Studies on the Thermomechanical Behaviours of PS: Pmma Blend

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Abstract: Polymer blending has become a technique for providing materials with extended useful properties beyond the range that can be obtained from single polymer equivalent. The tensile strength, elongation and thermal degradation profiles of PS: PMMA blends were investigated using Tensiometric and TGA methods. The highest tensile strength and elongation were prominent at 0.164 and 0.371 PMMA base mole fractions. The optimal temperature of blend degradation stabilizes are at 0.164, 0.228 and 0.019 PMMA base mole ratios. Thus, it is advisable to blend at these compositions.

Key words: Elongation · Optimal Interaction · Polymer Blend · TGA and Tensile Strength

INTRODUCTION

The blending of two or more polymers has become an increasingly important technique for improving the cost performance ratio of commercial plastics. For example, blending may be used to reduce the cost of an expensive engineering thermoplastic, to improve processibility of a high temperature or heat sensitive thermoplastic or to improve impact resistance [1, 2]. A shorter period of time and effort is required to develop a new product via blending existing materials in comparison with that needed to develop a new polymer. Polymer blends are becoming more important in specific sectors of polymer industry, as they can frequently meet performance requirements that cannot be satisfied by the currently available commodity polymers [3, 4]. Consequently their attractiveness increases with increasing demand for this class of materials. The scientific and commercial progress in this area during the past two decades has been tremendous and was driven by the realization that new molecules are not always required to meet needs for new materials and that blending can usually be implemented more rapidly and economically than development of new chemistry. This represents a very important field in processing new material which has better properties [5-7].

The physical and mechanical properties of these blends are sensitive to small variations in the amounts of the individual variety of analytical tools to monitor blend composition. The tools usually used include FTIR, TGA, DSC and Tensiometers [4]. In the present work the thermal and mechanical properties of the blends were analyzed using tensiometric and TGA techniques.

MATERIALS AND METHODS

Experimental: The materials were used as received: tetrahydrofuran from Pharmacos Ltd, Southend-on sea, Essex, England; cyclohexane from Riedel-Dahacnag Seelze-Hannover, Germany; PS and PMMA from British Drug House Poole, England.

Blend Preparation: PS (50g/ 950cm³) and PMMA (20g/ 800cm³) were respectively dissolved in tetrahydrofuran and cyclohexane. Varying volumes of PS solution were mixed each with 25cm³ of the stock solution of PMMA. Each polymer solution pair was stirred vigorously for uniform mixing and then was immediately transferred to a mould. Also, 25.0cm³ of each homopolymer was poured into their respective moulds. The method allowed the films of the blends to be formed on the surface of the moulds, after the evaporation of the solvents. The films were kept at room temperature for seven days to ensure absolute evaporation and further vacuum dried. Then the base mole ratios of the mixtures were calculated.

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Determination of the Mechanical Properties of the PS: PMMA Blends: The tensile strength and elongation of the blends were determined using the Abba Tensile Testing Machine, New Delhi, India 2005, following the approach as in Ref. [8].

Thermogravimetric Analysis (TGA): TGA was performed on a TGA-7 (Perkin Elmer) instrument. Data was analyzed with the Pyris v8 software (Perkin Elmer) at the Forest Product Laboratory, University of Idaho, USA (Courtesy of Prof. M. Armando). Ten milligram sample of each homopolymer/blend species was taken for analysis. Each sample was analyzed at a heating rate of 20°C/min from room temperature to 700°C in a nitrogen atmosphere (Flow rate 60mL/ min). The optimum scan parameters for the thermogravimetric studies were then selected; meanwhile, the sample was allowed to attain equilibrium within the furnace, after which the run was started. The run was automatically stopped as the set temperature was reached. The weight change was recorded as a function of temperature. Derivative peak temperature was taken as the maximum temperature acquired from the differentiation of the weight change as a function of temperature.

