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Ultrasonic Studies of Polymer Blend at Various Concentrations and Temperature

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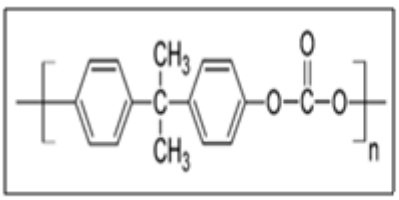
Abstract: ***The propagation of ultrasonic waves and the measurement of their velocity in solutions form an important tool for the evaluation of various acoustical and thermo dynamical parameters which give an insight into the nature of miscibility and molecular interactions in polymer blend. In the present investigation, ultrasonic velocity measurements in polycarbonate/poly(methyl methacrylate) blend were made at different concentration and temperature range. The measurements were carried out by using the ultrasonic pulse echo overlap technique at a frequency of 4MHz. The nature of polymer/polymer interaction and the effect of concentration and temperature on the molecular interaction are studied. The observed variation in acoustical parameters shows the linear behavior with increase in molar concentration of polycarbonate with poly(methyl methacrylate) in solvent chloroform at different range of temperature. It also gives evidence to the enhancement of full compatibility among the liquid molecules presence of molecular interaction in the polymer blend.***

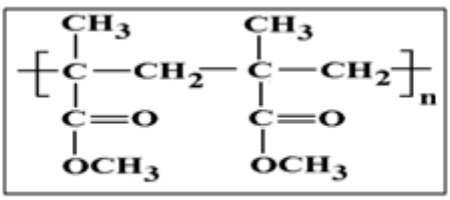
1. Introduction

Polymer blend are physical mixtures of two structurally different polymers which interact through weak secondary forces with no covalent bonds. The choice of suitable solvent for a given polymer plays an important role in deciding the end use. This depends on the nature of interaction in solvent and polymer[1]. The solution properties of polymer form the basis for the quantitative characterization of polymer molecules. Different techniques like spectroscopy, light scattering, viscometry and refractrometry are used to study the properties of solutions. Now a days, ultrasonic measurements in polymer blend solutions have gained momentum [2][3]. There has been a considerable speculation over the years concerning the role of solvent molecules on the local segment relaxation of a polymer molecule. It is often observed that changing the solvent leads to changes in the apparent activation energy for internal rotation. A linear variation in ultrasonic velocity in polymer solution is a measure of miscibility of the polymers in particular solvent. There is a strict correlation between the chemical structure, physical structure and the molecular mobility of polymers and the acoustical parameters[4]. A change in the nature of molecular organization of the macromolecules, structural changes and any change due to the change of temperature are determined both by the bond energy of the atoms forming the main chain of the polymer and the energy of interaction between the elements of adjacent polymer chains. These molecular interactions influence the velocity of sound, absorption and other acoustical parameters. It is thus obvious that the ultrasonic parameters are useful for the study of molecular interactions [5].

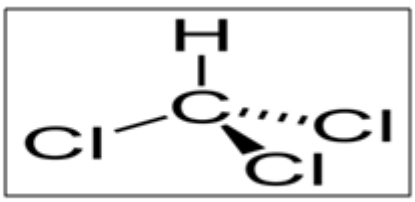
The present paper deals with the ultrasonic studies of polyblend solution of polycarbonate/poly(methyl methacrylate) (PC/PMMA) in chloroform (CF). CF is used as a solvent in the pharmaceutical industry and for producing dyes and pesticides. It is a common solvent in the laboratory because it is relatively unreactive, miscible with most organic liquids, and conveniently volatile. PC is a polymer which, when un-crystallized, has excellent transparency. When thick, it has a slight yellowish tint. PC received their name because they are polymers containing carbonate groups. Common examples include reusable water bottles, baby bottles, tableware such as plates and cups, and containers for storing food and reheating in a microwave oven. PMMA is a transparent thermoplastic, often used as a light or shatter-resistant alternative to glass. PMMA is a commonly used low cost thermoplastic polymer with boundless applications to everyday life. It is readily miscible with some of the other polymers to employ them in some important applications. PMMA has a good degree of compatibility with human tissue. PMMA is a widely used support medium for the embedding of intact, undecalcified bone[5].



