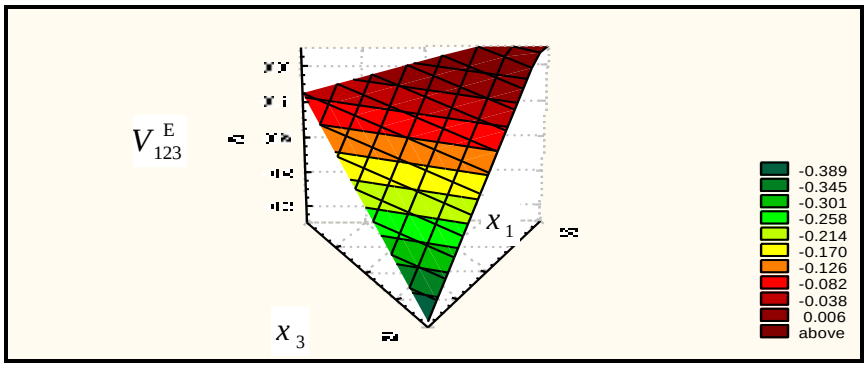
Figure (1): Excess molar volumes V_{123}^{E} for ternary system (x_1 cyclohexane. + x_2 1-pentanol+ x_3 n-hexane) at (a)298.15k, (b)308.15k, (c)318.15k, and (d)328.15k.



(a)

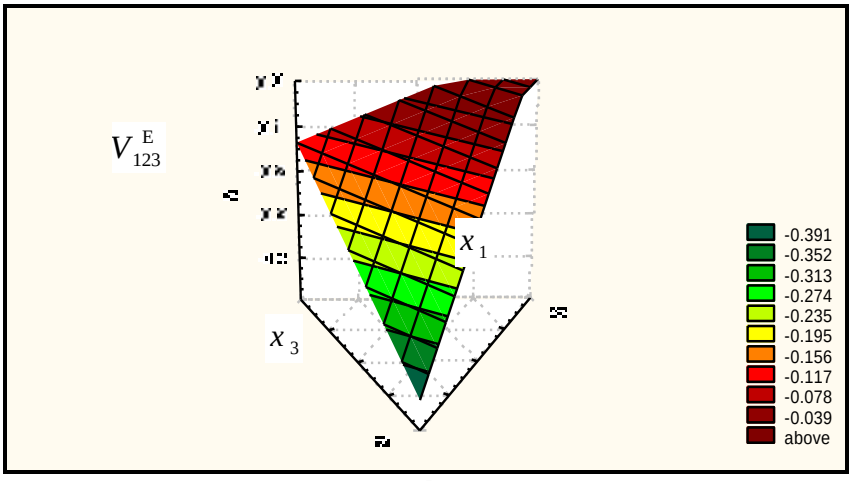


(b)



(c)

[



(d)

Figure (2): Excess molar volumes V^{E}_{123} for ternary system ($x_1$cyclohexane + x_2 3-hextanol + x_3 n-hexane) at (a)298.15k, (b)308.15k, (c)318.15k, and (d)328.15k.

The statistical mechanical concept of Flory theory [7-13], has been extended for the theoretical prediction of excess molar volume of the multicomponent mixture from the properties of pure components Flory theory[14], has been extended here to evaluate the excess molar volumes for ternary mixtures by calculating the excess molar volumes (V^E).

Directly from characteristic and reduced volumes and the segment fraction using thermal expansion coefficient (α) only and using the equation:

$$\tilde{V}\text{-}\tilde{V}^{\circ}=\tilde{V}^{E}=\frac{V^{E}}{x_1V_1^{*}+x_2V_2^{*}+x_3V_3^{*}}.....(2)$$

where $\tilde{V}^{\circ}$ is the ideal reduced volume given by

$$\tilde{V}^{\circ}=\phi_1\tilde{V}_1+\phi_2\tilde{V}_2+\phi_3\tilde{V}_3.....(3)$$

Where ϕ_1 , ϕ_2 and ϕ_3 are the segment fractions of components 1,2 and 3 and defined by the relations:

$$\phi_1=[1-\phi_2-\phi_3].....(4)$$

$$\phi_2=\frac{x_2}{x_2+x_3(\frac{V_3^{*}}{V_2^{*}})+x_1(\frac{V_1^{*}}{V_2^{*}})}.....(5)$$

$$\phi_3=\frac{x_3}{x_3+x_2(\frac{V_2^{*}}{V_3^{*}})+x_1(\frac{V_1^{*}}{V_3^{*}})}.....(6)$$

Substitution of equation (3) into equation (2) gives the excess molar volume of the ternary liquid system which can be written as :

$$V^{E}=(x_1V_1^{*}+x_2V_2^{*}+x_3V_3^{*})[\tilde{V}-(\phi_1\tilde{V}_1+\phi_2\tilde{V}_2+\phi_3\tilde{V}_3)].....(7)$$

where $\tilde{V}$ is the reduced volume of ternary liquid mixture which is obtained by the following equation :

$$\tilde{V}=\frac{V}{x_1V_1^{*}+x_2V_2^{*}+x_3V_3^{*}}.....(8)$$

where V is the molar volume of the mixture, given by :

$$V=\frac{x_1M_1+x_2M_2+x_3M_3}{\rho_m}.....(9)$$

By using the equation of state parameters of pure liquids, table (3) and applying the Flory theory to a ternary mixture, the researcher calculated the excess molar volumes for the ternary mixtures studied here at 298.15k . Table (4), presents the theoretical prediction of V^E values with experimental values for comparison for ternary mixtures studied here.

The maximum percent average deviation < 0.95%, which means that Flory theory for the ternary mixtures studied here did make good prediction.

Table (3) Parameters for the pure liquids according to the Flory Theory at 298.15k.

Liquid	$V/cm^3.mol^{-1}$	$V^*/cm^3.mol^{-1}$	$\tilde{V}$	T^*/K	$\tilde{T}$	$P^*/J.cm^{-3}$	$\alpha \times 10^{-3}/k^{-1}$	$S/A^{\circ -1}$
Cyclohexane	108.774	84.282	1.291	4717.56	0.0632	530	1.217	0.93
n- hexane	131.554	99.549	1.323	4430.16	0.0673	423	1.391	1.04
1- pentanol	115.9105	91.846	1.262	5331.17	0.0559	412	0.905	0.97
3- hexanol	125.827	101.448	1.240	5428.06	0.0549	426	0.948	0.99

Table(4) : Experimental and theoretical prediction of V^E for ternary mixtures at 298.15k.

x_1 Cyclohexane +x_2 1-Pentanol + x_3 n-Hexane				x_1Cyclohexane + x_2 3- Hexanol + x_3 n-Hexane			
x_1	x_2	$V^E_{exp.}$	$V^E_{pred.}$	x_1	x_2	$V^E_{exp.}$	$V^E_{pred.}$
0.0195	0.4463	0.0976	0.1210	0.0235	0.3845	-0.0310	-0.0319
0.0321	0.4411	0.1054	0.1103	0.0851	0.3751	-0.0082	-0.0026
0.0998	0.3920	0.0569	0.0522	0.1463	0.3564	-0.0431	-0.0549
0.1513	0.3700	0.0258	0.0148	0.1785	0.3277	-0.0701	-0.0637
0.1867	0.3394	0.0030	-0.0151	0.2311	0.3068	-0.1009	-0.1057
0.2715	0.3145	-0.0486	-0.0582	0.3097	0.2999	-0.1952	-0.1625
0.3623	0.2933	-0.0857	-0.0833	0.3316	0.2901	-0.1395	-0.1631
0.3877	0.2839	-0.0784	-0.0897	0.3623	0.2667	-0.1571	-0.1646
0.4349	0.2451	-0.1032	-0.1177	0.3978	0.3434	-0.1704	-0.1708
0.4678	0.2360	-0.1185	-0.1197	0.4160	0.2213	-0.1855	-0.1819
0.4984	0.2273	-0.1312	-0.1197	0.4300	0.2187	-0.1825	-0.1803
0.5162	0.2184	-0.1277	-0.1229	0.4529	0.1990	-0.1910	-0.1962
0.5595	0.1879	-0.1571	-0.1389	0.4909	0.1821	-0.2112	-0.2044
0.6330	0.1194	-0.1873	-0.1865	0.5516	0.1267	-0.2643	-0.2707
0.6722	0.0833	-0.2302	-0.2126	0.6320	0.0693	-0.3011	-0.2966
0.7015	0.0574	-0.2413	-0.2310	0.7614	0.0539	-0.3641	-0.3535
0.7293	0.0297	-0.2689	-0.2537	0.7801	0.0416	-0.3739	-0.3878
0.7479	0.0201	-0.2609	-0.2549	0.8881	0.0091	-0.4425	-0.4467
0.7520	0.0165	-0.2199	-0.2575	0.9015	0.0079	-0.4327	-0.4255