RESULTS AND DISCUSSION

In this study, the degrees of interaction of the blend components at various ratios were monitored. The observed tensile strength, elongation, start and end temperatures of degradation were compared with the theoretical values: $\gamma_{theoretical} = \gamma_1(M_1) + \gamma_2(M_2)$ [8], where $\gamma_{theoretical}$ is the theoretical tensile, elongation, start and end degradation temperatures, γ_1 and γ_2 are the observed blend properties and M_1 and M_2 are the base mole fractions of the blend components. The reason for employing this technique is to establish points of optimal interaction. The authors said that deviation from additive value is a measure of the degree of interaction.

Fig. 1 shows two outstanding interactions at o.164 and 0.371 PMMA base mole fractions. The interaction is minimal at other compositions. It is also obvious that at lower PMMA concentrations, theoretical tensile strength is higher than the observed. From this, it can be inferred that it will be appropriate to blend at these two compositions 0.164 and 0.371 where optimal interactions are located.

It is apparent in Fig.2 that strong interaction also occurs at same 0.164 and 0.371 PMMA base mole ratios. Thus, it is evident that whether tensile strength or elongation is used similar result is obtained.
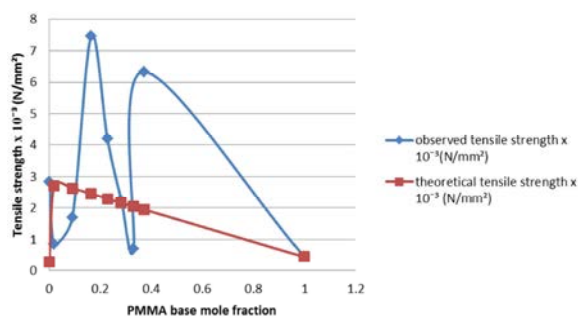

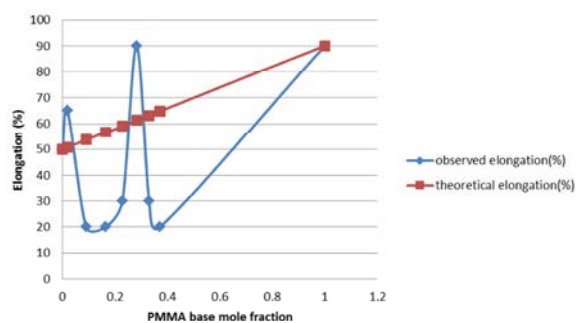Fig. 1: Effect of composition on the tensile strength of PS: PMMA blend.

Fig. 2: Effect of composition on the elongation of PS: PMMA blend

On considering the thermal properties of the blend, it is seen in Fig.3 that blending of PS with PMMA results in a material where the theoretical start temperature of degradation is higher than that of the observed. This theoretical start temperature decreases with increase in concentration while that of the observed increases with increase in the concentration. A sudden increase is evident at 0.33 PMMA base mole ratio. Using this technique, interaction occurs significantly in the range 0.019-0.164 PMMA base mole fractions. The blending decreases the temperatures of pure PS (285°C) and PMMA (280°C) in the range 270-280°C. In the case of the end temperature of degradation, Fig.4 depicts the theoretical end temperature to be greater than the observed end temperature. The optimal interaction is prominent at 0.330 PMMA base mole fraction and also at 0.164, 0.228 and 0.371 base mole ratios. The blending raised the end temperature of pure PS and PMMA from 420-440°C and 410-440°C respectively. The temperature of PS lowers at 0.09 base mole fractions. Fig. 5 shows the temperature range of theoretical and observed for start and End temperatures. The 0.164 PMMA base mole gave the highest temperature range followed by 0.228 and 0.019 base mole ratio. This indicates that the blend is more thermally stable at these concentrations.
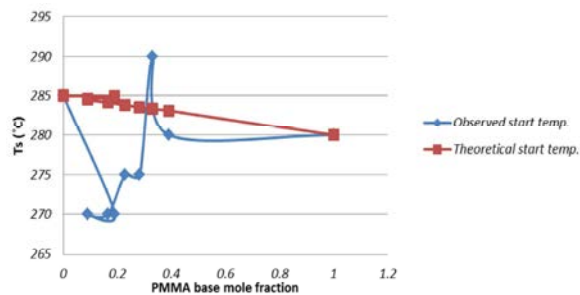
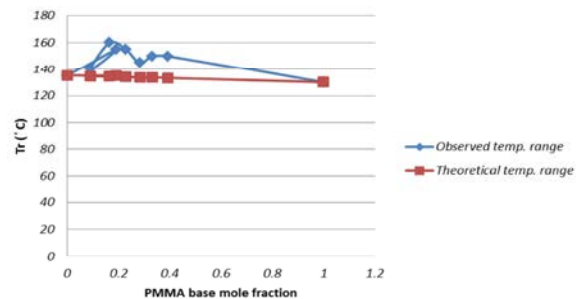Fig. 3a: Effect of blend composition on start temperature (Ts) of degradation.

