International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 8
August 2017

Compatibility Studies in Polymer Blends (PAA-PEO) In DMSO Through Ultrasonic Measurements at different Temperatures

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ABSTRACT :

*In this present paper the ultrasonic velocity (v), density (ρ) and viscosity (η) have been measured for the Polymer blend solutions of poly Acrylic acid (Average molecular weight 2000)and Poly ethylene oxide (average molecular weight 300000) in DMSO at concentration range of 2.00% and 4% and in temperature range 35 ^{0}C to 45 ^{0}C respectively . With the measured values of ultrasonic velocity, density and viscosity various acoustical parameters like adiabatic compressibility, acoustic impedance, Rao Number have been computed. The variation of adiabatic compressibility (**β**), acoustic impedance (**Z**), relaxation strength (**rs**) and Rao number (R) with concentration and temperature have been studied. Acoustical parameters provide important information in understanding the Polymer Blend behaviour in the - solvent .*

Keywords: Ultrasonic velocity, Adiabatic compressibility, Acoustic impedance, Relaxation strength and Rao number.

1. INTRODUCTION

In recent years the measurement of ultrasonic velocity has been adequately employed in understanding the nature of molecular interaction in pure liquids and liquids mixtures. Ultrasonic propagation parameters yield valuable information regarding the behavior of liquid systems, because intermolecular and intermolecular association, dipolar interactions, complex formation and related structural changes affect the compressibility of the system which in turn produces corresponding variations in the ultrasonic velocity. The acoustical and thermo dynamical parameters obtained in ultrasonic study show that the ion solvation is accompanied by the destruction or enhancement of the solvent structure. Ultrasonic studies provide wealth of information about the state of the any solution (N.Karunanidhi, et. al., 1999)[1]. The propagation of ultrasonic waves in a substance has become a fundamental test to investigate its properties (S.C.Bhatt, et. al., 1999)[2]. The Measurement of ultrasonic velocity and various acoustical parameters derived from it, are of considerable interest in understanding the nature of intermolecular interaction in polymer-solvent mixture (Nagamani.C, .et.al 2013)[3]((Rita Mehra&RekhaIsrani, 2000)[4] It also provides valuable information regarding the nature and strength of molecular interaction, formation of hydrogen bond etc. (V.Lalitha&K.Vijayalakshmi, 2000)[5]. Ultrasonic study of polymer solutions has got the attention of many workers in the past. There are different explanations available to predict the properties of mixtures based on the properties obtained in such study, which are used in turn to derive an insight into the molecular interaction present in such system (Nagamani, et. al., 2014)[6].

2. METHODOLOGY

The ultrasonic interferometer is a simple and direct device to determine the ultrasonic velocity in liquids. The principle used in the measurement of ultrasonic velocity is based on the determination of wavelength in the liquid mixture. The ultrasonic waves of known frequency are produced by a quartz crystal fixed at the bottom of the measuring cell. The measuring cell is connected to the output terminal of the high frequency generator

through the spherical cable. A movable metallic plate kept parallel to the quartz crystal reflects these waves. If the separation between these two plates is exactly a whole multiple of the sound wavelength, standing waves are formed in the medium. This acoustic resonance gives rise to an electrical reaction on the generator, driving the quartz crystal and anode current of the generator becomes a maximum.

The high frequency generator is designed to excite the quartz crystal fixed at the bottom of the measuring cell at its resonant frequency to generate ultrasonic waves in the experimental liquid filled in the measuring cell. The least count of micrometer used for measuring the wavelength is 0.001 mm. The ultrasonic velocity is obtained if the wavelength is known.

3. EXPERIMENTAL STUDY

In the present investigation solutions were prepared by adding the known weight of poly Acrylic acid (Average molecular weight 2000)and Poly ethylene oxide (average molecular weight 300000) in DMSO at concentration range of 2.00% and 4%(m/v) and in temperature range 35 ^{0}C to 45 ^{0}C respectively. Ultrasonic velocity is measured by using variable path ultrasonic interferometer at 1MHz frequency .An electronically controlled thermostatic water bath having an accuracy of ± 0.1 ^{0}C was used to maintain constant temperature. Viscosity and density measurements were also carried out for the solutions using Ostwald viscometer and specific gravity bottle of 10ml respectively for the above said range of temperatures. Single pan macro balance with an accuracy of 0.001gm has been employed for mass measurement. Various acoustical parameters like ultrasonic velocity, adiabatic compressibility, acoustic impedance, relaxation time, and ultrasonic attenuation were calculated for polymer blend solutions of PAA-PEO at different temperature, i.e., 30,35, 40 and 45°c respectively.

