SSRG International Journal of Electrical and Electronics Engineering (SSRG-IJEEE) – Volume 4 Issue 7 – July 2017

Effect of Electric Field on Viscosity and Excess Viscosity of Three Liquid Mixtures

P. Seshu Mani, Prof. S. Vijaya Bhaskara Rao

Abstract

Electric Field of 230 V is applied between two fudicial marks of Ostwald Capillary Viscometer measure flow time , calculate Viscosity and Excess viscosity of three liquid mixtures Benzene + Acetone, Nitrobenzene + Benzene and Nitrobenzene + Acetone at 23 Degree Centigrade. The graphs drawn between Mole fraction versus Viscosity and Mole Fraction versus Excess Viscosity are studied. Using this data interaction between molecules is studied.

I. INTRODUCTION

Viscosity of the liquid is dependent upon Electric Field [1 - 5]. An Electric Field of 230 V is applied between two fudicial marks of the Ostwald Capillary Viscometer bulb. The flow time is measured using Microcontroller Embedded System. Viscosity and Excess Viscosity are calculated. Electric Field is applied between two parallel plates made of Copper of an Attracted Plate Type Instrument. A U – Shaped Wooden Frame with long stick is used for fixing parallel plates, an electrostatic Field is developed between these two plates. While using instrument the following precautions are taken.

1. The liquid should not in contact with the Electric Field.
2. Any other wire or any other attracted materials are not placed in the vicinity of the Electric Field.
3. While doing the experiment we cannot touch the plates.
4. The distance between electrodes are not changed, they are fixed.
5. The poles are not interchanged.
6. The time of passage of Electric Field also changes the viscosity.

II. RESULTS – DENSITY, VISCOSITY AND EXCESS VISCOSITY

Applying an Electric Field of 230 V on the viscometer, there is a change in apparent viscosity due to potential divided by the distance between the plates. These fluids are also called Electro Rheological fluids [6 – 25]. The flow time for various liquids and liquid mixtures are measured at a temperature of 23°C. Viscometer with Electric Field as shown in Pic. 1.

By using flow time, Viscosity for pure liquids and liquid mixtures are calculated by using the relation [26].

$$\eta = \rho B t \dashrightarrow (1)$$

Where ρ is the density of liquid

B is the viscometer constant and

t is the flow time

The viscometer constant at 23°C is calculated as 0.0064232.

The Excess Viscosity of liquid mixtures are calculated using the formula [27].

$$\eta^E = \eta - \eta_1 X_1 - \eta_2 X_2 \dashrightarrow (2)$$

Where η is the viscosity of the mixture
η_1 is the viscosity of the solvent
X_1 is the mole fraction of the solvent
η_2 is the viscosity of the solute
X_2 is the mole fraction of the solute

The Density, the viscosity and the Excess Viscosity for the liquid mixtures Benzene + Acetone, Nitrobenzene + Benzene and Nitrobenzene + Acetone are listed in Table 1, Table 2 and Table 3 respectively.

Graphs are drawn between Mole Fraction and Viscosity for the liquid mixtures Benzene + Acetone, Nitrobenzene + Benzene and Nitrobenzene + Acetone are shown in Fig. 1, Fig. 3 and Fig. 5 respectively. The Mole Fraction versus Excess Viscosity curves for the liquid mixtures Benzene + Acetone, Nitrobenzene + Benzene and Nitrobenzene + Acetone are drawn in Fig. 2, Fig. 4 and Fig. 6 respectively.

Pic.1. Viscometer with Electric Field

Table 1-Benzene + Acetone System

S.No.	Concentrate of solute (mole)	Density (10^3 Kg m^{-3})	Viscosity (10^{-3} Nsm^{-2})	Excess Viscosity (10^{-3} Nsm^{-2})
Benzene	0.0000	0.93100	0.62535	0.0000
1	0.1142	0.93590	0.51622	-0.0675
2	0.2206	0.93041	0.49106	-0.0593
3	0.3198	0.92747	0.47194	-0.0458
4	0.4203	0.92649	0.46493	-0.0536
5	0.5104	0.91669	0.39458	-0.0569
6	0.5952	0.91356	0.37940	-0.0550
7	0.6871	0.90964	0.36400	-0.0419
8	0.7683	0.90513	0.35240	-0.0283
9	0.8461	0.90043	0.33012	-0.0265
10	0.9280	0.89415	0.31712	-0.0143
Acetone	1.0000	0.89298	0.31870	0.0000

