



Phase separation studies in polyvinyl chloride-polyvinyl acetate blend by ultrasonic technique

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ABSTRACT

The ultrasonic velocity and their related thermoacoustical parameters were successfully employed to understand the miscibility and molecular interactions in polymer blend. Ultrasonic velocity, density and viscosity in polyvinyl chloride with polyvinyl acetate in tetrahydrofuran and the thermoacoustic parameters viz., adiabatic compressibility, molar sound velocity, molar compressibility, expansion coefficient, acoustic impedance, van der Waal's constant and internal pressure have been computed from the experimental data. The measurements have been carried out by using pulse echo overlap technique (PEO) at frequency of 4MHz at temperature 313K. The variation of u.s. velocity and other thermo-acoustical parameters shows nonlinear variation with molar concentration which suggest immiscibility or semi compatibility among the component polymers. Two immiscible polymers are need to be compatibilized in order to be used in commercial applications. The nature of solvent/polymer/polymer interaction and the effect of concentration on the molecular interaction of polyvinyl chloride and polyvinyl acetate in tetrahydrofuran have been studied.

Key Words: Pulse echo overlap technique, acoustical parameters, solvent/polymer/polymer interaction.

INTRODUCTION

Acoustical studies in polymer solutions and in solid polymers have been the subject of research in recent years. Ultrasonic is the universally accepted technique to study the physico-chemical properties of the liquids, liquid mixtures, electrolytic solutions and polymeric solutions. The different acoustical parameters interpret the nature and strength of molecular interaction that exist in the system. Many workers [1,2] have carried out pioneering work on polymer/polymer compatibility using ultrasonic techniques. This provides powerful, effective and reliable tools to investigate properties of blends. A linear variation in ultrasonic velocity for a blend is a measure of compatibility or miscibility of the two polymers. Blending has been the most effective way to get better polymeric systems; they can offer better properties, cost and processing advantages in their applications. Depending upon the polymer/polymer miscibility, polymer blends can be single phase or multi phase. There is a strict correlation between the chemical structure, physical structure and the molecular mobility of polymers and the acoustical parameters [3]. 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 [4].

The present paper deals with the ultrasonic studies of polymer solution of polyvinyl chloride (PVC) in tetrahydrofuran (THF) as a function of increasing molar concentration of polyvinyl acetate (PVAc). Polyvinyl chloride is a thermoplastic polymer. It is a vinyl polymer constructed of repeating vinyl groups (ethenyls) having one hydrogen replaced by chloride. Poly (vinyl acetate) is the most widely used polymer of the vinyl ester. It is not only used as a plastic in form of emulsion, but also as the precursor for the two polymers, poly (vinyl Alcohol) and poly (vinyl Acetal) which cannot be prepared by direct polymerization. Polyvinyl chloride and polyvinyl acetate are synthetic polymers with the formulae $(\text{CH}_2\text{CHCl})_n$ & $(\text{C}_4\text{H}_6\text{O}_2)_n$ respectively. PVC is widely used in construction because it is cheap, durable, and easy to assemble. While polyvinyl acetate is a polymer of industrial importance which includes its application as strengthening agents for cements.

