Study of viscosity and refractive index of nylon 6,6 and poly(methyl methacrylate) in formic acid

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Polymer blends of nylon 6,6 with poly methyl methacrylate(PMMA) have been prepared by solution blending and their miscibility has been investigated using physical techniques. Viscosity and refractive index for blend solutions at different percentages of the blend composition have been measured at 30°C. The results are discussed.

Keywords: Nylon6,6, Polymethylmethacrylate, Viscosity, Refractive index, Miscibility

1 Introduction
Mixing two or more polymers together to produce blends is a well established strategy for achieving specified portfolio of physical properties without the need to synthesis specialized polymer systems. Blending of polymers is one of the simplest means to obtain a variety of physical and chemical properties from the constituent polymers. The blend of polymers always exhibits the superior properties when compared with individual components. The manifestation of superior properties of polymer blends depends upon the miscibility of polymers at the molecular scale. There are various techniques of studying the miscibility of polymer bends. Recently many simple and rapid solution techniques have been used for probing the miscibility of polymer blends in solution.

In this paper, miscibility behaviour of the polymer blends by determining the viscosity and refractive index has been studied.

2 Experimental Details
The blends of nylon 6,6/PMMA of different composition were prepared by solution blending in formic acid.

Viscosity measurements — The relative viscosity of blend solutions for different compositions was determined at a constant temperature of 30 ± 0.01°C by using an ubbelohode suspended level viscometer keeping in a constant-temperature water bath.

Refractive index — The refractive index of the blend solutions has been measured with Abbe’s refractometer (M/s. Mittal Enterprises, India). All the above parameters were measured at 30°C.

3 Results and Discussion
Fig. 1 shows the Huggins plots for nylon 6,6/PMMA blend in which the weight fraction of both the components has been maintained at 0.5.

Chee² has given an expression for the interaction parameter when the polymers are mixed in weight fractions of $W_1$ and $W_2$ as follows:

$$\Delta B = \frac{b - \bar{b}}{2W_1W_2}$$  \hspace{1cm} (1)

where $\bar{b} = W_1b_{11} + W_2b_{22}$.

Here $b_{11}$ and $b_{22}$ are the slopes of the viscosity curves for the components and $b$ is related to Huggins coefficient, $K_H$ as

![Fig. 1 — Variation of reduced viscosity with composition of Nylon6,6, Nylon6,6/PMMA blend, and PMMA](image-url)
\[ b = K_i [\eta]^2 \]  

... (2)

For ternary system, it is also given by

\[ b = W_1^2 b_{11} + W_2^2 b_{22} + 2 W_1 W_2 b_{12} \]  

... (3)

where \( b_{12} \) is slope of the viscosity curve for the blend solution.

Using these values, Chee\(^2\) has developed a novel approach, the \( \mu \) parameter to determine the polymer-polymer miscibility, which is as follows:

\[ \mu = \frac{\Delta B}{([\eta_i] - [\eta_{i2}])^2} \]  

... (4)

where \([\eta_i]_1\) and \([\eta_i]_2\) are the intrinsic viscosities for the pure component solutions.

The blend is miscible if \( \mu \geq 0 \) and immiscible when \( \mu < 0 \). In the present study, the value of \( \mu \) for Nylon6,6/PMMA blend was computed as 0.33256 indicating that the Nylon6,6/PMMA blend is miscible.

Sun et al.\(^{13}\) suggested for polymer-polymer miscibility, the \( \alpha \) parameter, which is given as follows:

\[ \alpha = K_m \frac{2 \sqrt{K_1 K_2} [\eta_i] [\eta_{i2}] W_1 W_2}{([\eta_i] W_1 + [\eta_{i2}] W_2)^2} \]  

... (5)

where \( K_1, K_2 \) and \( K_m \) are the Huggins constants for individual components 1, 2, and the blend respectively. While deriving this equation, the long-range hydrodynamics are taken into account. Sun et al.\(^{13}\) suggested that a blend is miscible if \( \alpha \geq 0 \) and immiscible when \( \alpha < 0 \). In the present study, the \( \alpha \) value was found to be 0.4950 for Nylon6,6/PMMA blend indicating that the Nylon6,6/PMMA blend is miscible.

The blend solutions are prepared with Nylon6,6, PMMA and Nylon6,6/PMMA blend in Formic acid as solvent. The relative viscosity \( \eta_{rel} \) for each composition of the polymer blend Nylon6,6/PMMA was determined by viscometer at 30°C. The relative, specific, reduced viscosities of the polymerblend solutions for different compositions are calculated by measuring the flow time of different solutions and the values are presented in Tables 1-3 respectively.

The measured values of refractive index of the Nylon6,6/PMMA blend solutions in formic acid are presented in Table 4. The graph of refractive index values verses percentage of blend composition clearly indicates that the blend is miscible because of linear variation of refractive index values with blend composition (Fig. 2).
4 Conclusions

In this paper, from graphs 1, 2 the variation of reduced viscosity, refractive index with blend composition is linear confirms the blend is miscible. So nylon 6,6/PMMA blend is miscible.

References