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Synthesis and Measurement of Physical and Acoustical Parameters of Poly(Ethyleneglycol-400 Maleate) Resin

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ABSTRACT

Poly(Ethyleneglycol-400 Maleate) Resin was synthesized and characterized by FT-IR. The physical and acoustical parameters such as Intrinsic viscosity, Acid value, Density, Viscocity, Sound velocity, Wavelength, Isentropic compressibility, Specific acoustical impedance, Rao's molar sound function, Apparent molecular weight, Van-der Waal's constant, Internal pressure, Classical absorption coefficient, Viscous relaxation time, Solvation number, Apparent molar volume, Apparent molar compressibility, Free volume and Inter molecular free path length were determined.

***Keywords*:** Acoustical parameters, FT-IR, Physical parameters, Poly(Ethyleneglycol-400 Maleate) resin, Sound velocity, Synthesis, Viscosity

1. INTRODUCTION

Polyesters are heterochain macromolecular substances characterized by the presence of carboxylate ester groups in the repeating units of their main chain. The traditional procedure for preparing linear aliphatic polyesters consists in the thermal polycondensation of diacids with diols or in the self-condensation of hydroxyacids followed by the elimination of water.

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Polyesters have received a great deal of attention since the early work of Carothers[1], who initiated study on many step-growth polymerizations.

Today, polyesters are widely used as both important thermoplastic and thermosetting materials. Polyester resins may be classified into three groups: linear, three dimensional and unsaturated polyesters. For example, Polyethylene adipate, aliphatic chain polyester; Polycarbonate, polyester of carbonic acid and bisphenols; Polyester of dihydroxy diphenyl and terephthalic acid. Unsaturated polyester resins were widely used in applications where advantage may be taken of their good range of mechanical properties, low cost, good corrosion resistance and low weight. Polyester resins were also used for clear casting, coatings, buttons, body fillers, work-surfaces (such as polyester marble), polyester concrete (for applications such as road drainage), cladding panels, sheeting, roofing tiles, pipes and also for application such as bathroom furniture (e.g. baths and shower trays).

In recent years, ultrasonic has become the subject of extensive research in different fields of science namely consumer industries, medical field, engineering, process industries, etc.[1]. It is also found most suitable to investigate various organic compounds (liquids), polymers, etc. Ultrasonic studies in aqueous and non-aqueous electrolytic solutions have led to new insight into ion- solvent interactions and valuable information about the ionic interactions and the nature and the strength of interactions[2].

Ultrasonic velocity offers a rapid non- destructive method for the characterization of materials. Elastic constants of an isotropic material can be determined ultrasonically when both longitudinal and transverse wave velocity are known. Some of the extensively used methods include light diffraction method; sing around method, the pulse echo superposition, the pulse echo overlap and the faster digital techniques using pulse echo method.

Non-destructive testing of ultrasonic involves incorporation of physical principles for determining flaws, dimensional variations, micro structural features and the mechanical properties of worked materials without impairing their usefulness. The non-destructive applications of ultrasonic for determining structural integrity, micro structural features and mechanical properties of worked materials. Ultrasonic non-destructive and evaluation(NDTE) plays a major role in the present day life assessment program of nuclear installation, chemical industries, gas pipe lines, etc. during preserves and in service inspection/conditions. Typical casting defects are non-metallic inclusions, porosity, shrinkage, cavities, cold shut, hot tear (shrink crack) cold or stress crack, blow holes or in homogeneity. All these defects can be tested ultrasonically by proper selection of probes (normal or angle) frequency and attenuation.

In recent years ultrasonic testing and evaluation techniques are widely used for obtaining information about micro structural and mechanical properties of metals[3-7] and wide applications have been found in medical and biological fields. The use of ultrasound for breaking kidney stones is well established in the medical field. The effect of sonic vibrations on the people suffering from other diseases of kidneys is not known. The ultrasonic technique provides a powerful effective and reliable tool to investigate properties of polymer solutions. Among the ultrasonic measurements, the ultrasonic velocity measurements are easy to carry out with less instrumentation and much reliability. Propagation of ultrasonic wave in polymer-polymer solution forms the basis for the qualitative characterization. The studies of ultrasonic wave propagation in solids provide valuable information[8, 9] on the structure of solids, the intra and intermolecular interactions and behavior of polymeric chain in an ultrasonic field[10].

A review of literature[11-14] on acoustical studies on polymer solutions reveals that ultrasonic velocity measurements are used to understand the nature of molecular interactions.

In recent years, an extensive use of polymeric materials in technology has necessitated the study of molecular interactions of polymers with solvents. Knowledge of acoustical properties of any solutions gives information about interactions occurring in the solutions like excess volume; the isentropic compressibility also throws light on the nature and degree of molecular interactions in the binary mixtures.

Recently sound velocity measurements on condensation polymers in protic or aprotic solvents are carried out by Parsania et.al.[15-31] and investigated the influence of solvent, concentration, temperature and the nature of the substituents on the structure of polymers and molecular interactions in the solutions under investigations.

The solvents and PEG-400 maleate resins used in the present study were purified by appropriate methods prior to their use. The densities (ρ), viscosities (η) and sound velocities (U) were measured by means of specific gravity bottle, Ubbelohde suspended level viscometer and multi frequency interferometer operating at 2 MHz. All the measurements were carried out at 308K temperature

2. RESULT AND DISCUSSION

2. 1. Synthesis

Maleic anhydride–PEG-400 co-polyester was synthesized taking the equimolar proportions (0.1 mol) of the monomers together with sulfuric acid (approximately 0.5 ml) as a catalyst in 500 ml round bottom flask which was connected to a Dean & Stark apparatus for eliminating water azeotropically with toluene (25 ml) as the reaction medium. The reaction mixture was heated at 120 ºC until elimination of water subsided about 3.0 hr. The expected structure of the co-polyester would be as shown below. It is yellow colored viscous liquid resin. Reaction scheme is shown in below Figure 1.

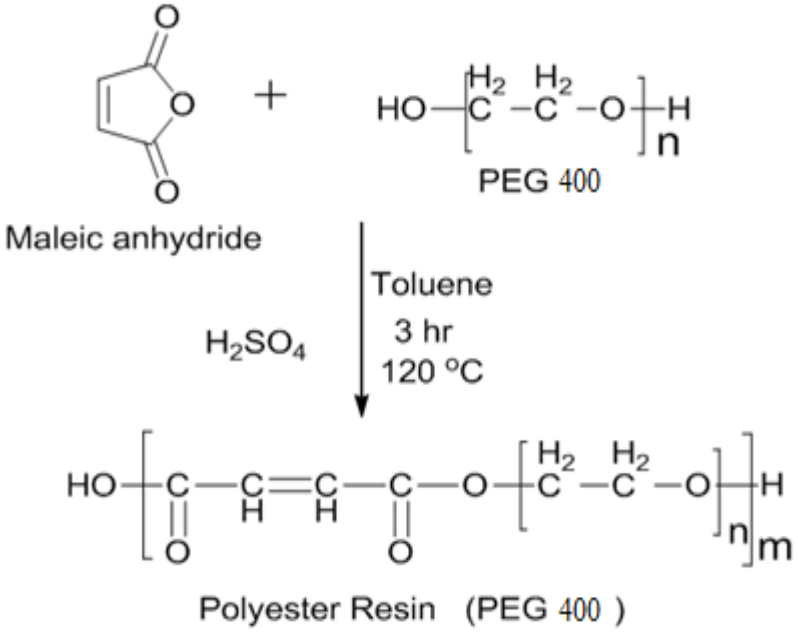

Figure 1. Reaction Scheme for the synthesis of PEG-400 maleate resin

2. 2. FT-IR spectral analysis

Information about the structure of a molecule could frequently be obtained from its absorption spectrum. The atomic and electronic configuration of a molecule is responsible for the position of absorption bands. The most structural information of organic molecules could be obtained from their IR spectra.

