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Research Article

INTERMOLECULAR INTERACTIONS AND EXCESS REFRACTIVE INDICES OF BINARY LIQUID MIXTURE FROM 298.15-323.15K: CORRELATION AND MODELING

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A B S T R A C T

From the measured work of Jose M. Navaza, In this paper we have presented the theoretical results of refractive index computed for non-polar binary liquid mixture of Cyclohexane + 2, 2, 4- Trimethylpentane by six mixing rules such as Arago-biot (A-B),Gladstone-Dale (G-D), Newton (NW), Eyring-John (EJ), Heller(H) and Weiner(W) from 298.15-323.15K over the entire composition range and compared with experimental data to test the validity of these mixing rules , which are expressed in term of average absolute % deviation (AAPD) .Excess refractive index (n^E) have also been evaluated for aforesaid liquid mixture to analyze the extent of intermolecular interaction between the binary components. Deviation in refractive index were evaluated and fitted to redlich kister polynomial equation to derive the binary coefficient and standard deviations at different temperatures. Furthermore, McAllister three and four body interaction models based on Eyring's theory of absolute reaction rates have been applied to test the accuracy of experimental findings.

INTRODUCTION

Density and Refractive index are fundamental physico-chemical properties of a substance, which is mainly, used for the identification as well as the confirmation of the purity of chemical compounds. Variation of densities and refractive indices with temperature and molar concentration provides useful information to design engineering processes[1]. Theoretical prediction of refractive index is essential for the analysis of solute-solvent interactions and determination of composition of multi component liquid system. In past few years long chain saturated hydrocarbon have become a subject of deep interest for various researchers[2-7] to understand the nature of interactions between like and unlike molecular components, when the mixed with other liquids. In the continuation of our previously published work[8] ,this paper is concerned with the computation of theoretical values of refractive index using six another mixing rules such as Arago-biot[9](A-B),Gladstone-Dale[10] (G-D), Newton[11] (NW), Eyring-John[12] (EJ), Heller[13](H) and Weiner[14](W) from 298.15-323.15K over the entire composition range of aforementioned binary liquid system and compared with the Literature[15] values. The validity of these mixing rules is expressed in term of average absolute % deviation (AAPD). Deviation in refractive index were evaluated and fitted to redlich kister[16] polynomial equation to derive the binary coefficient and standard deviations at different temperatures. Excess refractive index (n^E) evaluated by all the concerned mixing rule for aforesaid liquid mixture to analyze the non- ideality in terms specific and non-specific intermolecular interaction between the binary components. McAllister[17] multi body interaction model based on Eyring's theory of absolute reaction rates have been applied to test the accuracy of experimental findings. The main purpose of this work was to test the accuracy and applicability of these mixing rules in cyclic and branched hydrocarbon system at different temperatures and analyze the intermolecular interactions between the binary components.

MODELING

Subsequent six quantitative empirical relations are used for the theoretical evaluation of refractive index of binary liquid system at different temperatures:

Arago-biot: $n_{A-B} = n_1\emptyset_1 + n_2\emptyset_2$ (1)

Gladstone-Dale: $n - 1 = (n_1 - 1)\emptyset_1 + (n_2 - 1)\emptyset_2$ (2)

Newton: $n^2 - 1 = (n_1^2 - 1)\emptyset_1 + (n_2^2 - 1)\emptyset_2$ (3)

Eyring-John: $n = n_1\emptyset_1^2 + 2(n_1n_2)^{1/2}\emptyset_1\emptyset_2 + n_2\emptyset_2^2$ (4)

Heller: $\frac{n-n_1}{n_1} = \frac{3}{2}\left[\frac{(n_2/n_1)^2-1}{(n_2/n_1)^2+2}\right]\emptyset_2$ (5)

Weiner: $\frac{n^2-n_1^2}{n^2+2n_2^2} = \left[\frac{n_2^2-n_1^2}{n_2^2+2n_1^2}\right]\emptyset_2$ (6)

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Where $\emptyset_1$ and $\emptyset_2$ are volume fractions, n_1 and n_2 refractive index of pure liquid 1 and 2 respectively and n is refractive index of binary liquid mixture.

$$\emptyset_1 = \frac{x_1 v_1}{x_1 v_1 + x_2 v_2} \qquad \emptyset_2 = \frac{x_2 v_2}{x_1 v_1 + x_2 v_2}$$

RESULT AND DISCUSSION

Table 1 presents the comparison of experimental densities and refractive index of Cyclohexane and 2, 2, 4-timethylpentane with literature values at 298.15 K. Coefficients of redlich-kister polynomial and their standard deviations (σ) at different temperatures are listed in Table 2. Parameters of McAllister three and four body interaction models based on least square method and their standard deviations for refractive index are presented in Table 3.Experimental density, refractive index and theoretical refractive index computed by six mixing rules over the entire composition range from 298.15-323.15K were recorded in Table 4.Comparison of such mixing rules in term of average absolute % deviation (AAPD) is presented in Table 5. Values of excess refractive index for all the aforementioned mixing rules were listed in Table 6.