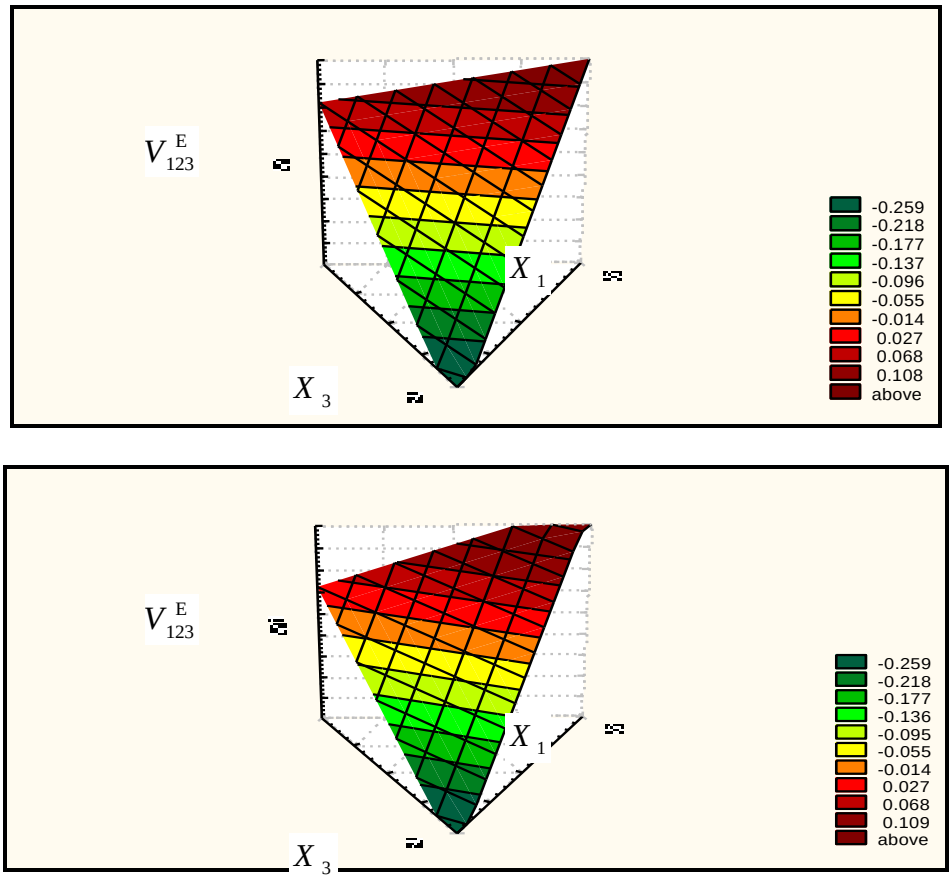
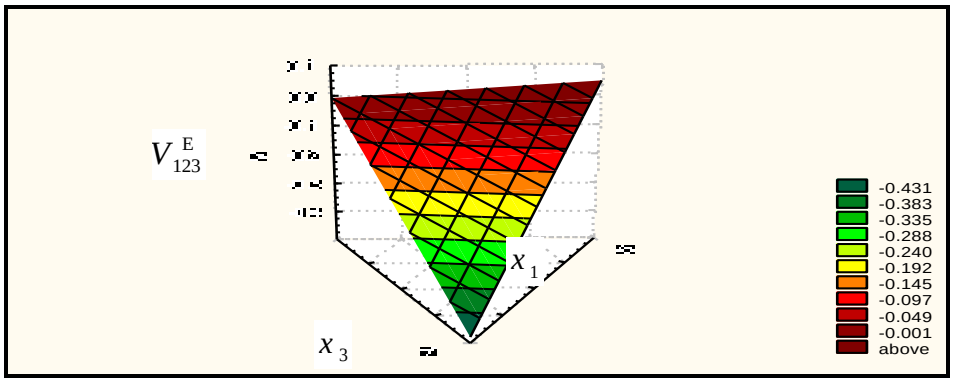
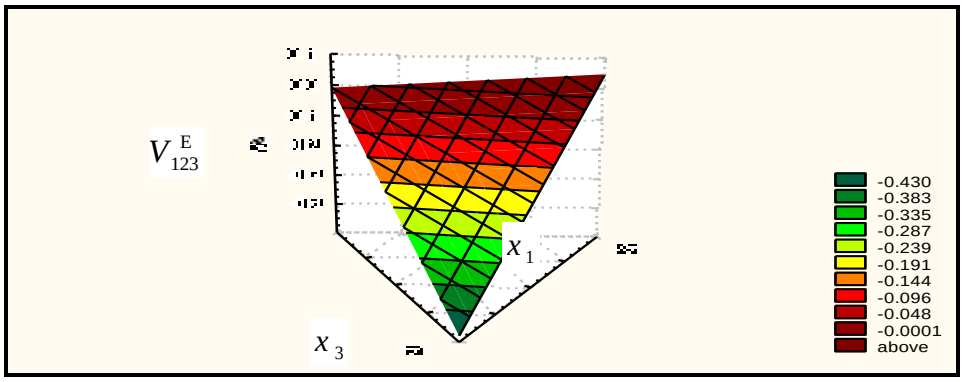


Figure (3): Excess molar volumes V^E_{123} for ternary system ($x_1$cyclohexane + x_2 1-pentanol+ x_3 n-hexane) (a) $V^E_{exp.}$,(b) V^E_{Flory} at 298.15 k.



(a)



(b)

Figure (4): Excess molar volumes V^{E}_{123} for ternary system (x_1 cyclohexane. + x_2 3-hextanol + x_3 n-hexane)(a) $V^{E}_{exp.}$,(b) V^{E}_{Flory} at 298.15 k.

The experimental results of refractive indices of ternary mixtures studied here are listed in table (5) at four temperatures .

Excess refractive indices for ternary mixtures at 298.15k, 308.15k, 318.15k, and 328.15k were calculated from measurements of the refractive indices of the mixture and the pure liquids by equation [15].

$$n^{E} = n_{D,m} - \sum_{s=i,i,k}^{m} x_s n_{D,S} \quad \text{.....(10)}$$

where $n_{D,m}$ is the refractive indices of the mixtures studied and $n_{D,S}$ is the refractive indices of the pure component liquids.

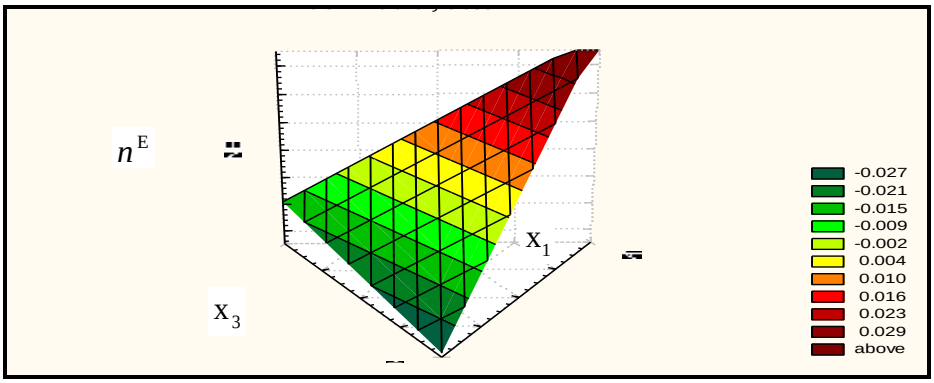
The experimental results from the excess refractive indices are listed in table (5) and plotted as a function x_1,x_2 and x_3 the mole fraction of the three components, at four temperatures in figures (3,4).

Table (6): Experimental values of the refractive indices (n_D) and excess refractive indices (n^E) for ternary mixtures at 298.15k,308.15k, 318.15k, and 328.15k.

