NANOSTRUCTURED MONTMORILLONITE CLAY ON RAW RUBBER PROPERTIES OF SKIM NATURAL RUBBER AND PHYSICO-MECHANICAL PROPERTIES OF NATURAL RUBBER / SKIM RUBBER BLEND

by

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The work described in this thesis was carried out by me under the supervision of Dr Upul N Ratnayake PhD (Loughborough,UK) Head, Raw Rubber Process Development & Chemical Engineering Rubber Research Institute of Sri Lanka (RRISL) 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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Signature Date

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DEDICATION

To my loving mother

To my loving husband

To my loving sister

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ABSTRACT

Skim natural rubber (SNR), a process by-product of centrifuged latex manufacturing, consists of low molecular weight rubber and a higher percentage of non-rubber constituents, especially nitrogenous substances. SNR, known as low quality grade of rubber, limits the industrial applications because of inappropriate physico-mechanical properties. Effect of nanostructured MMT clay on SNR was investigated in view of preparing value added raw rubber and hence improved industrial applicability. .

At 1st phase of the research, montmorillonite (MMT) clay filled SNR nanocomposites were prepared by incorporating aqueous dispersion of MMT clay into skim natural rubber latex followed by latex coagulation. Characterization of raw rubber properties have shown that clay loading has increased the thermo-oxidative stability of the skim rubber. Improved green strength of MMT clay filled SNR nanocomposite has revealed the presence of MMT nanostructures and its effect on strain-induced crystallization. However, processability, as measured with low shear strain rate viscoelastic behaviour, is affected by the added MMT clay. With this latex compounding methodology, a novel MMT clay filled SNR with improved physical properties has been developed as a value added raw rubber for different applications.

During the 2nd phase of the research, the effect of MMT clay structure on reinforcement of NR / SNR blends was examined. MMT filled SNR master batch being formulated from latex coagulating method was melt blended with NR using a laboratory scale internal mixer. Processability and reinforcement of the NR/SNR –MMT blend was studied in comparison to NR/SNR blend containing no MMT clay. Stress-strain properties of the nanocomposites vulcanizates measured under tensile deformation, especially tensile strength, modulus ,hardness and abrasion resistance, were manifest to

prove notable reinforcing effect of MMT clay as shown up to 32 % - 67 % increase of tensile modulus at 300 % elongation. Higher degree of exfoliation of MMT and resulted higher reinforcement at lower volume fraction of MMT (2- 4 phr) in NR/SNR-MMT blend justifies the formation of nano scale MMT clay platelets within the composite matrix. This phenomena can be further explained though adsorption of non-rubber substances onto MMT and formation of interactions with nano scale clay platelets.

Key words: Skim natural rubber, montmorillonite clay, green strength, thermo-oxidative degradation, nanocomposite, Mooney Viscosity, reinforcement, exfoliation, NR/SNR blend

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1.0 INTRODUCTION

1.1. Background

From centuries, Sri Lanka has been recognised as one of the largest and finest natural rubber (NR) and Latex (LX) manufactures. However, LX based industries can be sighted, as one of the key consumers of total rubber production. Mostly, LX being used to manufacture thin wall items, rubber gloves, balloons and etc. These products indeed to acquire superior physical and mechanical film properties. Therefore, in this process, ammonia preserved field LX being centrifuged in order to enhance its Dry Rubber Content (DRC) and other molecular properties. This process, centrifuging yields concentrated latex as the major output and Skim rubber latex (SRLX) as its process bi-product.

SRLX is being separated by centrifuging machine, giving angular rotation, leading latex to separate as per density of the rubber particles. As a result, low density latex which contains higher DRC and larger rubber molecules separate as the upper layer. Shorter rubber chains and higher amount of non-rubber carrying high density SRLX collects as the bottom layer.

As an industrial practise, SRLX is being sold to the cottage or small scale manufactures in bulk. SRLX is then coagulated using 10 % w/w, sulphuric acid (H_2SO_4) to produce Skim natural Rubber (SNR). SNR is being inherited poor physio-mechanical properties as well as poor aging due to higher amount of non-rubber constituents. Henceforth, usage of SNR to manufacture of value added products is restricted. Even though, SNR is being used to produce low quality products or being mixed with NR to