IMPROVEMENT OF PHYSICO-MECHANICAL PROPERTIES ACRYLONITRILE-BUTADIENE RUBBER WASTE BY INCORPORATING NANOCLAY

By

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CERTIFICATION OF THE SUPERVISOR

We certify that the candidate has incorporated all corrections, additions, and amendments recommended by the examiners to the final version of the M.Phil. thesis

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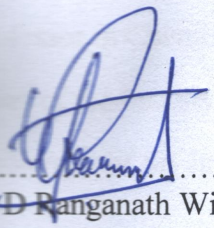
DECLARATION

The work described in this thesis was carried out by me under the supervision of Prof. Sudantha Liyanage, Professor in chemistry, and Dean of the faculty of Applied Sciences, University of Sri Jayewardenepura and Dr. Upul N Ratnayake, Technical General Manager, Dipped Products Lanka Private Limited,. and a report on this has not been submitted in whole or in part to any university or any other institution for anther Degree/Diploma.



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

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LIST OF ABBREVIATIONS

ACN : Acrylonitrile
AFM: Atomic Force Microscopy
ATR: Attenuated Total Reflectance
CB**: ** phr carbon black filled treatment plant nitrile rubber vulcanizates
CB: Carbon black
CBN**: ** phr carbon black filled treatment plant nitrile rubber/natural rubber blend vulcanizates (nitrile rubber: natural rubber 85:15)
CNT: Carbon nanotube
CTBN: Carboxyl terminated liquid butadiene acrylonitrile rubber
CTP: N-(cyclohexyl-thio)phthalimide
CV: Conventional vulcanizing system
DOP: dioctyl phthalate
DSC: Differential Scanning Calorimetry
EV: Efficient vulcanizing system
FTIR: Fourier Transform Infrared Spectroscopy
GPF: General Purpose Furnace
HNBR: Hydrogenated NBR
IRHD: International Rubber Hardness Degrees
LDH: Layered double hydroxide
LS: Layered silicates
MBTS: Bis(2-benzothiazoyl) disulphide
MDR: Moving Die Rheometer
MMT: Montmorillonite
NBR : Acrylonitrile butadiene rubber
NMR: Nuclear Magnetic Resonance
NR**: ** phr NR blended treatment plant nitrile rubber vulcanizates
NR: Natural rubber
OM**: ** phr OMMT clay filled treatment plant nitrile rubber vulcanizates
OMCB**: ** phr OMMT clay loaded treatment plant nitrile rubber/natural rubber blend vulcanizates with 30 phr of carbon black (nitrile rubber: natural rubber 85:15)
OMMT: Organically modified montmorillonite clay
OMN**: ** phr OMMT clay filled treatment plant nitrile rubber/natural rubber blend vulcanizates (nitrile rubber: natural rubber 85:15)
phr: parts per Hundred Rubber
PNC: Polymer nanocomposite
POSS: Polyoligo sesquesiloxane
PVI**: ** phr CTP mixed treatment plant nitrile rubber/natural rubber blend vulcanizates with 30 phr of carbon black (nitrile rubber: natural rubber 85:15)
RRISL: Rubber Research Institute Sri Lanka
SBR: Styrene-butadiene rubber
SEM: Scanning Electron Microscopy

Semi-EV: Semi efficient vulcanizing system
TEM: Transmission Electron Microscopy
T_g: Glass transition temperature
TGA: Thermogravimetric Analysis
TMTD: Tetramethylthiuram disulphide
WA: Waste material collected from dipping plant
WB: Waste material collected from treatment plant
XNBR: Acid functionalized NBR/Carboxylated NBR
XRD: X-ray diffraction
ZDC: Zinc diethyldithiocarbamate

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ABSTRACT

Acrylonitrile butadiene rubber (NBR) is a copolymer of acrylonitrile (ACN) and butadiene which has a remarkable resistance towards mineral oils, hydrocarbon fluids and aromatic solvents. In general NBR is compounded with conventional fillers such as carbon black (CB) to achieve the required reinforcement.

A compounded waste NBR generated from one of the leading glove manufacturing companies was used in this research project. NBR waste received was subjected to detailed characterization with rheometry, Thermogravimetric Analysis (TGA), Differential Scanning Calorimetry (DSC), Attenuated Total Reflectance (ATR), total ash content test and total nitrogen content test. Characterization results revealed that waste NBR is a carboxyl terminated NBR with about 45 % of acrylonitrile content and it contains a significant quantity of sulfur, accelerator and filler.

This waste NBR was blended with a small amount of natural rubber (NR) in order to improve the processability of it. Then this NBR/NR blend was compounded with carbon black and other vulcanizing ingredients. Carbon black filled waste NBR vulcanisates showed good physico-mechanical properties and oil resistance. However waste NBR/NR compounds showed superior processabilty, and cure characteristics to the non-blended NBR waste compounds. Also they showed moderate physico-mechanical properties compared to the non-blended vulcanisates. Waste NBR/NR vulcanisate containing 30 phr of carbon black showed the best processing capability whilst maintaining good physical properties compared to that of other carbon black filled vulcanisates.

Furthermore, blending of a small quantity of natural rubber (NR) with carbon black filled NBR significantly reduced the rate of continuous curing (i.e. marching) but sacrificing some of the physical properties of the vulcanisates such as, oil resistance, tensile strength and elongation at break.

Moreover, waste NBR material and waste NBR/NR blend was compounded with OMMT clay and other vulcanizing ingredients. Both NBR compounds showed good processability and cure characteristics in all OMMT loadings. However, compounds containing 4 phr and 6 phr of OMMT clay showed outstanding physico-mechanical properties than the others.

Carbon black filled waste NBR/NR blend was further value added by preparing a nanocomposite based on nanoclay (i.e. montmorillonite clay/OMMT clay). Waste NBR/NR/CB nanocomposite containing clay showed a significant improvement in reinforcement and chemical resistance. Results of the physico-mechanical properties of the nanocomposite have been interpreted with reference to intercalation/exfoliation of clay, synergistic effect of CB and clay and interaction between clay and NBR. Vulcanisates of CB filled waste NBR/NR compounds with 4 phr of OMMT clay showed the best reinforcement and chemical/oil resistance.

According to the results, 4 phr OMMT clay filled waste NBR/NR compound with 30 phr of CB showed superior processing ability, better cure characteristics and better physico-mechanical properties than those of 30 phr CB filled or 4 phr OMMT filled waste NBR compounds.