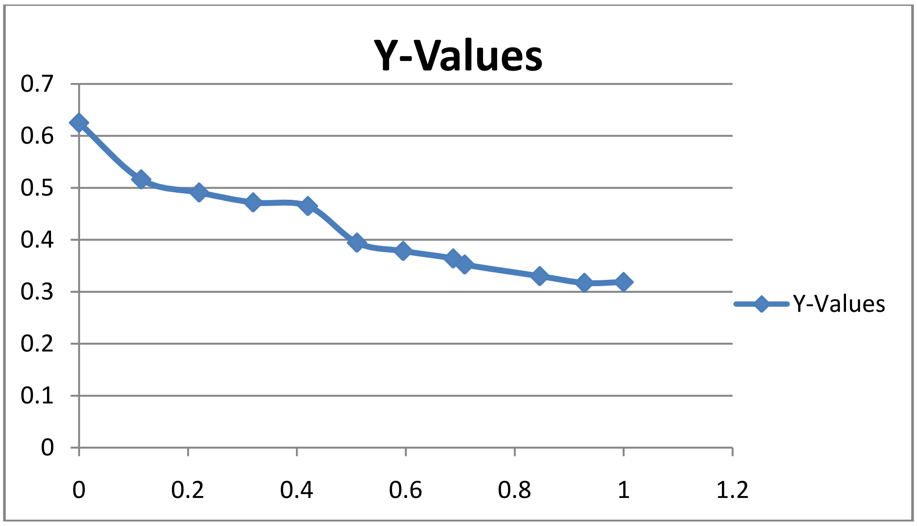

Fig. 1 Benzene + Acetone Mole Fraction Versus Viscosity Curve For Electric Field

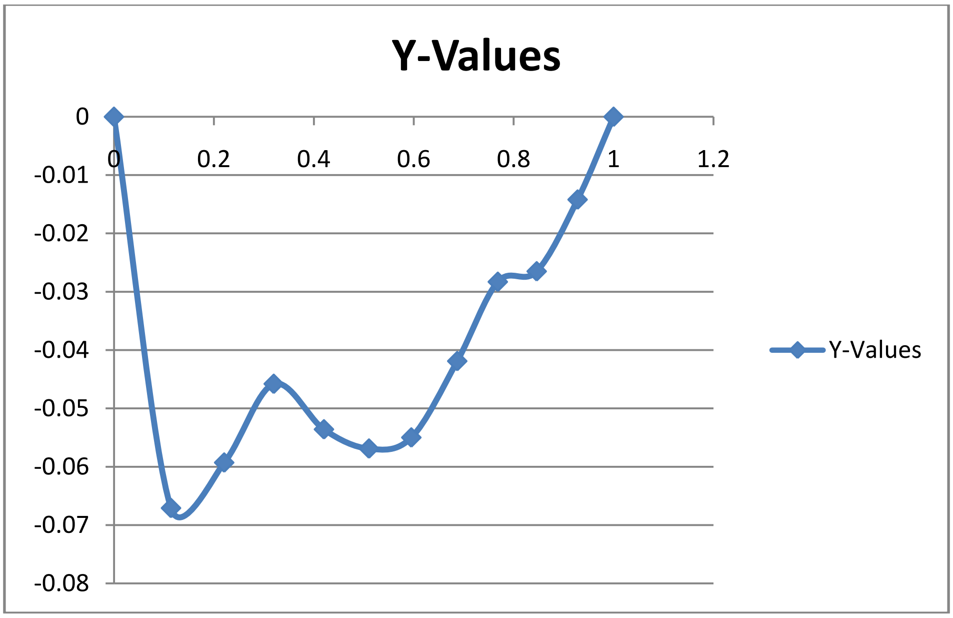

Fig. 2 Benzene + Acetone Mole Fraction Versus Excess Viscosity Curve For Electric Field

Table 2 - Nitrobenzene + Benzene

S.No.	Concentrate of solute (mole)	Density (10^3 Kg m^{-3})	Viscosity (10^{-3} Nsm^{-2})	Excess Viscosity (10^{-3} Nsm^{-2})
Nitrobenzene	0.0000	1.09996	1.38471	0.0000
1	0.1166	1.08643	1.20553	-0.1168
2	0.2265	1.07522	1.04657	-0.1882
3	0.3305	1.06762	0.99761	-0.1544
4	0.4288	1.04782	0.91791	-0.1558
5	0.5219	1.02744	0.81116	-0.1883
6	0.6104	1.00529	0.73931	-0.1897
7	0.6944	0.99627	0.70251	-0.1596
8	0.7743	0.98157	0.64542	-0.1530
9	0.8505	0.96765	0.5881	-0.1496
10	0.9302	0.94943	0.56064	-0.1136
Benzene	1.0000	0.93100	0.62535	0.0000

