IMPACT TOUGHENING AND CRYSTALLIZATION STUDIES ON BINARY BLENDS OF POLYPROPYLENE

by

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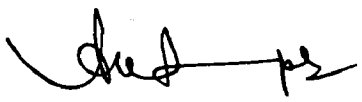
CERTIFICATE

This is to certify that the thesis entitled "**Impact Toughening and Crystallization Studies on Binary Blends of Polypropylene**" being submitted by Mr. **Seyed Hassan Jafari Amanabadi** to the Indian Institute of Technology, Delhi, for the award of the degree of Doctor of Philosophy in Polymer Science and Technology, is a record of bonafide research work carried out by him. Mr. Jafari 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 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

In order to investigate the effect of blending on property modification of polypropylene such as, impact toughening, mechanical properties, crystallization behaviour and dynamic mechanical properties etc. this work has been carried out on six different binary blends of PP. The polymers used as the second component of the blends viz. EPDM, EVA, ABS, Nylon6 (N6), PC and PMMA, are chosen to cover materials ranging from conventional elastomers to rigid polymers and polymers with inherent toughness. The blends were prepared under similar processing conditions in the range of 0 to 30 wt% of second component in PP. Various properties studied include: mechanical properties such as impact strength, tensile and flexural properties, dynamic mechanical properties (damping and stiffness), morphological characterization (i.e. dispersion, dispersed domain size, size distribution and its number density, mode of fracture etc), crystallization behaviour and crystalline morphology such as spherulite size, size distribution nucleation density, nucleation rate, degree of crystallinity and overall crystallization rate were studied.

Correlation of mechanical properties, and crystallization behaviour, with morphology of dispersed domains phase done to interpret the role of these different polymers in modifying properties of PP. The role of various parameters responsible for property modification of PP were investigated. Analysis of yield stress data revealed the role of stress concentration effects and interfacial adhesion in impact toughening of PP as one of the mechanisms of impact toughening. Correlation of yield stress with impact strength also revealed the role of shear yielding in impact toughening of PP. Moreover analysis of morphology of the dispersed domains and its correlation with impact toughening revealed the role of dispersed phase size, size distribution and number density in impact toughening of PP. Direct correlation is found between the impact strength and size, size distribution and number density of dispersed

domains in this group of blends.

Impact strength increases by increasing the size, size distribution and number density of dispersed domains in PP/elastomer blends. For shear yielding mechanism the number of dispersed domains were found to be more important whereas the size plays important role in crazing mechanism. Deformation of dispersed domain phase under impact loading was found to be another mechanism of energy dissipation for impact strength improvement. . The correlation of flexural strength and impact revealed the importance of flexural stiffness of the samples in impact toughening.

Crystallization behaviour of PP was found to be largely affected by presence of second component of the blend. The effects were seen in nucleation rate, and resulting crystallite size and size distribution and overall crystallinity. Nucleation rate of PP decreased in the presence of the second components, however EPDM and EVA behaved as nucleating agents for PP and increased the crystallinity of the matrix. These changes in crystallinity were found to be responsible for changes in various mechanical properties.

Crystallization behaviour of PP in the presence of a crystallizable polymer, viz. nylon 6 (N6), showed some new effect on the crystalline morphology of PP. This inspired a detailed investigation of the observed phenomena by carrying out the crystallization studies at different isothermal crystallization temperatures, and finally correlation between the crystallization behaviour observed in differential scanning calorimetry (DSC) and polarizing light microscopy (PLM) are presented to provide the greater insight into the crystallization of the PP in presence of other crystallizable component, viz. N6. This crystallization behaviour is ultimately correlated with the changes in mechanical properties as a function of blend compositions for the various blends.

Evidence of "engulfing" due to the presence of composite spherulites with N6 spherulites surrounded by PP spherulites, particularly at higher N6 content of the blend (i.e.

was seen
above 20% N6 content). However, at 10% N6 content, the inner core due to N6 spherulite is not distinguishable which is attributed to the predominance of the "rejection" process. The energy dissipation in rejection and/or engulfing processes are expected to reduce the crystallization wave-front growth rate, thereby reducing spherulite growth rate. The observed decrease of spherulite growth rate with blending ratio (i.e. wt% of N6 content) is thus interpreted in terms of the rejection and engulfing processes.

In case of PP/EVA blend, the inclusion is in the melt state at the crystallization temperature of PP, unlike PP/N6 blend in which N6 is already crystallized at the crystallization temperature of PP. It is found that EVA increases the nucleation rate, overall rate of crystallization and degree of crystallinity of PP, whereas, N6 decreases the nucleation rate, overall rate of crystallization and degree of crystallinity of PP in the range of low blending ratio. These variations of crystalline morphology were also supported by polarized light microscopy results. X-ray diffraction results of this blend are also presented and correlated with the DSC crystallization results.

Investigation of dynamic mechanical properties revealed the effect of blending on the various relaxation processes in PP which depend on nature of inclusion. The variation of the dynamic relaxation parameters with impact toughening showed the importance of dynamic mechanical energy dissipation as one of the mechanism contributing in impact strength improvement.

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