Miscibility Studies of polyvinyl chloride / polyether sulfone blend by viscosity, ultrasonic velocity and polarized optical microscopic methods.

G. Krishnakishore
Associate Professor in Physics
Department of Physics, V.R. College, Nellore – 524 001
Andhra Pradesh

Abstract

The solutions of blends of polyvinyl chloride/ polyether sulfone we prepared in different proportions in a common solvent. The miscibility of these blends was probed by solution techniques such as viscosity and ultrasonic velocity and a solid state technique such as polarized optical microscopy. Using viscosity data, the interaction parameters of these blends of different compositions were computed with the relevant equations. The immiscible nature of these blends as indicated by the viscosity data was confirmed by ultrasonic velocity and polarized optical microscopic methods. The immiscible nature of these blends suggests that these two polymers are favourable for preparing alloys using a suitable compatibiliser.

Keywords : Polymer blends, Polyvinyl chloride, Polyether sulfone, Ultrasonic velocity, Viscosity, Optical microscopy.

1. Introduction

Polymer blends and alloys are novel materials developed to meet specific needs. Blending leads to miscible and immiscible systems. Miscible blends are used to make tailor made articles whereas immiscible blends are used to prepare polymer alloys. So in order to make miscible blends or polymer alloys, it is necessary to study the miscibility of polymer blends at molecular level. Though various techniques are available to test polymer –polymer miscibility, most of them are expensive, time consuming and complicated. So, it is desirable to identify and employ low cost, simple and rapid techniques. In this direction, the author used the viscosity, ultrasonic velocity, refractive index, density and polarized optical microscopic techniques. In the present chapter, the results on the miscibility of polyvinyl chloride (PVC)/ PES blends of different compositions are presented. The author selected PVC and PES for making the blends as PVC is the cheapest polymer and PES is a polymer widely used for making membranes.

2. Materials and Methods

The blends of PVC / PES of different compositions were prepared by mixing solutions of the polymers in DMF. PVC (M/s Rishab Polymers $\overline{Mn}$= 65000) and PES (M/s Aldrich $\overline{Mn}$ = 100000) were employed in the present study. The total weight of the two components was always maintained at 2g/dl while preparing the experimental solutions. The relative viscosities of blend solutions were measured at 35 ^{0}C using an USLV. The polarizing optical micrograms of the blend frilms fast for different compositions were recorded using a microprocessor controlled Carl Zeiss Polarizing Optical Microscope.

3. Results and Discussion

The measured values of reduced viscosity for PVC, PES and PVC/ PES blend (for PVC/ PES composition of 0.5/0.5) in DMF at 35 ^{0}C are presented in Table 1. The Hunggin's plot for the blend of this composition is presented in Fig. 1. In the same figure, the Huggin's plots for the homopolymers PVC and PES are also presented. In order to probe the miscibility of the PVC / PES blends, the equations suggested by Chee (3) and Sun et al. (4) (Eqns. 1 and 2 respectively) and the interactions parameters μ and α were calculated.

$$\mu = \frac{\Delta B}{\left\{ [n]_2 - [n]_1 \right\}^2} \quad ..(1)$$

Here $\Delta B = W_1^2\, b_{11} + W_2^2\, b_{22} + 2\, W_1\, W_2\, b_{12}$ in which W_1 *and* W_2 are the weight fractions of the two polymers, b_{11} *and* b_{22} *and* b_{12} are the slopes of the Huggin's plots of the two polymers and b_{12} is that of the blend. $[\eta]_1$ *and* $[\eta]_2$ are intrinsic viscosities for pure component solutions.

$$\alpha = K_m - \frac{K_1\,[n]_1^2\, W_1^2 + K_2\,[\eta]_2^2\, W_2^2 + 2\,(K_1 K_2)^{1/2}\,[\eta]_1^2\,[\eta]_2^2\, W_1 W_2}{\left\{ [\eta]_1 W_1 + [\eta]_2 W_2 \right\}^2} \quad ...(2)$$

Where K_1, K_2 *and* K_m are the Huggin's constants for individual components 1,2 and blend respectively. While deriving this equation [Eq. (2)], the long range hydrodynamic interactions are taken into account. Sun et al.[3] suggested that the blend would be miscible if $\alpha \geq 0$ and immiscible when $\alpha < 0$.

