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

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Abstract

Magnetic Field is applied between two fudicial marks of Ostwald Viscometer and flow time is measured with Microcontroller Embedded System. Viscosity and Excess Viscosity are calculated for the three liquid mixtures Benzene + Acetone, Nitrobenzene + Benzene and Nitrobenzene + Acetone. The mole Fraction versus Viscosity and Mole Fraction versus Excess Viscosity graphs are drawn.

I. INTRODUCTION

Two different types of magnetic fields [1 – 5] are used. First one is un balanced magnetic field, having one magnet on one side and three magnets on the other side and second one is Balanced magnetic field having three magnets on one side and three magnets on the other side. The pole strength of each magnet is 1. 52 A m^2. The specimens are made of ALNICO maintained at a temperature of 23℃. For pure solutions and liquid mixtures two different types of magnetic fields are applied at one centimeter distance from the viscometer in opposite directions with the help of specially designed instrument. A U – Shaped wooden frame with long stick placed on both sides of the viscometer bulb B. While doing the experiment the following precautions are taken.

1. Magnets should be placed always at same distance. Otherwise magnetic effect calculated is not uniform.
2. Magnets are tightly fixed with rubber band. Otherwise they broken the viscometer, because opposite poles of magnets are attracted with each other.
3. After completion of experiment each and every time magnets are coupled with opposite poles to maintain the same magnetic field.
4. Objects attracted with magnets are placed far a distance from the Magnetic Field.
5. All the magnets are of equal size and dimension are taken, otherwise there is a difference in measuring the powers of the magnets.
6. Heat evolved objects and wet objects should not place near the magnets. Because they change the magnetic field strengths.
7. Magnets cannot be disturbed while measuring the viscosity.

II. RESULTS – DENSITY, VISCOSITY AND EXCESS VISCOSITY

Applied the Magnetic Field at 23℃ Density and Flow Time of some pure liquids and liquid mixtures are determined. By using flow time, Viscosity for pure liquids and liquid mixtures are calculated by using the relation [6].

$$\eta = \rho B t \quad \text{-------}\rightarrow (1)$$

Where ρ is the density of liquid

B is the viscometer constant and

t is the flow time

The viscometer constant at 23℃ is calculated as 0.0064232.

The Excess Viscosity of liquid mixtures are calculated using the formula [7].

$$\eta^E = \eta - \eta_1 X_1 - \eta_2 X_2 \text{-------}\rightarrow (2)$$

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

Viscometer with Magnetic Field is shown in Pic.1. Applying un balanced Magnetic Field the Density, the Viscosity and the Excess Viscosity of liquid mixtures Benzene + Acetone, Nitrobenzene + Benzene and Nitrobenzene + Acetone are measure and listed in Table 1, Table 2 and Table 3 respectively. For balanced Magnetic Field the Density, the Viscosity and the Excess Viscosity for the liquid mixtures Benzene + Acetone, Nitrobenzene + Benzene and Nitrobenzene + Acetone are determined and tabulated in Table 4, Table 5 and Table 6 respectively.

For un balanced Magnetic Field graphs are drawn between Mole Fraction and Viscosity for the liquid mixtures Benzene + Acetone, Nitrobenzene + Benzene and Nitrobenzene + Acetone shown in Fig. 1, Fig. 3 and Fig. 5 respectively. Mole Fraction versus Excess Viscosity curves are drawn for liquid mixtures Benzene + Acetone, Nitrobenzene + Benzene and Nitrobenzene + Acetone given in Fig. 2, Fig. 4 and Fig. 6 respectively.

In balanced Magnetic Field Mole Fraction versus Viscosity curves for the liquid mixtures Benzene + Acetone, Nitrobenzene + Benzene and Nitrobenzene + Acetone are represented in Fig. 7, Fig. 9 and Fig. 11 respectively. The Mole Fraction and Excess Viscosity Characteristics are presented in Fig. 8, Fig. 10 and Fig. 12 for liquid mixtures Benzene + Acetone, Nitrobenzene + Benzene and Nitrobenzene + Acetone respectively. Magnetic Field [8 – 25] changes viscosity considerably.