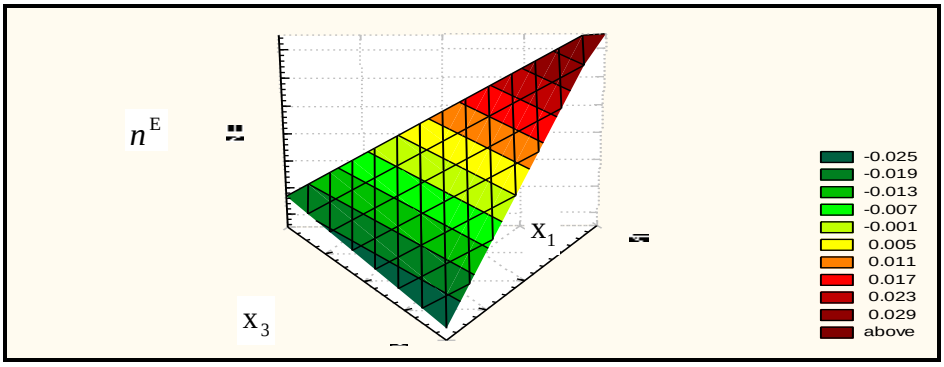
x_1 Cyclohexane + x_2 1- Pentanol + x_3 n- Hexane									
x_1	x_2	n_D	n^E	n_D	n^E	n_D	n^E	n_D	n^E
		298.15k		308.15k		318.15k		328.15k	
0.0195	0.4463	1.3865	-0.0286	1.3830	-0.0290	1.3790	-0.0294	1.3710	-0.0300
0.0321	0.4411	1.3875	-0.0271	1.3840	-0.0274	1.3800	-0.0278	1.3720	-0.0284
0.0998	0.3920	1.3900	-0.0220	1.3865	-0.0224	1.3825	-0.0227	1.3750	-0.0226
0.1513	0.3700	1.3925	-0.0173	1.3890	-0.0176	1.3850	-0.0179	1.3770	-0.0182
0.1867	0.3394	1.3950	-0.0136	1.3915	-0.0139	1.3875	-0.0142	1.3795	-0.0144
0.2715	0.3145	1.4000	-0.0046	1.3960	-0.0055	1.3888	-0.0088	1.3805	-0.0091
0.3623	0.2933	1.4020	0.0017	1.3985	0.0013	1.3940	0.0008	1.3855	0.0005
0.3877	0.2839	1.4050	0.0058	1.4015	0.0054	1.3965	0.0045	1.3880	0.0042
0.4349	0.2451	1.4045	0.0070	1.4000	0.0056	1.3945	0.0049	1.3860	0.0045
0.4678	0.2360	1.4010	0.0050	1.3975	0.0046	1.3910	0.0023	1.3820	0.0017
0.4984	0.2273	1.3980	0.0034	1.3945	0.0030	1.3890	0.0018	1.3800	0.0012
0.5162	0.2184	1.3960	0.0022	1.3925	0.0018	1.3870	0.0005	1.3778	0.0002
0.5595	0.1879	1.4000	0.0078	1.3950	0.0059	1.3880	0.0032	1.3780	0.0018
0.6330	0.1194	1.4030	0.0133	1.3975	0.0109	1.3895	0.0072	1.3795	0.0060
0.6722	0.0833	1.4050	0.0166	1.4000	0.0148	1.3915	0.0105	1.3820	0.0100
0.7015	0.0574	1.4065	0.0191	1.4030	0.0188	1.3935	0.0135	1.3835	0.0126
0.7293	0.0297	1.4075	0.0210	1.4040	0.0207	1.3955	0.0164	1.3860	0.0161
0.7479	0.0201	1.4080	0.0223	1.4045	0.0220	1.3965	0.0182	1.3870	0.0179
0.7520	0.0165	1.4095	0.0239	1.4060	0.0236	1.3975	0.0194	1.3880	0.0191

x_1 Cyclohexane + x_2 3- Hexanol + x_3 n- Hexane

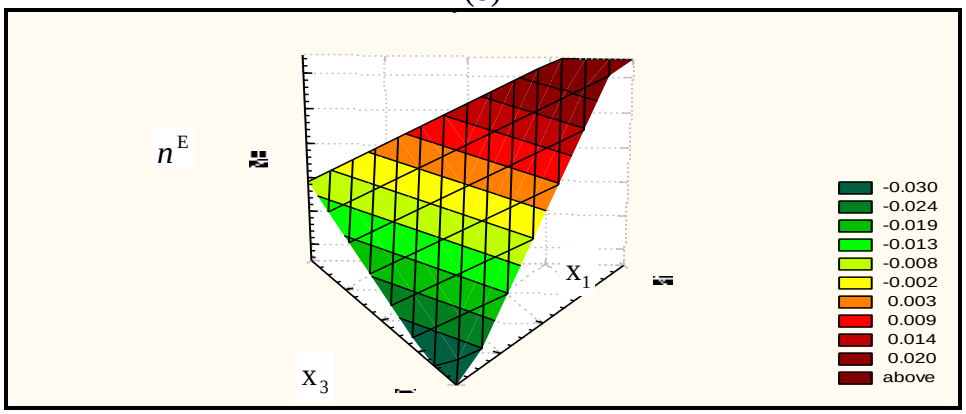
x_1	x_2	n_D	n^E	n_D	n^E	n_D	n^E	n_D	n^E
		298.15k		308.15k		318.15k		328.15k	
0.0235	0.3845	1.3840	-0.0321	1.3800	-0.0329	1.3760	-0.0336	1.3685	-0.0345
0.0851	0.3751	1.3880	-0.0251	1.3840	-0.0259	1.3790	-0.0274	1.3715	-0.0283
0.1463	0.3564	1.3950	-0.0153	1.3910	-0.0161	1.3850	-0.0185	1.3775	-0.0193
0.1785	0.3277	1.3990	-0.0112	1.3940	-0.0120	1.3890	-0.0134	1.3810	-0.0139
0.2311	0.3068	1.4030	-0.0099	1.3970	-0.0107	1.3920	-0.0120	1.3840	-0.0127
0.3097	0.2999	1.4040	0.0019	1.4005	0.0011	1.3960	0.0006	1.3880	0.0002
0.3316	0.2901	1.4060	0.0040	1.4025	0.0036	1.3180	0.029	1.3900	0.0022
0.3623	0.2667	1.4080	0.0071	1.4040	0.0063	1.3990	0.0052	1.3905	0.0039
0.3978	0.3434	1.4075	0.0050	1.4035	0.0042	1.3985	0.0038	1.3900	0.0029
0.4160	0.2213	1.4040	0.0044	1.4005	0.0037	1.3960	0.0022	1.3870	0.0015
0.4300	0.2187	1.4025	0.0038	1.3990	0.0035	1.3945	0.0017	1.3850	0.0012
0.4529	0.1990	1.4010	0.0055	1.3975	0.0042	1.3930	0.0027	1.3830	0.0031
0.4909	0.1821	1.4035	0.0076	1.4000	0.0063	1.3955	0.0049	1.3860	0.0038
0.5516	0.1267	1.4075	0.0137	1.4038	0.0132	1.3995	0.0129	1.3900	0.0121
0.6320	0.0693	1.4090	0.0182	1.4050	0.0175	1.4010	0.0155	1.3915	0.0140
0.7614	0.0539	1.4110	0.0267	1.4065	0.0253	1.4020	0.0242	1.3925	0.0228
0.7801	0.0416	1.4125	0.0289	1.4080	0.0275	1.4030	0.0270	1.3935	0.0266
0.8881	0.0091	1.4135	0.0349	1.4095	0.0340	1.4045	0.0336	1.3950	0.0325
0.9015	0.0079	1.4150	0.0370	1.4110	0.0361	1.4060	0.0358	1.3965	0.0347