Table 1 Comparison of experimental and literature data of pure liquids at 298.15K

	Density [a] (g/cc)		Refractive index[a]	
Component	**Exp**	**Lit**	**Exp**	**Lit**
Cyclohexane	0.7711	0.7712	1.4225	1.4232
2,2,4-Trimethylpentene	0.6860	0.6878	1.3885	1.3890
[a]Ref[15]				

Mixing function deviation in term of excess refractive index (n^E) can be presented mathematically by Redlich-kister[16] polynomial equation for correlating experimental data as:

$$y = x_1(1 - x_1)\sum_{i=0}^{p} A_i(2x_1 - 1)^i \qquad (7)$$

Where x_1 is the mole fraction of pure component, y is the deviation in refractive index and A_i is the coefficient of redlich –kister polynomial. The values of coefficient were determined by multiple regression analysis based on least square method, and analyzed along with standard deviations (σ) between fitted and experimental values. The values of standard deviation were computed by the following relation:

$$\sigma = \left[\sum_{i=1}^{m} \left(n_{exp}^E - n_{fit}^E\right)^2 \Big/ (n - p)\right]^{1/2} \qquad (8)$$

Where n is the number of experimental points and p is number of adjustable parameters. The values of standard deviation lie between $0.00010 < \sigma < 0.00034$. The largest value of standard deviation is observed at 323.15K.

McAllister[17] model based on Eyring's theory of absolute rate is widely used for correlating various physicochemical properties of liquid mixture with mole fraction.

McAllister-3- body

$$\begin{aligned}\ln n = {} & x_1^3 \ln n_1 + 3x_1^2 x_2 \ln n_{A_0} + 3x_1 {x_2}^2 \ln n_{A_1} + x_2^3 \ln n_2 \\ & - \ln[x_1 + x_2 M_2/M_1] + 3x_1^2 x_2 \ln[(2 + M_2/M_1)/3] \\ & + 3x_1 x_2^2 \ln[(1 + 2M_2/M_1)/3] \\ & + x_2^3 \ln[M_2/M_1] \end{aligned} \qquad (9)$$

McAllister-4-body

$$\begin{aligned}\ln n = {} & x_1^4 \ln n_1 + 4x_1^3 x_2 \ln n_{A_0} + 6x_1^2 x_2^2 \ln n_{A_1} + 4x_1 x_2^2 \ln n_{A_2} \\ & + x_2^4 \ln n_2 - \ln[(x_1 + x_2 M_2/M_1)] \\ & + 4x_1^3 x_2 \ln[(3 + M_2/M_1)/4] \\ & + 6x_1^2 x_2^2 \ln[(1 + M_2/M_1)/2] \\ & + 4x_1 x_2^3 \ln[(1 + 3M_2/M_1)/4] \\ & + x_2^4 \ln(M_2/M_1) \end{aligned} \qquad (10)$$

Where n is refractive index of liquid mixture, A_0, A_1 and A_2 are adjustable parameters. These characteristic parameters of binary mixture have been calculated by least square method. x_1, n_1, M_1 and x_2, n_2, M_2 are the mole fraction, refractive index and molecular weight of pure component 1 and 2 respectively. A close observation of Table 3 reveals that McAllister four body models correlated the refractive index of binary liquid mixture more accurately than three body models except 313.15K and their corresponding parameter have shown a decreasing tendency with rise in temperature.

Table 2 Parameters of redlich kister polynomial and standard deviation

T/K	A_0	A_1	A_2	A_3	σ
298.15	-0.0135	-0.0043	0.0089	-0.0003	0.00015
303.15	-0.014	-0.0086	0.0042	0.0028	0.0001
308.15	-0.0149	-0.0107	0.005	0.004	0.00021
313.15	-0.0149	-0.0075	0.0065	-0.0064	0.00019
318.15	-0.0179	-0.0039	0.0047	-0.0006	0.00018
323.15	-0.0156	-0.0048	0.0043	0.0046	0.00034

