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Ultrasonic Investigation of Solution Blends of Polybutadiene and Polymethyl Methacrylate

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Abstract: ***The present investigations deal with the study of ultrasonic velocity and related thermoacoustical parameters of Polybutadiene(PB) –Polymethyl Methacrylate(PMMA) blends. Ultrasonic velocity, density, measurements have been performed on solution blends of PB-PMMA in various blend ratios using THF as solvent. These measurements have been observed to deviate from linearity with variations in blend ratio. The ultrasonic velocity and density of solution blends are significantly depend on temperature and solid content of blend solution. Ultrasonic velocity, density measurements are done at 2MHz frequency and for temperatures 293K, 298K, 303K,308K and 313K.***

Keywords: ultrasonic velocity, polybutadiene, polymethyl methacrylate, blend

1. Introduction

Polymeric blends present one of most rapidly growing areas in polymeric materials.These materials are mixture of two structurally different polymers bonded together by secondary force [1]. However gain in the newer properties depends on miscibility of polymers at molecular level. Many experimental and theoretical methods have been used to investigate compatibility of polymer blend system[2,3]. Sidkey M.A. et al[4] has studied ultrasonic investigations of some rubber blends. Singh and Singh [5] have measured ultrasonic velocity and absolute viscosity in solution of compatible, incompatible and semi-compatible blends.

In present investigation, polybutadiene rubber, Polymethyl methacrylate are materials used , because these materials are recognized as high performance polymers. The present paper discusses in detail extensive investigations of ultrasonic velocity, density, adiabatic compressibility ,intermolecular free length measurements of PBR + PMMA blends in various blend ratios.

2. Materials and Methods

Materials and preparation of solutions blends: - Master solutions of Polybutadiene rubber and Polymethyl methacrylate have been prepared by dissolving these materials separately in desired concentrations (1gm in 100ml) in THF at room temperature(30^0C) and then kept for 4 hours in air tight bottles, resulting in transparent solutions. After this solution blends have been prepared in various blend ratios of PBR/PMMA (100/0, 80/20,60/40,40/60,20/80,0/100) taking appropriate amount from the stock solution for ultrasonic velocity, density measurement.

Ultrasonic Velocity measurement is done by MHF-400 high frequency pulser receiver (supplied by Roop Telsonic ultrasonix Ltd.) Ultrasonic pulser receiver is advanced technique which provides unique low cost ultrasonic measurement capability. The instrument has been spike pulser and broadband receiver. The receiver has max gain of 103dB, adjustable in minimum step of 1dB. 4 high pass and low pass filters each facilitate frequency cut off for optimization of received signal. Pulser section of instrument generates electronic pulses of controlled energy which are converted into short ultrasonic pulses when applied to an ultrasonic transducer. In receiver section voltage signals produced by the transducer which represent the received ultrasonic pulses are amplified. The amplified radio frequency (RF) signal is available as an output for display. The ultrasonic velocity is calculated from the captured signals automatically and is displayed on the screen. The absorption measurement is done by echo pulses displayed on oscilloscope (Tektronix TDS 2022B two channel DSO).

The ultrasonic velocity measurement is done at 2MHz frequency and at temperatures 293^0K, 298^0K, 303^0K, 308^0K, 313^0K for PBR/PMMA solutions blends in different ratios. The densities of all solution blends have been measured by pycnometer at temperatures 293^0K, 298^0K, 303^0K, 308^0K, 313^0K. Ultrasonic velocity, density measurements change even with very small change of temperature, therefore for such measurements it is very necessary to keep temperature constant accurately. Plasto craft thermostate (LTB -10) maintains desired accurate constant temperature with accuracy of $\pm 0.1^0$C in temperature range -10^0C to 95^0C.

3. Theoretical Formulations

1. Ultrasonic velocity is given by

$$u = \frac{2d}{t} \text{ m/sec}$$

Where, d – separation between transducer & reflector
t- travelling time period of ultrasonic wave

2. Density is given by

$$\rho = (\frac{M_l}{M_w})\rho_w \text{ ....Kg/m}^3$$

Where, M_l and M_w are the mass of liquid and water respectively.

ρ_w - density of water

3. Adiabatic Compressibility is given by

$$\beta_a = \frac{1}{u^2\rho} \ldots \text{m}^2/\text{Newton}$$

Where u is the velocity of sound in liquid and ρ is the density of the liquid for particular concentration of the constituents.

4. Intermolecular Free Length is given by

$L_f = K_j(\beta_a)^{1/2}$

Where K_j - Jacobson's constant & β_a - Adiabatic compressibility

4. Results and Discussion

Fig1 shows that ultrasonic velocity decreases with increase in temperature at 2MHz frequency. The phase equilibrium of polymer solutions has strongly affected by change in solution temperature. The decrease in velocity may be due to thermal expansion at higher temperature and structural changes related with state of association of liquid molecules. The rise or fall of ultrasonic velocity for various blend ratios is due to polymer solvent interactions and solid content of each polymer. Non linearity in ultrasonic velocity suggests immiscibility of polymer blends and double phase formation.