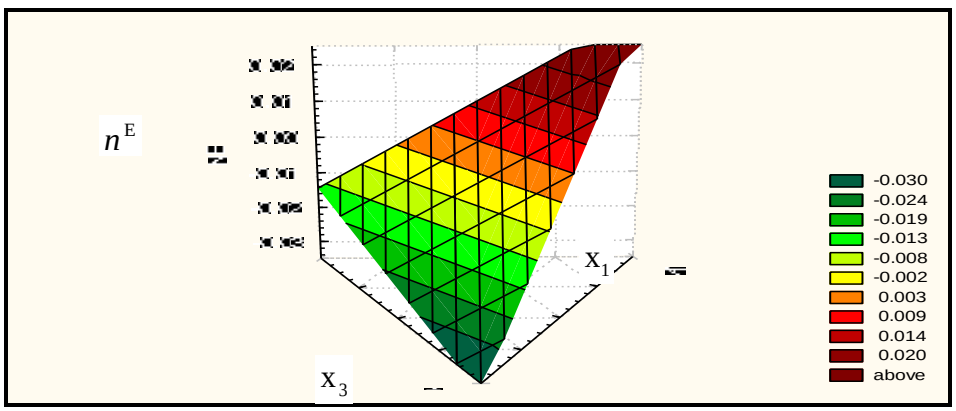
(a)



(b)

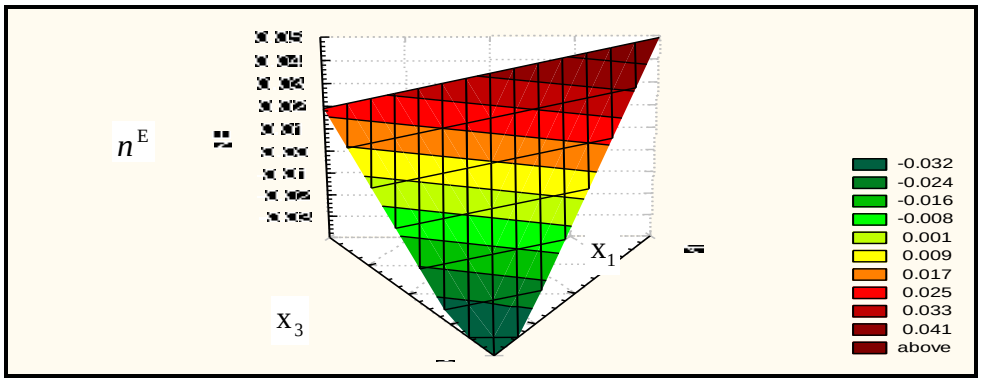


(c)

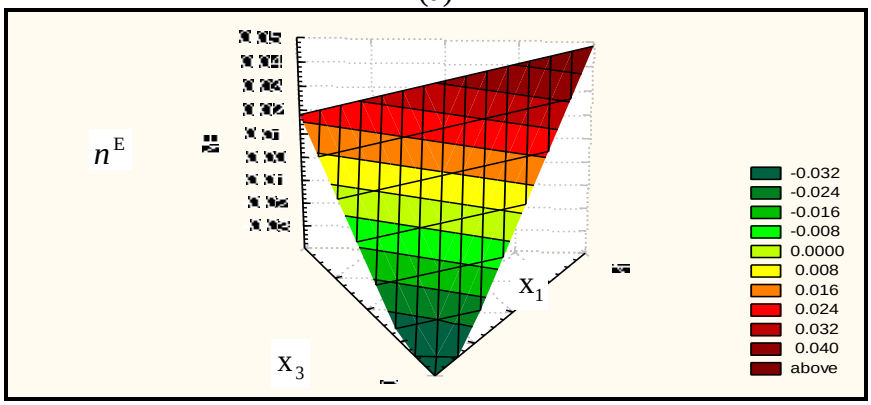


(d)

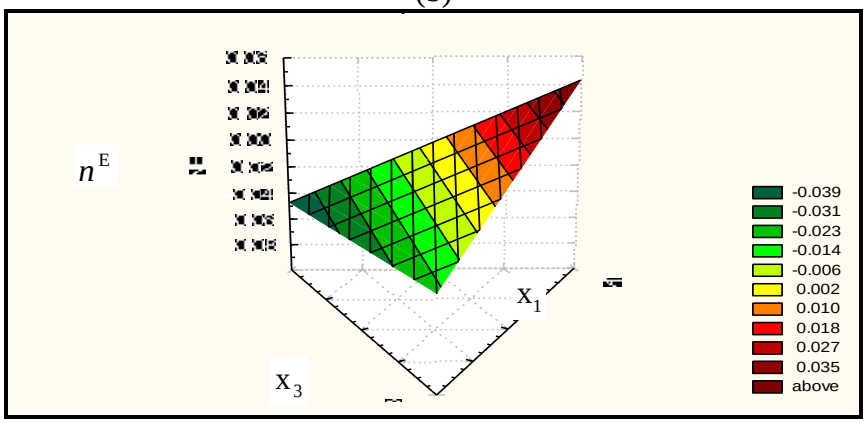
Figure (5): Excess refractive indices η^E for ternary system (x_1 cyclohexane + x_2 1-pentanol + x_3 n-hexane) at (a) 298.15k, (b) 308.15k, (c) 318.15k, and (d) 328.15k



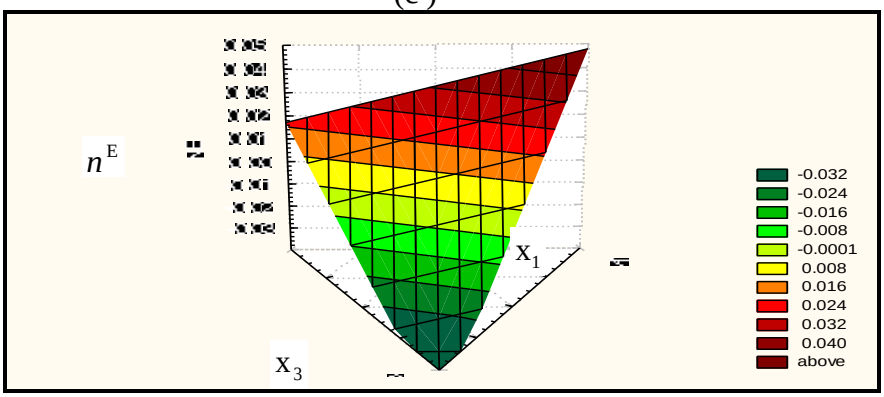
(a)



(b)



(c)



(d)

Figure (6): Excess refractive indices η^E for ternary system (x_1 cyclohexane + x_2 3-hexanol + x_3 n-hexane) at (a) 298.15k, (b) 308.15k, (c) 318.15k, and (d) 328.15k.

Many equations were proposed using mixing rules[7] for the analysis of the data for ternary mixtures. In order to check their validity, the measured refractive indices of mixtures were compared with that calculated from mixing rules.The calculated refractive indices from these equations are listed in table (6) for ternary mixtures have been studied at 298.15k, 308.15k, 318.15k and 328.15k. The researcher found good agreement between the experimental data and the calculated.

Table(6) : Experimental and predicted refractive indices (n_D) for ternary mixtures at 298.15k, 308.15k, 318.15k,and 328.15k.