A close perusal of Table 4 and 5 reveals that the density and refractive index of binary mixture increases linearly as the mole fraction (x_1) of Cyclohexane increases for a particular temperature but decreases with increase in temperature. Since Cyclohexane exhibit conformations and exist in either puckered shaped chair conformation or boat conformation having lower and higher potential energy respectively. These conformers undergo rapid inter conversion at room temperature. At higher temperature dispersive type interactions between binary components become ruptured. All the six mixing rules deal fair agreements with experimental findings except Weiner (W), which show higher absolute % deviation at 318.15K. Excess refractive index presented in Table 6 are found to be negative over the entire mole fraction of concerned binary mixture as shown in figure 1 indicative of dispersive intermolecular interactions between the binary components. Similar trends in excess refractive are observed for all mixing rules except Weiner. Excess refractive index (n^E) values for aforesaid binary liquid system are negative for all the mixing rules because packing effect is more dominating than other effects. This is due to interstitial accommodation of 2, 2, 4- Trimethylpentane in the voids created by Cyclohexane molecules. It is suggested that if excess volume is taken into consideration then deviation of evaluated value from measured value can be reduced.

Table 3 Parameters of McAllister models and their standard deviation

	McAllister three body				McAllister four body			
T/K	A_0	A_1	σ		A_0	A_1	A_2	σ

298.15	0.6457	0.9116	0.0003		1.4171	1.4032	1.4001	0.0001
303.15	0.6441	0.9105	0.0002		1.4132	1.4023	1.397	0.0001
308.15	0.6426	0.9092	0.0002		1.4104	1.3996	1.3952	0.0002
313.15	0.6414	0.9077	0.0004		1.4105	1.3944	1.3956	0.0006
318.15	0.6408	0.9046	0.0002		1.4065	1.3939	1.3892	0.0002
323.15	0.6399	0.903	0.0004		1.4042	1.3913	1.3868	0.0003

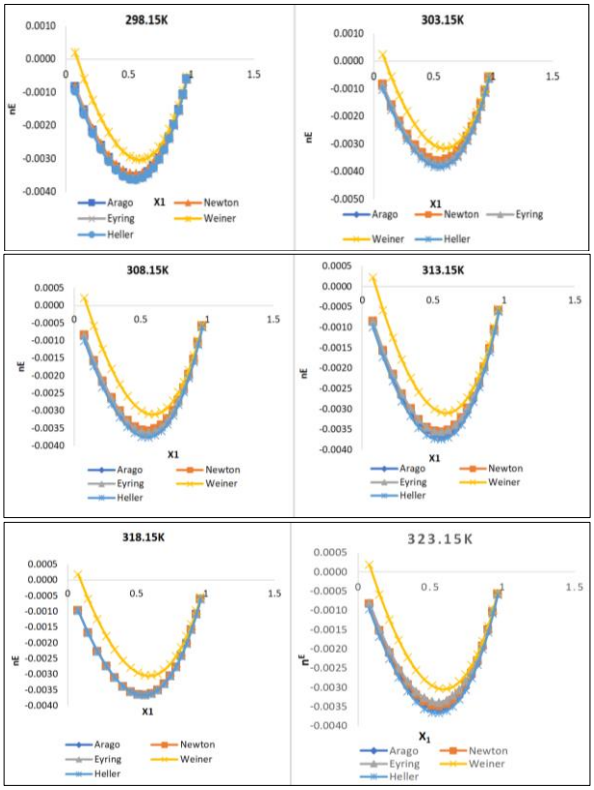

Fig 1 Plot of Excess refractive index (n^E) with mole fraction (x_1) at different temperatures

$$n^E = n_{mix} - \sum_{i=1}^{n} x_i n_i \qquad (11)$$

Table 4 Experimental density (ρ^{Mix}) , Experimental refractive index(n^{Exp}) and theoretical refractive index calculated by various mixing rules from 298.15K