Structure of Polycarbonate



Structure of Polymethyl methacrylate



Structure of chloroform

2. Materials and Experimental Method

Ternary polyblend system has been prepared by mixing known quantity of PC in CF solution and then adding PMMA in the solution. The solution of PC was prepared by dissolving in 250ml of CF, this solution having concentration 0.1M, was used as a stock solution. Various concentrations of the PMMA is added by weight percentage in the known and fixed concentration of stock solution. Total 50ml solution was used for the measurement of ultrasonic velocity, density, viscosity and absorption. The chemicals used were of excelar grade. The concentration range chosen in the solution are 0.00, 0.02, 0.04, 0.06, 0.08 & 0.1M while the temperature range chosen is 293, 298, 303, 308 & 313K.

The ultrasonic velocity and absorption measurements were carried out using highly versatile accurate pulse echo overlap technique by using automatic ultrasonic attenuation recorder (AUAR-102) supplied by Innovative Instruments, Hyderabad (India). The frequency of the pulses is kept constant at 4 MHz. The accuracy in the measurement of absorption is about 2 %. The density of the solutions was determined using hydrostatic plunger method. The viscosity of liquid was measured by using Oswald's viscometer. Thermostatically controlled water circulation system is used to maintain the temperature at 293K with an accuracy of 0.05^0C. The experimental set up and observed wave pattern for calculating acoustical parameters are shown in the images below.

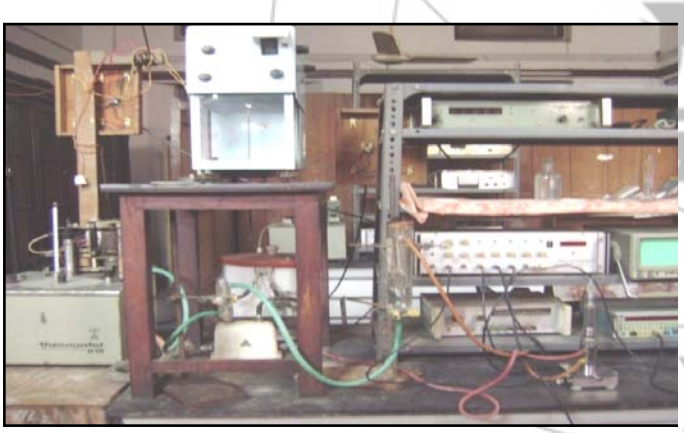


Figure 1: Experimental set up

Figure 2: Fine echo wave train pattern

Figure 3: Selection of two echoes

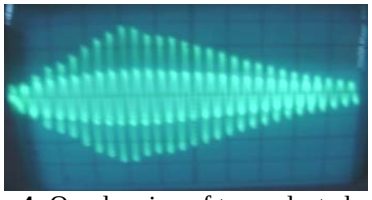


Figure 4: Overlapping of two selected echoes

3. Result and Discussion

The plot of variation of acoustical parameters for polyblend system of polycarbonate and polymethyl methacrylate in chloroform for concentration range different temperature range are shown in Fig. 1 to 6. The ultrasonic velocity, density, viscosity and absorption were calculated experimentally while adiabatic compressibility, acoustic impedance, relaxation time have been estimated by using standard formulae[6].