The masses of the atoms and forces holding them together are of such magnitudes that usual vibration of the organic molecules interacts with electromagnetic radiation to absorb and radiate in the IR region. During the absorption, it is necessary for the molecule to undergo a change in dipole moment. IR spectroscopy is an excellent method for the quantitative analysis because except for optical isomers, the spectrum of a compound is unique. It is most useful for the identification, purity and gross structure at detail. This technique is often faster than any other analytical methods

The IR spectrum (KBR pellet) of PEG-400 maleate resin was scanned on a Shimadzu-8400 FT-IR Spectrophotometer over the frequency range from 4000-400 cm^{-1}. The IR spectrum of PEG-400 maleate resin is shown in Figure 2. The characteristic IR absorption peaks (cm^{-1}) along with aliphatic and functional groups of PEG-400 maleate resin are reported in Table 1.

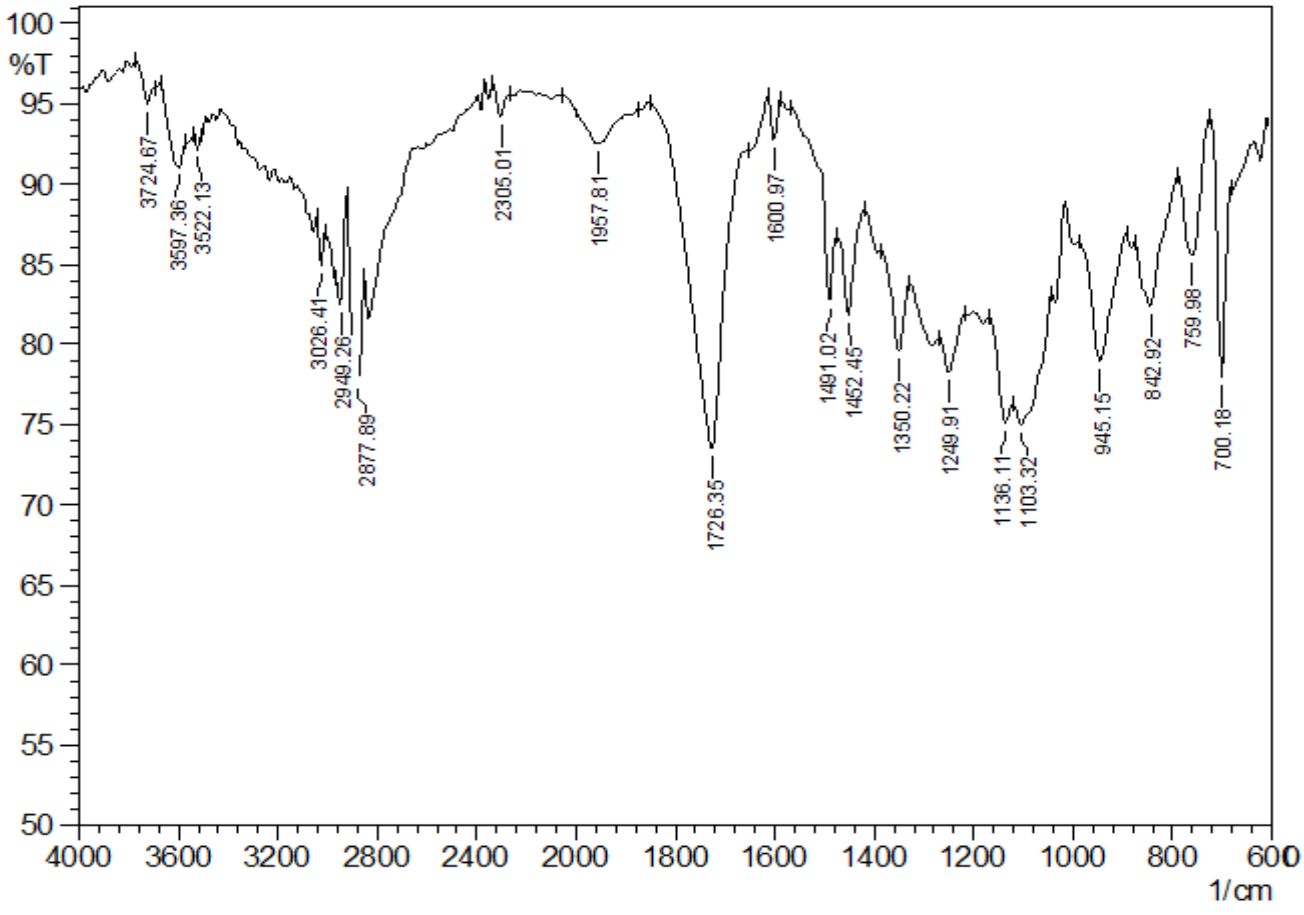

Figure 2. IR spectrum of PEG-400 maleate resin

Table 1. The characteristic IR absorption bands ($cm^{-1)}$ Polyester resin.

Types	Group vibration mode	Observed IR frequencies, (cm^{-1})	Expected frequencies, (cm^{-1})
Alkane -CH_2-	C-H (ν_{as})	2949.26	2975-2940
	C-H (ν_s)	2877.89	2880-2860
	C-H def.	1491.02, 1452.45	1470-1435
	Twisting & Wagging	1249.51	~1250
	Skeletal CH_2	759.98	770-730
-OH	O-H str.	3522.13	3600-3200
	O-H def.	1350.22	1360-1280
	C-O-H def.	1036.11	1120-1030
Ester	C=O str.	1726.35	1780-1710
	C-O str.	1249.91	1300-1250

The Figure 2 reveals that the broad band representing the –OH group in the diol is almost disappeared in the spectrum of polyester. The >C=O stretching frequency at the region 1710 cm^{-1} of the spectrum of the Maleic anhydride shifted to 1716-1730 cm^{-1} region and a new band representing ester linkage appeared at the 1265 cm^{-1} region in the spectrum of the polyester. All these indicate the reaction between –OH and anhydride groups forming ester linkage.

2. 3. Determination of physical and acoustic parameters

2. 3. 1. Intrinsic viscosity

The required amount of polymer was weighed accurately in 25 ml volumetric flasks and an adequate quantity of appropriate solvent was added in it. The flask was kept aside for some time. During this period, the sample swelled and dissolved completely. The solution was diluted up to the mark and filtered through G-3 sintered glass funnel before viscosity measurements.

Viscometer was washed with chromic acid, distilled water, acetone and then dried in an oven at 50 ºC. The viscometer was clamped in a thermostat and a measured quantity of solvent or solution was taken into the viscometer and was allowed to attain the temperature of the bath. The flow time for the liquid between the two marks of the viscometer bulb was measured accurately at least three times by means of a racer stop watch. The solution inside the viscometer was diluted by adding known quantity (2 ml) of solvent. The solution was thoroughly mixed by blowing a slow stream of air through it. The viscometer capillary bulb was rinsed with dilute solution by sucking the solution and allowed it to drain in the viscometer reservoir. Flow times for this liquid were measured accurately. The same procedure was followed for the successive

dilutions. From the knowledge of solution flow time (t) and solvent flow time (t_o) at a given temperature for a given solvent, the relative viscosity (η_r) and specific viscosity (η_{sp}) were determined according to eqns. 2.1 and 2.2, respectively:

$$\eta_r = t/t_0$$

$$\eta_{sp} = (\eta - \eta_0)/\eta_0 = \eta_r - 1 = (t - t_o)/t_o$$

The intrinsic viscosity [η], can be determined from the joint application of reduced viscosity (η_{sp}/C) and inherent viscosity ($\ln\eta_r/C$) data according to Huggin's[5] and Kraemer's relationships[6]