x_1 Cyclohexane +x_2 1- Pentanol + x_3 n- Hexane									
x_1	x_2	$n_{D\ exp.}$	$n_{D\ pred.}$	$n_{D\ exp.}$	$n_{D\ pred.}$	$n_{D\ exp.}$	$n_{D\ pred.}$	$n_{D\ exp.}$	$n_{D\ pred.}$
		298.15k		308.15k		318.15k		328.15k	
0.0195	0.4463	1.3865	1.3866	1.3830	1.3831	1.3790	1.3788	1.3710	1.3718
0.0321	0.4411	1.3875	1.3873	1.3840	1.3844	1.3800	1.3809	1.3720	1.3723
0.0998	0.3920	1.3900	1.3905	1.3865	1.3862	1.3825	1.3823	1.3750	1.3752
0.1513	0.3700	1.3925	1.3928	1.3890	1.3889	1.3850	1.3847	1.3770	1.3768
0.1867	0.3394	1.3950	1.3947	1.3915	1.3913	1.3875	1.3872	1.3795	1.3792
0.2715	0.3145	1.4000	1.4009	1.3960	1.3968	1.3888	1.3891	1.3805	1.3819
0.3623	0.2933	1.4020	1.4021	1.3985	1.3987	1.3940	1.3942	1.3855	1.3851
0.3877	0.2839	1.4050	1.4044	1.4015	1.4016	1.3965	1.3967	1.3880	1.3876
0.4349	0.2451	1.4045	1.4048	1.4000	1.4005	1.3945	1.3944	1.3860	1.3861
0.4678	0.2360	1.4010	1.4019	1.3975	1.3972	1.3910	1.3909	1.3820	1.3825
0.4984	0.2273	1.3980	1.3988	1.3945	1.3944	1.3890	1.3808	1.3800	1.3808
0.5162	0.2184	1.3960	1.3957	1.3925	1.3921	1.3870	1.3867	1.3778	1.3773
0.5595	0.1879	1.4000	1.4002	1.3950	1.3956	1.3880	1.3878	1.3780	1.3777
0.6330	0.1194	1.4030	1.4029	1.3975	1.3978	1.3895	1.3893	1.3795	1.3798
0.6722	0.0833	1.4050	1.4047	1.4000	1.4007	1.3915	1.3919	1.3820	1.3827
0.7015	0.0574	1.4065	1.4063	1.4030	1.4023	1.3935	1.3931	1.3835	1.3833
0.7293	0.0297	1.4075	1.4077	1.4040	1.4037	1.3955	1.3954	1.3860	1.3859
0.7479	0.0201	1.4080	1.4081	1.4045	1.4044	1.3965	1.3967	1.3870	1.3867
0.7520	0.0165	1.4095	1.4090	1.4060	1.4058	1.3975	1.3978	1.3880	1.3875
x_1 Cyclohexane + x_2 3- Hexanol + x_3 n- Hexane									
x_1	x_2	$n_{D\ exp.}$	$n_{D\ pred.}$	$n_{D\ exp.}$	$n_{D\ pred.}$	$n_{D\ exp.}$	$n_{D\ pred.}$	$n_{D\ exp.}$	$n_{D\ pred.}$
		298.15k		308.15k		318.15k		328.15k	
0.0235	0.3845	1.3840	1.3838	1.3800	1.3806	1.3760	1.3762	1.3685	1.3687
0.0851	0.3751	1.3880	1.3878	1.3840	1.3842	1.3790	1.3791	1.3715	1.3711
0.1463	0.3564	1.3950	1.3951	1.3910	1.3915	1.3850	1.3847	1.3775	1.3773
0.1785	0.3277	1.3990	1.3985	1.3940	1.3943	1.3890	1.3888	1.3810	1.3815
0.2311	0.3068	1.4030	1.4027	1.3970	1.3967	1.3920	1.3923	1.3840	1.3839
0.3097	0.2999	1.4040	1.4039	1.4005	1.4009	1.3960	1.3956	1.3880	1.3882
0.3316	0.2901	1.4060	1.4054	1.4025	1.4023	1.3180	1.3984	1.3900	1.3904
0.3623	0.2667	1.4080	1.4077	1.4040	1.4049	1.3990	1.3989	1.3905	1.3908
0.3978	0.3434	1.4075	1.4071	1.4035	1.4038	1.3985	1.3981	1.3900	1.3906
0.4160	0.2213	1.4040	1.4036	1.4005	1.4004	1.3960	1.3956	1.3870	1.3871
0.4300	0.2187	1.4025	1.4022	1.3990	1.3991	1.3945	1.3943	1.3850	1.3855
0.4529	0.1990	1.4010	1.4019	1.3975	1.3972	1.3930	1.3927	1.3830	1.3839
0.4909	0.1821	1.4035	1.4032	1.4000	1.4009	1.3955	1.3953	1.3860	1.3863
0.5516	0.1267	1.4075	1.4074	1.4038	1.4034	1.3995	1.3987	1.3900	1.3907
0.6320	0.0693	1.4090	1.4088	1.4050	1.4053	1.4010	1.4018	1.3915	1.3919
0.7614	0.0539	1.4110	1.4113	1.4065	1.4066	1.4020	1.4021	1.3925	1.3928
0.7801	0.0416	1.4125	1.4127	1.4080	1.408	1.4030	1.4032	1.3935	1.3934
0.8881	0.0091	1.4135	1.4133	1.4095	1.4097	1.4045	1.4048	1.3950	1.3988
0.9015	0.0079	1.4150	1.4154	1.4110	1.4115	1.4060	1.4055	1.3965	1.3962

Table(7) presented the experimental values of absolute viscosities for the ternary mixtures studied here at four temperatures .

Excess viscosities η^{E}_{123} for ternary system mixtures at(298.15,308.15,318.15 and 328.15k) were calculated from measurement of viscosity of the mixture of pure liquids the following equation[16].

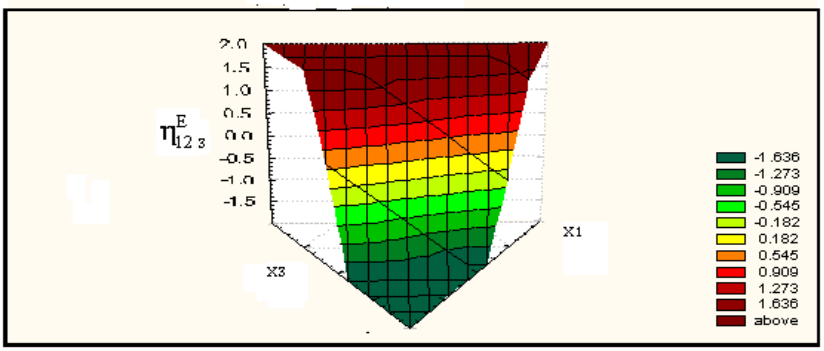
$$\eta^{E}_{123} = \eta_{mix} - x_1\eta_1 - x_2\eta_2 - x_3\eta_3 \quad \ldots\ldots\ldots (11)$$

Where x_1, x_2, x_3, η_1, η_2 and η_3 are the mole fractions and viscosities of pure component η_{mix} is the viscosity of the mixture.

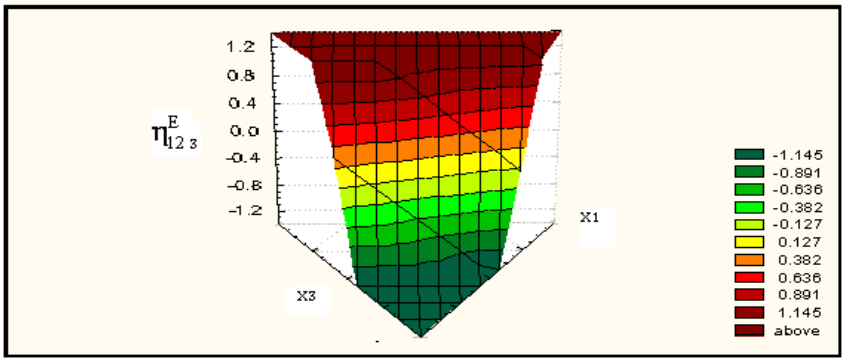
The obtained results of excess viscosities η^{E}_{123} are presented in table (7), figure (5,6) showed the variation of the excess viscosities η^{E}_{123} as a function of the mole fraction of cyclohexane.

Table(7): Experimental values of the viscosity (η)and excess viscosity (η^{E}_{123}) for ternary mixtures at 298.15k, 308.15k, 318.15k and 328.15k.

