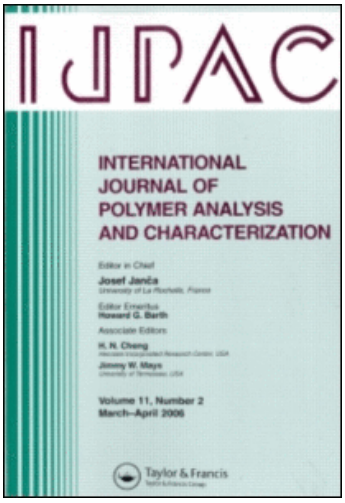

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Miscibility Studies of Poly(vinyl Acetate) Blends with Poly(methyl Methacrylate) and Poly(vinyl Chloride)

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Miscibility Studies of Poly(vinyl Acetate) Blends with Poly(methyl Methacrylate) and Poly(vinyl Chloride)

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Polymer blends of poly(vinyl acetate) (PVAc) with poly(vinyl chloride) (PVC) and poly(methyl methacrylate) (PMMA) have been prepared by solution blending, and their miscibility has been investigated using physical techniques. Viscosity, density, refractive index, and ultrasonic velocity for blend solutions at different percentages of the blend composition have been measured at 30°C. The interaction parameters calculated using the viscosity data and the results from physical techniques confirm that the blends PVAc/PMMA and PVAc/PVC are miscible.

Keywords: Polymer blends; Poly(vinyl acetate); Poly(vinyl chloride); Poly(methyl methacrylate); Miscibility

INTRODUCTION

Polymer blends are formed by combining two or more polymers by mechanical or chemical methods of intimate mixing. The importance of blending has increased recently because it has become a useful approach for the preparation of materials with new desirable properties that are absent from the component polymers. The blending of polymers may result in reduction of basic cost and improved processing and also may

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enable properties of importance to be maximized. However, the manifestation of these properties of polymer blends depends upon the miscibility of polymers at the molecular scale.

There are various techniques for studying the miscibility of polymer blends[1]. Solution blending methods for miscibility studies are simple and rapid in nature. Shaw and Singh[2] used ultrasonic and viscometric techniques to study the compatibility of polyblends. Singh and Singh[3] also used ultrasonic velocity in the solid state to study the miscibility of polyblends of poly(methyl methacrylate) with polystyrene. Hourston et al.[4] and Kuleznev et al.[5] suggested the use of sonic and viscosity measurements for miscibility determination. Chee[6], Sun et al.[7], and Pingping et al.[8] used viscosity methods to study the miscibility of various polymer blends in solution by evaluating interaction parameters. Edson et al.[9] investigated the influence of solvent and temperature on the miscibility of poly(methyl methacrylate)/poly(vinyl acetate) blends. Singh et al.[10] studied the miscibility of poly(vinyl chloride)/poly(vinyl acetate) blend in chlorobenzene. The present article discusses our investigation of miscibility of poly(vinyl acetate)/poly(methyl methacrylate) and poly(vinyl acetate)/poly(vinyl chloride) blends in toluene and tetrahydrofuran respectively, by viscometric, ultrasonic, density, and refractometric techniques.

EXPERIMENTAL METHODS

The blends of poly(vinyl acetate) (M/s. S.D. Fine Chem, India, $M_v = 150{,}000$) with poly(methyl methacrylate) (M/s. GSFC, India, $M_v = 98{,}000$) (PVAc/PMMA) and with poly(vinyl chloride) (M/s. Albert Victor, $M_v = 49{,}000$) (PVAc/PVC) of different compositions were prepared by mixing solutions of the polymers in toluene (Qualigens, AR Grade) and tetrahydrofuran (S.D. Fine Chem, AR Grade), respectively. The relative viscosity of blend solutions was determined at a constant temperature of 30 $\pm 0.01^\circ$C by immersing a Ubbelohde suspended-level viscometer (up to neck level) in a constant-temperature water bath.

Ultrasonic velocity measurements of the blend solutions of different compositions were carried out by an interferometric technique[11] using an ultrasonic interferometer (M/s. Mittal Enterprises, New Delhi). The temperature was maintained at 30°C by circulating water from a thermostat with a thermal stability of $\pm 0.05^\circ$C through the double-wall jacket of the ultrasonic experimental cell.

The densities of the polymer blends were measured using a specific-gravity bottle. The volume of the specific-gravity bottle was standardized using double-distilled water at 30°C. To maintain a constant temperature, the specific-gravity bottle with the sample was immersed up to the neck in the thermostat with a thermal stability of 0.05°C. Weight measurements

were made to 0.0001 gram. The accuracy was better than $\pm 0.01\%$. The refractive indices of solutions of compositions were measured at 30°C using an Abbe refractometer (M/s. Mittal Enterprises, New Delhi) at 30°C by circulating water from a thermostat. The total polymer concentration used for the ultrasonic velocity, density, and refractive index studies is 1%.