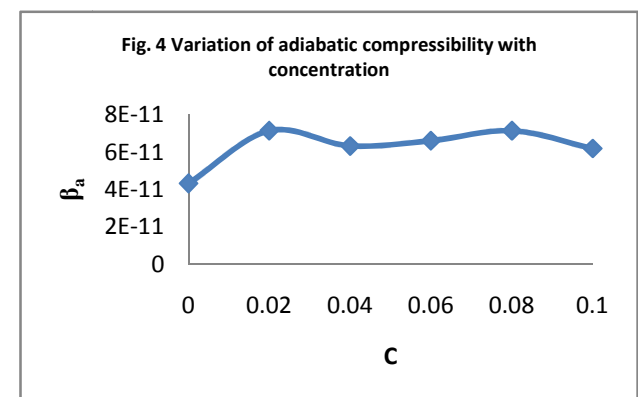
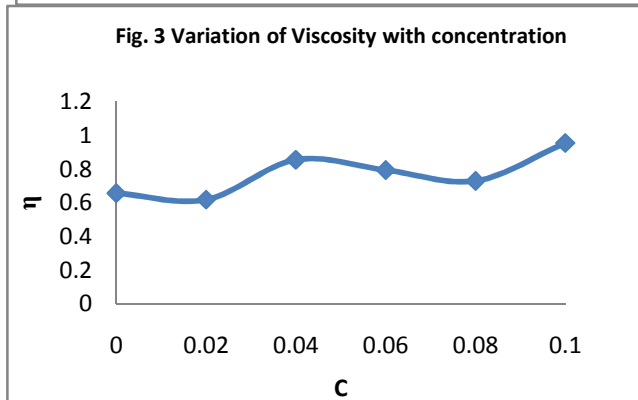
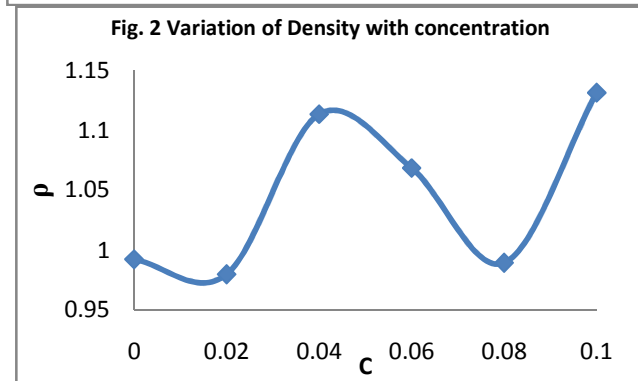
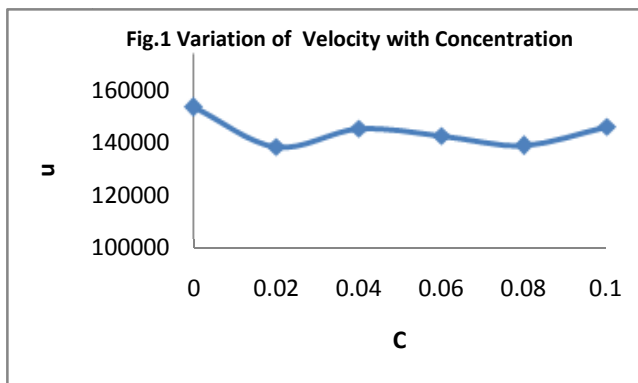
EXPERIMENTAL SECTION

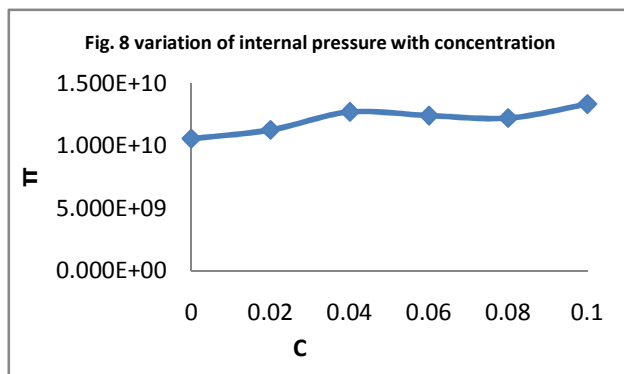
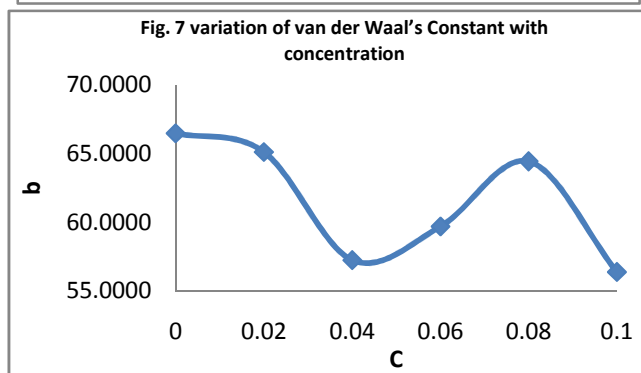
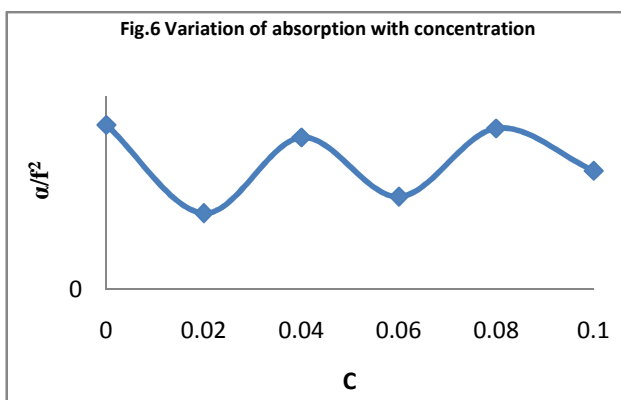
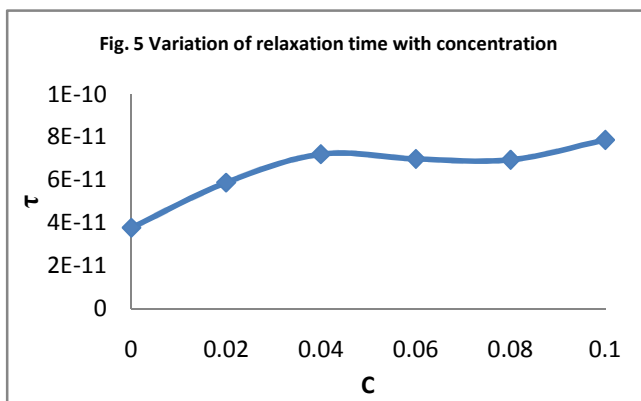
The solution of PVC was prepared by dissolving in 250ml of THF. This solution, having concentration 0.1M, was used as a stock solution. Various concentrations of the PVAc is added by weight percentage in the known and fixed concentration of stock solution to make poly-blend solution. Total 50ml solution was prepared for the measurement of u.s. velocity, density, viscosity. The chemicals used were of excelsar grade. The velocity was measured by using Automated Ultrasonic Attenuation Recorder AUAR – 102 (Innovative Instrument, Hyderabad) and frequency counter APLAB-1116. The measurements were carried out by using pulse echo overlap technique at frequency 4MHz. The density and viscosity were measured by employing hydrostatic plunger method and Ostwald's viscometer respectively. The temperature was maintained constant (298K) during the period of measurement by a water circulation system from the thermostat U-10 with thermal stability of $\pm 0.1^\circ\text{C}$.