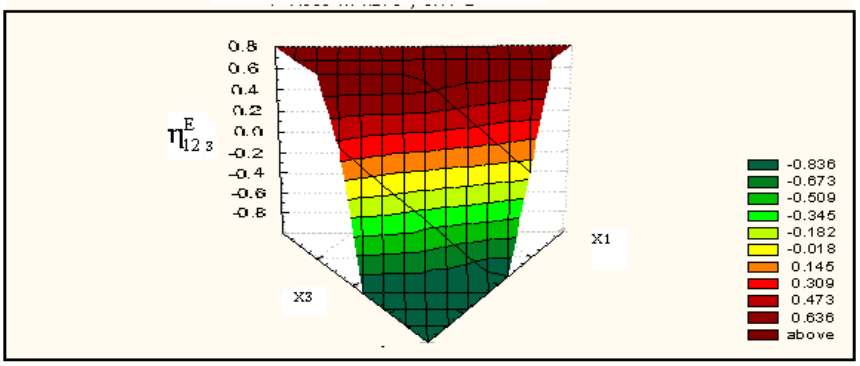
x_1 Cyclohexane + x_2 1- Pentanol + x_3 n- Hexane									
x_1	**x_2**	**η**	η^{E}_{123}	**η**	η^{E}_{123}	**η**	η^{E}_{123}	**η**	η^{E}_{123}
		298.15k		308.15k		318.15k		328.15k	
0.0195	0.4463	0.3519	-1.6680	0.3053	-1.1693	0.2604	-0.7878	0.2348	-0.5447
0.0321	0.4411	0.3698	-1.6292	0.3283	-1.1313	0.2813	-0.7565	0.2396	-0.5327
0.0998	0.3920	0.4293	-1.3997	0.3661	-0.9731	0.2953	-0.6610	0.2601	-0.4562
0.1513	0.3700	0.4717	-1.2697	0.4236	-0.8528	0.3485	-0.5647	0.2924	-0.3936
0.1867	0.3394	0.5504	-1.0888	0.4691	-0.7351	0.3955	-0.4690	0.3210	-0.3318
0.2715	0.3145	0.6564	-0.8693	0.5581	-0.5637	0.4573	-0.3503	0.4005	-0.2115
0.3623	0.2933	0.8850	-0.5339	0.6534	-0.3902	0.5111	-0.2423	0.4797	-0.0930
0.3877	0.2839	1.0921	-0.2876	0.8861	-0.1291	0.6749	-0.0592	0.5466	-0.0122
0.4349	0.2451	1.4471	0.1982	1.2996	0.3766	0.9677	0.2961	0.7512	0.2349
0.4678	0.2360	1.9463	0.7399	1.5825	0.6905	1.1992	0.5490	0.9015	0.4006
0.4984	0.2273	2.3266	1.1604	1.7729	0.9101	1.2420	0.6119	0.9630	0.4767
0.5162	0.2184	2.6189	1.4865	1.8407	1.0021	1.2872	0.6736	0.9755	0.5007
0.5595	0.1879	1.8913	0.8652	1.5370	0.7737	1.1658	0.6032	0.8671	0.4274
0.6330	0.1194	1.5782	0.7779	1.3893	0.7849	1.0657	0.6105	0.7402	0.3734
0.6722	0.0833	1.2046	0.5235	1.0410	0.5205	0.8939	0.4955	0.6442	0.3159
0.7015	0.0574	1.0364	0.4414	0.9039	0.4441	0.7872	0.4297	0.5715	0.2712
0.7293	0.0297	0.8717	0.3670	0.8081	0.4118	0.6958	0.3811	0.5153	0.2441
0.7479	0.0201	0.7650	0.2964	0.6347	0.2642	0.5658	0.2688	0.5045	0.2455
0.7520	0.0165	0.6923	0.2358	0.6125	0.2505	0.1160	0.1753	0.4576	0.2025
x_1 Cyclohexane + x_2 3- Hexanol + x_3 n- Hexane									
x_1	**x_2**	**η**	η^{E}_{123}	**η**	η^{E}_{123}	**η**	η^{E}_{123}	**η**	η^{E}_{123}
		298.15k		308.15k		318.15k		328.15k	
0.0235	0.3845	0.3508	-1.4991	0.3058	-1.0519	0.2617	-0.7088	0.2379	-0.5027
0.0851	0.3751	0.3641	-1.4270	0.3247	-0.9894	0.2793	-0.6606	0.2396	-0.4781
0.1463	0.3564	0.4453	-1.2619	0.3953	-0.8578	0.3226	-0.5753	0.2817	-0.4054
0.1785	0.3277	0.4886	-1.1232	0.4418	-0.7441	0.3763	-0.4763	0.3183	-0.3370
0.2311	0.3068	0.5487	-0.9779	0.5029	-0.6218	0.4013	-0.4092	0.3483	-0.2767
0.3097	0.2999	0.8065	-0.6588	0.6113	-0.4670	0.5016	-0.2762	0.4257	-0.1741
0.3316	0.2901	1.0317	-0.3952	0.7850	-0.2657	0.5692	-0.1897	0.4959	-0.0904
0.3623	0.2667	1.3180	-0.0287	1.0856	0.0914-	0.7327	0.0121-	0.6248	0.0654-
0.3978	0.3434	1.7530	0.2171	1.4481	0.3261	1.1191	0.3145	0.9007	0.2863
0.4160	0.2213	2.0913	0.8968	1.7668	0.8801	1.4128	0.7648	0.9598	0.4513
0.4300	0.2187	3.1970	2.0171	2.2473	1.3714	1.3686	0.7282	0.9755	0.4726
0.4529	0.199	3.9811	2.8671	2.5373	1.7079	1.4567	0.8477	1.0010	0.5201
0.4909	0.1821	2.0398	0.9923	1.7216	0.9398	1.3773	0.8008	0.9374	0.4799
0.5516	0.1267	1.6888	0.8246	1.5027	0.8500	1.2807	0.7914	0.8561	0.4596
0.6320	0.0693	1.4540	0.7892	1.1853	0.6738	1.0209	0.6273	0.7972	0.4683
0.7614	0.0539	1.1563	0.6032	0.9358	0.5081	0.7996	0.4649	0.7215	0.4372
0.7801	0.0416	1.0211	0.5116	0.8627	0.4658	0.7374	0.4237	0.6580	0.3886
0.8881	0.0091	0.8889	0.5261	0.7041	0.4137	0.6111	0.3708	0.5509	0.3350
0.9015	0.0079	0.7180	0.3657	0.6143	0.3319	0.5373	0.3027	0.4879	0.2763



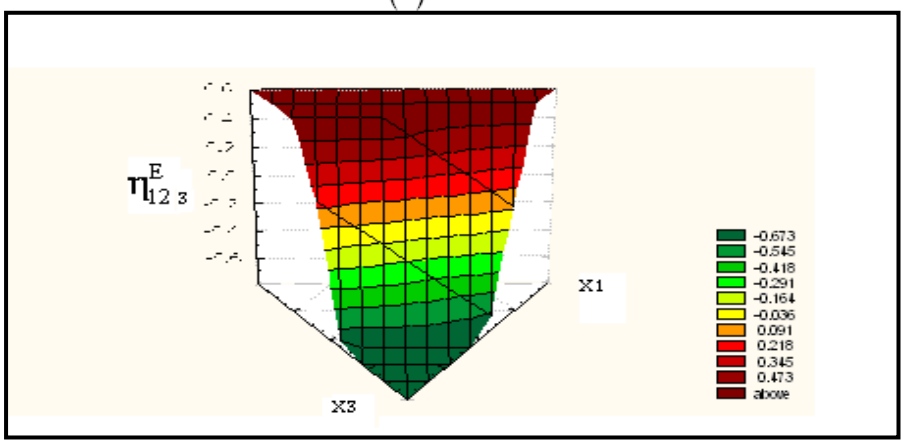
(a)



(b)

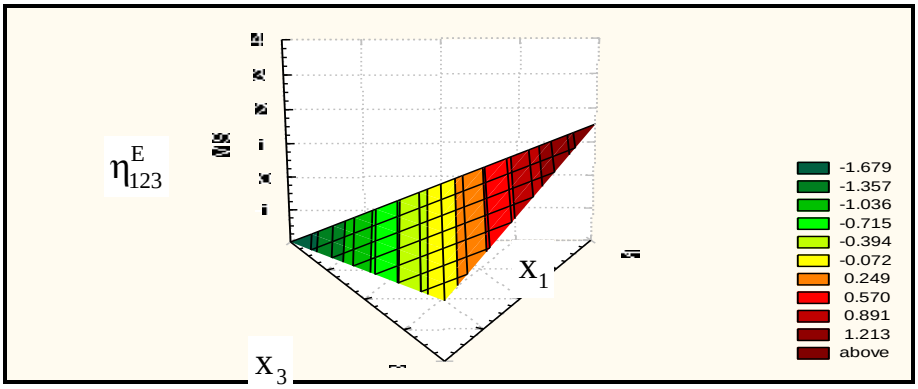


(c)

