INVESTIGATIONS OF PROPERTIES AND STRUCTURE OF POLYPROPYLENE/STYRENE-b-ETHYLENE-co-BUTYLENE-b-STYRENE TRI-BLOCK COPOLYMER BLENDS

By

S N. PURWAR

CENTRE FOR MATERIALS SCIENCE & TECHNOLOGY

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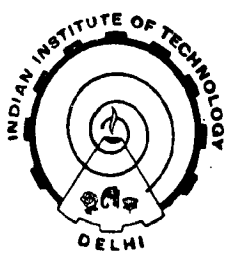

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C E R T I F I C A T E

This is to certify that the thesis entitled, "Investigations of Properties and Structure of Polypropylene/ Styrene-b-Ethylene-co-Butylene-b-Styrene tri-Block Copolymer Blend" being submitted by S.N. Purwar to the Indian Institute of Technology, Delhi, for the award of the degree of Doctor of Philosophy in Polymer Science & Technology, is a record of bonafide research work carried out by him. Mr. S.N. Purwar has worked under my guidance and supervision and has fulfilled the requirement for the submission of this thesis which to my knowledge has reached the requisite standard.

The result 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.

A.K. Gupta
Thesis Supervisor
Assistant Professor
Centre for Materials Science & Technology
Indian Institute of Technology,
New Delhi-110016, India.

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

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(S.N. Purwar)

ABSTRACT

Studies on the blends of polypropylene (PP) with recently developed thermoplastic elastomer viz. styrene-b-ethylene-co-butylene-b-styrene (SEBS) in the composition range 0 to 25 wt. % SEBS are reported. Studies include melt rheological behaviour, tensile, impact and dynamic mechanical properties, crystallization of PP component in the blend and the morphology and mode of fracture through scanning electron microscopy.

Melt rheological properties show in general a decrease of flow temperature and melt viscosity and melt elasticity of PP on blending with SEBS. Melt fracture or tendency towards extrudate distortion of PP is considerably reduced on blending with SEBS.

The tensile properties (tensile strength, modulus and yield stress) of PP decreases on blending with SEBS. Tensile yield behaviour studied on three different sets of samples, viz. solution blended compression moulded (SBCM), melt blended compression moulded (MBCM), and melt blended injection moulded (MBIM), showed a systematic variation with varying blend composition. Stress whitening during tensile stretching in the yield region showed characteristic features of shear bands as opposed to crazing.

Analysis of yield stress data on the basis of the various theories of blend composition dependence led to

consistent conclusions from all the theories about the differences of stress concentration effect in these different sets of samples MBIM, MBCM and SBCM. Differences in the blend morphology provide supporting evidence for these differences in stress concentration effects. Results on these three sets of samples are discussed in detail to describe the effects of these different blending techniques and the subsequent mixing of the two phases during injection moulding.

Impact strength of the three sets of samples, measured at ambient temperature as a function, of blend composition, showed following order of improvement of impact strength : MBIM > SBCM > MBCM. Impact behaviour at low temperatures, viz. -30°C and -190°C, for MBIM set of samples, showed no toughening effect at -190°C (where both the phases were at its glassy state). At -30°C (where PP is in its glassy state and SEBS is rubbery), the impact strength enhancement is considerably lower than that at ambient temperature. Distinctly different mechanisms of toughening are suspected at ambient temperature and at -30°C in this blend. From the results of dynamic mechanical measurements a third mechanism of toughening viz. viscoelastic energy dissipation is found to be operative in this blend. This

third mechanism accounted well for the observed superior toughening at ambient temperature than at -30°C.

Dynamic mechanical measurements, in addition to confirming the two phase character of this blend through two distinct glass transition relaxation peaks, show a non-linear decrease of shear modulus with SEBS content of the blend, showing minima around 10% SEBS content. This effect is discussed in terms of the morphological features such as the domain size of SEBS domains.

Crystallization behaviour of PP component in this blend is studied in detail using differential thermal analysis (DTA) and X-ray diffraction. Variation of X-ray and DTA crystallinity showed a remarkable agreement. The DTA data are analysed to show the effect of blend composition on the crystalline morphology, viz. degree of crystallinity and crystallite size. Non-linear variations of crystallization parameters with SEBS content are discussed in terms of differences in nucleation and growth rates, which finally result in the distinctly different crystalline morphology in the three regions of SEBS content, low (0-5%), intermediate (5-15%), and high (15-25%). Correlation of crystallization parameters with tensile properties in the entire range of blend composition studied is discussed and found linear in most cases which suggests a direct role of crystallization of PP on the mechanical properties of this blend.

Studies on ternary blends with the incorporation of PS or HDPE as a third component in the PP/SEBS blend are presented out in a later part of this thesis. All the above mentioned studies (viz. melt rheology, tensile and impact properties, morphology and mode of fracture) are carried out for these binary and ternary blends at constant blend composition. PP/SEBS/HDPE ternary blend showed distinct further improvement in the properties of PP/SEBS whereas PP/SEBS/PS was found inferior to the PP/SEBS binary blend. Impact strength of PP/SEBS blend increased nearly two-fold on incorporation of HDPE as a third component, and the tendency for extrudate distortion decreased considerably.

These data on the various blends enabled to propose a theoretical model for the dependence of the tendency for extrudate distortion on the material properties viz. melt elasticity and melt viscosity. According to this, at the critical shear stress for the first appearance of extrudate distortion the ratio (melt elasticity parameter)$^{\frac{1}{2}}$/(melt viscosity) should have a constant critical value, which is fully supported by these data on various binary and ternary blends.

Tensile properties of these ternary blends showed superior properties for PP/SEBS/HDPE blend than PP/SEBS/PS or binary blends PP/SEBS or PP/HDPE. Differences in the tensile yield behaviour of the different samples and their

correlation with impact strength suggested shear yielding as the possible mechanism of enhancement of impact strength, which is supported by the scanning electron microscopic studies of the mode of fracture of these samples.

C O N T E N T S