$$\eta_{sp}/C = [\eta] + k'[\eta]^2 C \qquad \text{Huggin's Eqn.}$$

$$\ln \eta_r/C = [\eta] - k''[\eta]^2 C \qquad \text{Kraemer's Eqn.}$$

Generally k' + k" = 0.5 for most polymer

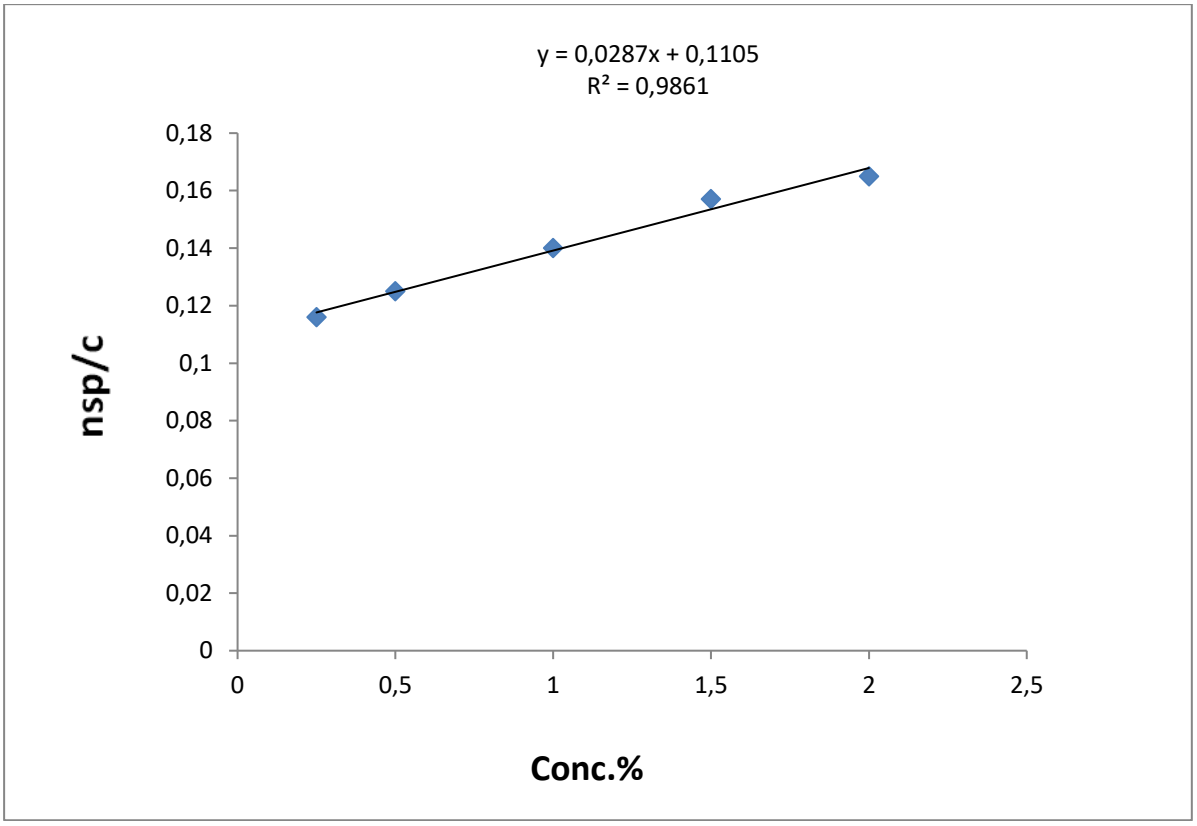

Figure 3. Plot of ηsp/C vs. Conc. % of PEG-400 Maleate Resin in Water at 308 K

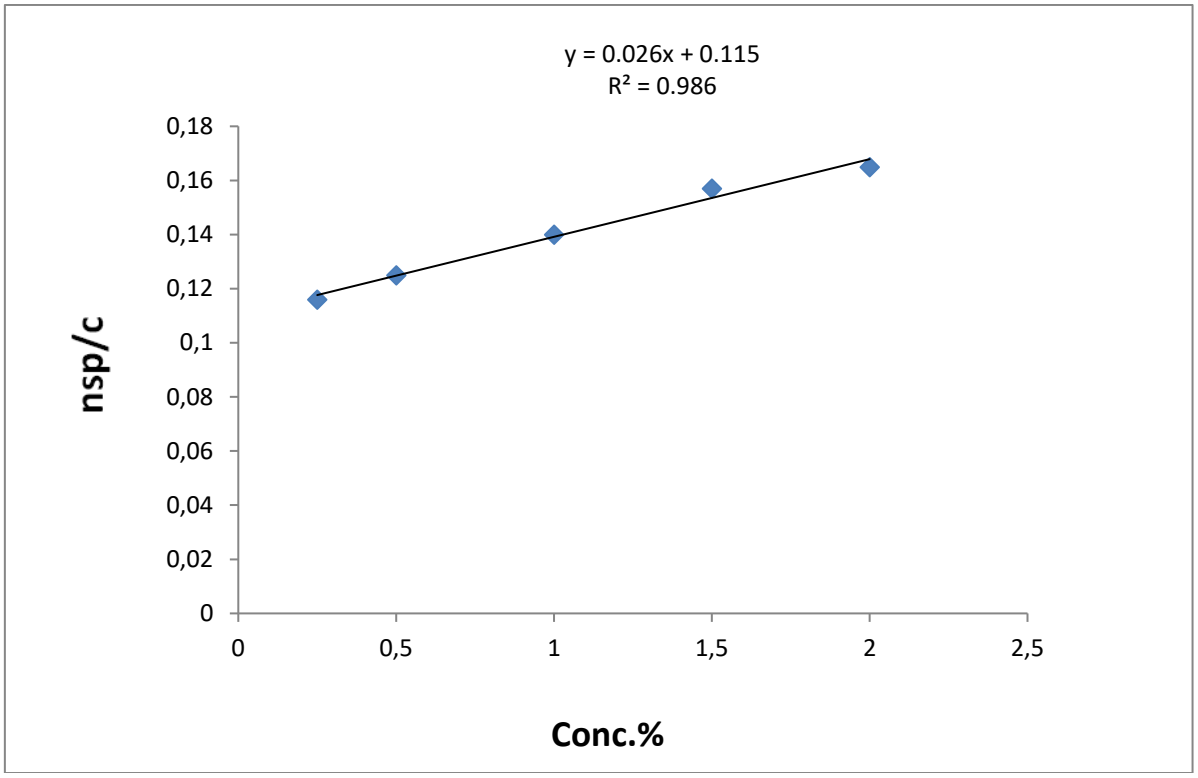

Figure 4. Plot of ηsp/C vs. Conc. % of PEG-400 Maleate Resin in Methanol at 308 K

The characterization of molecular interactions in solutions by viscosity is an important tool. It is a direct measure of hydrodynamic volume of molecules. The plot of η_{sp}/C against concentration of resin in water solvent at 308 K is presented in Figure 3. The plot of η_{sp}/C against concentration of resin in methanol solvent at 308 K is presented in Figure 4. The intrinsic viscosity [η] and Huggin's constant k' were determined from intercept and slope, respectively. The observed value of [η] and k' are 0.08 dl/g and 3.2, respectively

The viscosity of a polymeric solution depends on its molecular weight, temperature, and concentration, nature of solvent and on its thermodynamic affinity for a polymer. The viscosity of dilute solutions is greatly affected by the molecular weight and molecular shape of the dissolved polymer.

Intrinsic viscosity [η] and the slope of η_{sp}/C vs C line depend on the nature of a solvent and this is due to the fact that the polymer coil swells differently in different solvents and therefore has different sizes. For flexible polymers, high values of k' are the characteristics of the poor solvents and this is not observed in polymers with rigid chains and strong specific interactions. High value of k' indicates poor nature of a solvent.

2. 3. 2. Acid value

Acid value is a measure of the free fatty acids content of oil and is expressed as the number of milligrams of potassium hydroxide required to neutralize the free acid in 1 gram of the sample. Acid value quantifies the reaction, which is in the beginning of the reaction, the acid

value is high but as the reaction progresses acid is consumed to form ester and at the end of the reaction the acid value is low which signifies the completion of the ester reaction.

Acid values of polyester Resin were determined according to standard reported method[15]. Polyester Resin was exactly weighed (1- 2 g) in a small capsule and placed carefully in a 250 ml RBF and to it 25 ml of acetone was added. The flask was swirled for some time and heated gently for some time to dissolve sample completely. The solution was cooled and titrated with standard 0.1 N methanolic KOH by using phenolphthalein as an indicator. The procedure was repeated for blank titration under similar condition. The acid value of a given sample was determined according to following relationship.

$$\text{Acid Value} = \frac{56.1 \times N \times (A - B)}{W}$$

where: N = Normality of KOH, A = Sample burette reading, B = Blank burette reading and W = Weight of sample in grams. Observed Acid value of PEG-400 Maleate Resin is 94.0 mg KOH/g of resin

2. 3. 3. Density

The densities of pure solvents and solutions were measured by means of specific gravity bottle at 308K temperature by determining the weights of distilled water, solvents and solutions. The density (ρ) was calculated according to following equation with an accuracy of ± 0.0001 g/cm^3

$$\rho \text{ (g / cc)} = \frac{Wt.of solvent/solution}{Wt.of water}$$

2. 3. 4. Viscosity

The method for determining the dynamic viscosity or coefficient of viscosity of liquids relies on Stoke's law. The viscometer was washed with chromic acid, distilled water, acetone and then dried at 50 ºC in an oven.

