

The Modeling of the Coefficient Viscosity for Mixtures of Fluids

Anca Baci, Zoltan Borsos, Octavian Dinu

Universitatea Petrol-Gaze din Ploiești, Bd. București 39, Ploiești,
e-mail: bj_anca@yahoo.com; borsos.zoltan@gmail.com; octavytza@yahoo.com

Abstract

In this paper we present a comparison between values obtained for the dynamic viscosity through calculation using mathematical relationships known [2], with the experimental results obtained for the dynamics viscosity for binary liquid different.

The formulas known from the literature represents a mathematics dependence, which can not express all the variations appearing due to the physical and chemical phenomena that occur in solution, phenomena which differs according to by the state of the energy of the molecules, after their chemical features and after the external conditions.

We propose a relationship that leads to results that approximated better the experimental results.

Key words: *viscosity, mixture, temperature.*

Introduction

In the presented study we intend achievement a comparison between values obtained for the dynamic viscosity through calculation using mathematical relationships known, with the experimental results obtained for the dynamics viscosity for binary liquid different.

To determine the viscosity of liquid mixtures take into account: the shape the molecules, forces intermolecular interaction, the complex structure of groups of molecules that form the structure of flow.

Because studies about the viscosity of liquid mixtures have shown that it is influenced not only by composition, but also by temperature and pressure, our experimental approach is performed in conditions of constant pressure.

The Mathematical Expression of the Mixtures Viscosity

In literature there are several attempts to express the viscosity of mixtures with mathematical formulas. For example, Lees starts from the Newton relationship and get to the expression[2]:

$$\frac{1}{\eta} = \frac{V_1}{\eta_1} + \frac{V_2}{\eta_2}, \quad (1)$$

where η is the viscosity of a mixture of two liquids with viscosity η_1 and, respectively η_2 ; that a cubic centimeter of mixture containing $V_1 - cm^3$ fluid of viscosity η_1 and $V_2 - cm^3$ fluid of viscosity η_2 .

Also, Lees proposed the relationship:

$$\eta^x = V_1 \eta_1^x + V_2 \eta_2^x, \quad (2)$$

where x is a constant valid for each binary solution.

Starting from a series of physical and mathematical considerations, Schultze and Dolezalek [2] proposes, as the more convenient expression, quadratic form:

$$\eta = \eta_1 V_1^2 + \eta_2 V_2^2 + 2\eta_{12} V_1 V_2, \quad (3)$$

where η_{12} it would be the viscosity due to the mutual friction of the two components and whose expression, would be:

$$\eta_{12} = \sqrt{\eta_1 \eta_2} \quad (4)$$

and, therefore:

$$\eta = \left(\sqrt{\eta_1} V_1 + \sqrt{\eta_2} V_2 \right)^2, \quad (5)$$

and if the appears formation to a combination between components:

$$\eta = \left(\sqrt{\eta_1} V_1 + \sqrt{\eta_{12}} V_{12} + \sqrt{\eta_2} V_2 \right)^2, \quad (6)$$

where η_{12} and V_{12} are the viscosity and the volume for the compound formed.

In fact, this formula expresses a certain mathematics dependence, which can not express all the variations appearing due to the physical and chemical phenomena that occur in solution, phenomena which differs according to by the state of the energy of the molecules, after their chemical features and after the external conditions.

Studying the variation of viscosity with the composition of a binary mixture, Eyring gave the relationship [2]:

$$\lg \eta = x_1 \lg \eta_1 + x_2 \lg \eta_2, \quad (7)$$

or:

$$\eta = \eta_1^{x_1} \cdot \eta_2^{x_2}, \quad (8)$$

where η_1 and η_2 are the viscosities of the two components pure; x_1 and x_2 are their molar fractions.

Experimental Data

For this study we use the experimental data presented in Table 1 [3].

Is obtained dependence presented in figure 1:

where: on the OX axis is represented the concentration (in front),
 on the OY axis is represented temperature,
 on the OZ axis is represented the viscosity.

