STRUCTURE PROPERTY RELATIONSHIP STUDIES ON PA6/EVA BLENDS AND ALLOYS

By

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Polynomials

DEDICATED TO MY BELOVED PARENTS
TO WHOM I AM INDEBTED FOR WHAT I AM

CERTIFICATE

This is to certify that the thesis entitled **'STRUCTURE PROPERTY RELATIONSHIP STUDIES ON PA6/EVA BLENDS AND ALLOYS'** being submitted by Mr. Arup Ranjan Bhattacharyya to the Indian Institute of Technology, Delhi for the award of degree of Doctor of Philosophy, is a record of bonafide research work carried by him. Mr. Arup Ranjan Bhattacharyya has worked under my guidance and supervision and has fulfilled the requirements for the submission of this thesis, which to my knowledge has reached the requisite standard.

The results contained in this thesis have not been submitted, in part or full, to any other University or Institute for the award of any degree or diploma.

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ABSTRACT

Polyamide6 (PA6) is an engineering thermoplastic with many attractive properties, however it has certain shortcomings such as low impact strength particularly below its glass transition temperature, has low melt strength and exhibits poor dimensional stability. Modification of PA6 by melt blending for enhancement of its impact strength is the major thrust of this thesis. The technique of rubber toughening has been successfully applied to PA6 by melt blending with rubbery polymers such as EPM, EPDM, SEBS, EPDM-g-MA, SEBS-g-MA and ABS.

The main objective of the present study is to enhance the impact strength of PA6 by melt blending with EVA copolymer and by further compatibilizing the blend system using two different techniques, namely, (i) physical compatibilization - by adding an ionomer (Surlyn) and (ii) reactive compatibilization - by adding EVA grafted with maleic anhydride (MA). It was also aimed to establish the structure property relationship of the blends/alloys studied.

Binary blends of PA6/EVA were prepared with the level of EVA varying from 0 to 50 wt.%. In the ternary alloys of PA6/EVA/Surlyn, the ratio of PA6 and EVA plus Surlyn was kept at 80/20 while the level of Surlyn was varied from 0.4 to 1.6 wt.%. In the reactively compatibilized system, the effective level of MA varied from 0.2 to 1.2 wt.% with different levels of grafted MA keeping the ratio of PA6 and EVA-g-MA at 80/20. In the ternary blends of PA6/EVA/EVA-g-MA, the level of EVA-g-MA was varied from 10 to 15 wt.% keeping the overall ratio of PA6 and EVA plus EVA-g-MA at 80/20.

Studies on the mechanical properties showed that the addition of EVA to PA6 increased the impact strength, the increase being significantly enhanced by effective compatibilization in both physical as well as reactive methods. The brittle-to-tough transition temperature decreased on addition of either ionomer or EVA-g-MA. The effectiveness of reactive compatibilization was significantly superior to that of physical compatibilization with the increase in impact strength being over six times greater compared to a three fold increase by physical compatibilization as compared to the base PA6/EVA blend. Furthermore, uncompatibilized blends showed a decrease in tensile strength and modulus as well as flexural properties, whereas in the compatibilized systems the decrease was much less, and in fact in some cases tensile strength was higher than that of the base blend. The tensile strength of all the blends and alloys were analyzed by different theoretical models, such as the Neilsen's Power law models and Nicolais and Narkis model, to determine the interfacial adhesion between the two phases. All the three models correlated well with the experimental data and were useful in the analysis of results. It was found that the experimental relative tensile strength of the PA6/EVA binary blends showed higher values as compared to theoretically predicted values up to 20 wt.% EVA level confirming good adhesion between the two phases, while the interfacial adhesion decreased at EVA level of more than 20 wt.%. The analysis also showed that in the presence of the ionomer the interfacial adhesion improved significantly in PA6/EVA blend as compared to uncompatibilized PA6/EVA blend. The interfacial adhesion improved even further in the case of PA6/EVA-g-MA reactively compatibilized blends.

Morphological studies of all PA6/EVA based blends and alloys showed a two-phase morphology. The nature of the two-phase morphology was dependent on the composition of the blends. In general, it can be seen that from the morphological observations that PA6/EVA blends are immiscible/ incompatible due to higher interfacial tension and lower interfacial adhesion between the two components. The addition of an ionomer resulted in a finer morphology, which attributed to the lowering of interfacial tension and as well as higher interfacial adhesion between the two phases. It is also found that at a critical ionomer level (0.8 wt.%) the maximum reduction of EVA domain size took place due to emulsifying effect of the ionomers in this alloy system. Similarly, on addition of EVA-g-MA of different levels of MA content, the morphology of the binary and the ternary alloys changed significantly. It was found that the domain size of EVA decreased with increasing MA content indicating lowering of interfacial tension and reduction of rate of coalescence. The interfacial area per unit volume of dispersed phase increased with increasing MA content.

The melting and crystallization study showed that PA6/EVA binary blends are incompatible due to the limited miscibility between PA6 and EVA. In the binary blends, the two components crystallize separately at their bulk crystallization temperatures. On addition of the ionomer, the miscibility between PA6 and EVA improved as can be seen from the depression of melting point of PA6 in the ternary blends as compared to binary blends. The addition of EVA-g-

MA strongly affects the mobility of the PA6 chain, thus influencing the crystallization behaviour in the reactive blends. The improvement of miscibility is more than that of physically compatibilized blend.

In all, it has been successfully demonstrated that PA6 can be effectively modified by EVA for impact enhancement with the use of suitable compatibilization, which is either physical with the addition of small amounts of an ionomer or reactive with the addition of EVA-g-MA.

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