Viscometer was suspended in a thermostat at 35 ± 0.1ºC and measured quantity of the distilled water/solvent/solution was placed into the viscometer reservoir by means of a pipette and thermally equilibrated for about 10 min. The efflux time of liquid between two marks was measured by means of digital stopwatch with an accuracy of ± 0.01 sec. Three replicate measurements on each liquid were made and the arithmetic mean was considered for the purpose of calculations.

Using the flow times (t) and known viscosity of standard (water) sample, the viscosities of solvents and solutions were determined according to following equation.

$$\frac{\eta_1}{\eta_2} = \frac{t_1 \rho_1}{t_2 \rho_2}$$

where: η_1, ρ_1, t_1 and η_2, ρ_2, t_2 are the viscosities, densities and flow times of standard and unknown samples, respectively.

2. 3. 5. Sound velocity

Ultrasonic interferometer (F-81) was used in the present investigation. The working of interferometer was tested by measuring the sound velocity of pure solvents: Water, Methanol and 1,4-Dioxane and comparing the results with literature data. The advantage of this instrument is that the quantity of sample needed for measurement is small (15-20 ml). The measuring cell (2 MHz) with quartz crystal was filled with the solvent/ solution and then micrometer was fixed. The circulation of water from the thermostat (at 35 ºC) was started and the experimental liquid in the cell is allowed to thermally equilibrate. The high frequency generator was switched on and the micrometer was rotated very slowly so as to obtain a maximum or minimum of the anode current. A number of maximum readings of anode current (n) were counted. The total distance (d) traveled by the micrometer for n = 20 were read.

The sound velocity (U) of solvents and solutions were calculated from the wave length (λ) and frequency (F) according to following equation.

$$U = \lambda * F$$

2. 3. 6. Wave length (λ) was determined according to following equation.

$$\lambda = \frac{2d}{n}$$

2. 3. 7. Isentropic compressibility (κ_s) was evaluated according to Newton and Laplace using following equation.

$$\kappa_s = \frac{1}{U^2 \rho}$$

2. 3. 8. Specific acoustical impedance (Z) was calculated according to following equation.

$$Z = U\rho$$

2. 3. 9. Rao's molar sound function (R) was evaluated by employing a method suggested by Bagchi et. al[33] using following equation.

$$R = \frac{M}{\rho} U^{1/3}$$

2. 3. 10. Apparent molecular weight (M) of the solution was calculated according to following equation.

$$M = M_1W_1 + M_2W_2$$

where: W_1 and W_2 are weight fractions of solvent and resins respectively. M_1 and M_2 are the molecular weights of the solvent and polyester resins, respectively.

2. 3. 11. Van der Waal's constant (b)[34] was calculated according to following equation.

$$b = \frac{M}{\rho}\left[1-\left[\frac{RT}{MU^2}\right]\left[\sqrt{1+\frac{MU^2}{3RT}}-1\right]\right]$$

where: R (8.314 JK^{-1} mol^{-1}) is the gas constant and T (^oK) is the absolute temperature.

2. 3. 12. Internal pressure (π) was evaluated according to Suryanarayana and Kuppuswamy[35] using following equation.

$$\pi = bRT\left(\frac{K\eta}{U}\right)^{1/2}\frac{\rho^{2/3}}{M^{7/6}}$$

where: R = 8.3143 JK^{-1} mol^{-1} is the gas constant and b=2, is the packing factor and K = 4.28 X 10^9 is a constant. The internal pressure (π) depends on temperature**,** density, ultrasonic velocity and specific heat at a constant pressure.

2. 3. 13. Classical absorption coefficient $(\alpha/f^2)_{cl}$ has its origin in the viscosity of the medium and it was proposed by Subrahmanyam et.al[36] using following equation.

$$\left(\alpha/f^2\right)_{cl} = \frac{8\pi^2\eta}{3U^3\rho}$$

2. 3. 14. Viscous relaxation time (τ)

The resistance offered by viscous force in the flow of sound wave appears as a classical absorption associated with it is the viscous relaxation time (τ) which was evaluated according to following equation.

$$\tau = \frac{4\eta}{3\rho U^2}$$

2. 3. 15. Solvation number (S_n) was evaluated according to Passynsky[37] method. The number of grams of solvent connected in the apparent solvation of 1 g of solute assuming that the solvent molecules participating in the solvation are effectively incompressible due to strong localized electronic fields, is expressed as under.

$$n = \left[1-\frac{\kappa_s(100-X)}{\kappa_{s1}X}\right]$$

where: X is the number of grams of solute in 100 g of the solution. The Solvation number (Sn) was expressed as under.

$$Sn = \frac{M_2}{M_1\left(1-\frac{\kappa_s}{\kappa_{s1}}\right)\left(\frac{100-X}{X}\right)}$$

where: M_1 and M_2 are the molecular weights of solvent and PEG-400 maleate resins.

2. 3. 16. Apparent molar volume[38] was calculated according to following equation.

$$\phi_{V2} = \frac{M}{\rho_1}\left[1-\frac{(100)}{C}(\rho-\rho_1)\right]$$

where: M is the molecular weight of PEG-400 maleate resins and ρ_1 and ρ are the densities of solvent and PEG-400 maleate resins, respectively.

2. 3. 17. Apparent molar compressibility[39] was calculated according to following equation.

$$\phi\kappa_s = M_2\kappa_{s1}\left[\frac{100}{C}\left(\frac{\kappa_s}{\kappa_{s1}}-\frac{\rho}{\rho_1}\right)+\frac{1}{\rho_1}\right]$$

where: C is the concentration in dl/g and κ_{s1} and κ_s are the isentropic compressibility of solvent and PEG-400 maleate resins solutions, respectively

2. 3. 18. Free volume[40] was calculated according to following equation.

$$V_f = \left[\frac{MU}{K\eta}\right]^{3/2}$$

2. 3. 19. Inter molecular free path length (L_f) was evaluated according to following equation which was proposed by Jacobson.[53]

$$L_f = K.(\kappa_s)^{1/2}$$

where: $K_s = (93.875 + 0.375T) \times 10^{-8}$ is a constant and temperature dependent.

Table 2. Acoustic parameters of Polyester resin at 308 K in three different solvents

Conc., %	Density ρ, kg/m^3	Viscosity η, mPa·s	Ave. Dist. d, mm	Wave length λ, mm	U, ms^{-1} (F = 2MHz)	Std. devi., mm (±)
In Water at 308K						
0	994.1	0.7225	7.6222	0.76222	1524.44	0.0021
0.5	1000.2	0.7461	7.7016	0.77016	1540.32	0.0084

1.0	1000.8	0.7848	7.7636	0.77636	1552.72	0.0083
1.5	1002.7	0.8534	7.7984	0.77984	1559.68	0.0047
2.0	1004.7	0.9224	7.8718	0.78718	1574.36	0.0066
In Methanol at 308K						
0	777	0.4490	5.27	1.054	2108	0.0048
0.5	1000.4	0.5888	5.3524	1.0705	2140.96	0.0044
1.0	1001	0.6051	5.3756	1.07512	2150.24	0.0033
1.5	1003.1	0.6332	5.4022	1.08044	2160.88	0.0053
2.0	1007.4	0.6627	5.4214	1.08428	2168.56	0.0037
In 1,4,-Dioxane at 308K						
0	12	1.0140	6.531	1.3062	2612.4	0.0023
0.5	1018.9	1.0971	6.5709	1.3142	2628.36	0.0029
1.0	1022.1	1.1353	6.6025	1.3205	2641	0.0023
1.5	1025.6	1.1973	6.6423	1.32846	2656.92	0.0020
2.0	1028.8	1.2477	6.6732	1.33464	2669.28	0.0017

Table 3. The correlation equations and regression coefficients of unsaturated polyester resin solutions in three different solvents.

