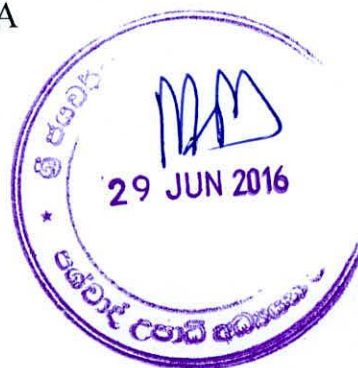


**A STUDY ON USE OF POLYPROPYLENE (PP) AND PP
COMPOSITES IN THE MANUFACTURE OF CASTOR WHEELS AND
THEIR EFFECT, ON PROCESSING, DYNAMIC AND STATIC
CHARACTERISTICS**

BY

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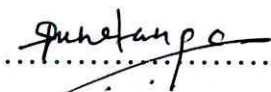


Thesis submitted to the University of Sri Jayewardenepura for the
award of the Degree of Doctor of Philosophy in Chemistry on

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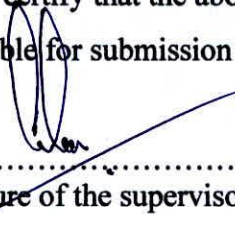
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LIST OF ABBREVIATIONS

ABS	Acrylonitrile butadiene styrene copolymer
ASTM	American society for testing and materials
ATR	Attenuated Total Reflection
BRHA	black rice husk ash
cCaCO ₃	Coated calcium carbonate
DMA	Dynamic mechanical analysis
DSC	Differential scanning calorimetry
EB	Elongation at break
EP	Ethylene propylene
EPDM	Ethylene propylene diene monomer
EPR	Ethylene propylene rubber
FEA	Finite element analysis
FRH	Flour rice husk
FTIR	Fourier transfer infrared spectroscopy
iPP	Isotactic polypropylene
IPPC	Impact polypropylene copolymer
IR	Infrared
LDPE	Low density polyethylene

LLDPE	Linear low density polyethylene
MA	Maleic anhydride
MA-PP	Maleic anhydride /PP homopolymer
MA-SEBS	MA/Styrene– ethylene– butadiene–styrene triblock copolymer
MFR	Melt flow rate
MFI	Melt flow index
PE	Polyethylene
PPB	Block copolymer polypropylene
PPH	Polypropylene homopolymer
PPC	Polypropylene copolymer
PP	Polypropylene
PS	Polystyrene
PVC	Poly vinyl chloride
PMMA	Poly methyl methacrylate
RHA	Rice husk ash
SA	Stearic acid
SBS	Styrene butadiene styrene copolymer
SEM	Scanning electron microscopy
TPV	Thermoplastic vulcanisates
UCaCO ₃	Uncoated calcium carbonate
WF	Wood flour

WRHA	White rice husk ash
ΔH_{-f}	Enthalpy of PP in composite
ΔH_f^0	Enthalpy of 100% crystalline PP
W_p	Weight fraction of PP in composite
T_m	Melting temperature
T_{om}	Onset melting temperature
T_{oc}	Onset crystallisation temperature
T_c	Crystallisation temperature
T_g	Glass transition temperature
J/m	joules per meter
MPa	Mega pascal
E'	Storage modulus
E''	Loss modulus
$Mg_3Si_4O_{10}(OH)_2$	Hydrated magnesium silicat

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Ranatunga Ramanayaka Mudiyansele Sisira Kumara Ranatunga

ABSTRACT

Present study is to explore the potential of using virgin Polypropylene (PP) materials (PP homopolymer, (PPH) and PP impact copolymer PPC)) and PP composites of rice husk ash (RHA), uncoated CaCO_3 (UCaCO₃) talc and stearic acid coated CaCO_3 (cCaCO₃) for low speed dynamic load applications such as manufacture of light weight castor wheel centre. Industrial grade PP, talc, UCaCO₃ and cCaCO₃ materials were used for the study. RHA was obtained by uncontrolled combustion of rice husk. Composites of PP/Talc PP/UCaCO₃, and PP/cCaCO₃ were compounded at 5, 10, 15, 20, 25, 30 and 35% by weight . Composites of PP/RHA were compounded at filler loadings 2.5, 5, 7.5, 10 and 12.5 % . Extruded pellets of PP and PP composites were tested for melt flow index (MFI). Injection moulded specimens were used for testing tensile strength, izod notched impact strength and dynamic mechanical analysis (DMA). Surface morphology of fillers and PP composites were examined using scanning electron microscopic (SEM) images. Thermal properties of PP and PP composites were studied using differential scanning calorimetry (DSC). Chemical characteristics of filler materials were determined by fourier transform infrared spectroscopy (FTIR). Castor wheel centres were injection moulded to a rubber ring and tested for dynamic load and stress generation using finite element analysis (FEA).

As per DSC results, the degree of crystallinity is higher in PPH (45%) compared to PPC (37%). DMA suggested that PPH is stiffer than PPC which has a multiphase structure. The ethylene propylene rubber (EPR) phase (T_g peak of EPR phase at -35.2 °C) which is amorphous in nature provides good impact strength, whereas, matrix made of PP (T_g peak at 15.4 °C) provides stiffness. A shoulder peak of PPC at temperature around 88 °C has been attributed to the α -relaxation in the crystalline phase. Drop weight impact test results suggested that impact property of PPH is 22 times lower at low temperature compared to that of PPC. Since a balance between impact strength and stiffness is required for optimum performance, PPC is more suitable for light weight dynamic load applications at low temperatures.

PP composites of Talc, RHA and $UCaCO_3$ show significant drop in elongation at break resulting brittle failure. DMA and impact test results suggested that PP composites of RHA, Talc and $uCaCO_3$ have very poor impact properties, whereas, PP composites with $cCaCO_3$ at 20% prevent T_α transition in the crystalline phase due to lowest stress developed in PP matrix under deformation. The shear yielding bare minimum improving the toughness. PP composite of locally available low cost $cCaCO_3$ is the most suitable material for light-weight dynamic load applications.

Novel FEA model suggested for wheel centre in present study can be applied universally to predict most vulnerable failure area and the stress and displacement of thermoplastic materials at different temperature applications.