X_1	ρ^{Mix}	n^{Exp}	n^{Arago}	n^{Newton}	n^{Eyring}	n^{Weiner}	n^{Heller}
			T=298 .15K				
0.0762	0.6901	1.3908	1.3902	1.3903	1.3902	1.3913	1.3901
0.1483	0.6942	1.393	1.392	1.392	1.392	1.3929	1.3919
0.2166	0.6982	1.3945	1.3937	1.3938	1.3937	1.3946	1.3936
0.2815	0.7023	1.396	1.3954	1.3955	1.3954	1.3963	1.3953
0.3431	0.7062	1.3975	1.3972	1.3973	1.3971	1.398	1.3971
0.4018	0.7101	1.399	1.3989	1.399	1.3989	1.3996	1.3988
0.4577	0.7142	1.4008	1.4006	1.4007	1.4006	1.4013	1.4005
0.5109	0.7182	1.4025	1.4023	1.4024	1.4023	1.4029	1.4022
0.5618	0.7223	1.4044	1.404	1.4041	1.404	1.4046	1.404
0.6105	0.7264	1.4062	1.4057	1.4058	1.4057	1.4062	1.4057
0.657	0.7306	1.4077	1.4074	1.4075	1.4074	1.4079	1.4074
0.7016	0.7349	1.4092	1.4091	1.4092	1.4091	1.4095	1.4091
0.7443	0.7392	1.4111	1.4108	1.4109	1.4108	1.4111	1.4108
0.7853	0.7436	1.413	1.4125	1.4126	1.4125	1.4128	1.4125
0.8246	0.7482	1.4148	1.4142	1.4142	1.4141	1.4144	1.4141
0.8624	0.7528	1.4165	1.4158	1.4159	1.4158	1.416	1.4158
0.8988	0.7574	1.418	1.4175	1.4176	1.4175	1.4177	1.4175
0.9338	0.762	1.4195	1.4192	1.4192	1.4192	1.4193	1.4192
0.965	0.7665	1.421	1.4207	1.4207	1.4207	1.4208	1.4207
			T=303.15K				
0.0762	0.6851	1.3878	1.3873	1.3873	1.3873	1.3884	1.3872
0.1483	0.6893	1.39	1.3891	1.3892	1.3891	1.3902	1.389
0.2166	0.6935	1.3918	1.3909	1.391	1.3909	1.3919	1.3908
0.2815	0.6977	1.3935	1.3927	1.3928	1.3928	1.3937	1.3926
0.3431	0.7019	1.3951	1.3945	1.3946	1.3946	1.3954	1.3944
0.4018	0.706	1.3967	1.3963	1.3964	1.3963	1.3971	1.3962
0.4577	0.7101	1.3984	1.3981	1.3982	1.3981	1.3989	1.398
0.5109	0.7142	1.4	1.3999	1.4	1.3999	1.4006	1.3998
0.5618	0.7184	1.4018	1.4017	1.4018	1.4017	1.4023	1.4016
0.6105	0.7226	1.4036	1.4035	1.4036	1.4035	1.404	1.4034
0.657	0.7269	1.4053	1.4052	1.4054	1.4053	1.4057	1.4052
0.7016	0.7312	1.407	1.407	1.4071	1.407	1.4074	1.407
0.7443	0.7357	1.4088	1.4088	1.4089	1.4088	1.4092	1.4087
0.7853	0.7401	1.4105	1.4105	1.4106	1.4105	1.4109	1.4105
0.8246	0.7446	1.4123	1.4123	1.4124	1.4123	1.4126	1.4123
0.8624	0.7491	1.414	1.414	1.4141	1.414	1.4142	1.414
0.8988	0.7535	1.4158	1.4158	1.4158	1.4158	1.4159	1.4158
0.9338	0.7579	1.4175	1.4175	1.4176	1.4175	1.4176	1.4175
0.965	0.7623	1.4193	1.4191	1.4192	1.4191	1.4192	1.4191
			T=308.15K				
0.0762	0.6813	1.3858	1.3853	1.3853	1.3853	1.3864	1.3852
0.1483	0.6854	1.388	1.3871	1.3871	1.3871	1.3881	1.387
0.2166	0.6896	1.3898	1.3889	1.3889	1.3889	1.3898	1.3888
0.2815	0.6938	1.3915	1.3907	1.3907	1.3907	1.3915	1.3905
0.3431	0.6979	1.3928	1.3924	1.3925	1.3925	1.3933	1.3923
0.4018	0.702	1.394	1.3942	1.3943	1.3942	1.395	1.3941
0.4577	0.7062	1.3959	1.396	1.3961	1.396	1.3967	1.3959
0.5109	0.7103	1.3977	1.3977	1.3978	1.3978	1.3984	1.3976
0.5618	0.7145	1.3994	1.3995	1.3996	1.3995	1.4001	1.3994
0.6105	0.7187	1.401	1.4012	1.4013	1.4013	1.4018	1.4012
0.657	0.7229	1.4027	1.403	1.4031	1.403	1.4035	1.4029
0.7016	0.7271	1.4043	1.4047	1.4048	1.4048	1.4051	1.4047