RESULTS AND DISCUSSIONS

The measured values of ultrasonic velocity, density, and refractive index of blend solutions of PVAc/PMMA and PVAc/PVC are presented in Table I. Figure 1 shows the Huggins plots for the blends of PVAc/PMMA and PVAc/PVC in which the weight fraction of both the components was maintained at 0.5. Chee[6] gave the expression for the interaction parameter (ΔB) when the polymers are mixed at weight fractions w_1 and w_2 as

$$\Delta B = \frac{b - \bar{b}}{2w_1 w_2} \tag{1}$$

TABLE I Ultrasonic velocity, density, and refractive index of PVAc/PMMA and PVAc/PVC blend solutions in toluene and tetrahydrofuran, respectively, at 30°C.

% PVAc in blend[a]	Ultrasonic velocity (m/s)	Density (g/cc)	Refractive index
PVAc/PMMA blend			
0	1278	0.8436	1.498
20	1275	0.8482	1.498
40	1272	0.8481	1.498
50	1272	0.8480	1.4985
60	1271	0.8479	1.499
80	1273	0.8470	1.499
100	1277	0.8407	1.499
PVAc/PVC blend			
0	1241	0.8625	1.412
20	1241	0.8619	1.412
40	1240	0.8607	1.412
50	1239	0.8581	1.411
60	1236	0.8596	1.411
80	1241	0.8594	1.412
100	1244	0.8584	1.412

[a]The total polymer concentration is 1%.

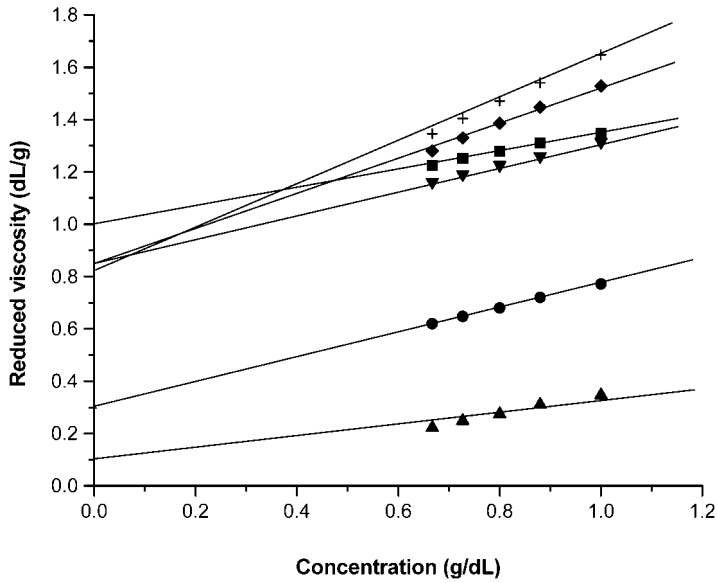

FIGURE 1 The variation of reduced viscosity with concentration in PVAc/PMMA and PVAc/PVC blends at 30°C; ■ PVAc in toluene, ● PVAc/PMMA in toluene, ▲ PMMA in toluene, ▼ PVAc in THF, ◆ PVAc/PVC in THF, + PVC in THF.

where $\bar{b} = w_1 b_{11} + w_2 b_{22}$, b_{11} and b_{22} are the slopes of the viscosity curves for the components, and b is related to Huggins coefficient K_H as

$$b = K_H[\eta]^2 \tag{2}$$

For ternary system, it is also given by

$$b = {w_1}^2 b_{11} + {w_2}^2 b_{22} + 2 w_1 w_2 b_{12} \tag{3}$$

where b_{12} is the slope for the blend solution.

Using these values, Chee[6] defined a more effective parameter

$$\mu = \frac{\Delta B}{\{[\eta]_2 - [\eta]_1\}^2} \tag{4}$$

where $[\eta]_1$ and $[\eta]_2$ are the intrinsic viscosities for the pure component solutions.

The blend is miscible if μ is positive and immiscible if μ is negative. In the present study the computed μ values for PVAc/PMMA and

VAc/PVC blends were found to be 0.07 and 19.84, respectively, confirming that the blends are miscible.

Recently Sun et al.[7] suggested a new equation by considering the long-range hydrodynamic interactions for the determination of the miscibility of polymers:

$$\alpha = K_m - \frac{K_1[\eta]_1{}^2 w_1{}^2 + K_2[\eta]_2{}^2 w_2{}^2 + 2\sqrt{K_1 K_2}[\eta]_1[\eta]_2 w_1 w_2}{\{[\eta]_1 w_1 + [\eta]_2 w_2\}^2} \qquad (5)$$

where K_1, K_2, and K_m are the Huggins constants for individual components 1, 2, and blend, respectively. Sun et al.[7] suggested that a blend would be miscible if α is positive and immiscible if α is negative. In the present study for the PVAc/PMMA and PVAc/PVC systems, α values were found to be 1.50 and 0.01, respectively, indicating that blends are miscible.

In order to confirm the miscibility of polymer blends under study, the variation of the ultrasonic velocity, density, and refractive index of the polymer blend solutions with composition are depicted in Table I. It is clearly evident that the linear variation infers the single phase for the blends and confirms that they are miscible. The data shows that PVAc/PMMA and PVAc/PVC blends do not vary significantly from the pure components, indicative that the blends are miscible.

CONCLUSION

The μ and α values for the blends PVAc/PMMA in toluene and PVAc/PVC in tetrahydrofuran are positive, and the variation in the ultrasonic velocity, density, and refractive index with the composition is linear, confirming that the blends are miscible.

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