Measurement of Viscosity and Excess Viscosity of Three Liquid Mixtures

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

Abstract

The Density, Viscosity and Excess Viscosity of Benzene + Acetone, Nitrobenzene + Benzene and Nitrobenzene + Acetone liquid mixtures are calculated at 23 degrees centigrade. The Mole Fraction versus Viscosity curves and Mole Fraction versus Excess Viscosity graphs for the three liquid mixtures drawn. From which interaction between the molecules is observed.

I. INTRODUCTION

Viscosity is an important thermodynamic property of a fluid. Ostwald Glass Capillary Viscometer [1 – 20] is used to determine viscosity of some pure liquids and their liquid mixtures. Flow time measured automatically using microcontroller embedded system. The accuracy obtained in this instrument is up to milli seconds. Densities of pure liquids and liquid mixtures are determined using pycnometer. Before doing experiment the following precautions must be taken.

1. Bottles cleaned thoroughly with deionized water and dried with acetone. Different solutions of known concentration were prepared and weighing the sample in MH – Series Pocket Scale machine with accuracy 0.01g.
2. while measuring viscosity for each and every time 3 - 5 readings are taken and average of all these values are taken.
3. By taking the liquid into the viscometer, is placed in A. C. more than half an hour to get equilibrium state of temperature.
4. Thermistor is used to measure temperature of the experimental liquid. Thermistor is very sensitive to temperature changes, so temperature maintained constantly, the accuracy for measuring the temperature is ± 0.5 %.
5. In viscometer fixed volume of liquid is taken every time.

II. RESULTS – DENSITY, VISCOSITY AND EXCESS VISCOSITY

At 23℃ Density and Flow Time of some pure liquids and liquid mixture are determined.

By using flow time, Viscosity for pure liquids and liquid mixtures are calculated by using the relation [21].

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

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 Densities and Viscosities of liquid mixtures Benzene + Acetone, Nitrobenzene + Benzene and Nitrobenzene + Acetone are calculated. These values of liquid mixtures are given in Table 1, Table 2 and Table 3 respectively. The Mole fraction versus Viscosity graphs for the liquid mixtures, Benzene + Acetone, Nitrobenzene + Benzene and Nitrobenzene + Acetone are drawn in Fig. 1, Fig . 2 and Fig . 3 respectively.

The Excess Viscosity of liquid mixtures are calculated using the formula [22].

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

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

The Excess Viscosity for the three liquid mixtures are find out. Mole fraction versus Excess Viscosity graphs for the Benzene + Acetone, Nitrobenzene + Benzene and Nitrobenzene + Acetone liquid mixtures are shown in Fig . 4 , Fig . 5 and Fig . 6 respectively.

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	0.62969	0.0000
1	0.1142	0.93590	0.51621	-0.0247
2	0.2206	0.93041	0.48602	-0.o287
3	0.3198	0.92747	0.48749	-0.0302
4	0.4203	0.92649	0.47195	-0.0346
5	0.5104	0.91669	0.41639	-0.0391
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	-0.0264
9	0.8461	0.90043	0.33304	-0.0217
10	0.9280	0.89415	0.31912	-0.0064
Acetone	1.0000	0.89298	0.31097	0.0000

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	1.41530	0.0000
1	0.1166	1.08643	1.24313	-0.0792
2	0.2265	1.07522	1.12332	-0.1114
3	0.3305	1.06762	1.06227	-0.1497
4	0.4288	1.04782	0.96097	-0.1627
5	0.5219	1.02744	0.81329	-0.1862
6	0.6104	1.00529	0.79802	-0.1310
7	0.6944	0.99627	0.73914	-0.1230
8	0.7743	0.98157	0.68249	-0.1159
9	0.8505	0.96765	0.60908	-0.1087
10	0.9302	0.94943	0.57912	-0.0951
Benzene	1.0000	0.93100	0.61875	0.0000