Pic. 1. Viscometer with Magnetic Field

Table 1-Benzene + Acetone System (Un Balanced Magnetic Field)

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	0.62969	0.0000
1	0.1142	0.93590	0.51621	-0.0097
2	0.2206	0.93041	0.48602	-0.0341
3	0.3198	0.92747	0.48749	-0.0302
4	0.4203	0.92649	0.47195	-0.0316
5	0.5104	0.91669	0.41639	-0.0351
6	0.5952	0.91356	0.39125	-0.0431
7	0.6871	0.90964	0.37187	-0.0340
8	0.7683	0.90513	0.35240	-0.0283
9	0.8461	0.90043	0.33304	-0.0236
10	0.9280	0.89415	0.31912	-0.0122
Acetone	1.0000	0.89298	0.31097	0.0000

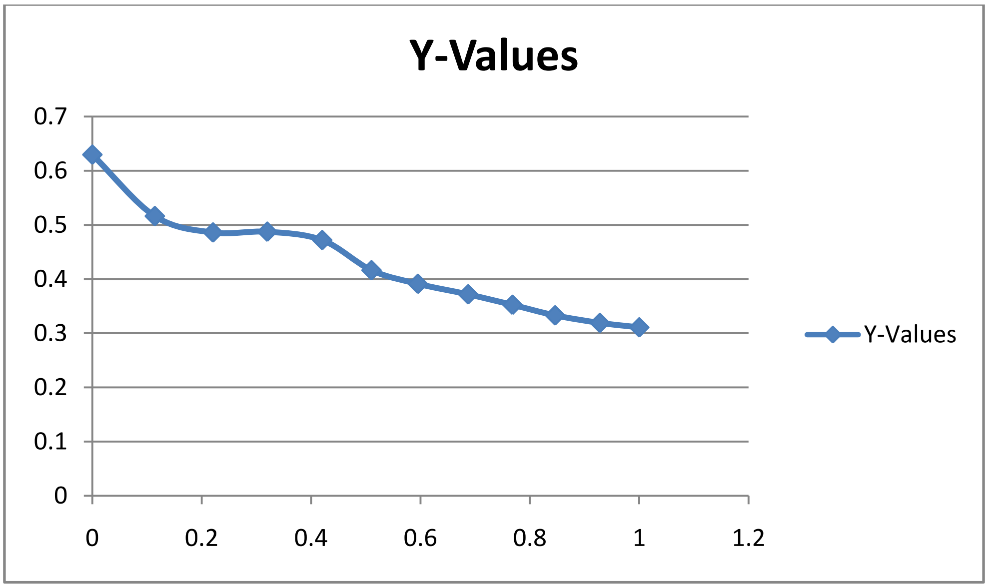

Fig. 1 Benzene + Acetone Mole Fraction Versus Viscosity Curve for Unbalanced Magnetic Field

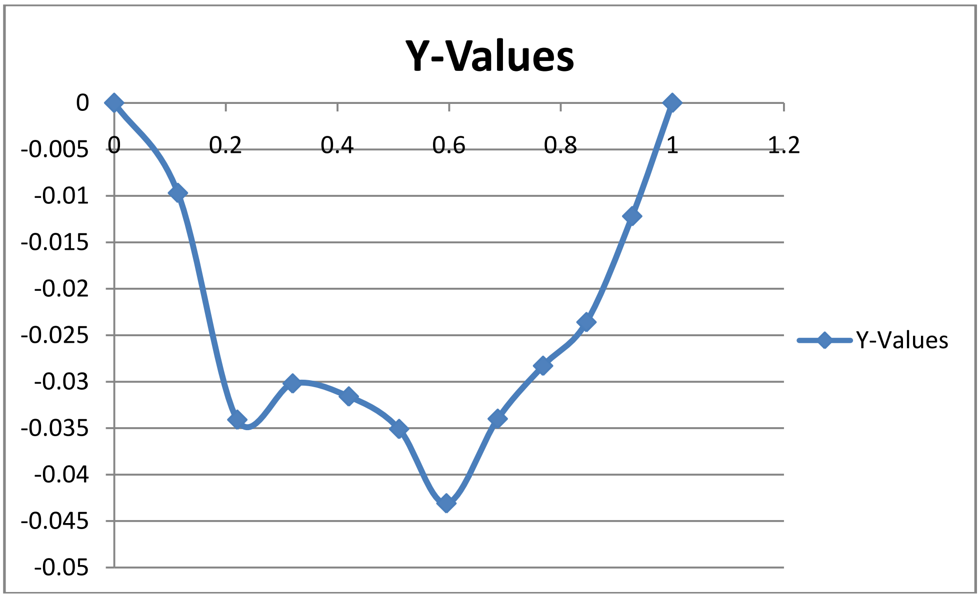

Fig. 2 Benzene + Acetone Mole Fraction Versus Excess Viscosity Curve for Unbalanced Magnetic Field