Parameter	**Correlation equation (regression coefficients), R^2**		
	Water	**Methanol**	**1,4,-Dioxane**
ρ, $kg \cdot m^{-3}$	$\rho = 3.08\ C + 998.2$ $R^2 = 0.954$	$\rho = 4.62C + 997.2$ $R^2 = 0.885$	$\rho = 6.64C + 1015.$ $R^2 = 0.999$
η, mPas	$\eta = 0.119\ C + 0.677$ $R^2 = 0.985$	$\eta = 0.05\ C + 0.56$ $R^2 = 0.984$	$\eta = 0.102\ C + 1.040$ $R^2 = 0.992$
U ms^{-1}	$U = 21.81C + 1529.$ $R^2 = 0.983$	$U = 18.68\ C + 2131.$ $R^2 = 0.996$	$U = 27.73\ C + 2614.$ $R^2 = 0.997$
Z, 10^6 $kg \cdot m^{-2} \cdot s^{-1}$	$Z = 0.026\ C + 1.526$ $R^2 = 0.987$	$Z = 0.028\ C + 2.125$ $R^2 = 0.989$	$Z = 0.046\ C + 2.654$ $R^2 = 0.998$
κ_α, 10^{-10} Pa^{-1}	$\kappa_\alpha = -0.038\ C + 1.439$ $R^2 = 0.998$	$\kappa_\alpha = -0.047\ C + 2.205$ $R^2 = 0.997$	$\kappa_\alpha = -0.128\ C + 4.278$ $R^2 = 0.987$
V_f, 10^{-7} m^3	$V_f = -0.083\ C + 3.704$ $R^2 = 0.828$	$V_f = 0.251\ C + 1.681$ $R^2 = 0.978$	$V_f = 0.744\ C + 3.027$ $R^2 = 0.968$
R, 10^{-4} $m^{10/3} \cdot s^{-1/3} \cdot mol^{-1}$	$R = 0.759\ C + 11.95$ $R^2 = 1$	$R = 0.836\ C + 4.395$ $R^2 = 0.999$	$R = 0.786\ C + 2.079$ $R^2 = 1$

b, 10^{-5} m^3	b = 0.516 C + 8.618 R^2 = 1	b = 0.631 C + 3.367 R^2 = 0.999	b = 0.653 C + 1.779 R^2 = 1
π, 10^8 Pa	π = -0.4 C + 2.195 R^2 = 0.975	π = -1.033 C + 8.455 R^2 = 0.985	π = -0.100 C + 3.568 R^2 = 0.978
L_f, 10^{-11} M	y = -0.033 C + 2.512 R^2 = 0.998	y = -0.033 C + 3.109 R^2 = 0.997	y = -0.066 C + 4.331 R^2 = 0.987

Table 4. ΔG data of PEG-400 Maleate Resin in three different solvents

Conc. %	**ΔG*, KJ mol^{-1} of PEG-400 Resin**		
	Water	**Methanol**	**1,4-Dioxane**
0.5	2.5687	3.8342	4.1581
1.0	2.6137	3.8833	4.2617
1.5	2.6668	3.9447	4.3532
2.0	2.7091	3.9997	4.4662
	Avg. = 2.6395	**Avg.** = 3.9154	**Avg.** = 4.3098
	ΔG =94.282C + 2521.3 R^2 = 0.999	**ΔG =110.75C + 3777.1 R^2 = 0.9978**	**ΔG = 201.97C + 4057.4 R^2 = 0.9985**