From the shape of variation of the ultrasonic velocity one can account for the compatibility or miscibility of the polymer in the solvent. It was observed that ultrasonic velocity (Figure 1) decreases with temperature for the polyblend system in CF. This may be due to molecular dissociation taking place in solution. As the temperature increases, more and more bonds are broken or the bonds are elongated which results in dilation of polymer chains. As the temperature increases, hydrogen bonds in solvent break, more and more monomers occupy the vacant space and increase the cohesion among molecules, thereby decreasing the ultrasonic velocity. There is a tendency for breaking the complex at higher temperature in the low molecular weight synthetic polymers[7]. The same phenomenon is also applicable to decrease in density (fig 2) & viscosity (fig 3). Decrease in density indicates structure- breaker of the solvent. Thus hydrogen bond forming or dissociating properties can be correlated with change in density and viscosity[8]. The adiabatic compressibility (fig 4) shows increasing trends with increasing temperature for the system, which is opposite to the nature of variation of velocity. This increasing adiabatic compressibility is due to cohesion between solvent molecules at that particular concentration. The increasing adiabatic compressibility shows the molecular dissociation is greater in solution[9]. Here we observe the variation of acoustic impedance (Figure 5), decreasing, similar to variation of velocity. Acoustic impedance is a characteristic property of the medium. The acoustic impedance is analogous to refractive index of the medium. The acoustic impedance can be used to access the strength of intermolecular attraction[10]. As the strength of intermolecular attraction decreases, the ultrasonic velocity also decreases. Consequently, the acoustic impedance value also decreases. Thus variation of *Z, here*, suggests strong molecular interaction between the component molecules in the polybend solution [11]. The relaxation time (fig 6) linearly decreases with increasing temperature in the polyblend system. This indicates that the solution is highly ordered due to strong hydration and such solution generally absorbs more ultrasonic energy[12]. This may be due to the increase in non-hydrated free solvent content of the solutions[13].

4. Conclusion

From the above discussion we conclude that there exist strong molecular interaction between CF in PC/PMMA and these solvent/polymer/polymer interactions are dominant. Further ternary mixture in CF supports dissociative nature in PC/PMMA. Also CF/PC/PMMA blend variation of velocity suggests miscibility of the constituent polymers.

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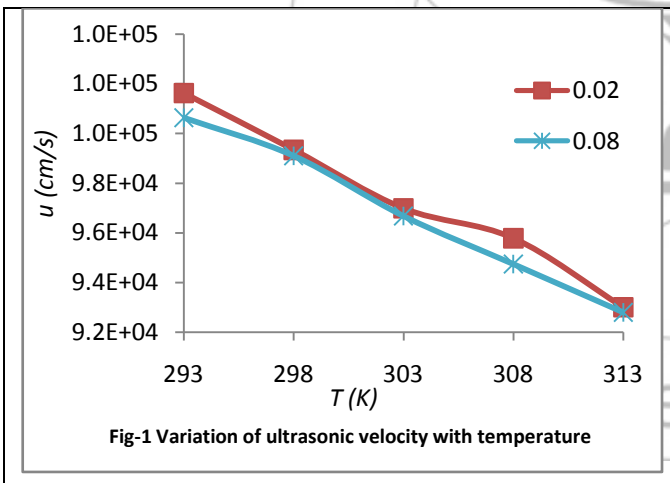