Table 2 . Nitrobenzene + Benzene (Unbalanced Magnetic Field)

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	1.41041	0.0000
1	0.1166	1.08643	1.24313	-0.0792
2	0.2265	1.07522	1.13495	-0.0998
3	0.3305	1.06762	1.05996	-0.0920
4	0.4288	1.04782	0.96324	-0.1104
5	0.5219	1.02744	0.80894	-0.1905
6	0.6104	1.00529	0.79585	-0.1332
7	0.6944	0.99627	0.74992	-0.1122
8	0.7743	0.98157	0.68507	-0.1133
9	0.8505	0.96765	0.62228	-0.1155
10	0.9302	0.94943	0.57629	-0.1013
Benzene	1.0000	0.93100	0.62969	0.0000

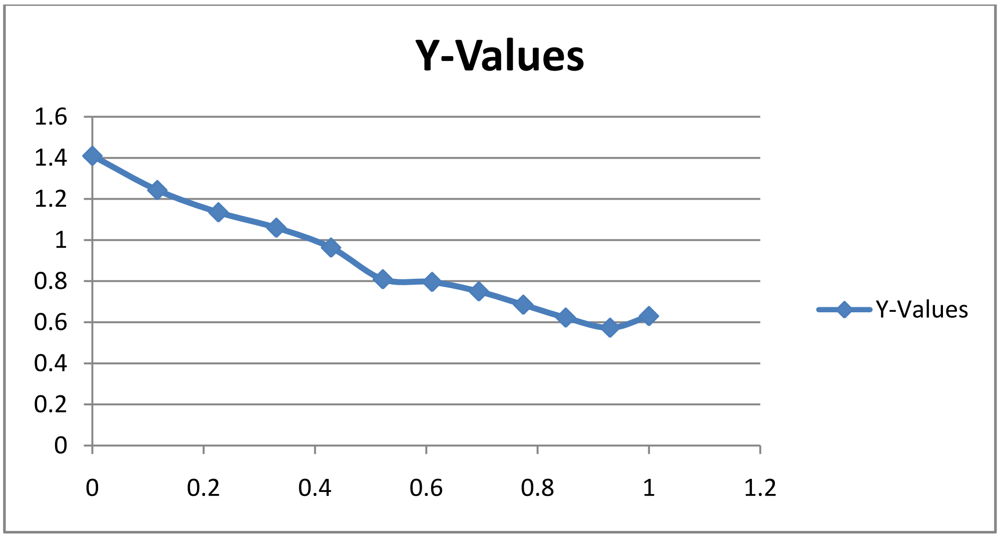

Fig. 3 Nitrobenzene + Benzene Mole Fraction Versus Viscosity Curve foe Unbalanced Magnetic Field