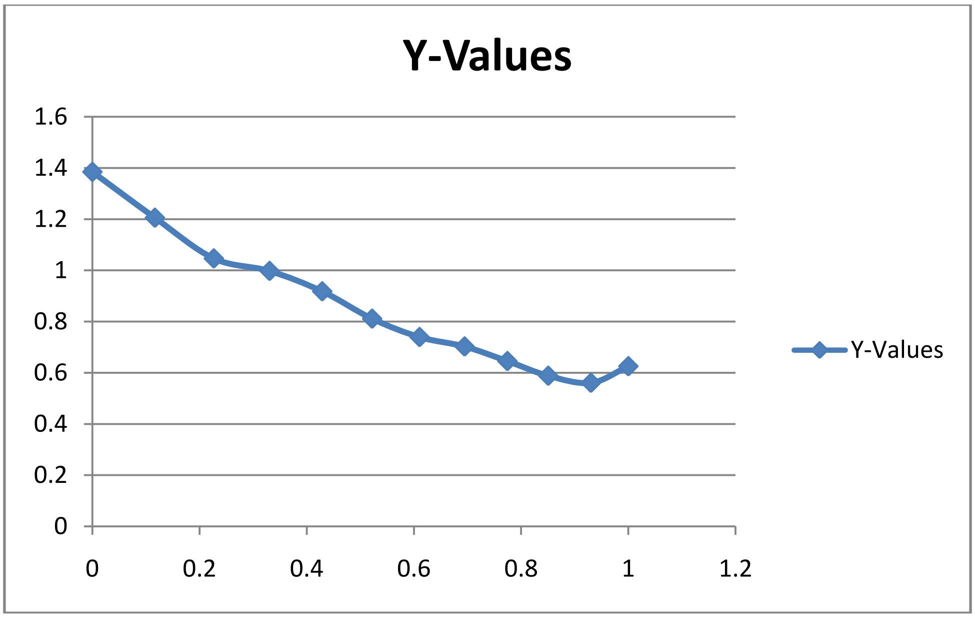

Fig. 3 Nitrobenzene + Benzene Mole Fraction Versus Viscosity Curve For Electric Field

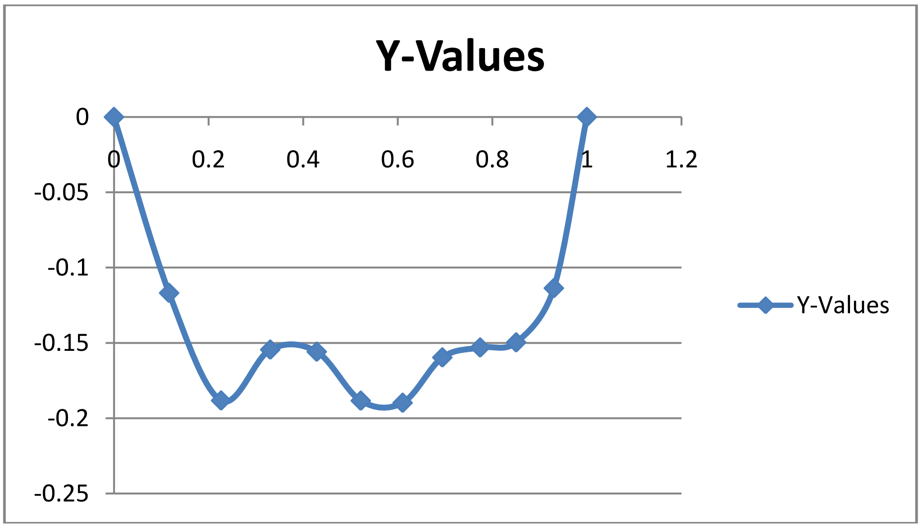

Fig. 4 Nitrobenzene + Benzene Mole Fraction Versus Excess Viscosity Curve for Electric Field