The μ *and* α values for blends of different compositions are presented in Table 2. From this table, it is clearly evident that μ and α for PVC/ PES blends of all compositions studied are negative. This clearly indicates that the blends under investigation are immiscible in nature. In order to further probe the miscibility of polymer blends under study, the ultrasonic velocity of polymer blend solutions was measured. The measured values of ultrasonic velocity of PVC/ PES polymer blends are presented in table 2. The variation of ultrasonic velocity of PVC/ PES polymer blends with composition is depicted in Fig. 2. From figure, it is clearly evident that the variation is non - linear for the system under study showing multiphases in the blend. Singh and Singh (5) have also attributed the non – linear variation of ultrasonic velocity with blend compositions to the immiscible nature of several blends. Varada Rajulu et al. (6-12) have also used these techniques to probe the miscibility of several polymer blends.

In order to further probe the miscibility or otherwise of PVC/PES blend, the author used the solid – state technique, viz., Polarized Optical Microscopy. The micrograms of the PVC/ PES blends of different compositions are presented in Fig. 3. From these micrograms, it is clearly evident that the components of PVC and PES exist as two phases. This clearly indicates that the blend is immiscible in nature. Chattopadhyay and Banerjee (13) also used polarized optical microscopic technique to confirm the miscibility or otherwise of the blends in film form. These studies provide us a clue that the combination of PVC and PES can be converted into a polymer alloy by suitable compatibilisation.

In order to explain immiscible nature of PVC / PES blend basing on thermodynamics, the author calculated the solubility (Hildebrand) parameters using Van Krevelen group additive method (14).

The computed values of solubility parameters of PVC and PES are found to be 18.9 $J^{1/2}/cm^{3/2}$ and 21.5 $J^{1/2}/cm^{3/2}$ respectively. The difference between these two values is 2.6 H (where H the Hildebrand parameter = 1 $J^{1/2}/cm^{3/2}$). As per thermodynamic criterion, the components in a mixture are miscible only when the difference in their solubility parameters is less than 2H. But in the present case, the difference exceeded 2H and hence the blend is immiscible.

Conclusions

Basing on the interaction parameters computed using the viscosity data, the blends of PVC/ PES for all compositions were found to be immiscible. The computed Hildebrand parameters of the components of the blend further confirmed the immiscible nature of the blend.

REFERENCES

1. Y.P. Singh, S. Das, S. Maiti and R.P. Singh, J. Pure Appl. Ultrason., 3, 1 (1981)
2. Y.P. Singh, Eur. Polym.J., 20, 201 (1984).
3. K.K. Chee, Eur. Polym.J., 26, 423 (1990).
4. Z. Sun, W.Wang and Z. Fung, Eur. Polym.J., 28, 1259 (1992).
5. Y.P. Singh and R.P. Singh, Eur. Polym. J., 19, 533 (1983).
6. A. Varada Rajulu, G.Babu Rao and R. Lakshminarayana Reddy, J. Polym. Mater., 19, 217 (2001).
7. A. Varada Rajulu, R. Lakshminarayana Reddy and G. Babu Rao, J. He and J. Zhang, J. Appl. Polym. Sci., 81, 557 (2001).
8. A. Varada Rajulu, G. Babu Rao and R. Lakshminarayana Reddy, J. Pure Appl. Ultrason., 23, 33(2001).
9. A. Varada Rajulu, L. Ganga Devi and G. Babu Rao, J. Appl. Polym. Sci., 89, 2970 (2003).
10. A. Varada Rajulu, and R. Lakshminarayana Reddy, Int. J. Polym. Anal. Charact., 5, 467 (2000).
11. A. Varada Rajulu and R. Lakshminarayana Reddy, Int. J. Polymeric Mater., 47, 469 (2000).
12. A. Varada Rajulu, R. Lakshminarayana Reddy, S. M. Raghavendra and S. Akheel Ahmed, Eur. Polym. J., 35, 1183 (1999).

13. S. Chatopadhyay and A.N. Banerjee, J. Polym. Mater ., 8, 351 (1991).

14. D. W. Van Krevelen, " Properties of Polymers – Their correlation with chemical structure : Their numerical estimation and prediction from additive group contributions", Elsevier, Amsteredam, pp. 189 – 226 (1990).

Captions for Figures

1. Fig. 1 Reduced Viscosity Vs Concentration of PVC, PES and PVC (0.5)/ PES (0.5) blend. (---- PES; ___ PVC/ PES Blend and .... PVC)

2. Fig.2 The variation of ultrasonic velocity with weight fraction of PVC in PVC/ PES Blend in DMF at 35 ^{0}C

3. Fig. 3 Polarized Optical Micrographs of PVC/ PES blends with the weight fraction of PVC – (a) 0.0; (b) 0.2; (c) 0.4; (d) 0.5; (e) 0.6; (f) 0.8; (g) 1.0.