Table 1. Viscosity of the mixture of glycerin and water

Glycerine percent weight	Temperature (°C)										
	0	10	20	30	40	50	60	70	80	90	100
0	1.792	1.308	1.005	0.8007	0.6560	0.5494	0.4688	0.4061	0.3565	0.3165	0.2838
10	2.44	1.74	1.31	1.03	0.826	0.680	0.575	0.500	–	–	–
20	3.44	2.41	1.76	1.35	1.07	0.879	0.731	0.635	–	–	–
30	5.14	3.49	2.50	1.87	1.46	1.16	0.956	0.816	0.690	–	–
40	8.25	5.37	3.72	2.72	2.07	1.62	1.30	1.09	0.918	0.763	0.668
50	14.6	9.01	6.00	4.21	3.10	2.37	1.86	1.53	1.25	1.05	0.910
60	29.9	17.4	10.8	7.19	5.08	3.76	2.85	2.29	1.84	1.52	1.28
65	45.7	25.3	15.2	9.85	6.80	4.89	3.66	2.91	2.28	1.86	1.55
67	55.5	29.9	17.7	11.3	7.73	5.50	4.09	3.23	2.50	2.03	1.68
70	76	38.8	22.5	14.1	9.40	6.61	4.86	3.78	2.90	2.34	1.93
75	132	65.2	35.5	21.2	13.6	9.25	6.61	5.01	3.80	3.00	2.43
80	255	116	60.1	33.9	20.8	13.6	9.42	6.94	5.13	4.03	3.18
85	540	223	109	58	33.5	21.2	14.2	10.0	7.28	5.52	4.24
90	1310	498	219	109	60.0	35.5	22.5	15.5	11.0	7.93	6.00
91	1590	592	259	127	68.1	39.8	25.1	17.1	11.9	8.62	6.40
92	1950	729	310	147	78.3	44.8	28.0	19.0	13.1	9.46	6.82
93	2400	860	367	172	89	51.5	31.6	21.2	14.4	10.3	7.54
94	2930	1040	437	202	105	58.4	35.4	23.6	15.8	11.2	8.19
95	3690	1270	523	237	121	67.0	39.9	26.4	17.5	12.4	9.08
96	4600	1580	624	281	142	77.8	45.4	29.7	19.6	13.6	10.1
97	5770	1950	765	340	166	88.9	51.9	33.6	21.9	15.1	10.9
98	7370	2460	939	409	196	104	59.8	38.5	24.8	17.0	12.2
99	9420	3090	1150	500	235	122	69.1	43.6	27.8	19.0	13.3
100	12070	3900	1410	612	284	142	81.3	50.6	31.9	21.3	14.8

[<http://www.dow.com/glycerine/resources/table18.htm>]

Results

For our study we used three models:

$$\eta_{Lees}(\eta_1, \eta_2, v_1, v_2, i) := \frac{v_1^i + v_2^i}{\frac{v_1^i}{\eta_1} + \frac{v_2^i}{\eta_2}} \quad (9)$$

$$\eta_{Schultze}(\eta_1, \eta_2, v_1, v_2) := \eta_1 v_1^2 + 2v_1 v_2 \sqrt{\eta_1 \eta_2} + \eta_2 v_2^2 \quad (10)$$

$$\eta_{Eyring}(\eta_1, \eta_2, v_1, v_2) := \exp(v_1 \log(\eta_1) + v_2 \log(\eta_2)) \quad (11)$$

The comparison between these models and real model (see table 1) for different temperatures (0°C, 40°C, 100°C) shows that the closest model is the Lees model.

In our representation is traced with blue the real model, with purple is traced the Lees model (below), with the mustard is traced the Eyring model and with green is traced the Shultze model.