Table 3 Nitrobenzene + Acetone

S.No.	Concentrate of solute (mole)	Density (10^3 Kg m^{-3})	Viscosity (10^{-3} Nsm^{-2})	Excess Viscosity (10^{-3} Nsm^{-2})
Nitrobenzene	0.0000	1.09996	1.38471	0.0000
1	0.1468	1.08437	1.21262	-0.1962
2	0.2742	1.06781	0.98162	-0.2904
3	0.3890	1.04998	0.88574	-0.3263
4	0.4919	1.03469	0.73202	-0.4262
5	0.5848	1.01862	0.69379	-0.4116
6	0.6689	0.98020	0.55124	-0.5145
7	0.7456	0.96844	0.46504	-0.5607
8	0.8157	0.94805	0.42574	-0.5616
9	0.8800	0.92924	0.37184	-0.5836
10	0.9451	0.91317	0.33973	-0.5818
Acetone	1.0000	0.89298	0.31870	0.0000

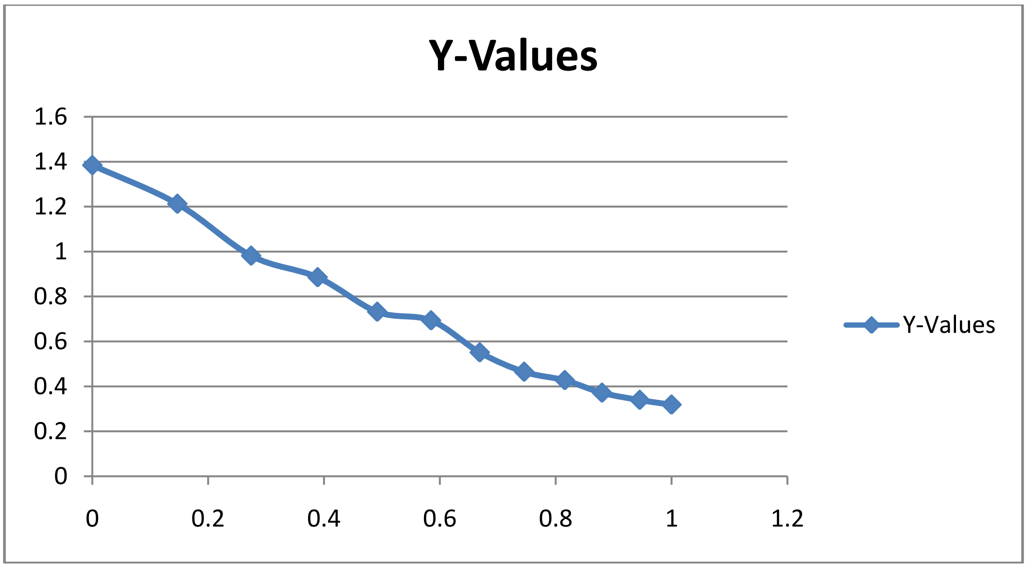

Fig. 5 Nitrobenzene + Acetone Mole Fraction Versus Viscosity Curve for Electric Field