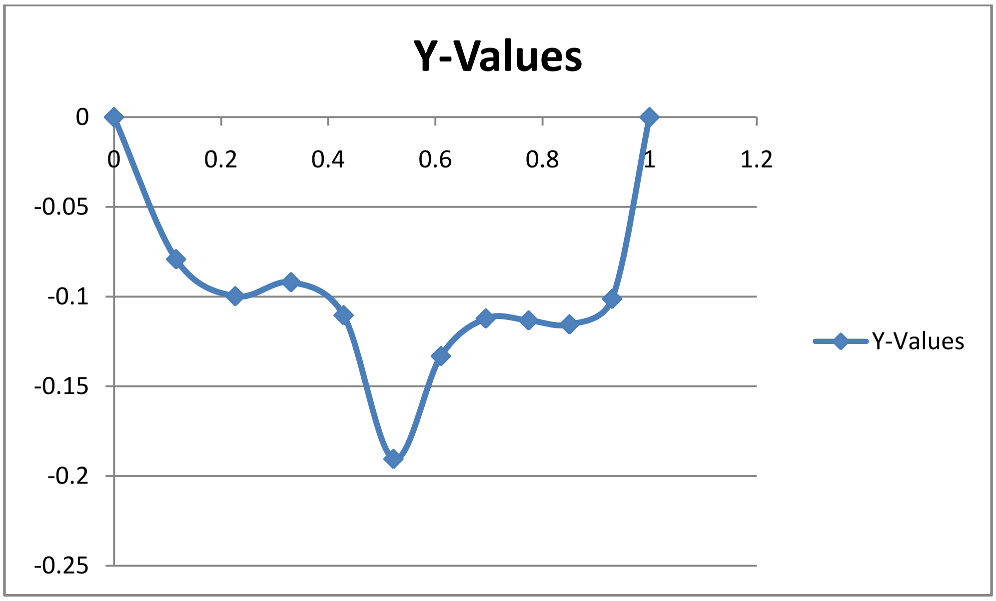

Fig. 4 Nitrobenzene + Benzene - Mole Fraction Versus Excess Viscosity Curve for Unbalanced Magnetic Field

Table 3 Nitrobenzene + Acetone (Un Balanced Magnetic Field)

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	1.41014	0.0000
1	0.1468	1.08437	1.24313	-0.0925
2	0.2742	1.06781	1.13495	-0.3788
3	0.3890	1.04998	1.05996	-0.3422
4	0.4919	1.03469	0.96324	-0.3839
5	0.5848	1.01862	0.80894	-0.3921
6	0.6689	0.98020	0.79585	-0.4001
7	0.7456	0.96844	0.74992	-0.4371
8	0.8157	0.94805	0.68507	-0.5585
9	0.8800	0.92924	0.62228	-0.5354
10	0.9451	0.91317	0.57296	-0.5759
Acetone	1.0000	0.89298	0.62969	0.0000

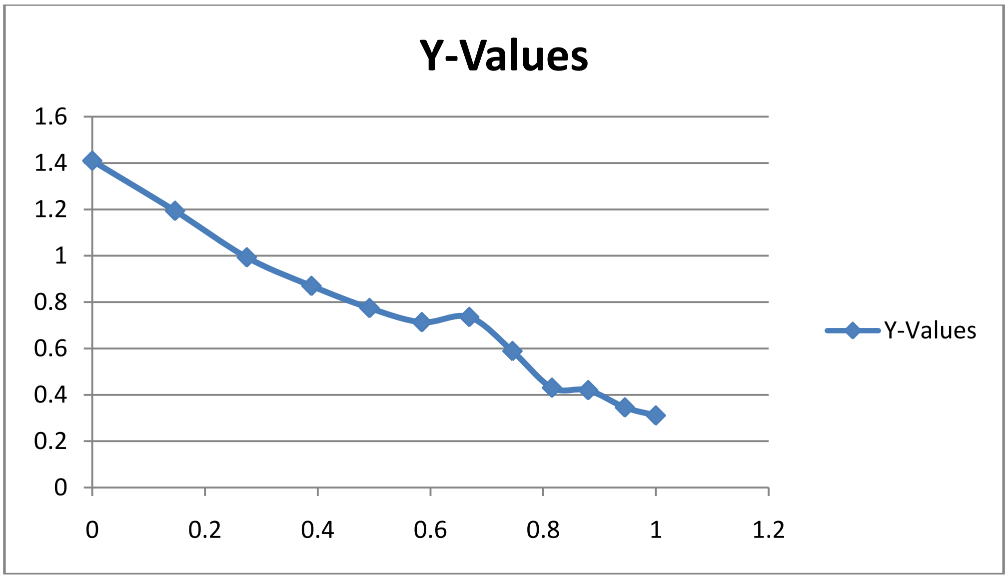

Fig. 5 Nitrobenzene + Acetone Mole Fraction Versus Viscosity For Unbalanced Magnetic Field