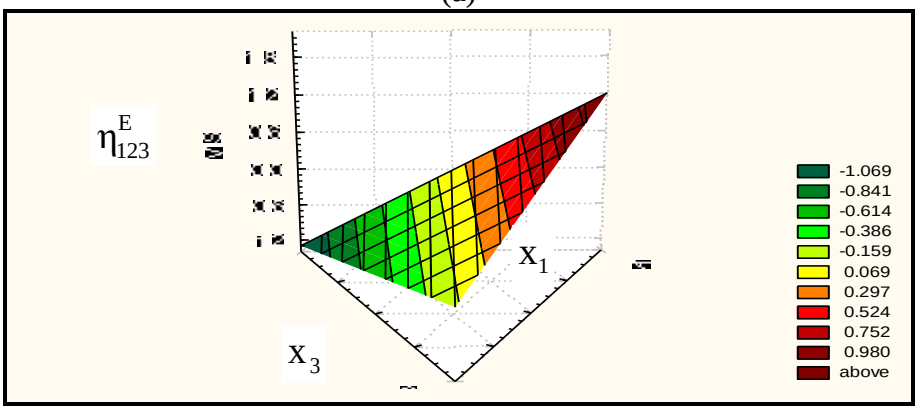


(d)

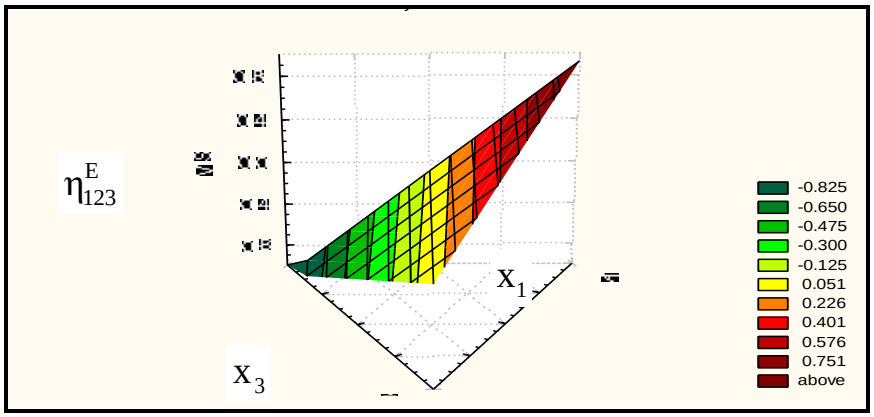
Figure (7): Excess viscosities $\eta^E_{12\,3}$ for ternary system ($x_1$cyclohexane + x_2 1-pentanol+ x_3 n- hexane) at (a) 298.15k, (b) 308.15k, (c) 318.15k, and (d) 328.15k.



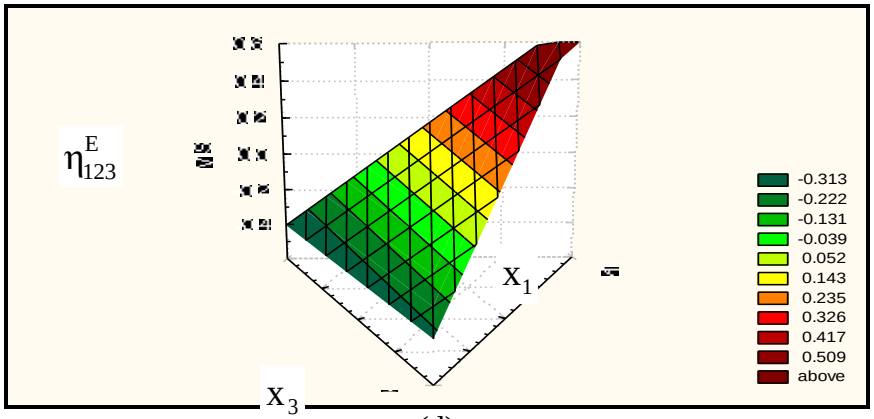
(a)



(b)



(c)



(d)

Figure (8): Excess viscosities $\eta^E_{12\ 3}$ for ternary system ($x_1$cyclohexane + x_2 3-hexanol + x_3 n- hexane) at (a) 298.15k, (b) 308.15k, (c) 318.15k, and (d) 328.15k.

Several empirical equations have been proposed to calculate excess viscosity of multicomponent systems based on the available experimental results of viscosities of mixture and pure components. The equation of Heric and Coursey[17] was used.

$$\eta^E = \ln \eta_{mix} - \Sigma\, x_i \ln \eta_i \quad \text{.....(12)}$$

Where $\eta_{mix.}$ is the viscosity of the mixture, x_i and η_i are mole fraction and viscosity for pure component respectively .Table(8) shows the predicted values with the experimental values of excess viscosity for comparison for ternary mixtures studied here at 298.15, 308.15, 318.15 and 328.15 k.

Table(8) : Experimental and the predicted excess viscosities (η^E) for ternary mixtures at 298.15k, 308.15k, 318.15k,and 328.15k.

x_1 Cyclohexane + x_2 1- Pentanol + x_3 n- Hexane									
x_1	x_2	$\eta^E_{exp.}$	$\eta^E_{Pred.}$	$\eta^E_{exp.}$	$\eta^E_{Pred.}$	$\eta^E_{exp.}$	$\eta^E_{Pred.}$	$\eta^E_{exp.}$	$\eta^E_{Pred.}$
		298.15k		308.15k		318.15k		328.15k	
0.0195	0.4463	-1.6680	-1.6678	-1.1693	-1.1698	-0.7878	-0.7877	-0.5447	-0.5431
0.0321	0.4411	-1.6292	-1.6289	-1.1313	-1.1319	-0.7565	-0.7570	-0.5327	-0.5325
0.0998	0.3920	-1.3997	-1.3997	-0.9731	-0.9737	-0.6610	-0.6613	-0.4562	-0.4564
0.1513	0.3700	-1.2697	-1.2686	-0.8528	-0.8527	-0.5647	-0.5644	-0.3936	-0.3942
0.1867	0.3394	-1.0888	-1.0874	-0.7351	-0.7367	-0.4690	-0.4695	-0.3318	-0.3315
0.2715	0.3145	-0.8693	-0.8671	-0.5637	-0.5616	-0.3503	-0.3509	-0.2115	-0.2104
0.3623	0.2933	-0.5339	0.5319	-0.3902	-0.3911	-0.2423	-0.2432	-0.0930	-0.0950
0.3877	0.2839	-0.2876	0.2863	-0.1291	-0.1281	-0.0592	-0.0594	-0.0122	-0.0135
0.4349	0.2451	0.1982	0.1975	0.3766	0.3774	0.2961	0.2967	0.2349	0.2338
0.4678	0.2360	0.7399	0.7368	0.6905	0.6930	0.5490	0.5487	0.4006	0.4013
0.4984	0.2273	1.1604	1.1611	0.9101	0.9123	0.6119	0.6116	0.4767	0.4760
0.5162	0.2184	1.4865	1.4857	1.0021	1.0007	0.6736	0.6733	0.5007	0.5019
0.5595	0.1879	0.8652	0.8677	0.7737	0.7735	0.6032	0.6021	0.4274	0.4262
0.6330	0.1194	0.7779	0.7764	0.7849	0.7869	0.6105	0.6102	0.3734	0.3751
0.6722	0.0833	0.5235	0.5215	0.5205	0.5216	0.4955	0.4934	0.3159	0.3169
0.7015	0.0574	0.4414	0.4406	0.4441	0.4434	0.4297	0.4285	0.2712	0.2710
0.7293	0.0297	0.3670	0.3682	0.4118	0.4113	0.3811	0.3805	0.2441	0.2427
0.7479	0.0201	0.2964	0.2977	0.2642	0.2644	0.2688	0.2693	0.2455	0.2479
0.7520	0.0165	0.2358	0.2356	0.2505	0.2511	0.1753	0.1772	0.2025	0.2028
x_1 Cyclohexane + x_2 3- Hexanol + x_3 n- Hexane									
x_1	x_2	$\eta^E_{exp.}$	$\eta^E_{Pred.}$	$\eta^E_{exp.}$	$\eta^E_{Pred.}$	$\eta^E_{exp.}$	$\eta^E_{Pred.}$	$\eta^E_{exp.}$	$\eta^E_{Pred.}$
		298.15k		308.15k		318.15k		328.15k	
0.0235	0.3845	-1.4991	-1.4991	-1.0519	-1.0517	-0.7088	-0.7074	-0.5027	-0.5019
0.0851	0.3751	-1.4270	-1.4270	-0.9894	-0.9899	-0.6606	-0.6610	-0.4781	-0.4774
0.1463	0.3564	-1.2619	-1.2619	-0.8578	-0.8579	-0.5753	-0.5731	-0.4054	-0.4047
0.1785	0.3277	-1.1232	-1.1232	-0.7441	-0.7447	-0.4763	-0.4774	-0.3370	-0.3361
0.2311	0.3068	-0.9779	-0.9779	-0.6218	-0.6216	-0.4092	-0.4084	-0.2767	-0.2762
0.3097	0.2999	-0.6588	-0.6588	-0.4670	-0.4665	-0.2762	-0.2763	-0.1741	-0.1740
0.3316	0.2901	-0.3952	-0.3952	-0.2657	-0.2631	-0.1897	-0.1892	-0.0904	-0.0953
0.3623	0.2667	-0.0287	-0.0287	0.0914-	-0.0910	0.0121-	-0.0110	0.0654-	-0.0650
0.3978	0.3434	0.2171	0.2171	0.3261	0.3264	0.3145	0.3148	0.2863	0.2855
0.4160	0.2213	0.8968	0.8968	0.8801	0.8807	0.7648	0. 7641	0.4513	0.4510
0.4300	0.2187	2.0171	2.0171	1.3714	1.3724	0.7282	0.7299	0.4726	0. 4723
0.4529	0.199	2.8671	2.8671	1.7079	1.7070	0.8477	0.8490	0.5201	0.5200
0.4909	0.1821	0.9923	0.9923	0.9398	0.9377	0.8008	0.8001	0.4799	0.4790
0.5516	0.1267	0.8246	0.8246	0.8500	0.8506	0.7914	0.7910	0.4596	0.4591