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	1.41530	0.0000
1	0.1468	1.08437	1.18231	-0.3365
2	0.2742	1.06781	1.00471	-0.3383
3	0.3890	1.04998	0.87211	-0.3399
4	0.4919	1.03469	0.76765	-0.3906
5	0.5848	1.01862	0.71063	-0.3948
6	0.6689	0.98020	0.76751	-0.4002
7	0.7456	0.96844	0.58653	-0.4392
8	0.8157	0.94805	0.43474	-0.5213
9	0.8800	0.92924	0.43415	-0.5544
10	0.9451	0.91317	0.34170	-0.5798
Acetone	1.0000	0.89298	0.30905	0.0000

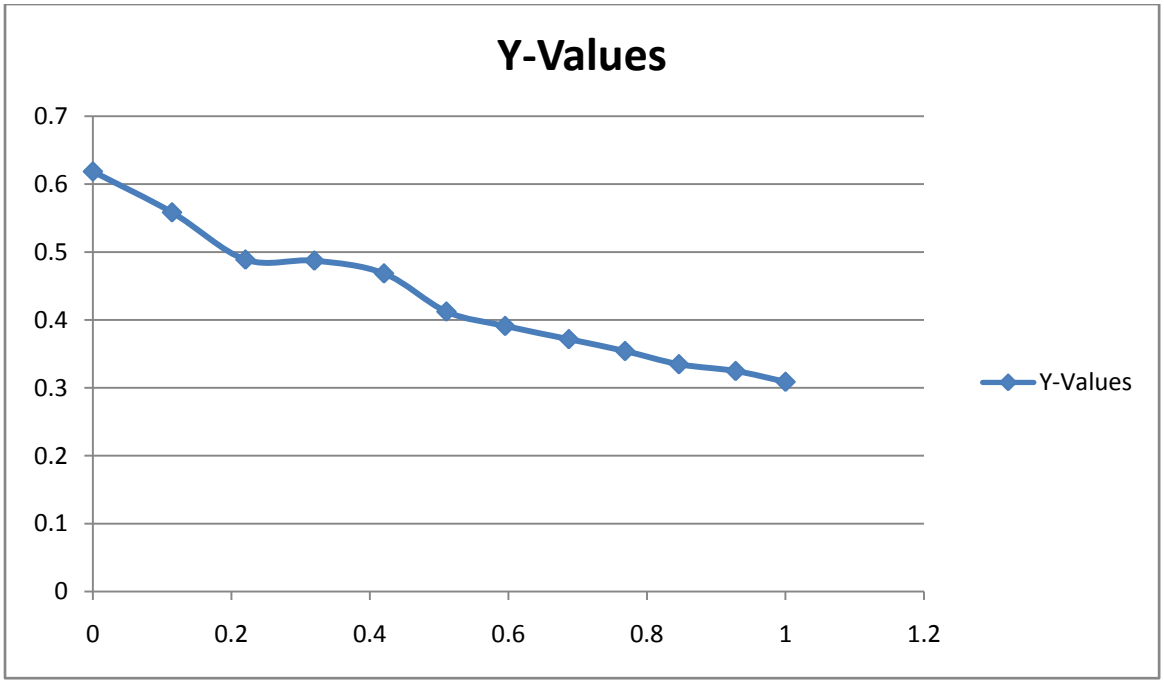

Fig. 1 benzene + acetone - mole fractiion versus viscositycurve

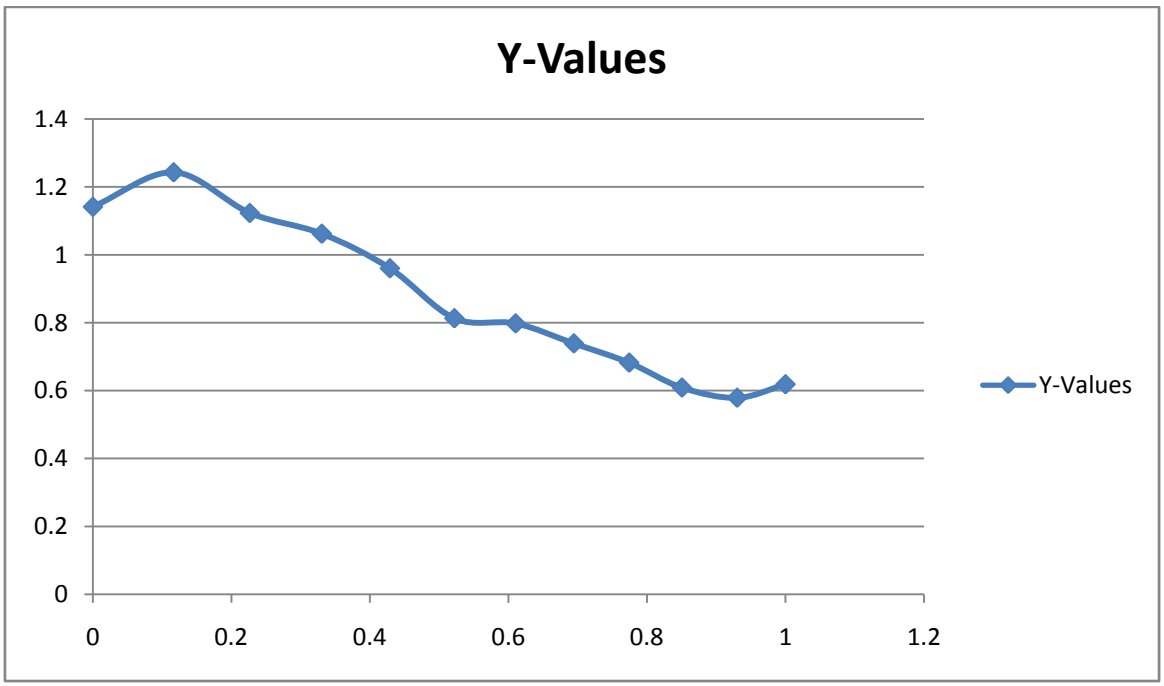

Fig. 2 nitrobenzene + benzene- mole fraction versus viscosity curve

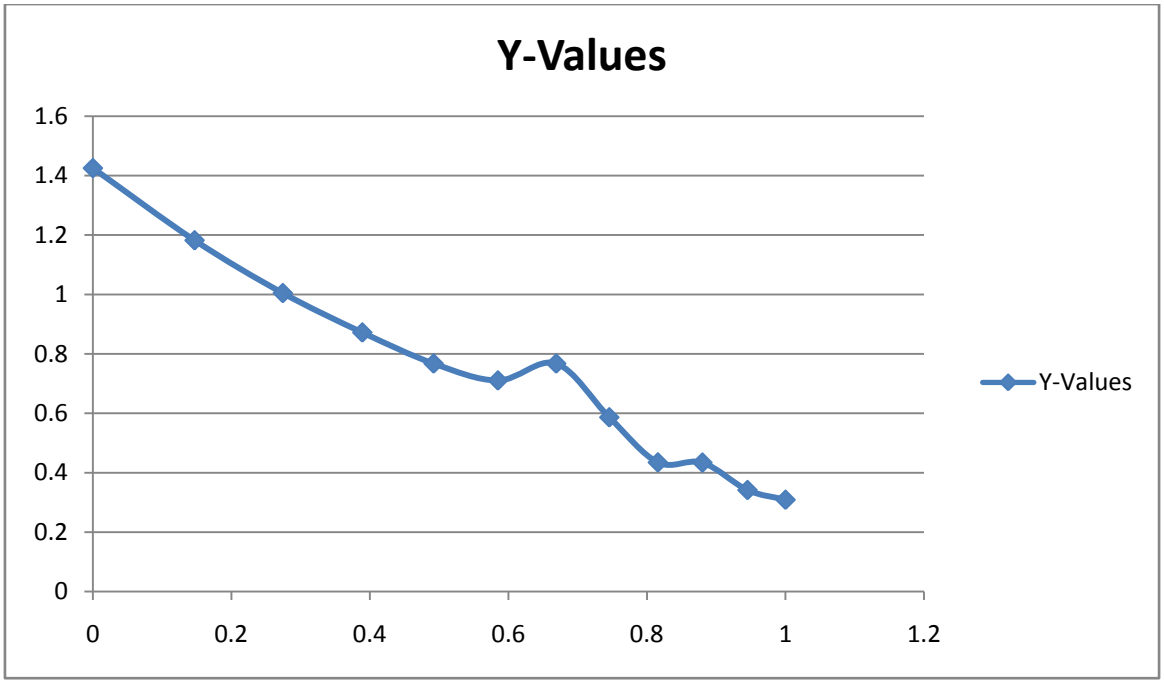

Fig. 3 nitrobenzene + acetone – mole fraction versus viscosity curve

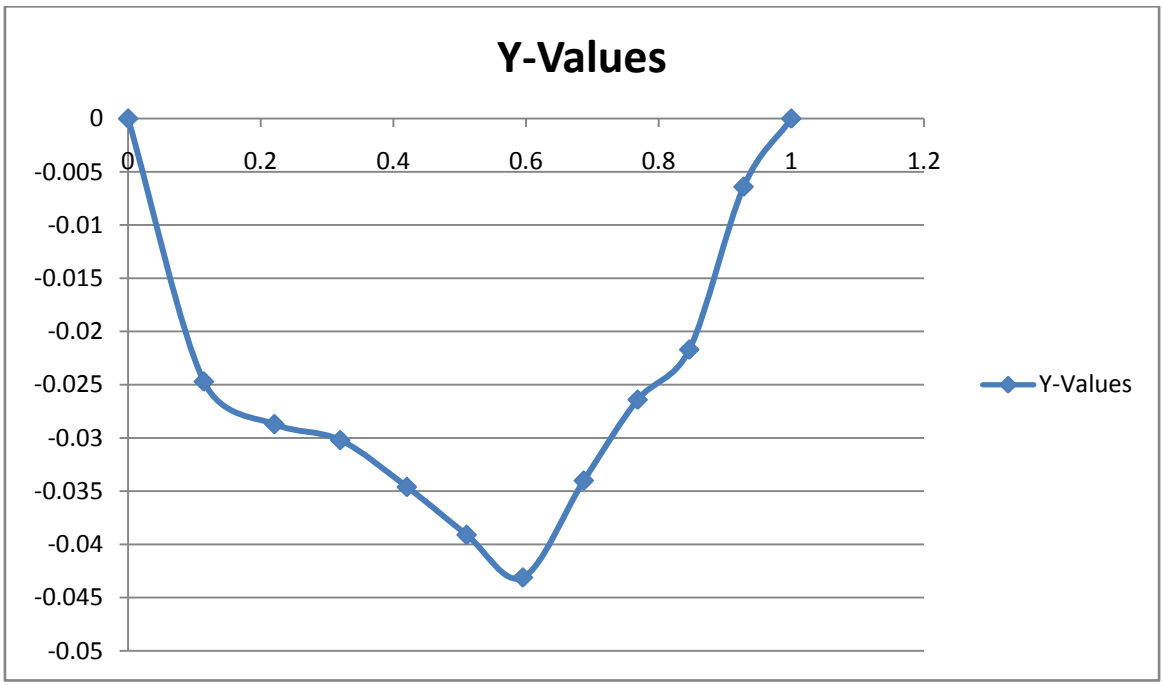

Fig. 4 benzene + acetone - mole fraction versus excess viscosity curve