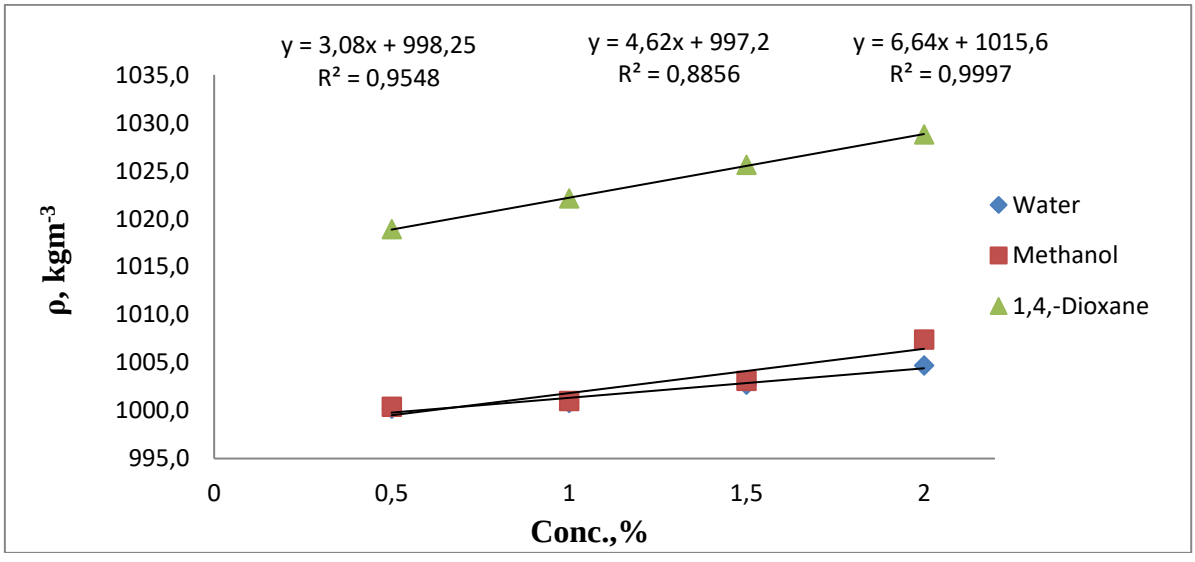

Figure 5. The plots of ρ against C for PEG 400 maleate resin at 35 °C

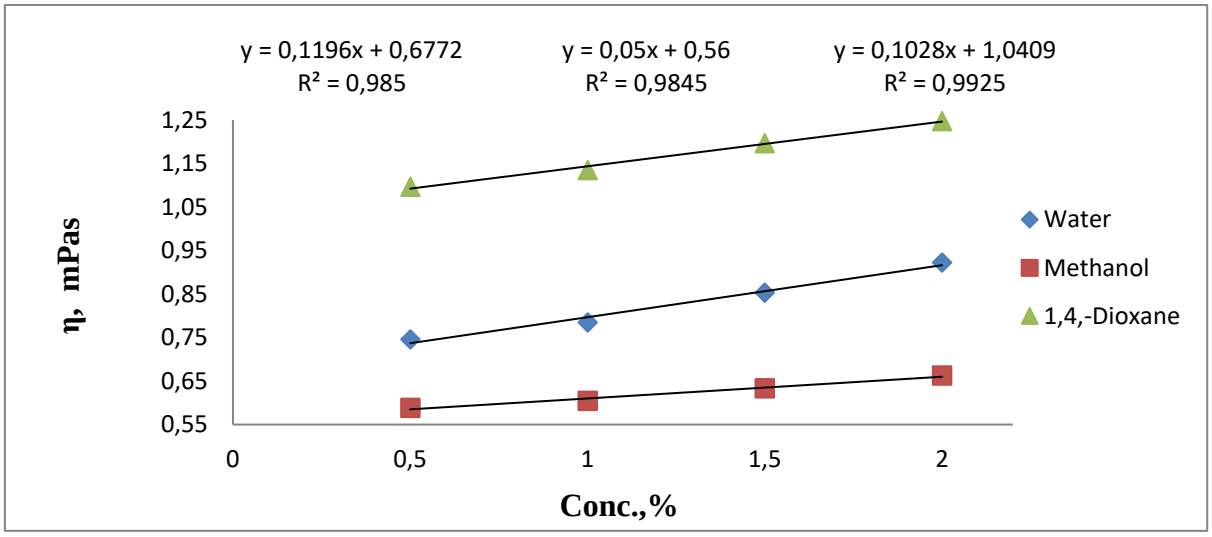

Figure 6. The plots of η against C for PEG 400 maleate resin at 35 °C

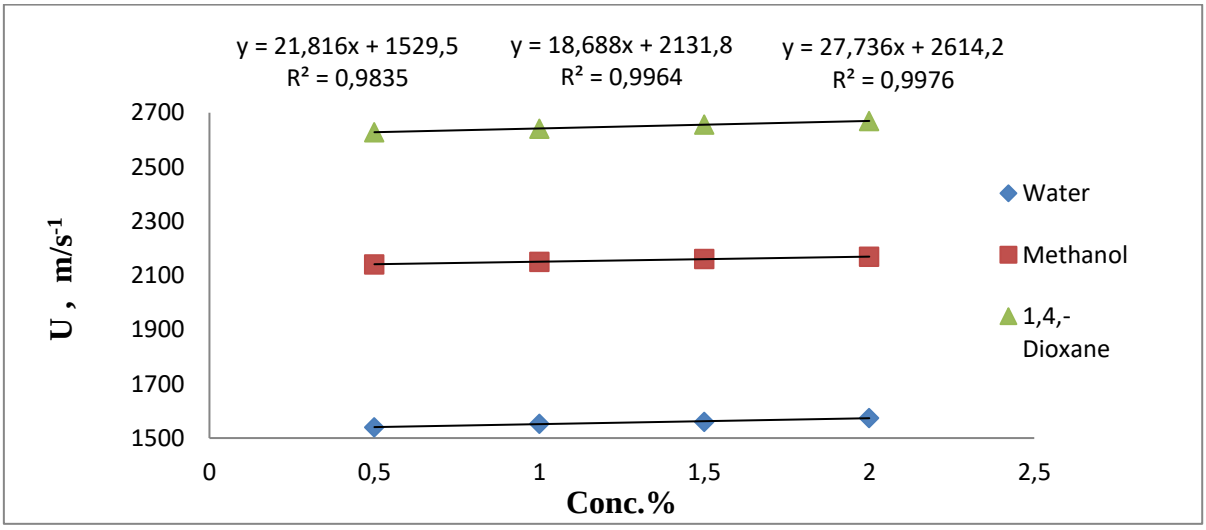

Figure 7. The plots of U against C for PEG 400 maleate resin at 35 °C

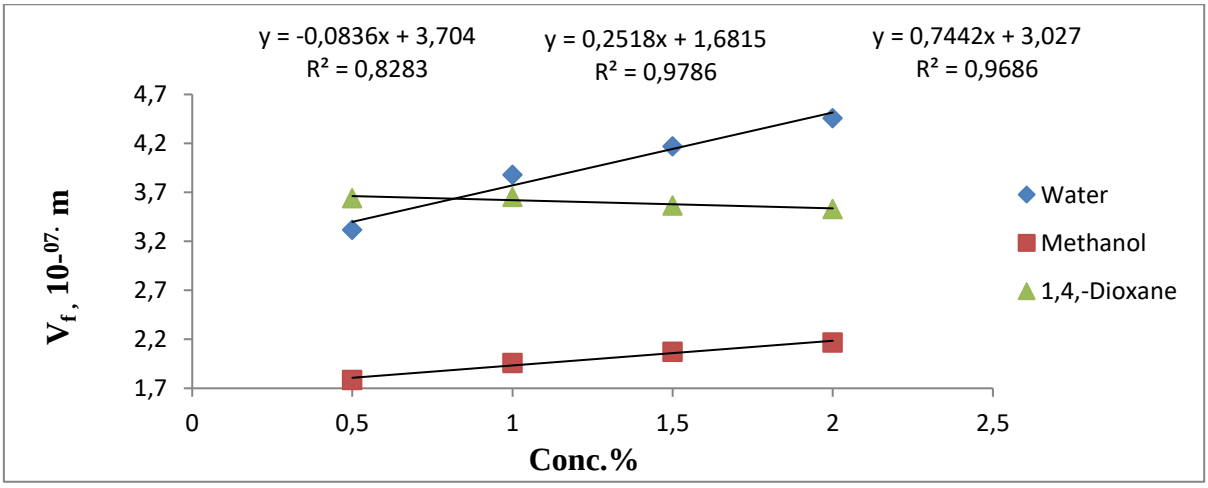

Figure 8. The plots of V_f against C for PEG 400 maleate resin at 35°C

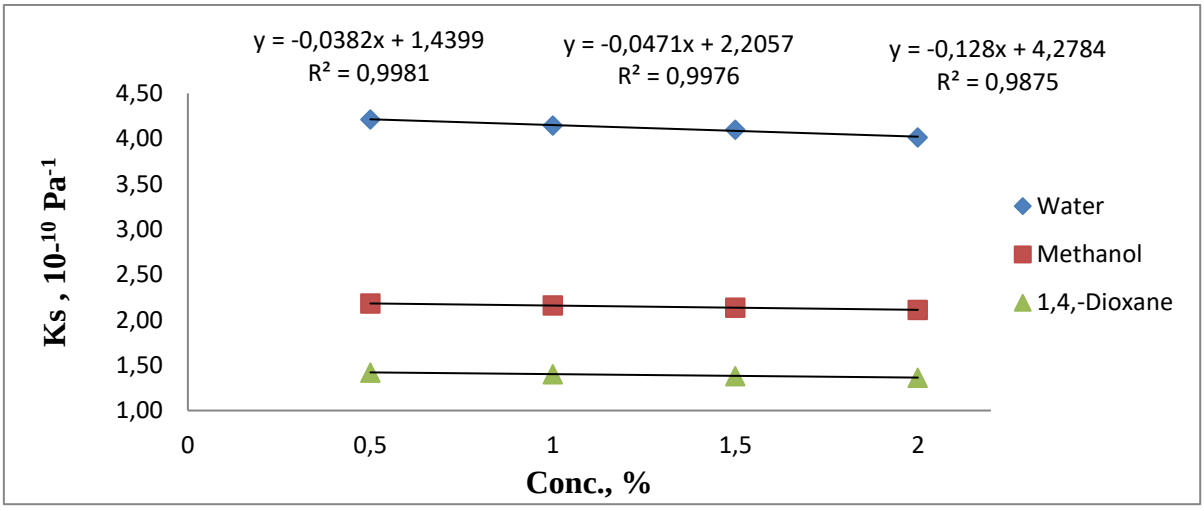

Figure 9. The plots of K_S against C for PEG 400 maleate resin at 35 °C