0.6320	0.0693	0.7892	0.7892	0.6738	0.6725	0.6273	0.6284	0.4683	0.4679
0.7614	0.0539	0.6032	0.6032	0.5081	0.5090	0.4649	0.4639	0.4372	0.4377
0.7801	0.0416	0.5116	0.5116	0.4658	0.4651	0.4237	0.4236	0.3886	0.3885
0.8881	0.0091	0.5261	0.5261	0.4137	0.4137	0.3708	0.3707	0.3350	0.3559
0.9015	0.0079	0.3657	0.3657	0.3319	0.3314	0.3027	0.3025	0.2763	0.2765

Discussion:-

The experimental excess molar volume V_{123}^{E} for ternary mixtures (cyclohexane +1-pentanol +n-hexane, and cyclohexane+3-hexanol+n-hexane) are listed in Table (2) and plotted as a function of the mole fraction x_1, x_2 and x_3 at 298.15, 308.15, 318.15, and 328.15 K , Figures (1,2).

For the first and the second ternary mixtures (cyclohexane+1-pentanol+n-hexane) (cyclohexane+3-hexanol+n-hexane) , V_{123}^{E}, are negative from ideality at high mole fraction of n-hexane x_3, and become positive at low mole fraction of n-hexane x_3 at 308.15, 318.15, and 328.15 K, but at 298.15K for the second ternary mixture show a negative deviation from ideality over the whole mole fraction, here indicate that the third component liquid, n-hexane, modifies both the nature and degree of molecular interactions, the orientationl order between the two other component liquids cyclohexane + n-alkane + alcohol, n-hexane molecule condensate with alkanol (Condensation effect). This gives highly orientation order and packed structure in their mixtures.

Excess molar volumes V_{123}^{E} of ternary mixtures studied here at 298.15 K were calculated using Flory theory [6-12]. The researcher calculated from characteristic and reduced volumes and the segment fraction using thermal expansion coefficient (α) of the pure three component liquids equation.

The predicted values from Flory theory are present in table (4) with those values obtained experimentally and plotted as a function of the mole fraction x_1, x_2, and x_3 with the experimental values for comparison figures (3 and 4) scrutiny of table (4) and figures(3,4) reveals that the excellent agreement between the experimental and theoretical excess molar volumes for the ternary mixtures studied here, that means Flory theory could be successfully used to predict the excess molar volumes of the ternary systems from the properties of pure components.

Excess refractive indices η_{123}^{E}, are negative deviation from ideality at high mole fraction of n-hexane x_3 and become positive allow mole fractions of n-hexane x_3 at 298.15, 308.15, 318.15, and 328.15 K, for the ternary mixtures studied here table (5). This behavior increases when increasing the chain length of alkanol and when increasing the temperature.

The researcher attempted to test the validity of different refractive index mixing rules as given by Argo and Biot, Gladstone and Dale, Lorentz and Lorenz, Wiener and Heller [6]. By comparing the experimental and calculated values of n_{Dm} of ternary mixtures table (6).

However, all equations produced by the experimental data are well within the limits of experimental error.

Experimental data of viscosity η_m and excess viscosity η_{123}^{E} are listed in table (7) and a plotted as function of the mole fraction x_1, x_2, and x_3 for the three components at four temperatures in figures (7,8) for all ternary mixtures studies here. The viscometric behavior for the ternary mixtures studied here show the same behavior for excess refractive indices.

Heric and Coursey equation (12) was used to calculated excess viscosity of ternary mixtures and pure components, table (8) shows good agreement between the experimental values of the excess viscosities for the ternary mixtures studied in this work and with the predicted values from Heric and Coursey equation.

References:-

1. Rafael Alcalde, Santiago Aparicio, Begona Garcia, Maria J.Davila and Jose M.Leal (solute-solvent interaction in lactams)-water ternary solvents, 27th April 2005, New .J.Chem., 29, page 817-825 (2005).
2. Santiago Aparicio, Rafael Alcalde, Begona Garcia and Jose M. Leal (Thermophsical beahviour of n-alkane + alkylbenzoate mixed solvents, Measurements and properties Modeling).Ind. Eng. Chem. Res., 44, 7575-7583 (2005).
3. Kareem, E.T. Volumetric Behavior of Binary, Ternary and Quaternary mixtures of some normal alkenes and cyclohexane comparison with theory Baghdad University phD thesis (2003).
4. S.Aparicio, R. Alcala, J.M. Leal and B. Garcia (Characterization and prefereutial salvation of the Hexane / Hexane -1-01 /μ dhy/benzoate ternary solvent). J.Phys.Chem., 109, 6375-6385 (2005).
5. Battino, R. Volume changes on mixing for binary mixtures of liquids chem.. Rev., 71., 5-45 (1971) .
6. Scatchard, G. and W. J.Hamer, The Application of Equations for the chemical potentials to partially miscible solutions. Chem. Soc., 57,1805 (1935) .
7. Salman T.A., Journal for Science **,** Al- Nahrain university (2008) .
8. Flory,P.J., R.A. Orwoll and A. Vrij, Statistical Thermodynamic of chain molecule liquids -1- An Equation of state for normal paraffin hydrocarbons J.Am. Chem. Soc., 86., 3507-3514 (1964) .
9. Flory, P.J. and A. Abe, Thermodynamic properties of Nonpolar Mixtures of small molecules. J.Am. Chem. Soc., 86.,3563-3565 (1964) .
10. Orwoll, R.A. and P.J. Flory, Equation of state parameters for normal alkanes correlation with chain length. J.Am. Chem. Soc., 89.,6814-6822 (1967) .
11. Orwoll,R.A. and P.J. Flory, Thermodynamic properties of binary mixtures of n-alkanes.J. Am. Chem. Soc.,89., 6822-6829 (1967) .
12. Abe, A. and P.J. Flory., Thermodynamic properties of mixtures of small, Non polar molecules J.Am. Chem. Soc., 87., 1838-1846 (1965) .
13. Flory,P.Y., Statistical thermodynamic of liquid mixtures. J. Am. Chem. Soc. 87.,1833-1838 (1965) .
14. Pandey J.D.,R.K. shukla, A.K. shukla and R.D.Rai, J.Chem. Soc. Faradar Trans. ,1, 84,1853 (1988).
15. Ritzoulis,G., D. Misso polinon, S. Doulami, and C.Panayioton, Relative permittivities Densities, Refractive indices and ultra sound velocities of the Binary systems of γ-Butrolactone with methanol, Ethanol, 1-Butanol and 1-octanol, J.Chem. Eng. Data., 45.,638 (2000) .
16. Tu, C.H., S.L. Lee, and I.H.Peng. Excess volumes and viscosities of Binary Mixtures of Aliphatic alcohols (c1 –c4) with Nitro methane. J. Chem. Eng. Data., 46.,151 (2001) .
17. Heric, E.L. and B.M. coursey, Properties of binary systems of hexane and normal chloro alkanes. J. Chem. Eng. Data, 17., 41-44 (1972) .