Fig. 3b: Effect of composition on degree of interaction of PS: PMMA in a blend.
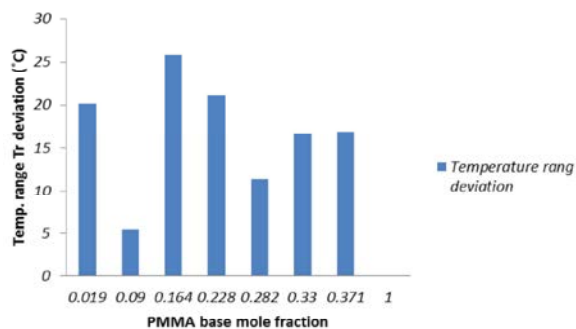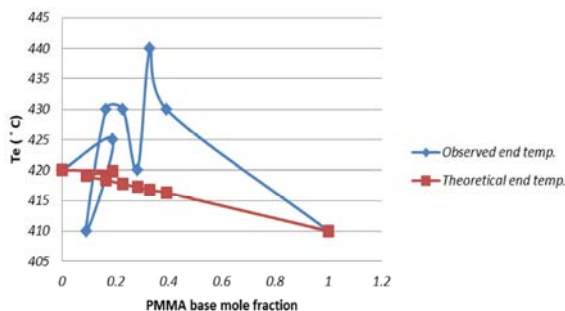

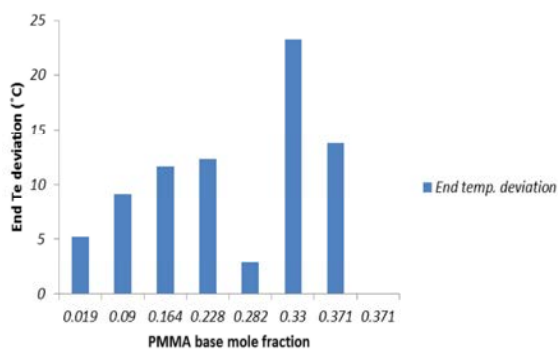Fig. 4a: Effect of blending composition on end temperature (Te) of degradation).

Fig. 4b: Effect of composition on degree of interaction of PS: PMMA in a blend.

Fig. 5a: Effect of blending composition on temperature range (Tr) of degradation).

Fig. 5b: Effect of composition on degree of interaction of PS: PMMA in a blend

CONCLUSION

The optimal interactions considering tensile and elongation occur at the same PMMA base mole fractions 0.164 and o.371. The blend gave the highest temperature of stability at 0.164 PMMA base mole fraction. It is also evident at 0.228 and 0.019 base mole ratios. The study demonstrates that it is possible to use Tensiometric technique to establish the optimal ratio at which PS and PMMA could be blended. It is concluded that blending somewhat reduced the temperatures of on-set of degradation vis-à-vis the homopolymers. It is great of importance to always consider the points of optimal interaction before blending.

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