0.7443	0.7314	1.4062	1.4065	1.4066	1.4065	1.4068	1.4064
0.7853	0.7357	1.408	1.4082	1.4083	1.4082	1.4085	1.4082
0.8246	0.74	1.4096	1.4099	1.41	1.41	1.4102	1.4099
0.8624	0.7442	1.4112	1.4116	1.4117	1.4117	1.4118	1.4116
0.8988	0.7485	1.4131	1.4134	1.4134	1.4134	1.4135	1.4133
0.9338	0.7528	1.415	1.4151	1.4151	1.4151	1.4152	1.4151
0.965	0.7571	1.4168	1.4167	1.4167	1.4167	1.4167	1.4167
			T=313.15K				
0.0762	0.6775	1.3835	1.3828	1.3828	1.3828	1.3839	1.3827
0.1483	0.6816	1.386	1.3846	1.3846	1.3846	1.3856	1.3845
0.2166	0.6857	1.3875	1.3864	1.3864	1.3864	1.3873	1.3863
0.2815	0.6899	1.389	1.3882	1.3882	1.3882	1.389	1.388
0.3431	0.694	1.3903	1.3899	1.39	1.39	1.3908	1.3898
0.4018	0.6982	1.3915	1.3917	1.3918	1.3918	1.3925	1.3916
0.4577	0.7024	1.3933	1.3935	1.3936	1.3936	1.3942	1.3934
0.5109	0.7065	1.395	1.3952	1.3953	1.3953	1.3959	1.3951
0.5618	0.7107	1.3967	1.397	1.3971	1.3971	1.3976	1.3969
0.6105	0.7148	1.3984	1.3987	1.3989	1.3988	1.3993	1.3987
0.657	0.719	1.4002	1.4005	1.4006	1.4006	1.401	1.4004
0.7016	0.7232	1.402	1.4022	1.4023	1.4023	1.4027	1.4022
0.7443	0.7274	1.4038	1.404	1.4041	1.4041	1.4043	1.4039
0.7853	0.7315	1.4055	1.4057	1.4058	1.4058	1.406	1.4057
0.8246	0.7357	1.4073	1.4074	1.4075	1.4075	1.4077	1.4074
0.8624	0.7398	1.409	1.4092	1.4092	1.4092	1.4094	1.4091
0.8988	0.744	1.4106	1.4109	1.4109	1.4109	1.411	1.4109
0.9338	0.7483	1.4122	1.4126	1.4126	1.4126	1.4127	1.4126
0.965	0.7524	1.4141	1.4142	1.4142	1.4142	1.4142	1.4142
			T=318.15K				
0.0762	0.6723	1.3813	1.3812	1.3813	1.3813	1.3823	1.3811
0.1483	0.6766	1.383	1.383	1.383	1.383	1.3839	1.3829
0.2166	0.6808	1.3845	1.3847	1.3848	1.3848	1.3856	1.3846
0.2815	0.685	1.386	1.3864	1.3865	1.3865	1.3873	1.3863
0.3431	0.6893	1.3875	1.3882	1.3882	1.3883	1.3889	1.3881
0.4018	0.6935	1.389	1.3899	1.39	1.39	1.3906	1.3898
0.4577	0.6978	1.3905	1.3916	1.3917	1.3917	1.3923	1.3915
0.5109	0.7021	1.392	1.3933	1.3934	1.3935	1.3939	1.3932
0.5618	0.7063	1.3941	1.395	1.3951	1.3952	1.3956	1.3949
0.6105	0.7106	1.3962	1.3967	1.3968	1.3969	1.3972	1.3966
0.657	0.7149	1.3979	1.3984	1.3985	1.3986	1.3989	1.3983
0.7016	0.7191	1.3996	1.4001	1.4002	1.4003	1.4005	1.4
0.7443	0.7234	1.4013	1.4018	1.4019	1.4019	1.4021	1.4017
0.7853	0.7277	1.403	1.4035	1.4036	1.4036	1.4038	1.4034
0.8246	0.7319	1.4048	1.4052	1.4052	1.4053	1.4054	1.4051
0.8624	0.7362	1.4065	1.4068	1.4069	1.4069	1.407	1.4068
0.8988	0.7404	1.4083	1.4085	1.4086	1.4086	1.4086	1.4085
0.9338	0.7447	1.41	1.4102	1.4102	1.4102	1.4103	1.4102
0.965	0.7489	1.4118	1.4117	1.4117	1.4117	1.4118	1.4117
			T=323.15K				
0.0762	0.6689	1.3783	1.3782	1.3783	1.3783	1.3793	1.3781
0.1483	0.6732	1.38	1.38	1.38	1.3801	1.3809	1.3799
0.2166	0.6774	1.3818	1.3817	1.3818	1.3818	1.3826	1.3816
0.2815	0.6816	1.3835	1.3834	1.3835	1.3836	1.3843	1.3833
0.3431	0.6859	1.3853	1.3852	1.3852	1.3853	1.3859	1.3851
0.4018	0.6901	1.387	1.3869	1.387	1.3871	1.3876	1.3868
0.4577	0.6944	1.388	1.3886	1.3887	1.3888	1.3893	1.3885