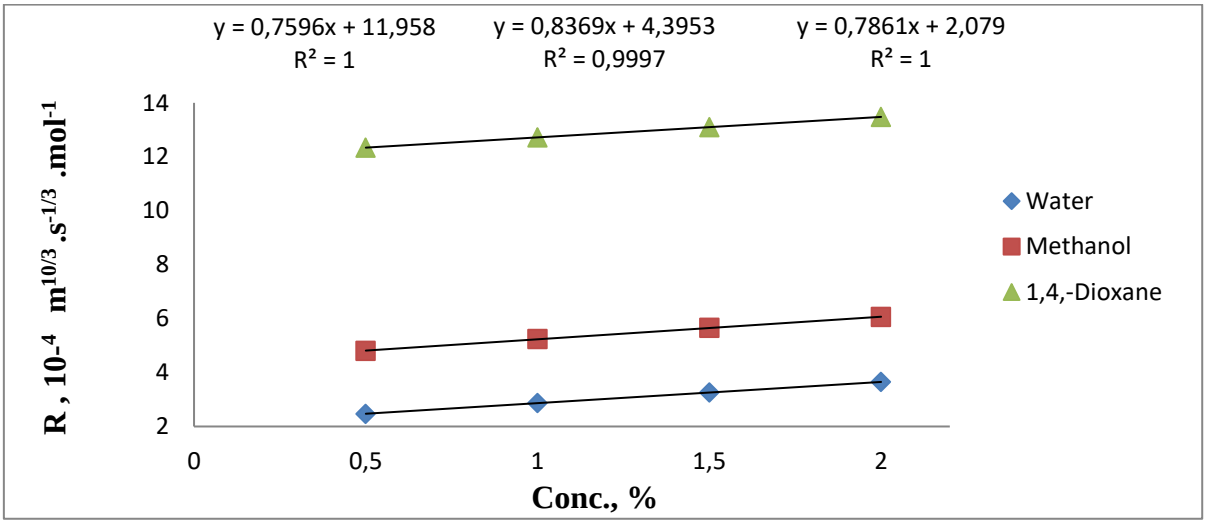

Figure 10. The plots of R against C for PEG 400 maleate resin at 35 °C

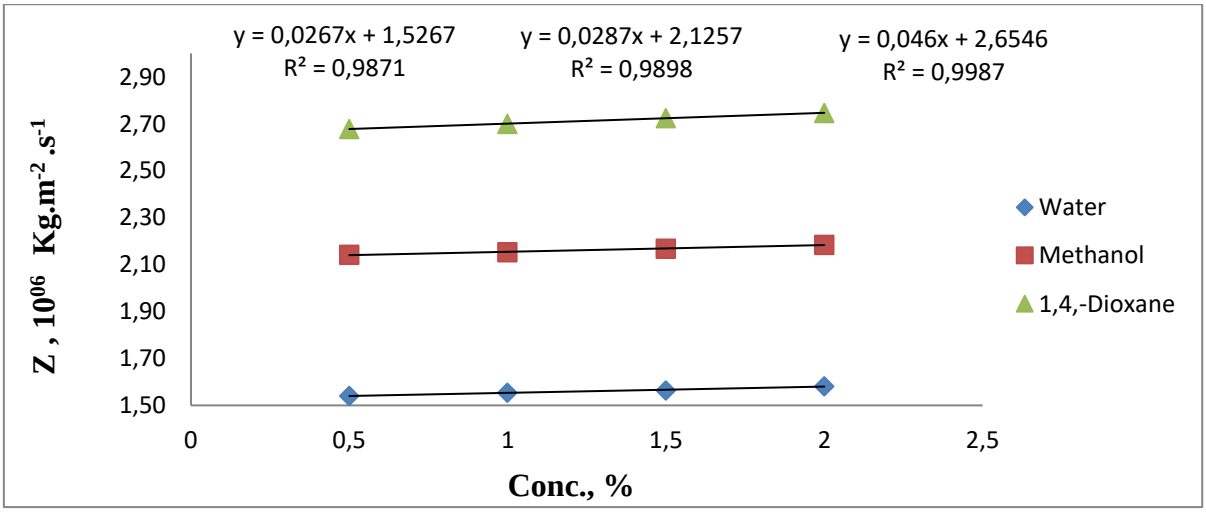

Figure 11. The plots of Z against C for PEG 400 maleate resin at 35 °C

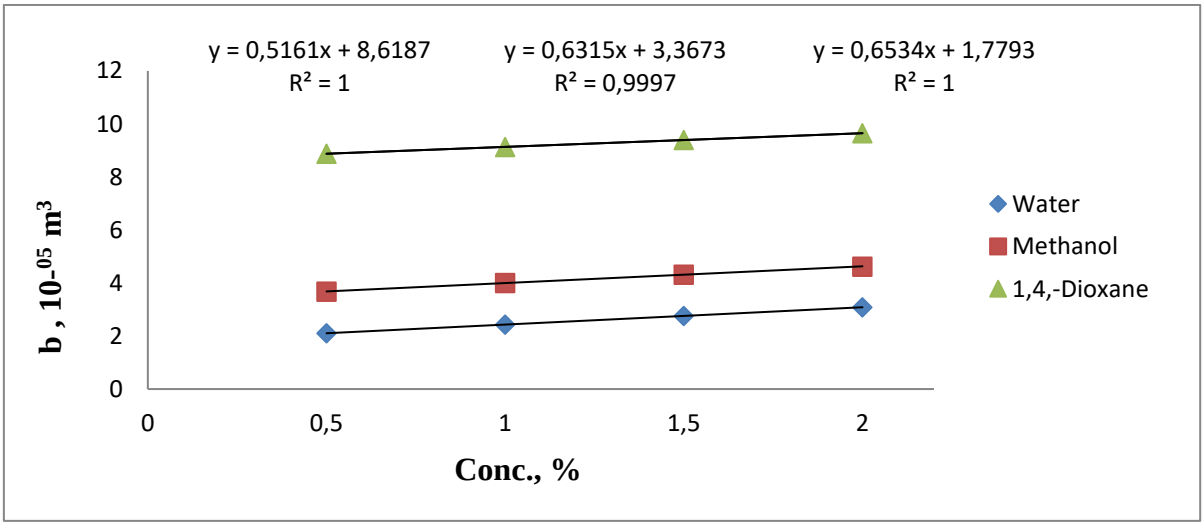

Figure 12. The plots of b against C for PEG 400 maleate resin at 35 °C

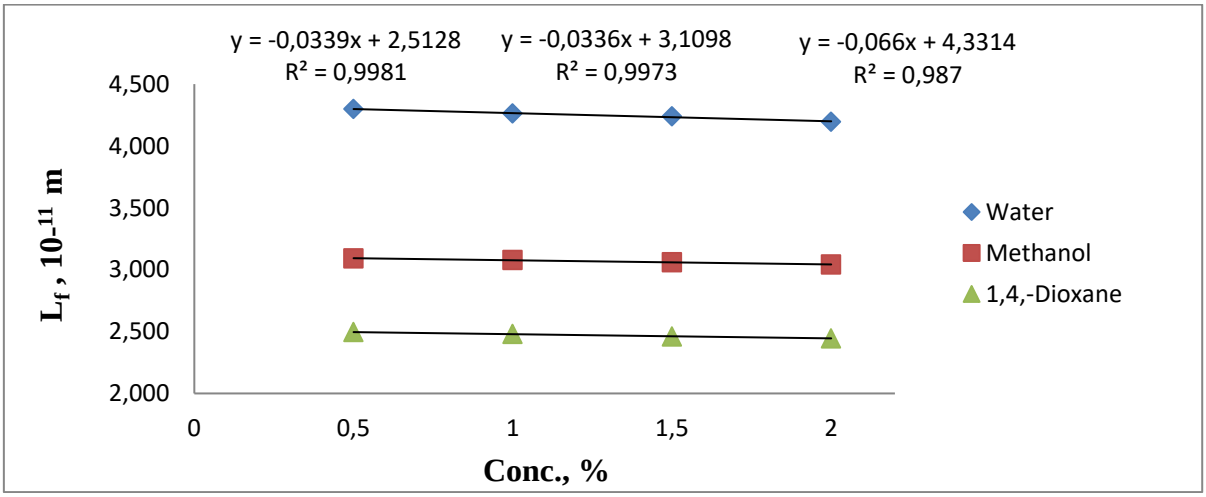

Figure 13. The plots of L_f against C for PEG 400 maleate at 35 °C

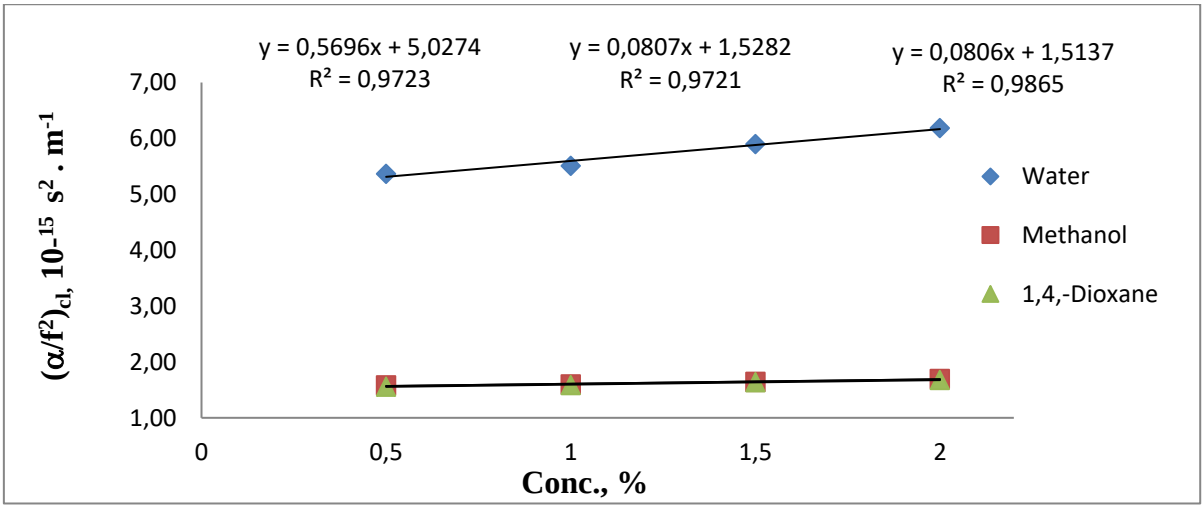

Figure 14. The plots of $(\alpha/f^2)_{cl}$ against C for PEG 400 maleate resin at 35 °C