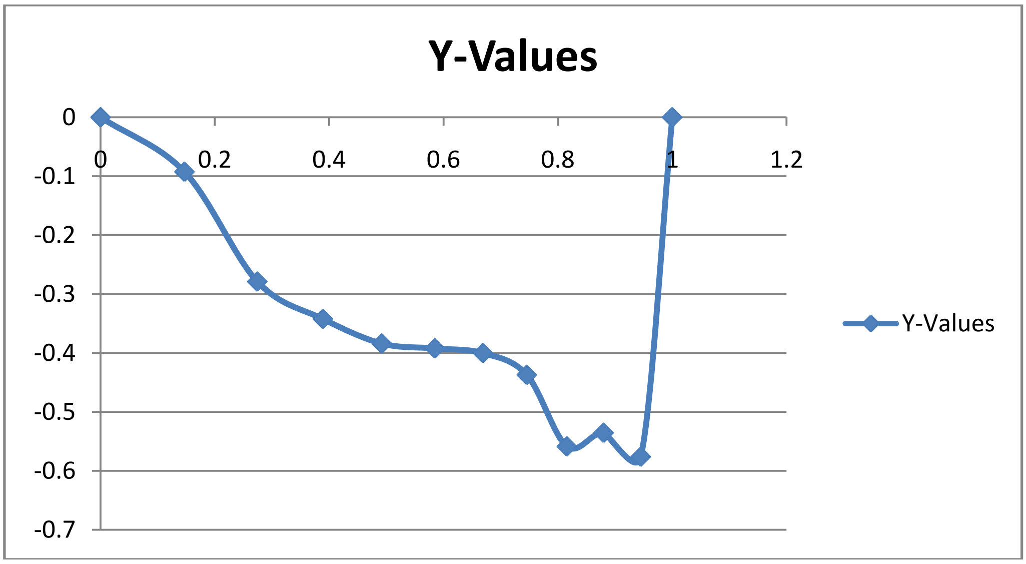

Fig. 6 Nitrobenzene + Acetone Mole Fraction Versus Excess Viscosity Curves For Unbalanced Magnetic Field

Table 4 (Balanced Magnetic Field) 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	0.62203	0.0000
1	0.1142	0.93590	0.52229	-0.0610
2	0.2206	0.93041	0.49205	-0.0583
3	0.3198	0.92747	0.48749	-0.0402
4	0.4203	0.92649	0.47194	-0.0366
5	0.5104	0.91669	0.41044	-0.0411
6	0.5952	0.91356	0.39521	-0.0392
7	0.6871	0.90964	0.37187	-0.0340
8	0.7683	0.90513	0.35045	-0.0303
9	0.8461	0.90043	0.33304	-0.0236
10	0.9280	0.89415	0.32492	-0.0064
Acetone	1.0000	0.89298	0.31291	0.0000

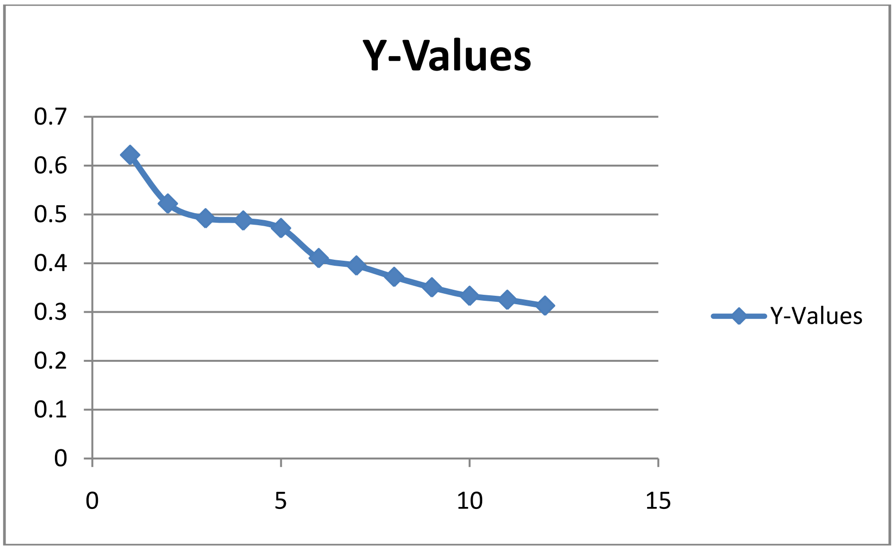

Fig. 7 Benzene + Acetone Mole Fraction Versus Viscosity Curve for Balanced Magnetic Field