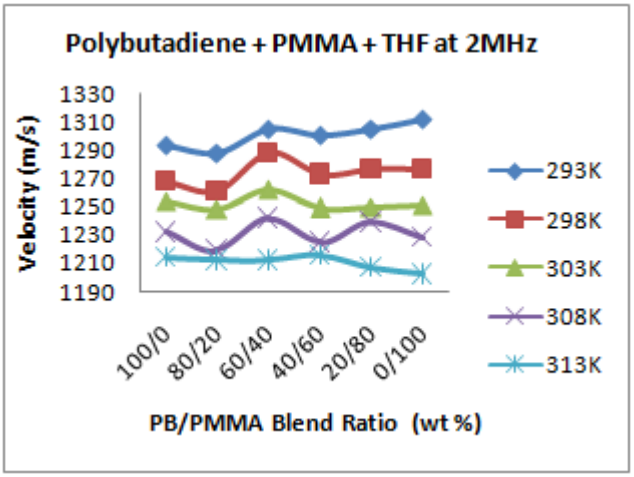

Figure 1

Fig2 shows that density varies non-linearly for solution blends at various temperatures. The significant increase in density for blend ratio (40/60) shows polymer-polymer relative polarity and strong molecular interactions.

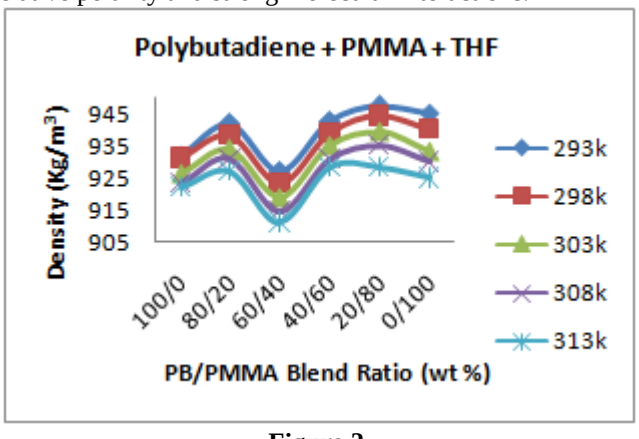

Figure 2

From Fig3 it is clear that adiabatic compressibility shows non-linearity for different blend ratios with respect to temperature 293K-303K for 2MHz. frequency. The behaviour is slightly different for higher temperature 313K. The adiabatic compressibility shows opposite behaviour as that of ultrasonic velocity. For solution blends with various blend ratios when ultrasonic velocity increases adiabatic compressibility decreases indicating increase in degree of association which favours strong heteromolecular interactions.

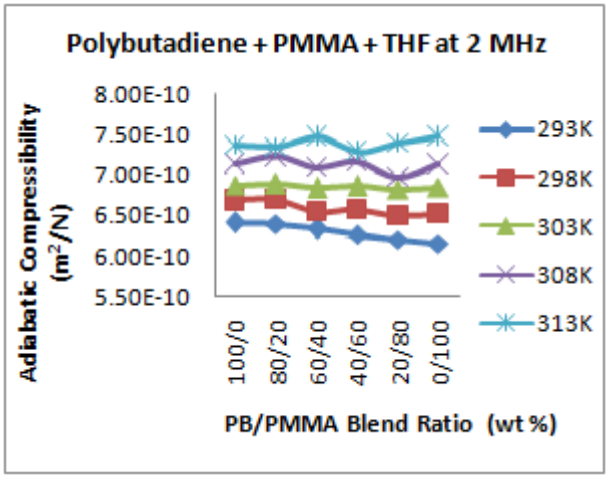

Figure 3

Intermolecular free length (L_f) is the distance between surfaces of neighbouring molecules. From figure 4 it is clear that free length increases with increase in temperatures at 2MHz frequency. Intermolecular free length shows same behaviour as that of adiabatic compressibility and opposite behaviour as that of ultrasonic velocity. Non-linearity in the free length for different solution blends shows effect of intermolecular forces such as dipole-dipole interactions and dipole induced dipole interactions.

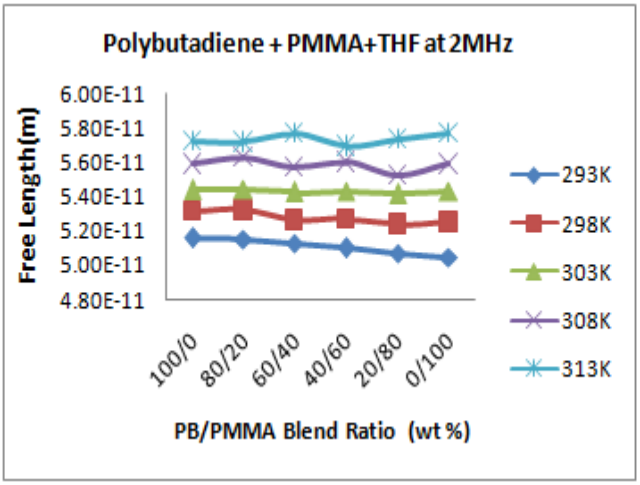

Figure 4

5. Conclusion

1) The ultrasonic velocity is used to determine elasticity of medium.
2) The measurement of thermoacoustical parameters such as ultrasonic velocity, density, adiabatic compressibility

and free length indicates strength of molecular interactions in polymer blends with various blend ratios.

3) The non linearity of acoustical parameters for different solution blends confirms presence of polymer-polymer, polymer-solvent interactions and also complex formation and immiscibility.

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