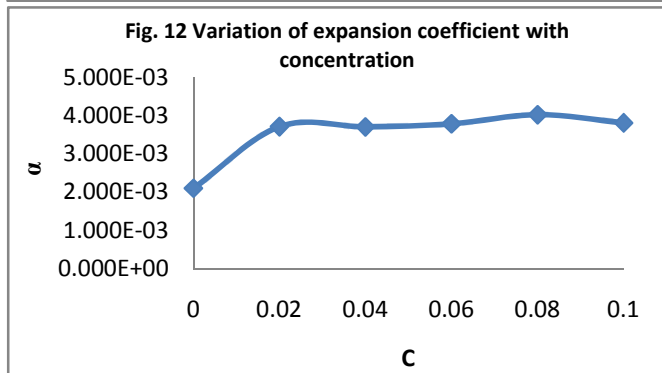
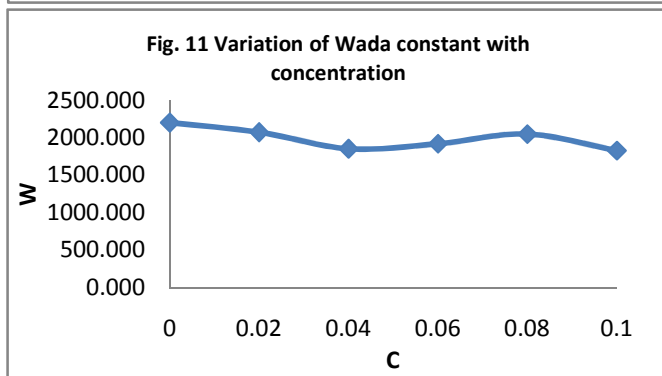
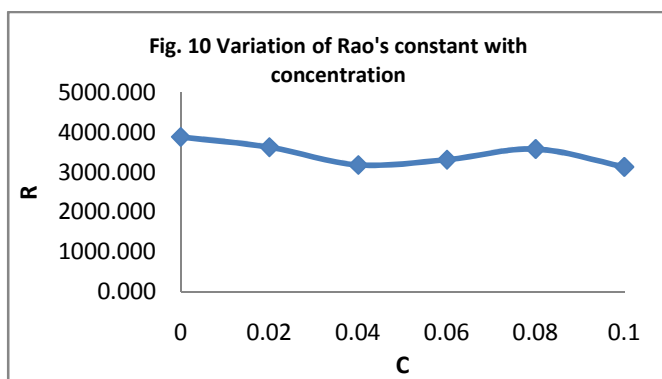
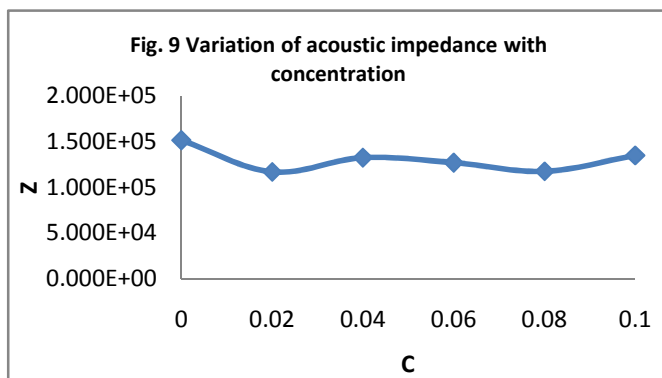
RESULTS AND DISCUSSIONS

The u.s. velocity (u), density (ρ), viscosity (η) and absorption (αf^2) were calculated experimentally while adiabatic compressibility (β_a), relaxation time (τ), Rao's molar sound velocity (R), Wada constant (Molar compressibility) (W), acoustic impedance (Z), van der Waal's constant (b), internal pressure(π), expansion coefficient (α) have been estimated by using standard formulae [5-6]. Figure 1-12 shows the plots of experimental and the calculated values of all the above acoustical parameters at different molar concentration for polymer/polymer solution of PVC/PVAc with tetrahydrofuran.