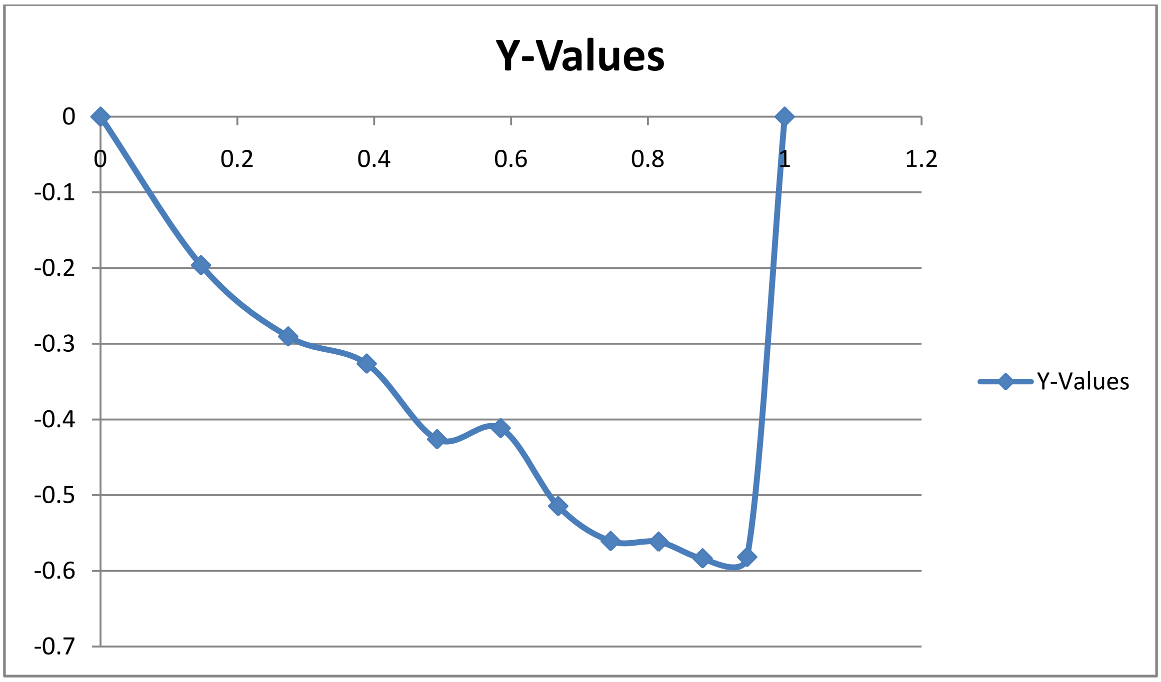

Fig. 6 Nitrobenzene + Acetone Mole Fraction Versus Excess Viscosity Curve for Electric Field

III. DISCUSSION

A. Mole Fraction - Viscosity Graph

From the Mole Fraction versus Viscosity curves of the liquid mixtures Benzene + Acetone , Nitrobenzene + Benzene and Nitrobenzene + Acetone, we noticed that these curves obtained are not a straight line, but slightly non – linear. This explains that there is an interaction between these molecules.

B. Mole Fraction - Excess Viscosity Graph

Mole Fraction versus Excess Viscosity curves of the liquid mixtures Benzene + Acetone, Nitrobenzene + Benzene and Nitrobenzene + Acetone, occurred in Negative direction. Large Excess Viscosity in negative indicates that dispersive forces are responsible for interaction. The negative and large value of Excess Viscosity explains that strong solute - solute dipolar interactions in addition to the solute – solvent and solvent – solvent interactions. The Static Electric

Field considerably changes the viscosity of the liquid.

REFERENCES

[1] Herzog, Kudur and Paersch, Naturwise 36, 662 (1933).
[2] Herzog, Kudur and Paersch, Physik, Zeits, 35, 446 (1934)
[3] Alcock E. D., J. Appl. Phys. 7, 126 (1936).
[4] Electrorheological fluid, from Wikipedia, the free encyclopedia.
[5] SiddharthGadkari and RichishThaokar, International J. of Chemical, Molecular, Nuclear, Materials and Metallurgical Engineering, 6(6), 516-521 (2012).
[6] Andrade, E. N. da C., and Dodd, c., The Royal Society Collaborating with JSTOR , Proceedings of London, Series a, Mathematical and Physical Sciences (1945).
[7] Andrade, E. N. da C., Phil. Mag., 17, 497, 698 (1934).
[8] Andrade, E. N. da C., Proc. Phys. Soc., Lond., 52, 748 (1940).
[9] Andrade, E. N. da C., and Dodd, C., Nature, 143, 26 (1939a).
[10] Andrade, E. N. da C., and Dodd, C., Nature, 144, 117 (1939b).
[11] Bjornstahl, Y., and Snellman, O., Physics, 6, 257 (1935).
[12] Dobinski, S., Phys. Z., 36, 509 (1935).
[13] Duff, W., phys. Rev., 4, 23 (1896).
[14] Ereolini, G., NuovoCim., 5, 249 (1903).
[15] Eyring, H., J. Chem. Phys., 4, 283 (1936).
[16] Herzog, R. O., Kudar, H., and Paersch, E., Naturwissenschaften, 21, 662 (1933).
[17] Herzog, R. O., Kudar, H., and Paersch, E., Phys. Z., 35,446 (1934).
[18] Jffe, G., Ann. Phys., Lpz., 25 , 257 (1908).
[19] Jffe, G., Ann. Phys., Lpz., 32, 148 (1910).
[20] Kimura, O., Bull. Chem. Soc.Japan., 12, 147 (1937).
[21] Konig, W., Ann. Phys., Lpz., 25,618 (1885).
[22] Pacher, G., and Finazzi, L., NuovoCim., 11, 290 (1900).
[23] Pochettino, A., R. C. Accad. Lincei, 12, II, 363 9 1903).
[24] Quineke, G., Ann. Phys., Lpz., 62, 1 (1897).
[25] Schweidler, E. Von., Anne. Phys., Lpz., 4, 307 (1901a).
[26] Fort, R. J., and Moore, W. R., Trans Faraday Society, 62, 1112 (1996).
[27] Liler, and Kosanovic, Hydrogen Bonding ed. Hadzi, Pergamon Press, London (1959).