

**SHORT GLASS FIBRE REINFORCED  
COMPOSITES BASED ON THE BLENDS OF  
POLYAMIDE 6/ABS**

*by*  
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**DEDICATION**  
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**TO MY PARENTS**

## CERTIFICATE

This is to certify that the thesis entitled ' **SHORT GLASS FIBRE REINFORCED COMPOSITES BASED ON THE BLENDS OF POLYAMIDE 6/ABS** ' being submitted by **Mr. K. Kannan** to the Indian Institute of Technology, Delhi for the award of degree of Doctor of Philosophy, is a record of bonafide research work carried out by him. Mr. K. Kannan 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

The development of technology for the upgradation of performance properties of existing polymers is growing rapidly because of high cost associated in the development of new polymers. Considerable efforts have gone into the development of blends, alloys and reinforced thermoplastics to obtain desirable properties. Many of the binary polymer blends are immiscible and incompatible. The immiscibility of polymers is due to wide difference in solubility parameters of the components. Immiscible polymer blends are often preferred over the miscible types since they may combine the most desired properties of both polymer components while avoiding their major drawbacks. The key to obtain satisfactory performance in immiscible blends is to minimize interfacial tension and to improve adhesion between the phases leading to greater resistance to gross separation and improved overall properties. The blends are then to be considered effectively compatibilized. Numerous methods of compatibilization are already developed. The most important category involves the addition of a third component viz. a block co-polymer or a graft copolymer or polymers containing ionic groups.

Polyamide 6 is an engineering thermoplastic with many attractive properties. However, there remains a need to rectify or improve some of its deficiencies such as high moisture absorption, high notch sensitivity and poor dimensional stability. Hence it has been often blended with other polymers such as polyolefins, ABS, rubbery polymers and thermoplastic elastomers. Polyamide 6 and ABS form an immiscible and incompatible blend system. It is well known that styrene maleic anhydride (SMA) compatibilizes polyamide 6 and ABS blends. It has been observed that the overall mechanical properties are better for the blend

having polyamide 6 and ABS in the ratio 70:30. The objective of this study is to develop and investigate short glass fibre reinforced composites based on this blend composition with and without the compatibilizer, SMA. The level of SMA was kept at 5 wt%. The blend and composite samples were prepared by extrusion compounding followed by injection moulding at 250 °C. The result of various studies are analyzed in terms of SMA and glass fibre content.

The blend containing SMA shows higher strength and modulus (tensile and flexural) but slightly lower impact strength compared to the blend without SMA. Both matrices show significant improvement in strength and modulus on reinforcement with short glass fibres. Composites of the blend without the compatibilizer show superior mechanical properties than the composites of the blend containing the SMA. In other words, SMA has no favourable effect on the mechanical properties of the composite systems. The mechanical properties of the composites prepared in this study are at par with the composites of Triax 1180. Interfacial shear strength ( $\tau$ ) has been evaluated using three different existing models viz., i) Ramsteiner and Theysohn's model ii) modified Bowyer and Bader's model iii) Cox's model. Interfacial shear strength values evaluated using Ramsteiner and Theysohn's model and modified Bower & Bader's model are value close to each other. It has been found that the composites without SMA show higher values of  $\tau$  compared to the composites containing SMA. The  $\tau$  value obtained using Cox's model is not in agreement with the values obtained using the first two methods. This is attributed to the fact that the Cox's model is based on the assumption that the matrix is elastic at all strains, which is not true in real system. The variation of shear stress along the length of the fibre at different strain levels, evaluated using Cox's model is also discussed.

DMTA studies show that both the blends show three distinct  $\tan \delta$  peaks

corresponding to the glass transitions of polyamide 6 and ABS. This indicates that the blend is immiscible in the presence of the compatibilizer. There is no significant shift in  $\tan \delta$  peak locations by glass fibre. The storage modulus ( $E'$ ) is enhanced considerably by glass fibre in both matrices. The drop in modulus on passing through transition is less for the fibre filled systems compared to blend polymers. The pure polymers as well as their blends lose their rigidity considerably at higher temperatures, whereas the composites retain their modulus at higher temperatures. Glass fibre reduces damping of the blend polymers. The fibre-matrix bonding is better in the absence of SMA as indicated by the low values of  $\tan \delta$  in the composites without SMA.

Glass fibre increases melt viscosity of the blend polymers considerably. Blend and composite samples containing SMA show higher viscosity. First normal stress difference is increased and extrudate swell is reduced by the addition of glass fibres in to the blend polymers. SEM studies of the blend matrices reveal that the blend components are mixed well in the presence of SMA. SMA increases interfacial adhesion by involving in chemical reaction with polyamide 6 in the blend. The superior mechanical properties of the composites in the absence of SMA, is due to excellent fibre-matrix bonding, as revealed by the SEM studies. Composites containing SMA show poor fibre-matrix bonding. The high melt viscosity of the composites in the presence of SMA, causes wetting of the melt on the fibre surfaces very difficult. This results in poor fibre-matrix bonding in the composites containing SMA. Moreover, the fibre breakage is excessive in the presence of SMA due to the higher flow stresses involved. Fibre breakage is also excessive at higher fibre content. Fibre alignment is improved at higher concentration of fibres in the moulded samples.

DSC results indicate that glass fibre promotes crystallization of polyamide 6 component in the composites, and this effect is more pronounced in the absence of SMA. Crystallinity also found to be higher in the blends and composites in the absence of SMA. There is considerable depression of  $T_m$  in the samples containing SMA, which is due to the compatibilization of the blend leading to lower crystallinity values.

Summary, major conclusions and suggestions for future work are given in the last chapter. The composites of polyamide 6 and ABS can be commercially exploited with a little modification to further improve its performance properties especially toughness.

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