0.5109	0.6986	1.389	1.3903	1.3904	1.3905	1.3909	1.3902
0.5618	0.7029	1.3915	1.392	1.3921	1.3922	1.3926	1.3919
0.6105	0.7071	1.394	1.3937	1.3938	1.3939	1.3942	1.3936
0.657	0.7113	1.3954	1.3954	1.3955	1.3956	1.3959	1.3953
0.7016	0.7156	1.3968	1.3971	1.3972	1.3973	1.3975	1.397
0.7443	0.7198	1.3986	1.3988	1.3989	1.399	1.3991	1.3987
0.7853	0.7241	1.4003	1.4005	1.4006	1.4007	1.4008	1.4004
0.8246	0.7283	1.4023	1.4022	1.4022	1.4023	1.4024	1.4021
0.8624	0.7325	1.4042	1.4038	1.4039	1.404	1.404	1.4038
0.8988	0.7368	1.4058	1.4055	1.4056	1.4056	1.4056	1.4055
0.9338	0.741	1.4073	1.4072	1.4072	1.4072	1.4073	1.4072
0.965	0.7451	1.4089	1.4087	1.4087	1.4088	1.4088	1.4087

Table 5 Average absolute % deviation from 298.15-323.15K

	AAPD				
T/K	n^{Arago}	n^{Newton}	n^{Eyring}	n^{Weiner}	n^{Heller}
298.15	0.0303	0.0253	0.0328	0.0207	0.0349
303.15	0.0184	0.0171	0.018	0.0234	0.0227
308.15	0.0249	0.0281	0.0266	0.0364	0.0251
313.15	0.0287	0.0321	0.032	0.0383	0.0282
318.15	0.0345	0.0391	0.0425	0.0706	0.0317
323.15	0.0189	0.0189	0.0204	0.0452	0.0207

Table 6 Excess refractive index (n^E) of various liquid state models from 298.15-323.15K