The variation of u with increasing concentration of PVAc in solution is non-linear (Fig. 1). From the shape of the u variation versus composition of the second polymer in the mixture, one can account for the compatibility or miscibility of the polymer-polymer blend [7]. Here variation of u is observed to be S shaped indicating non-compatibility or immiscibility between PVC/PVAc. Observed non-linear variation in u with increase of PVAc in PVC/THF solution has been attributed to polymer-polymer interactions [8]. Variation of Z with concentration (fig. 9) shows same trend as that of u . Variation of ρ with concentration (fig. 2) and variation of η with concentration (fig. 3) of polyblend system is observed to be varying non-linearly with increase in concentration of PVAc in THF/PVC mixture. This is because with the addition of PVAc in the mixture increases the number of chains in the mixture [9]. Decrease in ρ with increasing concentration of PVAc in THF/PVC mixture also indicates non-compatibility or immiscibility of constituent polymers. The non-linear variation in β_a with increasing concentration of PVAc in THF/PVC solution (fig. 4) shows nature opposite to that of u . Trend of β_a opposite to that of u indicates complex formation in the system [10]. β_a is an important parameter as its low value gives data of compact structure characterized by a greater strength of bonding[11]. Variation of τ (fig. 5) shows non-linear increasing trend with increase in concentration of PVAc in THF/PVC solution which also suggests complex formation in the mixture. Variation of αf^2 (fig 6) show two peak structured polymer blend system, which indicates the presence of two phases in polyblend system. The first peak which we get is in the PVC-rich region while second peak is in the PVAc rich region. This suggests non homogeneity, indicated by double phase formation in the system. It also suggests heterogeneity, indicated by double phase separation in the blend and thus it suggests non-compatibility of the polymers. The non-linear variation in R (fig. 10), W (fig. 11) and b (fig. 7) may be attributed to dipole-dipole interaction, and complex formation between the molecules of solvent/polymer/polymer. In this polyblend system it was observed that π (fig. 8) & α (fig. 12) are showing non-linear variation which also suggests complex formation in the system and semi-compatibility or immiscibility in the blend [12]. The π in a binary mixture is a measure of cohesive forces between the components [13].







CONCLUSION

The non-linear variation of ultrasonic velocity and other acoustical parameters suggest, heterogeneity, indicated by double phase separation in the blend, due to immiscibility or non-compatibility of constituent polymers.

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REFERENCES

- [1] R.P. Singh, *Acoust. Soc. Ind.* 21, **1993**, 159.
- [2] S.Rajgopalan And S.J.Sharma, *J. Pure & Appl. Ultrason.*, **2005**, 27, 105.
- [3] K.M.E. Pia, , S. Mallika, and S. Kalyansundaram, *J. Pure Appl. Ultrason.*, **2008**, 30, 54.
- [4] V.A. Tabhane, S. Agrawal, K.G.Rewatkar, *J. Acous. Soc. Of Ind.*, **2000**, 28, 369.
- [5] V.A. Tabhane, O.P. Chimankar, S. Manjha and T.K. Nambinarayanan, *J. Pure Appl. Ultrason.*, **1999**, 21, 67.
- [6] SJ Askar Ali, *J. Chem. Pharm . Res.*, **2012**, 4(1):617.
- [7] OP.Chimankar; R.Shiriwas and V.A.Tabhane., *J. Chem. Pharm . Res.*, **2011**,3 (3):587.
- [8] Saneel K. Thakur; Shivani Chouhan, *J. Chem. Pharm . Res.*, **2011**, 3(2):657.
- [9] K. Ch. Rao, A.V. Rajulu and S.V. Naidu, *Journal Polym. Mater.*, **1989**, 8, 149.
- [10] VD.Bhandarkkar; OP.Chimankar and NR.Pawar. *J. Chem. Pharm . Res.*, **2010**,2 (4): 873.
- [11] O.P.Chimankar, D.V. Nandanwar, K.G. Rewatkar & V.A. Tabhane, *18th National Symp. On Ultrason.*, **2009**, 1(107), 353.
- [12] Tabhane Priyanka, Chimankar O.P., Jajodia S. & Tabhane V.A., *Acoustics Waves*; **2011**, 250.
- [13] K Rajathi; SJ Askar Ali; and A Rajendran. *J. Chem. Pharm . Res.*, **2011**,3 (5): 348.