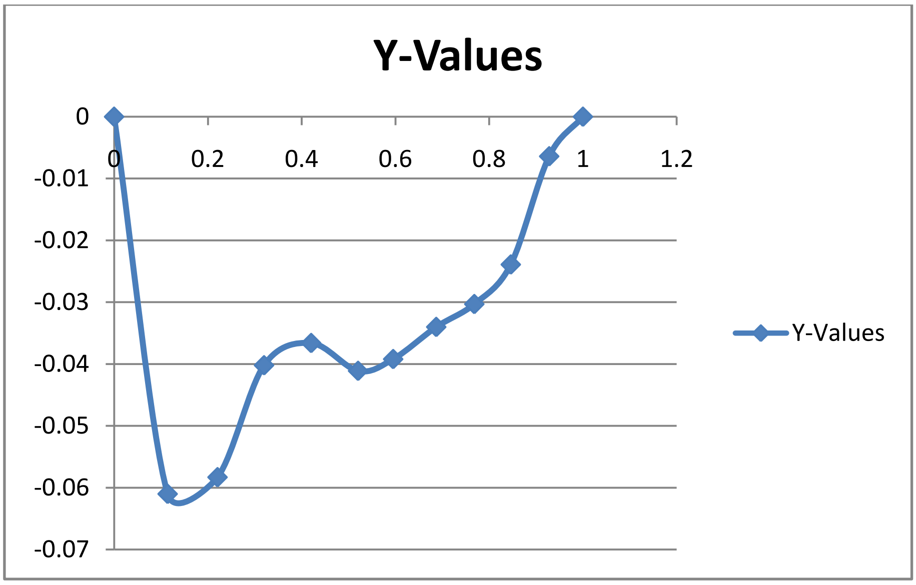

Fig. 8 Bengene + Acetone Mole Fraction Versus Excess Viscosity Curve for Balanced Magnetic Field

Table 5 . Nitrobenzene + Benzene (Balanced Magnetic Field)

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	1.41275	0.0000
1	0.1166	1.08643	1.24078	-0.0816
2	0.2265	1.07522	1.14425	-0.0905
3	0.3305	1.06762	1.05534	-0.0966
4	0.4288	1.04782	0.95644	-0.1172
5	0.5219	1.02744	0.80005	-0.1994
6	0.6104	1.00529	0.79367	-0.1353
7	0.6944	0.99627	0.75638	-0.1057
8	0.7743	0.98157	0.68978	-0.1086
9	0.8505	0.96765	0.61937	-0.1184
10	0.9302	0.94943	0.57706	-0.0972
Benzene	1.0000	0.93100	0.62203	0.0000

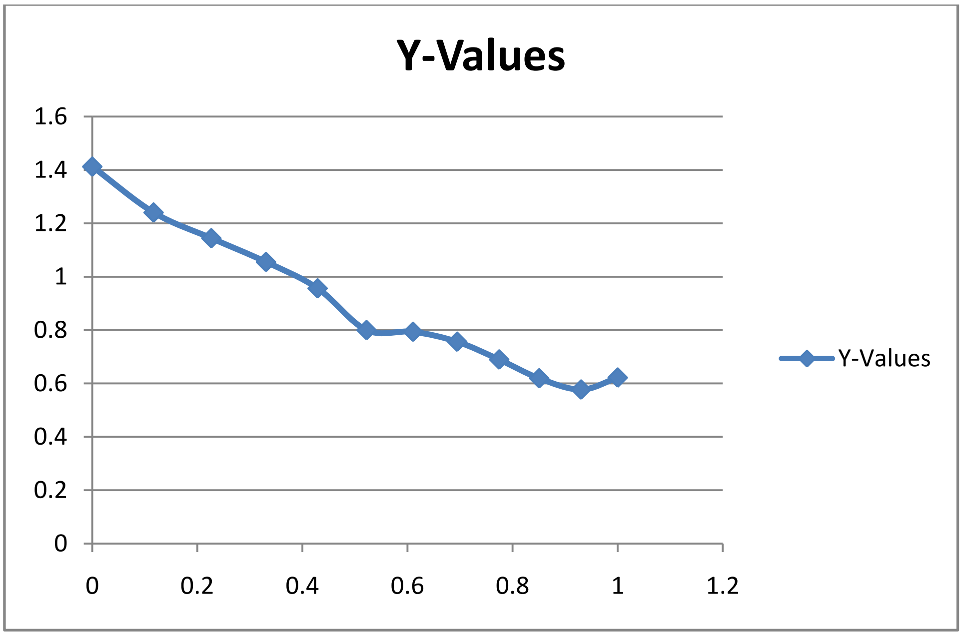

Fig. 9 Nitrobenzene + Benzene Mole Fraction Versus Viscosity Curve For Balanced Magnetic Field