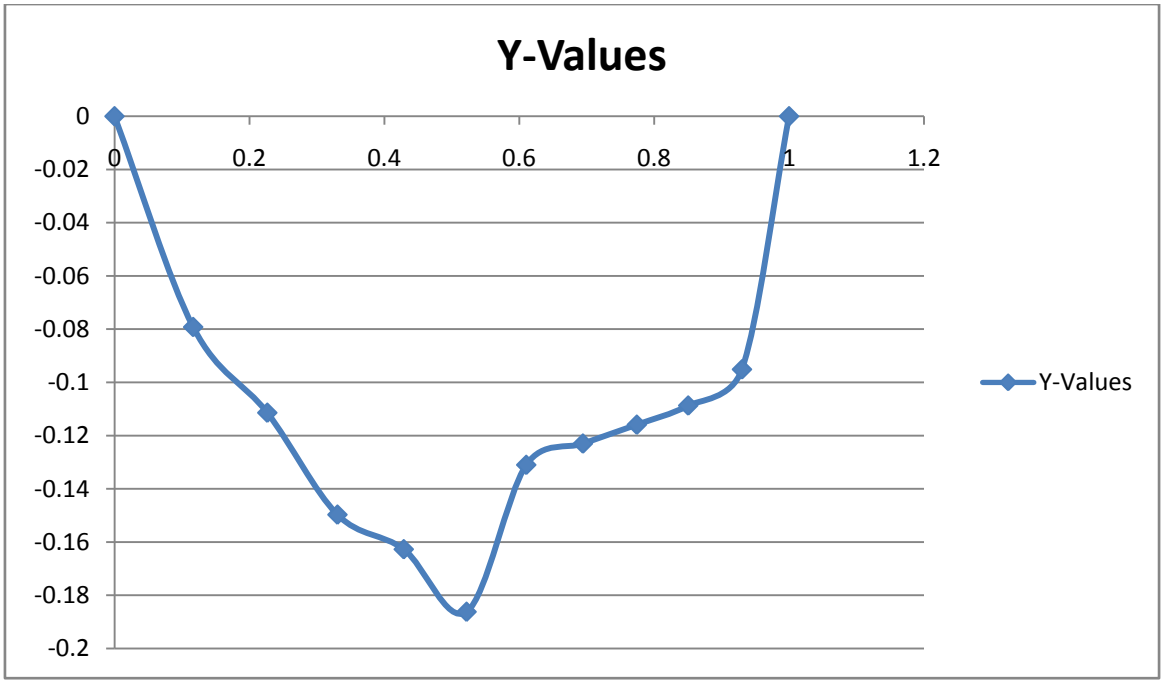

Fig. 5 nitrobenzene + benzene - mole fraction versus excess viscosity curve

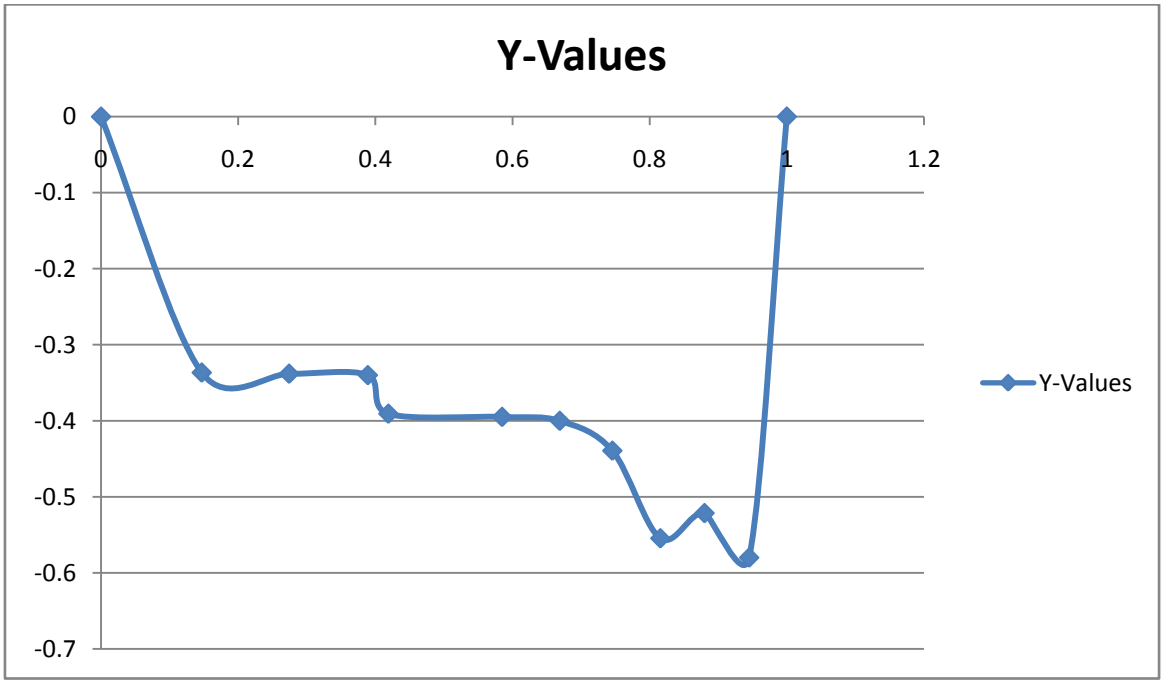

Fig.6 Nitrobenzene + Acetone - Mole Fraction Excess Viscosity Curve

III DISCUSSION

A. MOLE FRACTION VERSUS VISCOSITY CURVES

The Mole Fraction versus viscosity curves for the systems Benzene + Acetone, Nitrobenzene + Benzene and Nitrobenzene + Acetone are not a straight line, but they are slightly nonlinear . The variation of η indicates that there is some amount of interaction between solute and solvent interaction. Benzene is a nonpolar liquid whereas Nitrobenzene and acetone are polar liquids. There is a strong interaction of Nitrobenzene + Acetone system at the concentration 0.6689 of the solute. At this concentration flow time increases suddenly. We

