STUDIES ON THE MODIFICATION OF THERMOPLASTIC POLYESTERS BY BLENDING WITH POLYCARBONATE AND POLYPROPYLENE

BY

RAMSANKAR HALDAR

CENTRE FOR MATERIALS SCIENCE AND TECHNOLOGY

Submitted
in the fulfilment of the requirements
of the degree of

DOCTOR OF PHILOSOPHY

to the

INDIAN INSTITUTE OF TECHNOLOGY, DELHI

May, 1987

D E D I C A T E D

T O

M Y M O T H E R

ABSTRACT

Blends of polyethylene terephthalate (PET) as well as polybutylene terephthalate (PBT) have been developed in order to modify these two thermoplastic polyesters to attain superior performance properties which can be suitable for a wide field of engineering applications. This has been made possible by overcoming the drawbacks of these polymers by judicially blending other polymer/polymers with them. A number of blends, both binary and ternary have been prepared keeping PET or PBT as the primary component. Other polymers chosen for blending were Bisphenol-A-polycarbonate (PC) and polypropylene (PP). In this way binary blends of PET/PC and PBT/PC of differen t compositions were prepared. On the other hand, ternary blends comprising of PET, PC, and PP, as well as PBT, PC, and PP were made where the concentration of PP was varied while the ratio of polyester to polycarbonate was kept fixed.

Various studies have been performed on the blends thus developed and their results are reported in this work. These include the phase behaviour by thermal analysis, dynamic mechanical analysis, and microscopy; crystallization characteristics by density measurements; superstructure morphology by light scattering; intercomponent interactions by thermogravimetric analysis and viscosity measurements;

and the mechanical properties of the blends by tensile and impact experiments.

Thermal analysis of the blends was done by differential scanning calorimetry. 50/50 (w/w) binary blends of PET and PC, and PBT and PC show a single glass transition which is indicative of a single amorphous phase formed by a mixture of the components. In the ternary blends also, a single T_g was observed in the experimental temperature limits and it was found to vary with the increasing percentage of PP. This signifies that although PP is immiscible to the other components, it affects significantly the morphology of the miscible polyester/polycarbonate blend. In the ternary blends of PET as well as PBT, an exothermic transition was found to occur before the melting temperature of the polyester component and this was attributed to a combination of the degradation of PP and the melting of the polyester component.

The results of dynamic mechanical analysis revealed that all the binary blends comprised of multiple phases and the composition of these phases depends largely on the blend composition. Addition of PP, on the other hand, shows significant effect on the formation of phases in a ternary blend. Composition of the phases formed has also been found to vary with the increasing concentration of the PP component.

Scanning electron microscopy was used to visualize the phase structure of the blends. Micrographs for binary blends show an almost uniform dispersion of the components. In the ternary blends, PP forms a continuous sleeve around the miscible polyester/polycarbonate blend. This has been confirmed by dissolving away the PP component from the sheath and core regions of a ternary blend moulded samples with boiling xylene. The amount of PP leached away was estimated quantitatively by weighing the samples before and after treatment.

Overall crystallinity of the blends was determined by density measurement technique. Percent crystallinity of the annealed binary blends was found to decrease linearly with the PC concentration. Crystallinity of the ternary blends as moulded decreases initially with the amount of PP followed by a rise in its value till the maximum percentage of PP is added. Annealing increases the crystallinity of the ternary blends in all compositions and the major improvement was found at 10-20% PP level. Crystallization kinetics for the polyester component in the binary blends has been studied from the crystallinity data. It has been observed that as the percentage of PC increases, the rate of crystallization of the polyester in the blend decreases.

Superstructure morphology of the binary blends was studied by small angle light scattering. H_v-scattering

patterns were analysed to study the change in shape, size and nature of the superstructures formed with crystallization time and with the increasing amount of PC in the blend. Spherulitic nature of superstructure changes to disc-and/or rod-like at higher percentages of PC. The unusual type pattern of PBT changes to usual type pattern in the blends of PBT containing higher amount of PC.

Binary blends of PET and PC, and PBT and PC form miscible phases. Interchange reaction between the ester and carbonate linkages has been found to be insignificant in these systems. Viscometric and thermogravimetric study refer to strong interactions between the polyester and polycarbonate components and it has been presumed to be physical in nature. Although PP is immiscible with PET (or PBT) and PC it shows some kind of interactions with those components in the ternary blends.

Mechanical properties of the pure polyesters (PET as well as PBT) have been found to increase significantly with the incorporation of PC. In the ternary blends, variations of mechanical properties with PP content have been measured keeping the ratio of polyester and polycarbonate constant. Tensile strength and modulus are found to decrease with increasing PP content. Impact strength increases up to a certain level of PP and then decreases, while the unnotched values fall gradually with PP concentration. This has been

explained on the basis of different skin and core morphologies of the blends. The effect of annealing on the mechanical properties are also discussed on the basis of increased crystallinity of the polyester component in the blend.

CERTIFICATE

This is to certify that the thesis entitled "Studies on the Modification of Thermoplastic Polyesters by Blending with Polycarbonate and Polypropylene" being submitted by Sri Ramsankar Halder to the Indian Institute of Technology, Delhi for the award of the degree of Doctor of Philosophy, is a record of bonafide research work carried out by him. Sri Ramsankar Haldar has worked under our guidence and supervision and has fulfilled the requirements for the submission of the thesis which to our knowledge has requisite standard.

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

(B.L. DEOPURA)
Asstt. Professor
Department of Textile Technology
Indian Institute of Technology.
New Delhi - 110 016

(ASHOK MISRA)
Professor
Centre for Materials Science &
Technology,
Indian Institute of Technology
New Delhi - 110 016

A C K N O W L E D G E M E N T S

I wish to express my sincere thanks to Dr. Ashok Misra, Professor, Centre for Materials Science and Technology, Indian Institute of Technology, Delhi for his dynamic guidance, constant encouragement and kind help which motivated me in doing this work.

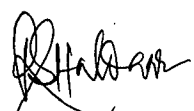
I am thankful to Dr. B.L. Deopura, Assistant Professor, Department of Textile Technology, Indian Institute of Technology, Delhi for his ready help, fruitful discussions and valuable suggestions.

I am thankful to Prof. (Mrs.) I.K. Verma, Head, Centre for Materials Science and Technology and Prof. (Miss) P. Bajaj, Former Head, Department of Textile Technology, Indian Institute of Technology, Delhi for providing the laboratory facilities.

Thanks are due to Mr. V.C. Agerwal, General Manager and Dr. S.K.Bahl, General Works Manager, Xpro India Ltd., for their kind encouragement to carry out this work.

I wish to acknowledge the National Science Foundation (U.S.A.) for providing the fund for this research work.

The help rendered by Dr. S.K. Sharma, Dr. S.K. Bhattacharya, Dr. Ashok Tendolkar, Mr. D.P. Mitra, Mrs. Mangala Joshi, Mr. S.K. Dhara, Mr. A.K. Rakshit, Mr. Kashi Bhowmick and Mr. Anjan Mukhopadhyay, is gratefully acknowledged. Lastly I thank all my friends of Materials Science and Textile Technology department for their help and Co-operation. The assistance from the technical staff to carry out this work is also sincerely acknowledged.



(Ramsankar Haldar)

New Delhi.

CONTENTS