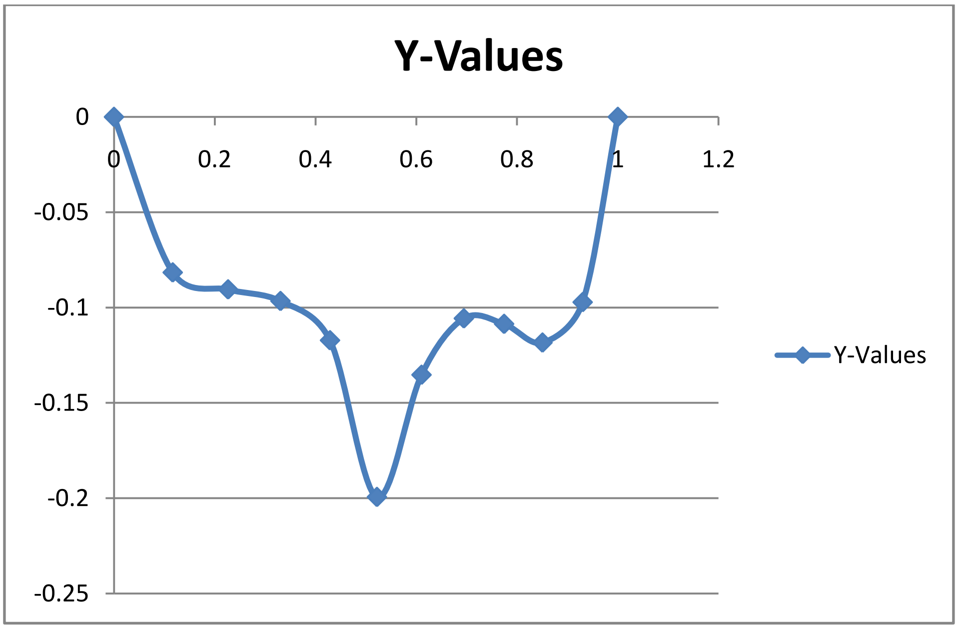

Fig. 10 Nitrobenzene + Benzene Mole Fraction Versus Excess Viscosity Curve for Balanced Magnetic Field

Table 6. Nitrobenzene + Acetone (Balanced Magnetic Field)

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	1.41275	0.0000
1	0.1468	1.08437	1.19433	-0.1245
2	0.2742	1.06781	0.97700	-0.2950
3	0.3890	1.04998	0.87211	-0.3399
4	0.4919	1.03469	0.78555	-0.3727
5	0.5848	1.01862	0.71387	-0.3916
6	0.6689	0.98020	0.73994	-0.4058
7	0.7456	0.96844	0.58444	-0.4413
8	0.8157	0.94805	0.43268	-0.5564
9	0.8800	0.92924	0.42410	-0.5314
10	0.9451	0.91317	0.34368	-0.5778