Fig-1 Variation of ultrasonic velocity with temperature

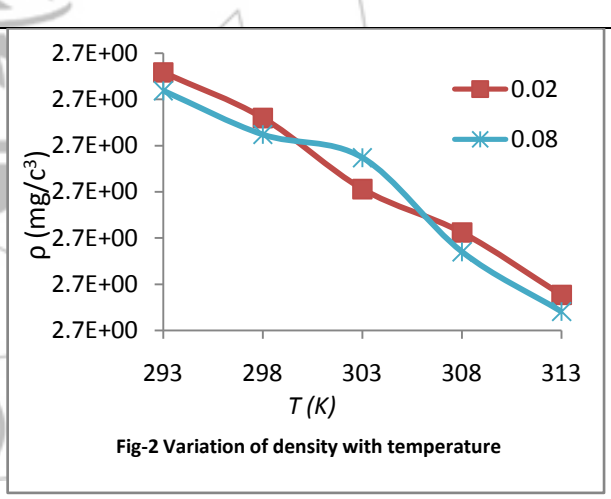

Fig-2 Variation of density with temperature

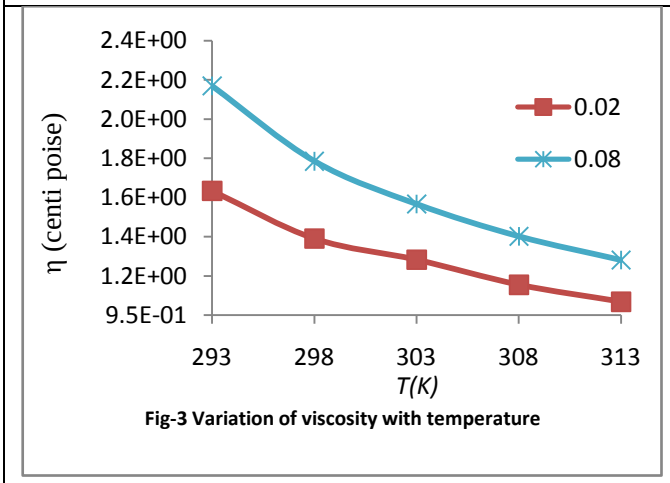

Fig-3 Variation of viscosity with temperature

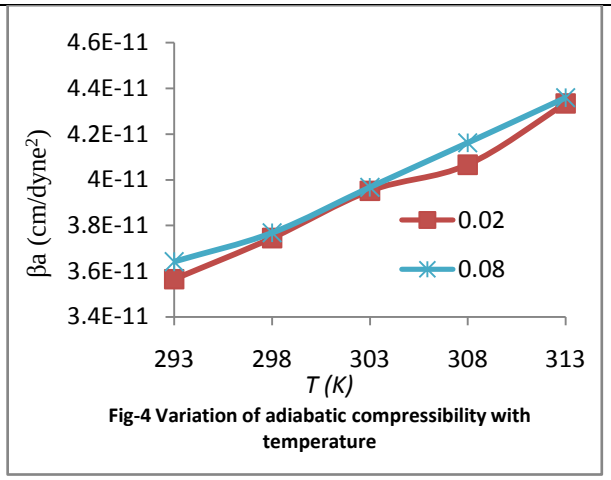

Fig-4 Variation of adiabatic compressibility with temperature

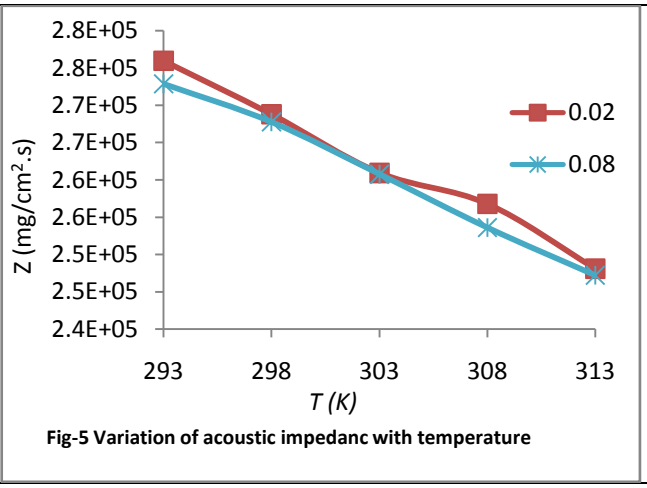

Fig-5 Variation of acoustic impedanc with temperature

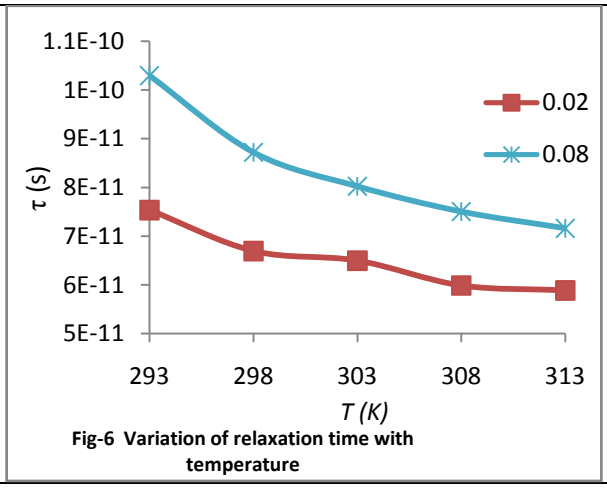

Fig-6 Variation of relaxation time with temperature