4.CALCULATION OF ACOUSTICAL PARAMETERS

The ultrasonic velocity measurement is extensively used to study the physico-chemical behaviour of liquids. With the help of measurements of density and viscosity the following parameters like ultrasonic velocity, adiabatic compressibility, acoustic impedance, relaxation time and Rao number are calculated by using the following expressions (S.C.Bhatt, et. al., 2005 a, b, c)

(i) *Ultrasonic velocity*

(ii) *Acoustic impedance*

(iii) *Relaxation strength*

(iV) Rao Number

$V = \lambda f$

$Z = \rho v$,

$r_s = (1 - V^2 / V_x)$

R = (M/p)v1/3

Where; ρ = density of the solution, v = ultrasonic velocity in the solution, η = viscosity of the solution, λ = wavelength of the ultrasonic wave, measured by micrometer, f = frequency of ultrasonic wave,

M=molecular weight

5. RESULT AND DISCUSSION

The present study, we have measured the density (a), viscosity (η) and the ultrasonic velocity (v) of the polyvinyl acetate solution, at different concentration and In the temperature, at 1MHz frequency which are shown in table-1&2 and the variation with temperature and concentration are shown in fig.1 By using these values for Polymer blend solution of PAA-PEO in DMSO, acoustic impedance, relaxation strength and Rao number have been calculated by using above equations and the results indicates that the interactions of blend

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IJETSR
www.ijetsr.com
ISSN 2394 – 3386
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are incomplete and incompatible. The polymer –polymer interactions are due to the presence of polar groups like acidic and oxide groups in the constituent polymers, the non-linearity behavior of blend at all temperatures clearly indicates that aggregation and conformational changes of macromolecules. The similar behavior was reported by A.Beamiish[7]and D.J.Hourston[8] for polymer blends in aprotic solvents..

It is evident from table-1&2and fig 1, that the ultrasonic viscosity varies non-linearly with increase in temperature. It blends which shows non-linearity or S –shaped curves indicate immiscibility of the blend in solvent which is further confirmed by the similar nature of blend with other derived parameters like. The variation of adiabatic compressibility (β), acoustic impedance (Z), relaxation strength (rs) and Rao number (R) with concentration and temperature have been studied**.**

TABLE-1

Ultrasonic velocities data for 2% blend of PAA-PEO in DMSO at different temperatures

% of PAA in PAA - PEO	Density ρ (g / cm^3)	Ultrasonic velocity v x 10^{-2} (cm / s)	Adiabatic compressibility β_{ad} x 10^{11} (cm^2 / dyne)	Acoustic impedance z x 10^4 (g / cm^2 s)	Molar compressibility β {(cm^3 / mol) (cm^2/dyne)$^{1/7}$}	Relaxation strength r_s	Rao number R {(cm$^{10/3}$ / s$^{1/3}$ mol)}
				30° C			
0	1.0949	1493.46	4.095	16.353	2215.04	0.1287	3856.06
20	1.0948	1492.26	4.102	16.337	2214.66	0.1301	3855.32
40	1.0955	1500.40	4.055	16.437	2216.80	0.1206	3859.71
50	1.0954	1504.66	4.032	16.481	2218.46	0.1156	3863.19
60	1.0961	1498.13	4.065	16.421	2214.00	0.1233	3854.23
80	1.0969	1497.46	4.066	16.425	2212.31	0.1241	3850.82
100	1.0981	1499.86	4.048	16.469	2211.16	0.1213	3848.52
				35° C			
0	1.0900	1483.46	4.1687	16.171	2219.52	0.1404	3865.12
20	1.0898	1483.06	4.1717	16.163	2219.48	0.1541	3865.09
40	1.0903	1493.06	4.1141	16.279	2216.58	0.1292	3861.02
50	1.0910	1494.66	4.1028	16.307	2221.86	0.1273	3870.05
60	1.0919	1491.46	4.1170	16.286	2218.56	0.1611	3863.50
80	1.0917	1491.73	4.1163	16.285	2214.95	0.1642	3855.29
100	1.0935	1492.88	4.1034	16.324	2216.26	0.1294	3858.86