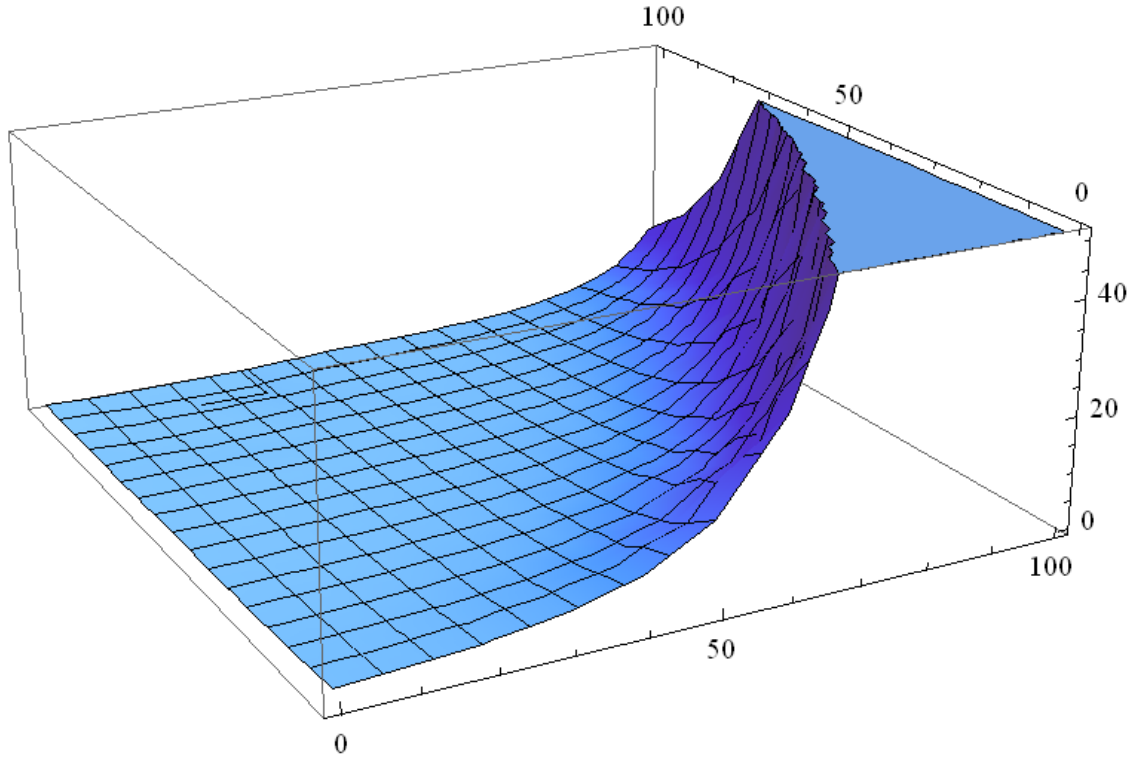


Fig. 1.

After the comparative analysis, we propose a modification of the Lees relationship (see formula (9)).

One can see that for certain values of i ($i = 1$ in Lees model) can be obtained better approximations, especially for higher concentrations for $i = 1.7$.

This approach leads to the following results:

Thus, the formula that we propose for the determination of the viscosity of a binary mixture of fluids, is:

$$\frac{1}{\eta} = \frac{V_1^{1.7}}{\eta_1} + \frac{V_2^{1.7}}{\eta_2}$$

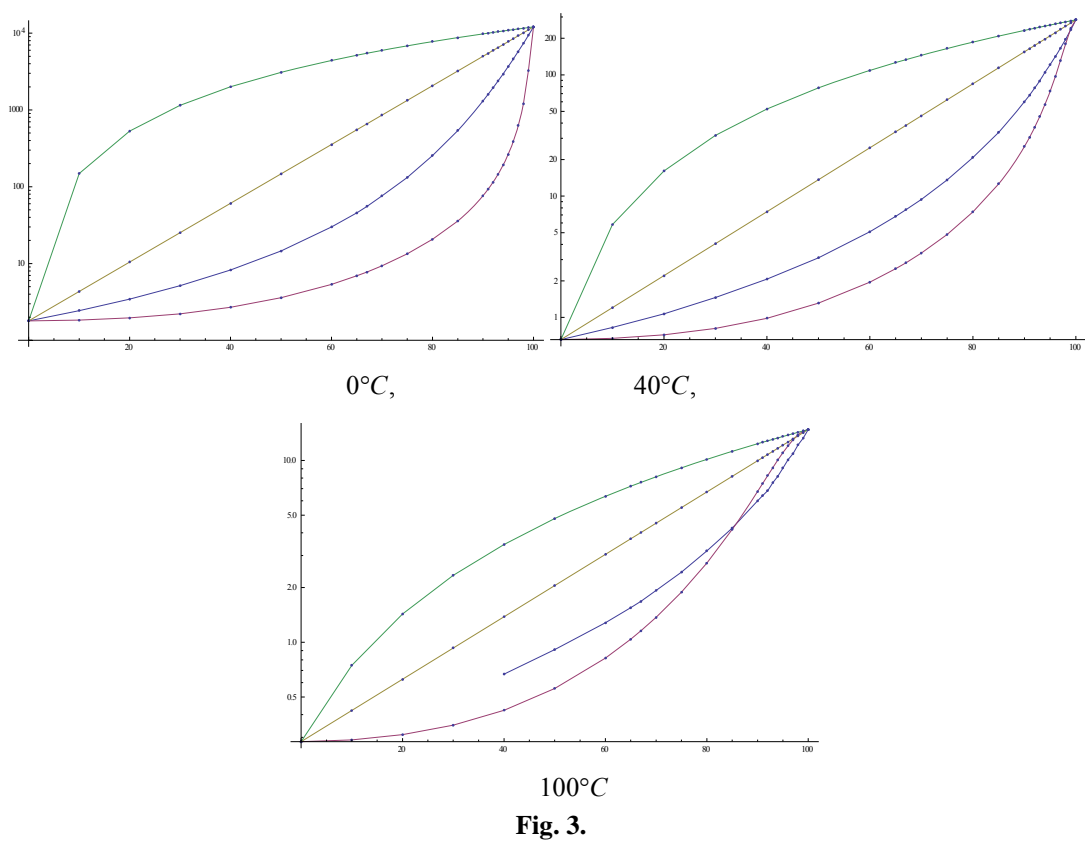
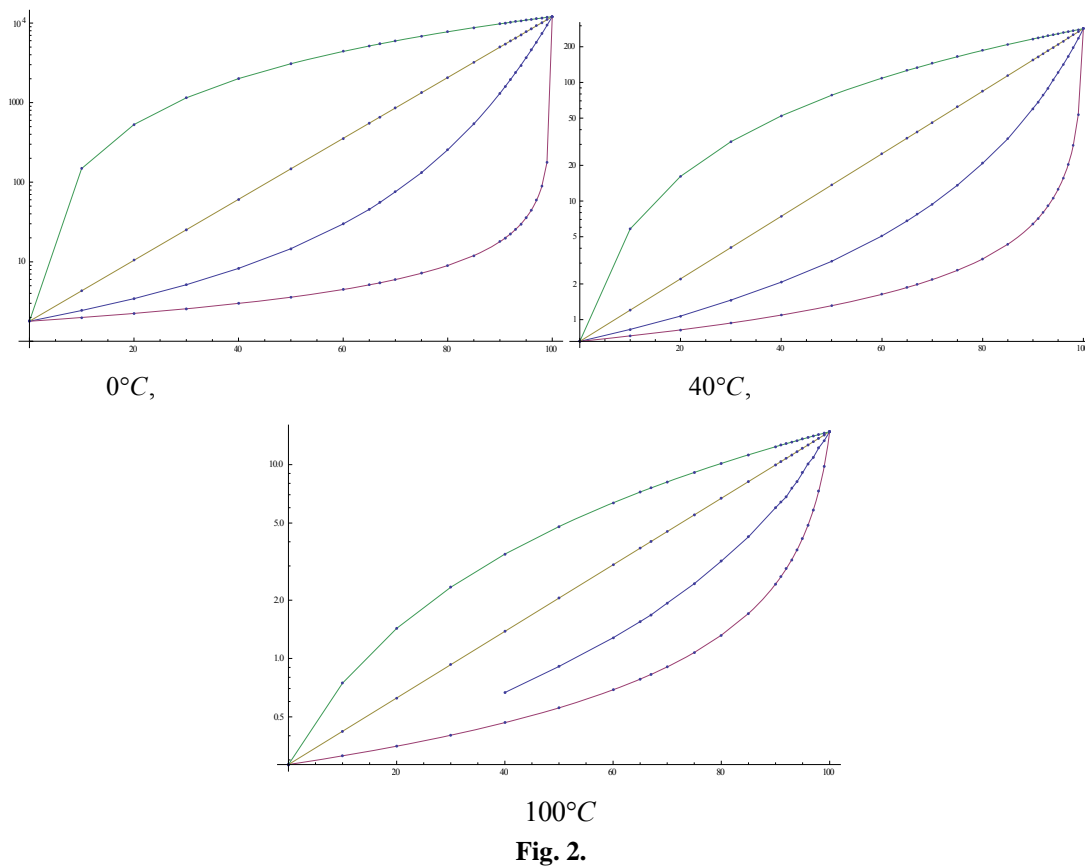
Conclusion

Following a comparative analysis between the real model and the models proposed by the literature we found that the model proposed by Lees is closest to the real model.

We proposed a relationship that leads to results that approximated better the experimental results.

References

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2. Solomon M. – *Vâscozimetre și elemente de teoria vâscozității*, Edit. Tehnică, București, 1958.
3. *** – <http://www.dow.com/glycerine/resources/table18.htm>.



Modelarea coeficientului de vâscozitate pentru amestecuri de lichide

Rezumat

În acest articol vom prezenta o comparație între valorile obținute pentru vâscozitatea dinamică prin calcul utilizând relații matematice cunoscute [2], cu rezultatele experimentale obținute pentru vâscozitatea dinamică pentru lichide binare diferite.

Formulele cunoscute din literatura de specialitate reprezintă o dependență matematică care nu poate exprima toate variantele care apar ca urmare a fenomenelor fizice și chimice care au loc în soluție, fenomene care diferă în funcție de starea de energie a moleculelor, după caracteristicile lor chimice și după condițiile externe.

Noi propunem o relație care să conducă la rezultate care aproximează mai bine rezultatele experimentale.