carefully repeated the experiment and same result is noted.

B. MOLE FRACTION VERSUS EXCESS VISCOSITY CURVES

The Mole Fraction versus Excess Viscosity curves for the liquid mixtures Benzene + Acetone, Benzene + Nitrobenzene and Nitrobenzene + Acetone are obtained in negative direction. For negative deviation the dispersive forces are primarily responsible for interaction [23, 24, 25]. This indicates that the components are interact more strongly. The large negative deviation explains that Excess Viscosity is also changes more. This indicates that there is a strong interaction between solute – solute dipolar interactions in addition to the solute – solvent and solvent – solvent interactions.

REFERENCES

[1] Hiroshi Kobayashi., Rev. Sci. Instr., 51, 357 (1980).
[2] Narayan Akkarachittor, S., Arthur Fricke, L., and Jamessmall, D., Rev. Sci. Instr., 57, 1182 (1986).
[3] Cunningham, D. B., Doe, P. H., Joshi, S. D.,andMoradi _ Araghi, A., Rev. Sci. Instr., 57, 2310 (1986).
[4] Wed Lake, G. D., Vera, J. H., and Ratcliff, G. A.,Rev. Sci Instr., 50, 93 (1979).
[5] Hoogland, J. H. B., Vanben Berg H. R., and Ttappeniers, N. J., Physica., 134 A, 169 (1985).
[6] Dutta, A., Rheol. Acta., 25, 191 (1986).
[7] James, C. J., Mulcahy, D. E., and Steel B. J., J. Phys. D., 17, 225 (1984).
[8] Einfeldt, J., Exp. Tech. Phys., 31, 339 (1983).
[9] Mulcahy, D. E., J. Phys. D., 17, 219 (1984).
[10] Shiba, K., Trans. Soc. Instr. And Control Eng., 20, 149 (1984).
[11] Shaw, M. T., Burkert, S., and Sundstrom, D. W., Rev. Sci. Instr., 49, 1597 (1978).
[12] Kilp,T., Houvenaghel – Defoort, B., Panning, W., and Gufllet, J. E., Rev. Sci. Instr., 47, 1496 (1976).
[13] John Bujake, Jr., E., Rev. Sci. Instr., 36, 1368 (1965).
[14] Driel, Z., J. Phys. E., 13, 814 (1980).
[15] Shiba, K., and Yamaguchi, T., Oyo Buturi., 50, 131 (1981).
[16] Einfeldt, J., andSchmelzer, N., RheolActa., 21, 95 (1981).
[17] Vrentas, J. B., andVrentas, C. M., J. Non – Newtonian Fluid Mech., 12, 212 (1983).
[18] Bauer, H., and Meerlenber, G., Rheol. Acta., 21, 499 (1982).
[19] Flude, M. J. C., and Daborn J. E., J. Phys. E., 15, 1313 (1982).
[20] Collings, A. F.,andBajenov, N., Metrologia., 19, 61 (1983).
[21] Fort R. J. and Moore W. R., Trans Faraday Soc., 62, 1112 (1996).
[22] Lilerand Kosanovic, Hydrogen Bonding ed. Hadzi, Pergamon Press, London, (1959).
[23] Cowie, andToporowski, Can. J. Chem., 39, 2240 (1961).
[24] David Shoemaker P. and Carl Garland W., Experiments in Physical Chemistry, McGraw – Hill Book Company, Inc. New York (1962)
[25] PoonamRathore and Mukhtar Singh, Indian J. of Chemistry, 45A, 2650-2657 (2006).