CHARACTERIZATION OF CALCIUM CARBONATE FILLED NATURAL RUBBER- LOW DENSITY POLYETHYLENE BLENDS PREPARED WITH A TITANATE COUPLING AGENT

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Degree of Master of Philosophy

Department of Chemical & Process Engineering

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DECLARATION

I certify that work described in this thesis was carried out by me under supervision of Dr. (Mrs.) S.M. Egodage and Dr. (Mrs.) D.G. Edirisinghe and the thesis has not been submitted to any university for any other degree. I also declare that this thesis does not include any material previously submitted for a degree, published, written or oral communicated by another person without acknowledgement to the best of my knowledge except where due references is made in the text.

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Wickagamage Don Manjula Sampath

We certify that the above statement made by the candidate is true & that this thesis is suitable for submission to the university for the purpose of evaluation

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Characterization of Calcium Carbonate Filled Natural Rubber-Low Density Polyethylene Blends Prepared with a Titanate Coupling Agent

ABSTRACT

The aim of this study was to develop reactive blends from natural rubber (NR) and low density polyethylene (LDPE) with acceptable physico-mechanical properties. NR and LDPE blends at different blend ratios were produced in a Brabender Plasticorder by melt mixing at a temperature of 150 ^{o}C, and rotor speed of 60 rpm. 20 parts per hundred parts of polymer (pphp) calcium carbonate was added as an inorganic filler. Physico-mechanical and chemical properties of the blends and composites were determined according to international standards. Thermal properties were determined using a differential scanning calorimeter. Morphology and structural characteristics were examined by a scanning electron microscope and fourier transform infrared analyzer, respectively. 50/50 NR/LDPE blends were prepared using three vulcanizing systems: sulphur, peroxide and mixture of sulphur and peroxide. NR/LDPE blend prepared with the mixed vulcanizing system showed the highest physico-mechanical, chemical, and ageing properties with a fine morphology. A series of simple blends was formulated by varying the LDPE loading from 10 to 90 pphp at 20 pphp intervals. The tensile strength, tear strength, and hardness increased with the increase of LDPE loading, while elongation at break decreased. The continuous phase of blends changed from NR to LDPE above 30 pphp LDPE loading. The optimum tensile and ageing properties were obtained for the composite prepared with 20 pphp calcium carbonate with or without titanate coupling agent (titanate CA) at 30 pphp LDPE loading. Further, 70/30 NR/LDPE composite prepared with 0.7 pphp titanate CA presented the highest physico-mechanical, chemical and ageing properties. Furthermore, the performance of the 70/30 NR/LDPE blends produced with 0.3 pphp peroxide was greater than that of the composites prepared without the peroxide and with a high amount of peroxide. Nevertheless, tensile properties, stress and strain of the 70/30 NR/LDPE composite improved with partial replacement of LDPE with recycled LDPE (rLDPE). The composite with 20 pphp rLDPE indicated the best improvement in all physico-mechanical properties.

Keywords: NR/LDPE blend, titanate coupling agent, peroxide, recycled LDPE, calcium carbonate

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LIST OF ABBREVIATIONS

Abbreviation	Description
A/O	Antioxidant
ASTM	American Society for Testing and Materials
BKF	(2, 2'-methylene bis (4-methyl-6-tert butyl phenol))
BR	Polybutadiene rubbber
CA	Coupling agent
$CaCO_3$	Calcium carbonate
CR	Polychloroprene rubber
CV	Conventional vulcanization
DCP	Dicumyl peroxide
DV	Dynamic vulcanization
DVs	Dynamic vulcanizates
EB	Electron beam
ENR	Epoxidized natural rubber
EPDM	Ethylene- propylene diene monomer
EPDM-*g*-MA	Ethylene- propylene- diene monomer-graft-maleic anhydride
EPR	Ethylene-propylene rubber
EV	Efficient vulcanization
EVA	Ethylene vinyl acetate copolymer
FTIR	Fourier transform infrared
GTR	Ground tire rubber
HDPE	High density polyethylene
HNBR	Hydrogenated nitrile butadiene rubber
IRHD	International rubber hardness degree
ISO	International standards organization
LDPE	Low density polyethylene
LLDPE	Linear low density polyethylene
MAH	Maleic anhydride
MDPE	Medium-density polyethylene
MW	Molecule weight
M_1	Masses of before swelling
M_2	Masses of after swelling

M_i	Masses of the sample before water absorption
M_f	Masses of the sample after water absorption
m_1	Initial weight of the specimen
m_2	Weight of the oven dried gel
NBR	Nitrile rubber
NR	Natural rubber
OENR	Oil extended natural rubber
PA	Phthalic anhydride
PE	Polyethylene
PFMs	polyfunctional monomers
PhHRJ-PE	Phenolic modified polyethylene
PP	Polypropylene
PS	Polystyrene
PVC	Polyvinylchloride
RH	Rice husk
rPE	Recycled polyethylene
RSS	Ribbed smoked sheets
S	Sulphur
SEV	Semi-efficient vulcanization
TBBS	N-tertbutyl1-2-benzothiazole sulfonamide
TEOs	Thermoplastic polyolefins
T_g	Glass transition temperature
TPE	Thermoplastic elastomer
TPE-A	Thermoplastic polyamide elastomer
TPE-E	Thermoplastic polyester elastomer
TPE-O	Thermoplastic polyolefin
TPE-V	Thermoplastic vulcanizate
TPNR	Thermoplastic natural rubber
TPR	Thermoplastic rubber
wLDPE	Waste low density polyethylene
ZnO	Zinc oxide
ΔGm	Gibbs free energy
ΔHm	Enthalpy

LIST OF SYMBOLS

Symbol	Description
ΔG	Gibb's energy
ΔH	Enthalpy
ΔT	Entropy
°C	Degree Celsius
µm	Micrometer
Cm	Centimeter
DC	Degree of crystallinity
E_b	Elongation at break
F	Force
g	Grams
Kg	Kilograms
kGy	Kilo Gray
m	Meter
mA	Miliampere
MeV	Megaelectron volt
mg	Milligram
min	Minutes.
mm	Milimeter
MPa	Mega pascal
MT	Metric Tons
nm	Nanometer
Nm	Newton meter
php	Parts per hundreds plastics
phpp	Part per hundred of polymer
phr	Parts per hundreds rubber
rpm	Revolutions per minute
S	Seconds
Tg	Glass-transition temperature
T_m	Melting point
V	Volt

LIST OF APPENDICES