Molecular Interaction Studies in Terpolymer Resin Through Ultrasonic Measurements at 310.15K

Chemical Science

KEYWORDS : Terpolymer, ultrasonic interferometer, ultrasonic velocity, acoustic impedance.

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ABSTRACT

The terpolymer resin has been synthesized by using the microwave assisted synthesis. The ASF terpolymer resins have been prepared from anthranilic acid (A), salicylic acid (S) and formaldehyde (F) in DMF media. Density (d), ultrasonic velocity (Us) and viscosity (ηs) of terpolymer resin have been measured in DMSO at different concentrations. The experimental data have been used to calculate the acoustical parameters namely acoustic impedance (z), adiabatic compressibility (βs), intermolecular free length (Lf).

INTRODUCTION

Ultrasonic studies in polymer solutions have been the subject of research in recent years [1-8]. Recently many workers have carried out work on polymer solution using ultrasonic technique. An acoustical study provides a useful technique to understanding the physico-chemical properties of the interacting components in polymer solution. Ultrasonic technique is extensively used in biology, biochemistry, dentistry, consumer, medical, engineering process industries, polymers, geography etc. uses of polymers in technology have promoted ultrasonic studies to understand structures of polymers and furnish knowledge on solvophobic or solvophilic nature of polymers. In the present investigation, free intermolecular length, acoustic impedance, adiabatic compressibility, relaxation time of terpolymer resin derived from anthranilic acid (A), salicylic acid (S) and formaldehyde (F) in DMF media has been evaluated in DMSO at different concentration using experimentally determined values of ultrasonic velocity, viscosity and density.

MATERIALS & METHODS

The chemicals used in the present work were of analytical reagent (AR) with minimum assay of 99.9% were obtained from Anthranilic acid (Loba, Mumbai), Formaldehyde (37%) (S.D. Fine Chemicals, Mumbai), Salicylic acid (Thomas Baker, Mumbai) was used as received. The solvents and monomers were purified by the conventional methods. The densities of the terpolymer resin were measured at different concentrations. The viscosities of the terpolymer resin were measured by using the Ostwald viscometers. The viscometer was suspended in an experimental bath having a glass window to observe the meniscus of the liquid.

To determine the flow time the viscometer was cleaned thoroughly with doubly distilled DMSO, dried and then filled with a fixed amount of DMSO and mounted inside the thermostat vertically. The liquid was then allowed to flow down through the capillary. The stop watch was started as soon the liquid meniscus touched the upper fiducially mark, the stop-watch having an uncertainty of + 0.1s. To measure the flow for given solution, the viscometer was rinsed with given solution and same amount of the solution was introduced in the viscometer and time of flow was measured between same two marks on the capillary. On average, three readings were taken. Ultrasonic velocity measurements were made by variable path single crystal interferometer (Mittal Enterprises, Model F–81) at 2MHz with the accuracy of +0.03 %. Ultrasonic and thermodynamic parameters have been measured at 310.15 K.

THEORY

The ultrasonic velocity (Us), density (d) and viscosity (ηs) in terpolymer resin of various concentrations have been measured at 310.15 K. Acoustical parameters such as adiabatic compressibility (βs), free length (Lf), acoustic impedance (Z), relaxation time (τ), were determined using the observed values of velocity, density & viscosity using the standard relations given below.

Adiabatic compressibility (βs) has been calculated from the ultrasonic velocity (Us) and the density (d) of the medium using the equation as:

$$\beta s = 1 / 2\ Usd$$

Intermolecular free length (Lf) has been determined as:

$$Lf = K \times \sqrt{\beta s}$$

Where K – is a Jacobson's constant.

Relaxation time (τ) has been calculated from the adiabatic compressibility (βa) and viscosity of the liquid (η) as:

$$\tau = 4/3\ \beta s\ \eta$$

Acoustic impedance (Zs) The specific acoustic impedance is related to density and ultrasonic velocity by the relation.

$$Zs = Us \times d$$

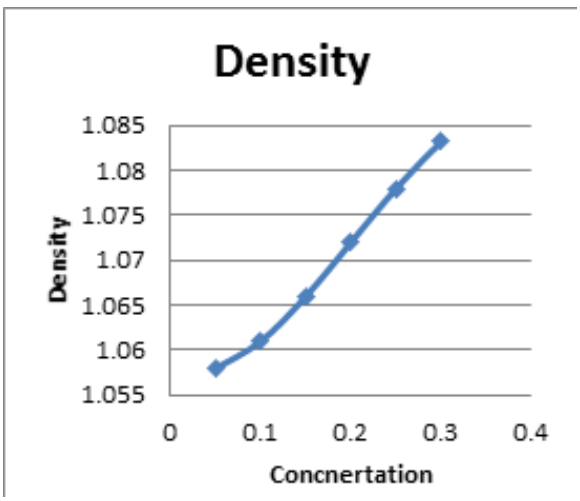
RESULTS & DISCUSSION

Table 1: Values of Density(d), Velocity (Us), Viscosity (ηs), Adiabatic Compressibility (βs), Specific Acoustic Impedance (Zs), Intermolecular Free Length (Lf), Relaxation time (τ): at 310.15 K in DMSO.