TABLE : 2

% of PAA in PAA - PEO	Density ρ (g / cm^3)	Ultrasonic velocity v x 10^{-2} (cm / s)	Adiabatic compressibility β_{ad} x 10^{11} (cm^2 / dyne)	Acoustic impedance z x 10^4 (g / cm^2 s)	Molar compressibility β {(cm^3 / mol) (cm^2/dyne)$^{1/7}$}	Relaxation strength r_s	Rao number R {(cm$^{10/3}$ / s$^{1/3}$ mol)}
				40° C			
0	1.0845	1472.80	4.251	15.972	2224.69	0.1527	3875.60
20	1.0837	1466.00	4.294	15.887	2223.07	0.1605	3872.35
40	1.0851	1473.26	4.191	16.091	2227.33	0.1409	3882.01
50	1.0859	1479.60	4.258	15.969	2220.72	0.1552	3867.72
60	1.0864	1474.60	4.289	15.916	2216.83	0.1617	3859.92
80	1.0857	1468.33	4.308	15.875	2216.79	0.1649	3859.87
100	1.0880	1471.86	4.243	16.013	2216.99	0.1538	3860.31
				45° C			
0	1.0794	1449.46	4.410	15.645	2223.58	0.1793	3873.32
20	1.0789	1448.80	4.416	15.631	2224.12	0.1806	3874.44
40	1.0793	1453.86	4.383	15.692	2225.41	0.1743	3877.11
50	1.0820	1460.93	4.330	15.807	2223.48	0.1663	3873.29
60	1.0809	1460.26	4.339	15.784	2224.73	0.1670	3875.93
80	1.0810	1455.06	4.370	15.729	2222.37	0.1730	3871.13
100	1.0831	1458.26	4.342	15.795	2219.66	0.1693	3865.70

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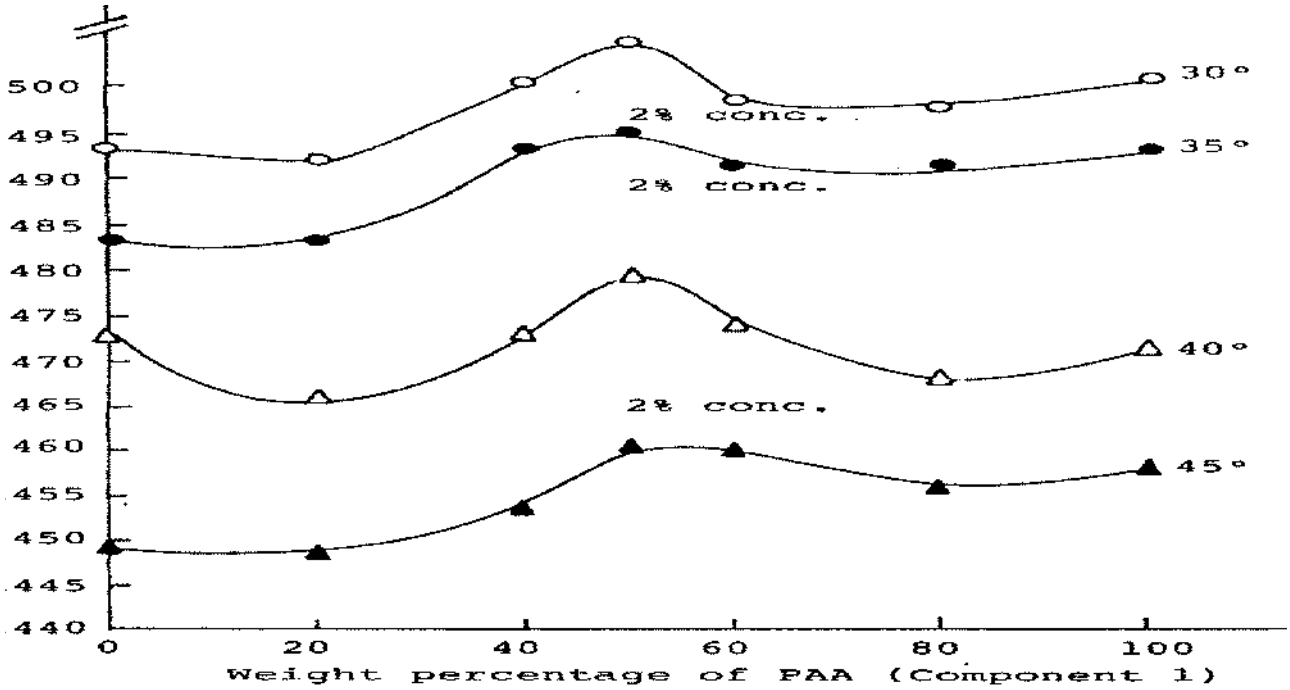

Figure : 1

6.CONCLUSIONS

The studies of Ultrasonic velocity ,acousticimpedence, Relaxation strength and Rao number varied non-linearly with increase in temperature and increasing concentration of polymer blend of PAA-PEO in DMSO.. Indicates the immisciblenature of polymer blend in DMSO solvent .DMSO being aprotiic solvent and does not plays a greater role in bringing out molecular interactions to the maximum extent. Hence the blend behavior remained as incompatible.

The variation in the acoustical parameters with temperature and concentration for poly Acrylic Acid and Poly ethylene oxide in DMSO suggest that there are weak polymer-solvent interactions at higher temperatures and concentrations**.**

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