Acetone	1.0000	0.89298	0.31291	0.0000

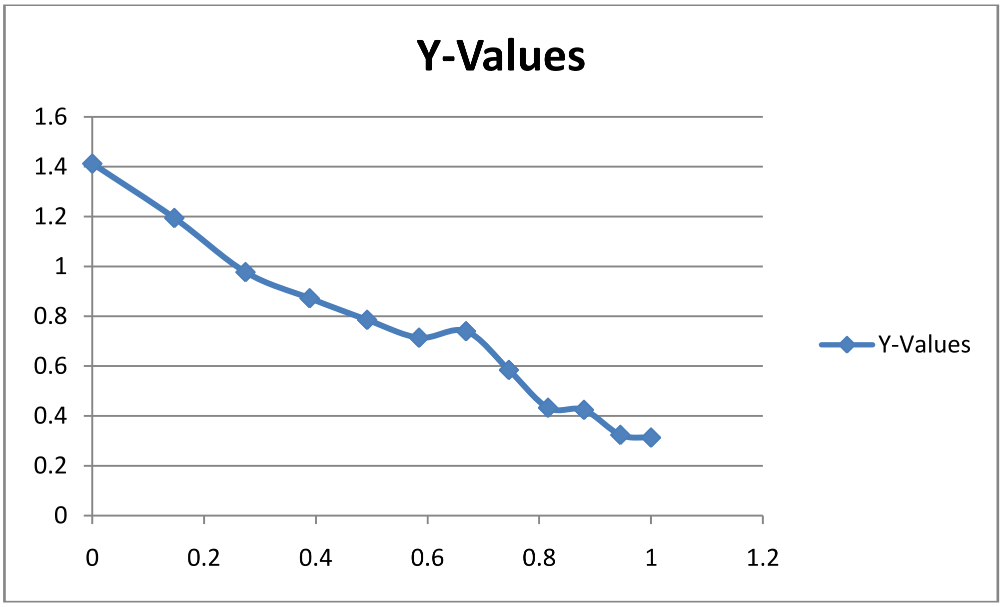

Fig. 11 Nitrobenzene + Acetone Mole Fraction Versus Viscosity for Balanced Magnetic Field

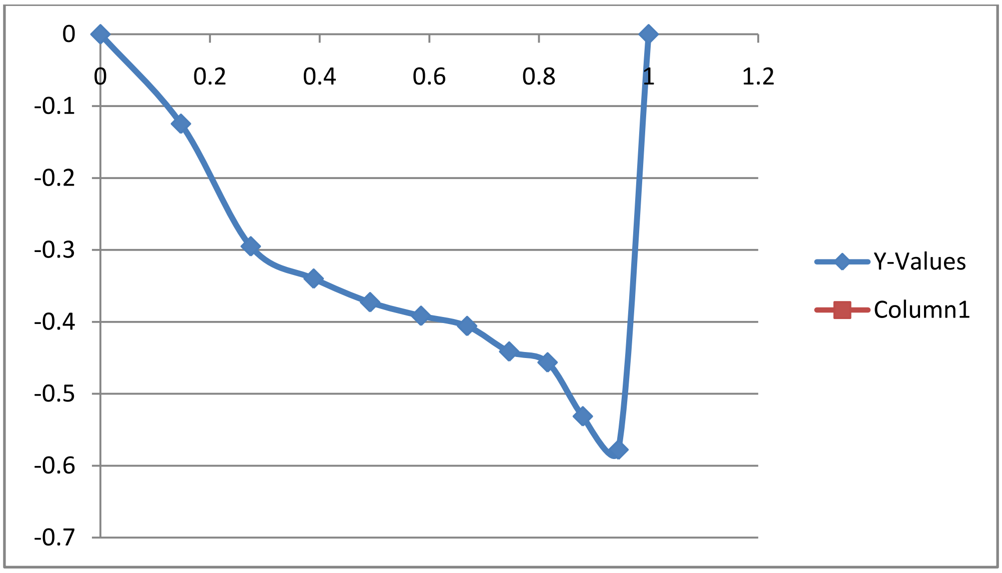

Fig. 12 Nitrobenzene + Acetone Mole Fraction Versus Excess Viscosity Curve for Balanced Magnetic Field

III. DISCUSSION

A. Mole Fraction – Viscosity Curves

For the Un Balanced / Balanced Magnetic Field Mole Fraction versus Viscosity curves of Benzene + Acetone, Nitrobenzene + Benzene and Nitrobenzene + Acetone are nonlinear indicates that there is some amount of interaction between molecules. Magnetic Field appreciably changes the Viscosity of the three liquid mixtures.

B. Mole Fraction - Excess Viscosity Curves

By applying Un Balanced / Balanced Magnetic Field the Mole Fraction versus Excess Viscosity curves for the liquid mixtures Benzene + Acetone, Nitrobenzene + Benzene and Nitrobenzene + Acetone are negative and large indicates that dispersive forces are responsible for interaction. This indicates that strong solute – solute dipolar interactions in addition to the other solute – solvent and solvent – solvent interactions.

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