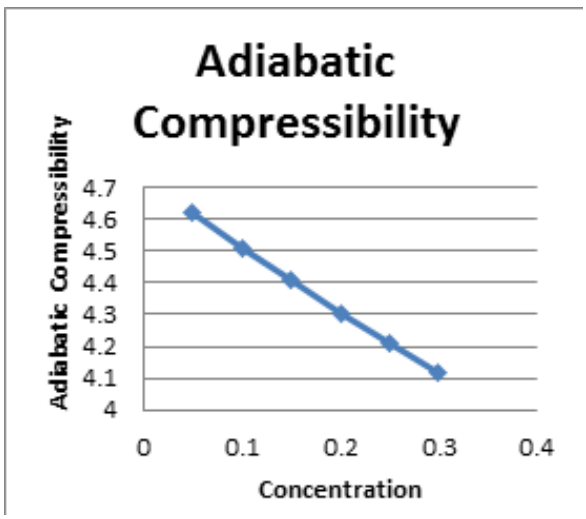
r.No	Conc	D (Kgm^{-3})	Us (ms^{-1})	ηs cp	βs ($X10^{-5}m^2N^{-1}$)	Zs ($kgm^{-2}s^{-1}$)	Lf (A^0)	τ (10^{-5})
1	0.3	1.0832	1497.78	1.5271	4.1152	1622.3952	134.491	8.3791
2	0.25	1.078	1484.38	1.4917	4.2101	1600.1616	136.038	8.3736

Volume : 5 | Issue : 7 | July 2016 • ISSN No 2277 - 8179 | IF : 3.508 | IC Value : 69.48

3	0.2	1.072	1472.52	1.4552	4.3021	1582.9591	137.511	8.3472
4	0.15	1.066	1459.24	1.4097	4.4054	1555.5498	139.152	8.2804
5	0.1	1.061	1445.61	1.3845	4.5101	1533.7922	140.795	8.3256
6	0.05	1.058	1430.82	1.3528	4.6168	1513.8075	142.451	8.3275



(Figure-1)



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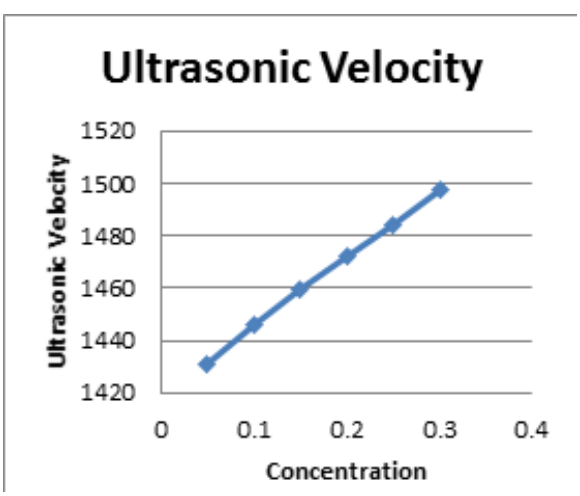

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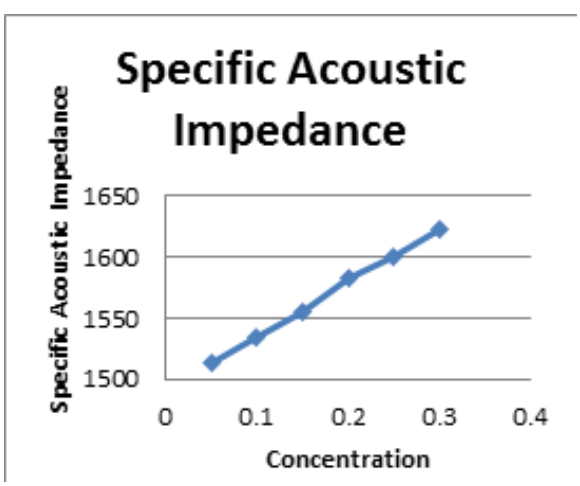

