

STUDIES ON PP/SEBS-g-MA BLENDS AND THEIR WOOD FLOUR REINFORCED COMPOSITES

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**CENTRE FOR POLYMER SCIENCE AND ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY DELHI**

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by

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Centre for Polymer Science and Engineering

Submitted

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Dedicated To

My Family

CERTIFICATE

This is to certify that the thesis entitled “**Studies on PP/SEBS-g-MA Blends and Their Wood Flour Reinforced Composites**” being submitted by **Mr. Rishi Sharma** to the Indian Institute of Technology Delhi for the award of the degree of **Doctor of Philosophy**, in the **Centre for Polymer Science and Engineering**, is a record of original and bonafide research work carried out by him. Rishi Sharma 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 are original and 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 demand of high performance materials is increasing, which is also enhancing focus to develop new homopolymer. Wood plastic composites had drawn attention of researches due to their ecofriendliness, economical advantages and enormous end uses such as in structural, interior and automotive components. The wood waste which was created all over world can be used in plastics. It also dilutes the use of plastic phase and creates partial biodegradability in the product. In this work binary blends of Polypropylene (PP)/Styrene/ethylene-co-butenestyrene grafted maleic anhydride (SEBS-*g*-MA) at varying concentrations of SEBS-*g*-MA were prepared by first dry blending followed by melt mixing. The blend composition of 80 mass % PP and 20 mass % SEBS-*g*-MA was selected for composite preparation because it registered highest impact strength. Composites of PP/SEBS-*g*-MA/WF were prepared by varying concentrations of TWF. PP/Wood flour composites were developed by incorporation of teak wood flour in polypropylene.

The characterizations of composites were performed by evaluating thermal, melt rheological, crystallization, morphological and mechanical properties like tensile and impact behaviors.

The mechanical properties of polypropylene and SEBS-*g*-MA copolymer blends up to volume fraction 0.5 of SEBS-*g*-MA were evaluated. Tensile properties and impact strength were described and correlated with theoretical models. Crystallinity on which strength properties depend decreased with increasing concentrations of SEBS-*g*-MA copolymer. Tensile modulus and strength decreased, however tensile elongation and

impact strength enhanced. Morphological studies show good dispersion of SEBS-*g*-MA in polypropylene with a weak level of interaction between the phases.

Melt rheological properties of blends were studied at volume fraction of 0-0.5 at shear rate range from 100 to 3500 s⁻¹. Melt viscosity increased with SEBS-*g*-MA content implying interaction between PP and SEBS-*g*-MA. The blends showed power law behaviour for pseudo plastic fluids. The power law index value increased with SEBS-*g*-MA concentration. The value of consistency coefficient (K) decreased with increase in temperature which shows ease of flow due to high thermal energy at high temperature. Viscosity-composition plot showed positive deviation from log additivity rule evincing interfacial stick mechanism during processing of the blends. Dynamic interfacial tension decreased which showed increase in phase adhesion with enhancement in SEBS-*g*-MA copolymer concentrations.

The mechanical properties of PP/SEBS-*g*-MA/WF composites up to volume fraction 0.31 of wood flour were evaluated. Tensile parameters like modulus, strength, elongation-at-break and the impact property were described and correlated with theoretical models. The crystallinity of PP in PP/TWF composites, on which strength properties depend, increased with wood flour content. The value of tensile modulus and strength increased but elongation-at-break and impact strength decreased. Morphological studies by SEM analysis showed good dispersion of wood flour in polypropylene up to $\Phi_d=0.31$.

The rheological properties of PP/SEBS-*g*-MA/TWF composites were evaluated by capillary rheometer from range of volume fraction 0 to 0.31. Shear thinning behaviour is shown by PP/SEBS-*g*-MA/TWF composites. The values of melt viscosities decreased with temperature which may be due to lesser resistance to flow of PP chains by wood

flour. The value of n decreased with wood content for all three temperatures. It indicates decrease in resistance to flow or shear thinning behaviour in presence of TWF particles which may be attributed to less entanglement of PP chains because of wood particles. The values of n decreased with temperature which may be due to increase in thermal motion of PP chains at high temperature. The values of consistency coefficient (K) increased with wood flour content which may be attributed to hindrance in flow of PP chains due to increased mechanical restraint by TWF.

The non-isothermal crystallization kinetics of PP/SEBS-g-MA blends and PP/SEBS-g-MA/TWF composites were studied by differential scanning calorimetry at four different cooling rates. Crystallization parameters were analysed by Ozawa and Liu models. Ozawa model fits in the PP/SEBS-g-MA blends and indicates the effect of SEBS-g-MA copolymer on the crystallization process of polypropylene. Augis-Bennet model has been used to calculate activation energy, ΔE , during non-isothermal crystallization process. The value of ΔE decreased with SEBS-g-MA due to flexibility of SEBS-g-MA by which movements of chains of PP become easier.

The polypropylene phase of the composite is diluted with sufficient quantities of wood flour, thus reducing the amount of petroleum products. The prepared composite can be termed as 'green composite' which can be used in different application such as: manufacturing of building materials, decking, furniture's, roof and garden fencing etc.

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List of Abbreviations

DP	Degree of polymerization
DSC	Differential scanning calorimetry
HDPE	High density polyethylene
HIPS	High Impact Polystyrene
ID	Interparticle distance
LDPE	Low density polyethylene
MFI	Melt flow index
PA	Polyamide
PC	Polycarbonate
PDI	Polydispersity index
PE	Polyethylene
POM	Polyoxymethylene
PP	Polypropylene
PS	Polystyrene
PVC	Poly (vinyl chloride)
SB	Polybutadiene
SBS	Polystyrene-block-polybutadiene-block-polystyrene
SEBS	Styrene-Ethylene-Butylene-Styrene
SEBS- <i>g</i> -MA	Styrene-ethylene-butylene-styrene grafted maleic anhydride
SEM	Scanning electron microscopy
SIS	Polystyrene-block-polyisobutene-block-polystyrene
TGA	Thermogravimetric analysis

TPE	Thermo plastic elastomer
TWF	Teak wood flour
WPC	Wood plastic composite
α	Measure of weakness
Φ_d	Volume fraction of the dispersed phase
Φ_f	Volume fraction of the filler
ΔE	Activation energy