X_1	$n^E_{(Exp)}$	$n^E_{(Arago)}$	$n^E_{(Newton)}$	$n^E_{(Eyring)}$	$n^E_{(Weiner)}$	$n^E_{(Heller)}$
			T=298.15K			
0.0762	-0.0003	-0.0008	-0.0008	-0.0009	0.0002	-0.001
0.1483	-0.0005	-0.0016	-0.0015	-0.0016	-0.0006	-0.0017
0.2166	-0.0014	-0.0021	-0.0021	-0.0022	-0.0012	-0.0023
0.2815	-0.0021	-0.0026	-0.0026	-0.0027	-0.0018	-0.0027
0.3431	-0.0027	-0.003	-0.0029	-0.003	-0.0022	-0.0031
0.4018	-0.0032	-0.0033	-0.0032	-0.0033	-0.0025	-0.0034
0.4577	-0.0033	-0.0035	-0.0034	-0.0035	-0.0028	-0.0035
0.5109	-0.0034	-0.0036	-0.0035	-0.0036	-0.0029	-0.0036
0.5618	-0.0032	-0.0036	-0.0035	-0.0036	-0.003	-0.0036
0.6105	-0.0031	-0.0035	-0.0034	-0.0036	-0.003	-0.0036
0.657	-0.0031	-0.0034	-0.0033	-0.0035	-0.003	-0.0035
0.7016	-0.0032	-0.0032	-0.0031	-0.0033	-0.0028	-0.0033
0.7443	-0.0027	-0.003	-0.0029	-0.003	-0.0027	-0.003
0.7853	-0.0022	-0.0027	-0.0026	-0.0027	-0.0024	-0.0027
0.8246	-0.0017	-0.0024	-0.0023	-0.0024	-0.0021	-0.0024
0.8624	-0.0013	-0.002	-0.0019	-0.002	-0.0018	-0.002
0.8988	-0.0011	-0.0015	-0.0015	-0.0016	-0.0014	-0.0016
0.9338	-0.0007	-0.0011	-0.001	-0.0011	-0.001	-0.0011
0.965	-0.0003	-0.0006	-0.0006	-0.0006	-0.0005	-0.0006
			T=303.15K			
0.0762	-0.0004	-0.0009	-0.0009	-0.0009	0.0002	-0.001
0.1483	-0.0008	-0.0016	-0.0016	-0.0016	-0.0006	-0.0018
0.2166	-0.0014	-0.0023	-0.0022	-0.0022	-0.0013	-0.0024
0.2815	-0.002	-0.0028	-0.0027	-0.0027	-0.0018	-0.0029
0.3431	-0.0026	-0.0031	-0.0031	-0.0031	-0.0023	-0.0032
0.4018	-0.0031	-0.0034	-0.0033	-0.0034	-0.0026	-0.0035
0.4577	-0.0033	-0.0036	-0.0035	-0.0036	-0.0029	-0.0037
0.5109	-0.0036	-0.0037	-0.0036	-0.0037	-0.0031	-0.0038
0.5618	-0.0036	-0.0037	-0.0036	-0.0037	-0.0031	-0.0038
0.6105	-0.0036	-0.0037	-0.0036	-0.0037	-0.0032	-0.0038
0.657	-0.0035	-0.0036	-0.0035	-0.0036	-0.0031	-0.0036
0.7016	-0.0034	-0.0034	-0.0033	-0.0034	-0.003	-0.0034
0.7443	-0.0031	-0.0031	-0.003	-0.0031	-0.0028	-0.0032
0.7853	-0.0029	-0.0028	-0.0027	-0.0028	-0.0025	-0.0029
0.8246	-0.0025	-0.0025	-0.0024	-0.0025	-0.0022	-0.0025
0.8624	-0.0021	-0.0021	-0.002	-0.0021	-0.0019	-0.0021
0.8988	-0.0016	-0.0016	-0.0016	-0.0016	-0.0015	-0.0016
0.9338	-0.0011	-0.0011	-0.0011	-0.0011	-0.001	-0.0011
0.965	-0.0005	-0.0006	-0.0006	-0.0006	-0.0006	-0.0006
			T=308.15K			
0.0762	-0.0004	-0.0009	-0.0009	-0.0009	0.0002	-0.001
0.1483	-0.0007	-0.0016	-0.0016	-0.0016	-0.0006	-0.0017
0.2166	-0.0013	-0.0022	-0.0022	-0.0022	-0.0013	-0.0023
0.2815	-0.0019	-0.0027	-0.0026	-0.0027	-0.0018	-0.0028
0.3431	-0.0027	-0.0031	-0.003	-0.003	-0.0023	-0.0032
0.4018	-0.0036	-0.0034	-0.0033	-0.0033	-0.0026	-0.0035
0.4577	-0.0036	-0.0036	-0.0035	-0.0035	-0.0028	-0.0036
0.5109	-0.0037	-0.0037	-0.0036	-0.0036	-0.003	-0.0037
0.5618	-0.0038	-0.0037	-0.0036	-0.0036	-0.0031	-0.0038
0.6105	-0.0039	-0.0036	-0.0035	-0.0036	-0.0031	-0.0037
0.657	-0.0038	-0.0035	-0.0034	-0.0035	-0.003	-0.0036
0.7016	-0.0038	-0.0033	-0.0032	-0.0033	-0.0029	-0.0034
0.7443	-0.0034	-0.0031	-0.003	-0.003	-0.0027	-0.0031
0.7853	-0.003	-0.0028	-0.0027	-0.0027	-0.0025	-0.0028
0.8246	-0.0028	-0.0024	-0.0024	-0.0024	-0.0022	-0.0025
0.8624	-0.0025	-0.002	-0.002	-0.002	-0.0018	-0.0021
0.8988	-0.0019	-0.0016	-0.0015	-0.0016	-0.0014	-0.0016
0.9338	-0.0012	-0.0011	-0.0011	-0.0011	-0.001	-0.0011
0.965	-0.0005	-0.0006	-0.0006	-0.0006	-0.0006	-0.0006
			T=313.15K			
0.0762	-0.0002	-0.0009	-0.0008	-0.0008	0.0002	-0.001
0.1483	-0.0002	-0.0016	-0.0016	-0.0016	-0.0006	-0.0017
0.2166	-0.0011	-0.0022	-0.0022	-0.0022	-0.0013	-0.0023
0.2815	-0.0019	-0.0027	-0.0026	-0.0026	-0.0018	-0.0028
0.3431	-0.0027	-0.0031	-0.003	-0.003	-0.0022	-0.0032