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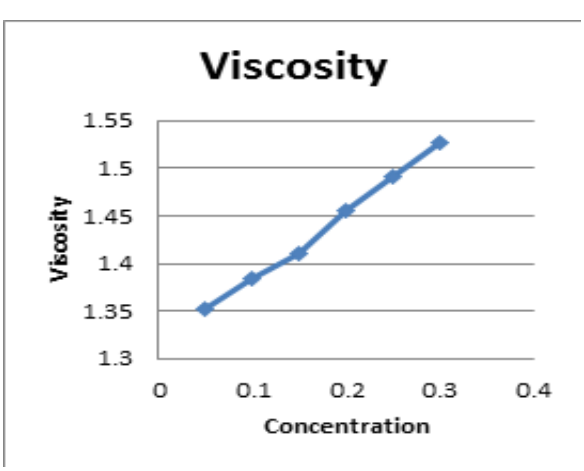

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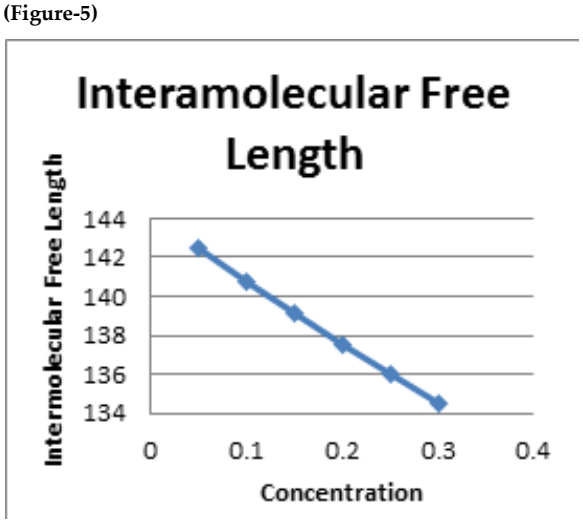
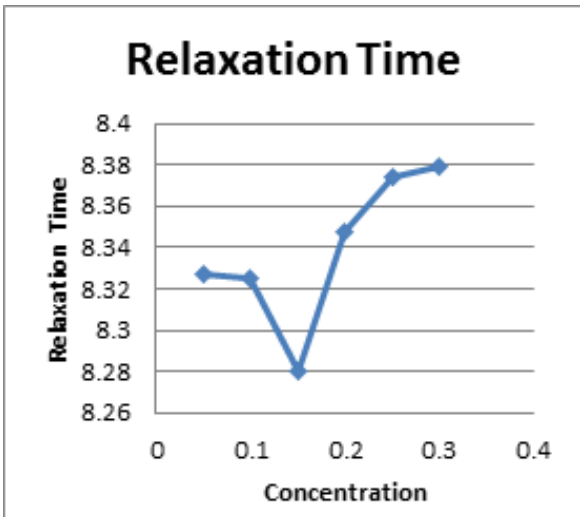


(Figure-6)



(Figure-7)

Increase in density (figure-1) with increase in concentration. It is observed from figure-2 that the ultrasonic velocity increases with increase in concentration and this is probably due to solute-solvent interactions. Figure 3 depicts that viscosity of the liquid increases with the increase in concentration. Ultrasonic velocity and viscosity increase with increase in the concentration of solute. The increase suggests a structure-making capacity of terpolymer resin in solution. Moreover, the increase in ultrasonic velocity indicates the possibility of H-bond formation between solute and solvent. There is also an indication of greater association among the molecules [10, 11]. The adiabatic compressibility (βs) (figure-4) decreases with increasing concentration of solute. This may be due to the aggregation of solvent molecules around the ions supporting solute-solvent interaction [12, 13]. As concentration increases, a larger portion of the solvent molecules are electro restricted and the amount of bulk solvent decreases causing the compressibility to decrease. Decrease in adiabatic compressibility indicates the formation of large number of tightly bound systems.Acoustic impedance (figure-5) is the product of ultrasonic velocity and density. As density and velocity both increase with increase in concentration of solute. This indicates the complex formation and intermolecular weak association which may be due to hydrogen bonding [14].Intermolecular free length (Lf) (figure-6) depends on the intermolecular attractive and repulsive forces. As concentration increases, number of ions or particles increase in a given volume leading to decrease in the gap (intermolecular free length) between solute-solvent. Also, the decreased compressibility brings the molecules to a closer packing resulting in decrease in intermolecular free length [15]. Relaxation time increases (figure-7) with an increase in concentration.

CONCLUSIONS

The ultrasonic study of terpolymer resin shows the presence of molecular interactions between the solute-solvent interactions. The ultrasonic velocity increase with increase in concentration which is due to the decreases in intermolecular free length of the solute-solvent. The density and viscosity increases with increase in concentration. Adiabatic compressibility and intermolecular free length decreases with increase in concentration.

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