

**EFFECT OF COMPOSITION ON PHYSICOCHEMICAL  
PROPERTIES OF  
LINEAR LOW DENSITY POLYETHYLENE/NATURAL RUBBER  
BLENDS**

**By**

**G.K.R.P Gajanayake**

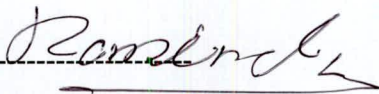
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University of Sri Jayawardhanapura

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## Declaration

I hereby declare that this submission is a result of a work carried out by me and the best of my knowledge it contains no materials previously written or published by another author nor material which has been accepted for the award of any degree or acceptable qualification of a university or other institute of higher education, except where the due reference material is made.



GKR P Gajanayake

July 2014

I certify that the above statement made by GKR P Gajanayake, is true and this dissertation is suitable to the University of Sri Jayawardhanapura for the purpose of evaluation.

Date 10.07.2014



Dr. S.M. Egodage (Supervisor)

Date-----

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Dr. S.P.D.M. Chinthake (Co-Supervisor)

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### List of Abbreviation.

ABS	Acrylonitrile butadiene styrene rubber
°C	Centigrade
°C	Carbon centered radical
DCP	Dicumyl peroxide
DSC	Differential scanning calorimetry
FTIR	Fourier transformed infra red spectroscopy
F	Shear force
G	Shear modulus
EPDM	Ethylene propylene diene monomer
I	Level of synergism
IR	Infrared radiation
IRHD	International rubber hardness
ISO	International standard organization
$k_{tc}$	Rate constant for combination
$k_{td}$	Rate constant for disproportionation
kg	Kilogram
LDPE	Low density poly ethylene
LLDPE	Linear low density poly ethylene
MAH	Maleic anhydride
MPa	Mega Pascal
mm	millimeter
$M_I$	Initial torque
$M_L$	Minimum torque
$M_H$	Maximum torque
MT	Metric tons
N	Degree of polymerization /Newton
ODR	Oscillating disk rheometer
O°	Oxygen centered radical
P	Property value

PP	Polypropylene
pH	$-\log_{10}[\text{H}_3\text{O}^+]$
PH	Polymer chain
Ph	Phenyl group
P°	Polymer radical
PS	Poly styrene
R	Universal gas constant
-R-	Alkyl group
Rh	Rate of cure
RO	Alkoxy group
RO°	Alkoxy radical
RRI	Rubber Research Institute
RSS	Ribbed Smoked Sheets
SG	Specific gravity
S	Sulphur
T	Thermodynamic temperature
TDS	Technical data sheet
$T_g$	Glass transition temperature
$T_m$	Crystalline melting point
TPV	Thermoplastics vulcanizates
$t_{90}$	Optimum cure time
$t_{s2}$	Time for scorch
TMPTM	Trimethylolproanetrimethacrylate
TAC	Triallyl cynaurate
t	time
PRI	Plastic retention index
V	Total volume
v	Cross linking density
$\alpha\text{H}$	$\alpha$ hydrogen
$\Delta\text{G}$	Change in free energy
$\Delta\text{H}$	Change in enthalpy

$\Delta S$	Change in entropy
wt%	Weight presentage
$\gamma$	Shear strain
$\delta$	Solubility parameter
$\chi$	Flory interaction parameter
$\phi$	Volume fraction
$\eta'$	Viscosity ratio
$\eta$	Viscosity of continuous phase
$\eta^*$	Mean viscosity
$\dot{\gamma}$	Shear rate
$\lambda$	Youngs modulus
$\mu\text{m}$	Micro meter
1,2 BR	1,2- polybutadiene
1 <sup>o</sup>	Primary bonds
2 <sup>o</sup>	Secondary bonds
3 <sup>o</sup>	Tertiary bonds

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## Abstract

A series of melt blended, peroxide vulcanized natural rubber (NR) and linear low density polyethylene (LLDPE) rubber-thermoplastic vulcanizate was developed using classical rubber processing equipment such as internal dispersive mixer, two-roll mill etc. Two types of NR/LLDPE thermoplastic vulcanizate were developed varying LLDPE loading from 10 to 80 wt. % at 10 wt. % loading intervals with and without co-agent namely modified and unmodified blends respectively. Dicumyl Peroxide (DCP) and Maleic anhydride (MAH) was used as crosslinking agent and co-agent. Melt blending of polymers and other additives was done in an internal dispersive mixer and curatives and co-agent were incorporated in to the blend in two-roll mill. Vulcanization was carried out using a hydraulic press at 140 °C temperature and 3.5 MPa pressure. Morphology, cure characteristics, physicochemical properties and extrudability of the blends were determined using respective ISO and ASTM standards. Thermal properties were determined using differential scanning calorimetry (DSC), Fourier transformation infra red (FTIR) spectroscopy was used to study bond structure. Morphological study revealed that co-continuous morphology of vulcanizates remains up to 50 wt. % LLDPE loading thus the processability with classical rubber processing equipment. However, blends with higher LLDPE loading behave like thermoplastics. LLDPE loading increases scorch time ( $t_{s2}$ ) and reduces rate of cure index. An improved state of cure was observed in modified blends than that of unmodified blends at each LLDPE loading. Tensile properties were improved up to 40 wt. % LLDPE loading in comparisons to the peroxide vulcanized NR compound and then it comes to a decline. Hardness, tear resistance, resistance to thermo-oxidative degradation and resistance to organic solvents improves with LLDPE loading in both modified and unmodified blends. Further modified blends always showed improved physicochemical properties than in the unmodified blends at each LLDPE loadings. Extrudability developed up to 30-50 wt. % LLDPE loading then it declined. Thermal properties and topology of tensile fracture obtained from scanning electron microscope used to study the interfacial adhesion. Accordingly, better interfacial adhesion was “observed” in modified blends.

[ Key words: rubber-thermoplastic vulcanizate, co-agent, morphology, state of cure, extrudability and interfacial adhesion]