0.4018	-0.0036	-0.0034	-0.0033	-0.0033	-0.0026	-0.0035
0.4577	-0.0037	-0.0035	-0.0034	-0.0034	-0.0028	-0.0036
0.5109	-0.0039	-0.0037	-0.0035	-0.0035	-0.003	-0.0037
0.5618	-0.004	-0.0037	-0.0036	-0.0036	-0.0031	-0.0038
0.6105	-0.004	-0.0036	-0.0035	-0.0035	-0.0031	-0.0037
0.657	-0.0038	-0.0035	-0.0034	-0.0034	-0.003	-0.0036
0.7016	-0.0036	-0.0033	-0.0032	-0.0032	-0.0029	-0.0034
0.7443	-0.0033	-0.0031	-0.003	-0.003	-0.0027	-0.0031
0.7853	-0.003	-0.0028	-0.0027	-0.0027	-0.0025	-0.0028
0.8246	-0.0026	-0.0024	-0.0024	-0.0024	-0.0022	-0.0025
0.8624	-0.0022	-0.002	-0.002	-0.002	-0.0018	-0.0021
0.8988	-0.0019	-0.0016	-0.0015	-0.0015	-0.0014	-0.0016
0.9338	-0.0015	-0.0011	-0.0011	-0.0011	-0.001	-0.0011
0.965	-0.0007	-0.0006	-0.0006	-0.0006	-0.0006	-0.0006
			T=318.15K			
0.0762	-0.001	-0.001	-0.001	-0.001	0.0002	-0.001
0.1483	-0.0017	-0.0017	-0.0017	-0.0017	-0.0006	-0.0017
0.2166	-0.0023	-0.0023	-0.0023	-0.0023	-0.0013	-0.0023
0.2815	-0.00 27	-0.0027	-0.0027	-0.0027	-0.0018	-0.0027
0.3431	-0.0031	-0.0031	-0.0031	-0.0031	-0.0022	-0.0031
0.4018	-0.0034	-0.0034	-0.0034	-0.0034	-0.0026	-0.0034
0.4577	-0.0036	-0.0036	-0.0036	-0.0036	-0.0028	-0.0036
0.5109	-0.0037	-0.0037	-0.0037	-0.0037	-0.003	-0.0037
0.5618	-0.0037	-0.0037	-0.0037	-0.0037	-0.003	-0.0037
0.6105	-0.0036	-0.0036	-0.0036	-0.0036	-0.003	-0.0036
0.657	-0.0035	-0.0035	-0.0035	-0.0035	-0.003	-0.0035
0.7016	-0.0033	-0.0033	-0.0033	-0.0033	-0.0029	-0.0033
0.7443	-0.0031	-0.0031	-0.0031	-0.0031	-0.0027	-0.0031
0.7853	-0.0028	-0.0028	-0.0028	-0.0028	-0.0024	-0.0028
0.8246	-0.0024	-0.0024	-0.0024	-0.0024	-0.0021	-0.0024
0.8624	-0.002	-0.002	-0.002	-0.002	-0.0018	-0.002
0.8988	-0.0016	-0.0016	-0.0016	-0.0016	-0.0014	-0.0016
0.9338	-0.0011	-0.0011	-0.0011	-0.0011	-0.001	-0.0011
0.965	-0.0006	-0.0006	-0.0006	-0.0006	-0.0005	-0.0006
			T=323.15K			
0.0762	-0.0008	-0.0009	-0.0008	-0.0008	0.0002	-0.001
0.1483	-0.0015	-0.0016	-0.0015	-0.0015	-0.0006	-0.0017
0.2166	-0.0021	-0.0022	-0.0021	-0.002	-0.0013	-0.0023
0.2815	-0.0026	-0.0026	-0.0026	-0.0025	-0.0018	-0.0027
0.3431	-0.0029	-0.003	-0.0029	-0.0028	-0.0022	-0.0031
0.4018	-0.0032	-0.0033	-0.0032	-0.0031	-0.0026	-0.0034
0.4577	-0.0041	-0.0035	-0.0034	-0.0033	-0.0028	-0.0036
0.5109	-0.0049	-0.0036	-0.0035	-0.0034	-0.003	-0.0037
0.5618	-0.0041	-0.0036	-0.0035	-0.0034	-0.003	-0.0037
0.6105	-0.0033	-0.0036	-0.0034	-0.0033	-0.003	-0.0036
0.657	-0.0034	-0.0034	-0.0033	-0.0032	-0.003	-0.0035
0.7016	-0.0036	-0.0033	-0.0032	-0.0031	-0.0029	-0.0033
0.7443	-0.0032	-0.003	-0.0029	-0.0028	-0.0027	-0.0031
0.7853	-0.0029	-0.0027	-0.0026	-0.0025	-0.0024	-0.0028
0.8246	-0.0022	-0.0024	-0.0023	-0.0022	-0.0021	-0.0024
0.8624	-0.0016	-0.002	-0.0019	-0.0019	-0.0018	-0.002
0.8988	-0.0013	-0.0016	-0.0015	-0.0014	-0.0014	-0.0016
0.9338	-0.0009	-0.0011	-0.001	-0.001	-0.001	-0.0011
0.965	-0.0004	-0.0006	-0.0006	-0.0006	-0.0005	-0.0006

CONCLUSION

Finally, it is concluded that the theoretical results computed from all five mixing rules deal a fair agreement with experimental findings for all the temperatures but Wiener (W) shows a large deviation at 318.15K. McAllister three and four body interaction model provides excellent results for refractive index. Excess refractive index computed from all the six mixing rules are found to be negative, which generally represents that packing effect are more dominant than other effect. The higher negative value of excess refractive index represents the strong intermolecular interactions.

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