Table 1 Reduced viscosities of PVC, PES and PVC/ PES blend (0.5 : 0:5 composition) in DMF at 35 ^{0}C

Concentration (g/dl)	Reduced Viscosity $(\eta_{sp}/C)(dl/g)$		
	PVC	PES	PVC/PES
1.43	1.1160	0.4340	0.6674
1.54	1.1902	0.4807	0.7013
1.67	1.2100	0.4661	0.7088
1.82	1.3140	0.5770	0.7310
2.00	1.3720	0.5683	0.7250

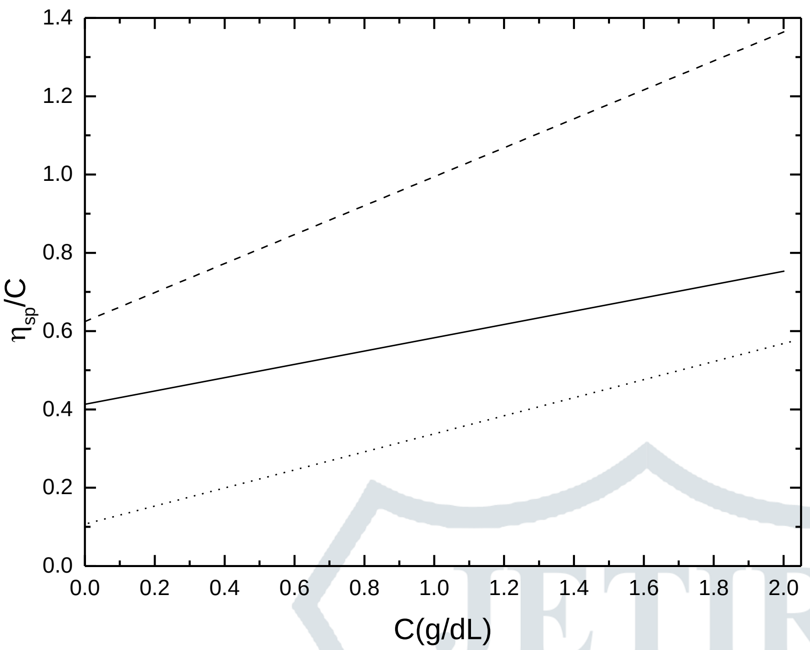

Fig. 1 Reduced viscosity vs concentration curve for PVC (0.5)/ PES (0.5) composition

(----- PVC; ___ PVC/ PES Blend; ..... PES)

Table 2 Interaction parameters μ *and* α for PVC/ PES blends of different compositions in DMF at 35 ^{0}C

Weight fraction of PVC/ PES Blend	μ	α
0.2/0.8	-0.08036	-0.5072
0.4/0.6	-0.04418	-0.2641
0.5/0/5	-0.03316	-0.0440
0.6/0.4	-0.14800	-0.8620
0.8/0.2	-0.10040	-0.0574

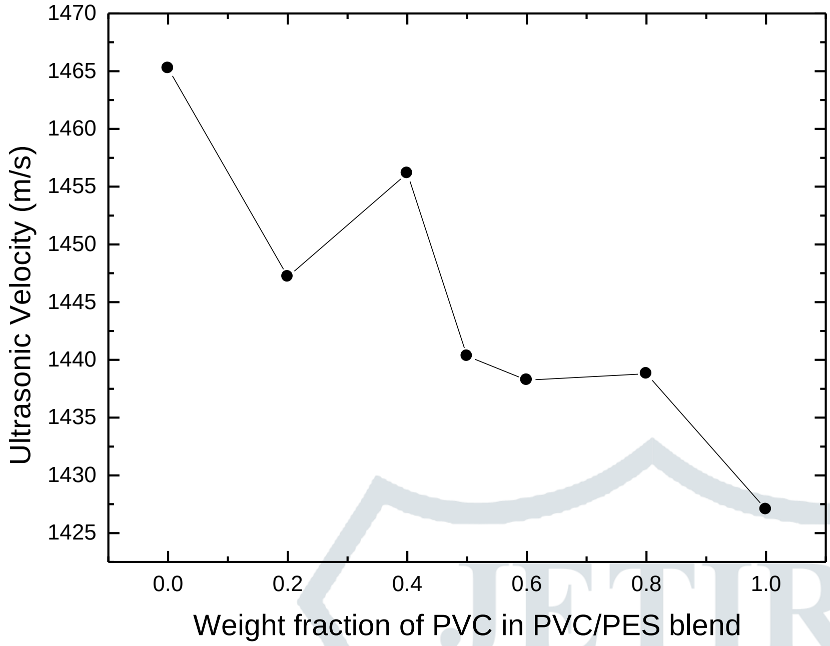

Fig. 2 The variation of ultrasonic velocity with weight fraction of PVC in PVC/ PES Blend in DMF at 35 ^{0}C