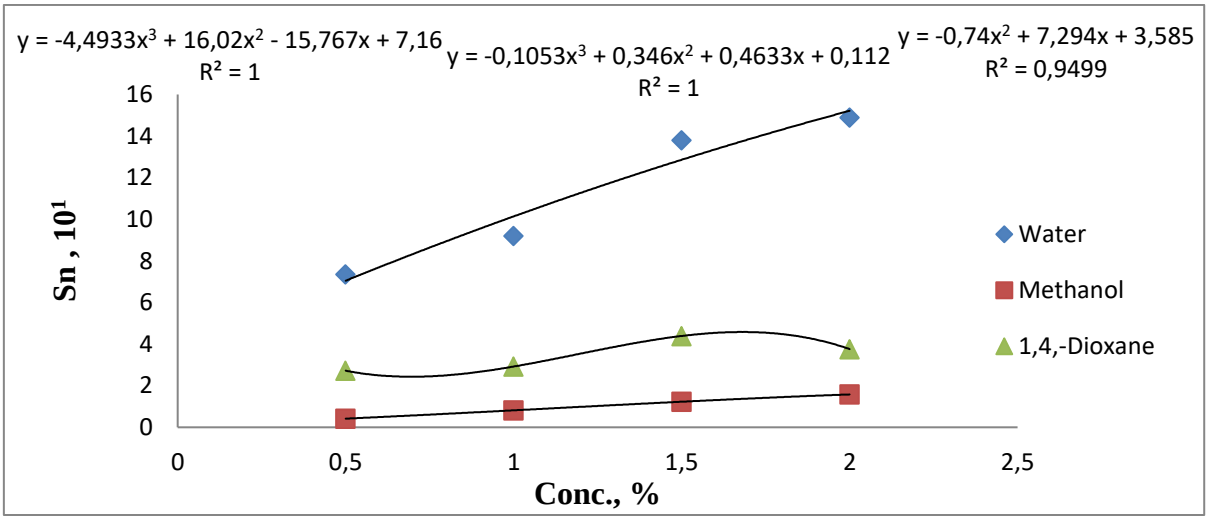

Figure 15. The plots of Sn against C for PEG 400 maleate resin at 35 °C

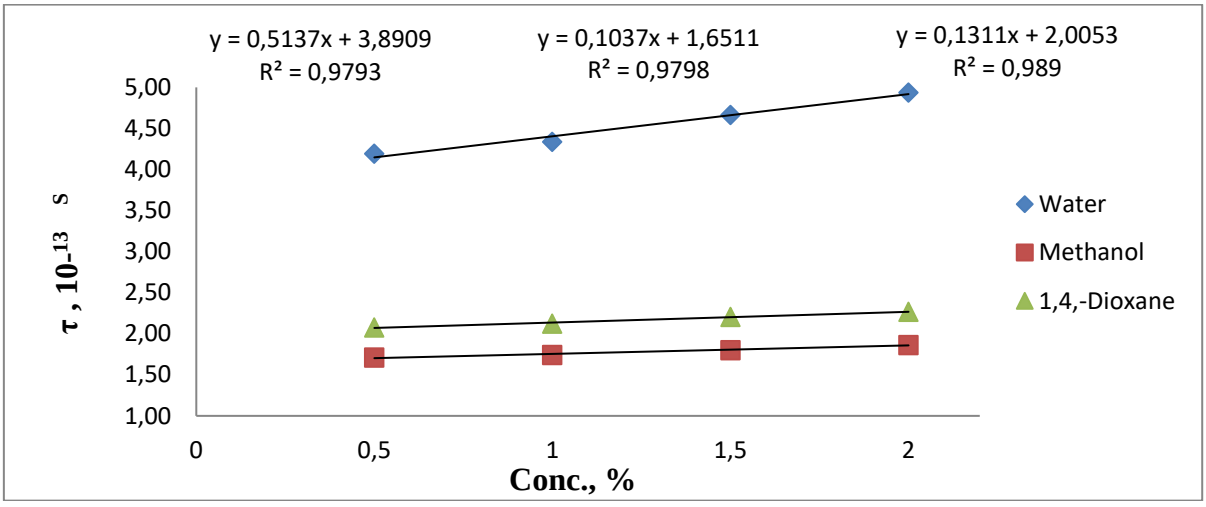

Figure 16. The plots of τ against C for PEG 400 maleate resin at 35 °C

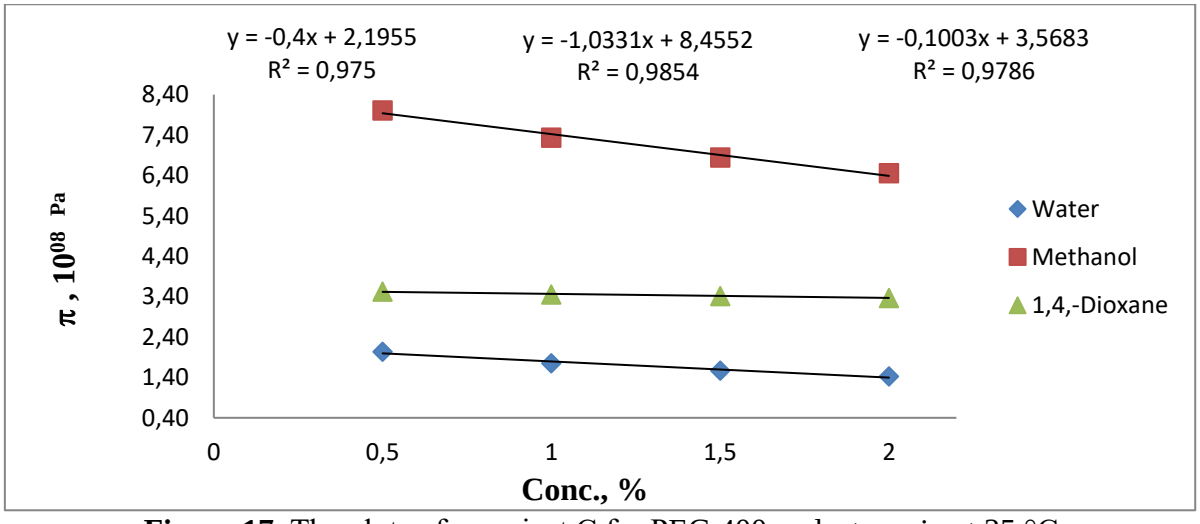

Figure 17. The plots of π against C for PEG 400 maleate resin at 35 °C

3. CONCLUSIONS

Poly(Ethyleneglycol-400 Maleate) Resin was synthesized successfully and was characterized by RT-IR. In order to understand the effect of concentration, temperature, nature of solvents and nature of solute, various acoustical parameters were determined by using the experimental data on ρ, η and U of PEG-400 maleate resins solutions at 308K temperature according to above mentioned standard relations. The concentration and temperature dependence acoustical parameters provide valuable information about strength of molecular interaction occurring in the solutions. Experimental data on ρ, η and U of pure solvents and PEG-400 maleate resins solutions at 35 ºC are reported in Table 3 and are correlated with concentration (C). The least square plots and least square equations along with regression coefficients (R^2) are shown in Figure 5-17 from which it is observed that change in ρ and U with C are not as appreciable as η because molecular motion is much more affected by solute-solvent interactions. Density, sound velocity, viscosity and velocity varied linearly. A good to excellent correlation is observed as judged on the basis of R^2 values. Linear increase of ρ, η and U with C supported the increase of cohesive forces due to powerful molecular interactions present in the solutions.[32]

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