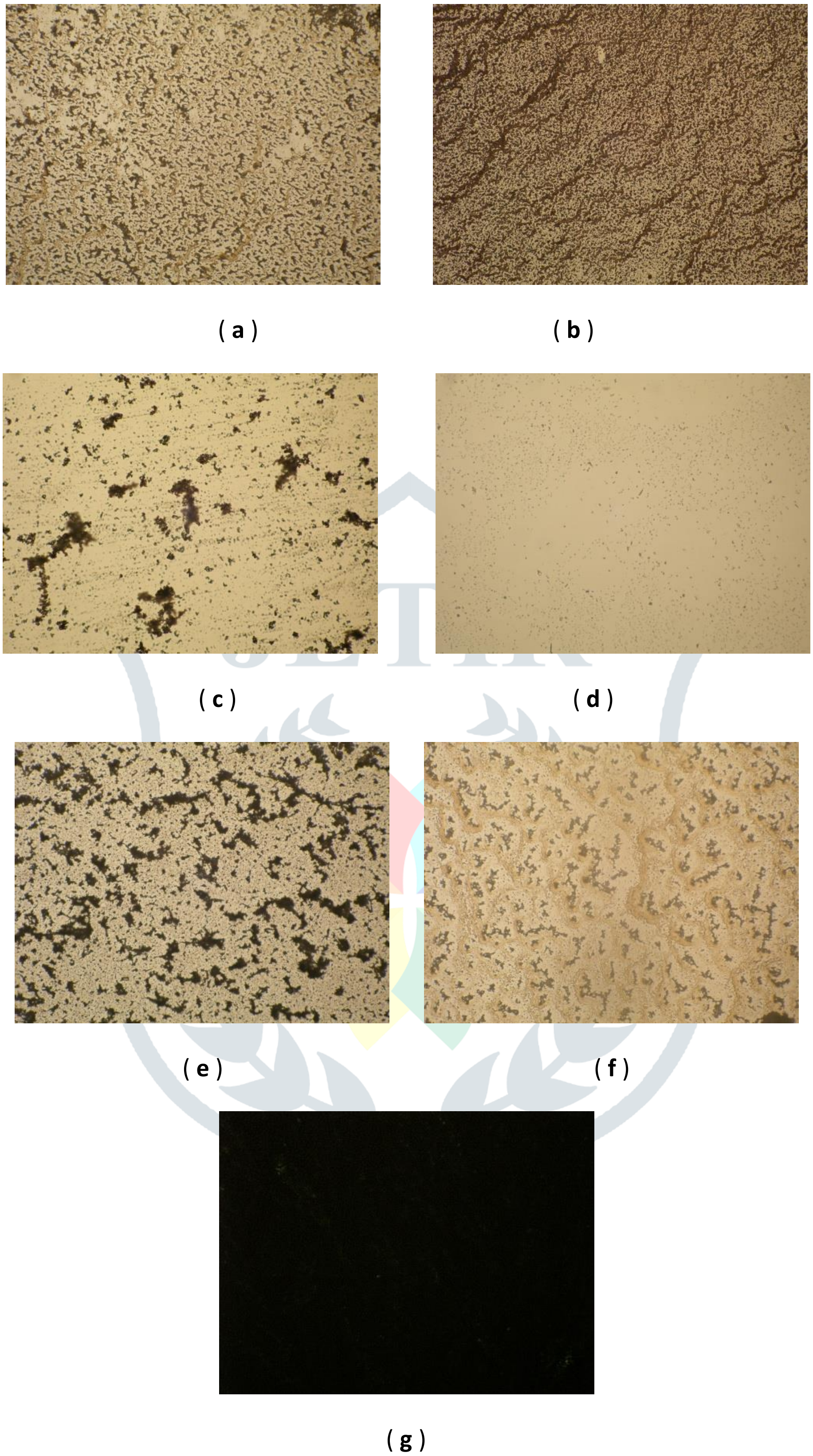

Fig. 3 Polarized Optical Micrographs of PVC/ PES blends with the weight fraction of PVC – (a) 0.0; (b) 0.2; (c) 0.4; (d) 0.5; (e) 0.6; (f) 0.8 ; (g) 1.0.