

**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 another Degree/Diploma".

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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

TABLE OF CONTENTS

| | Page |
|---|------|
| DEDICATION | II |
| ACKNOWLEDGMENT | III |
| ABSTRACT | IV |
| | |
| 1.0 INTRODUCTION | 13 |
| 1.1. Background | 13 |
| 1.2. Motivation for the study | 15 |
| 1.3. Project Objectives | 16 |
| | |
| 2.0 LITERATURE SURVEY | 17 |
| | |
| 2.1. Natural Rubber and Skim Rubber | 17 |
| 2.1.1. Introduction | 17 |
| 2.1.2. Natural rubber latex..... | 17 |
| 2.1.3. Concentrating NR latex..... | 19 |
| 2.1.3.1. Centrifuge latex manufacturing process. | 21 |
| 2.1.4. Skim rubber latex and skim natural rubber | 23 |
| 2.1.4.1. Recovery of skim natural rubber | 26 |
| 2.1.4.2. Properties of skim natural rubber. | 27 |
| 2.1.4.3. Application of skim natural rubber | 28 |
| | |
| 2.2. Composites and blends | 29 |
| 2.2.1. Composites | 29 |
| 2.1.1.1. General classification of composites. | 29 |
| 2.1.1.2. Composite types based on continuous phase. | 30 |
| 2.1.1.3. Composite types based on discontinuous /dispersed phase. | 30 |
| 2.2.2. Rubber nanocomposites. | 31 |
| 2.2.2.1. Rubber composites | 31 |
| 2.2.2.2. Rubber nanocomposites. | 31 |
| 2.2.2.3. Skim natural rubber composites. | 32 |
| 2.2.2.4. Characterization of nanomaterial | 33 |
| 2.2.3. Montmorillonite nanoclay (MMT)..... | 34 |
| 2.2.3.1. Structure of Montmorillonite clay | 34 |
| 2.2.4. Processing methods of skim rubber MMT nanocomposites | 37 |
| 2.2.4.1. Latex blending method | 37 |
| 2.2.4.2. Melt blending method | 38 |
| 2.2.4.3. Solution blending method | 39 |
| 2.2.4.4. In-situ formation or in-situ polymerization | 40 |

| | Page |
|--|-----------|
| 2.2.5. Factors affect polymer composite properties. (Galimberti, Clipoletti, & Kumar, 2013)..... | 41 |
| 2.2.6. Analytical method of characterization of Rubber nanocomposites..... | 41 |
| 3.0 MATERIALS AND METHODS | 50 |
| 3.1. Materials | 50 |
| 3.1.1. Montmorillonite clay | 50 |
| 3.1.2. Skim rubber latex | 50 |
| 3.1.3. Ribbed smoke sheet (RSS) | 51 |
| 3.1.4. Skim Natural Rubber (SNR) | 51 |
| 3.1.5. Chemicals used in latex blending of MMT and SRLX | 52 |
| 3.1.6. Chemicals used in melt blending method | 52 |
| 3.1. Methodology | 53 |
| 3.1.1. Preparation of MMT filled SNR composites | 53 |
| 3.1.1.1. Preparation of MMT aqueous solution | 53 |
| 3.1.1.2. Preparation of MMT filled SNR composite | 53 |
| 3.1.2. Characterization of raw rubber properties of MMT filled SNR..... | 57 |
| 3.1.2.1. Initial plasticity (P_0) | 57 |
| 3.1.2.2. Plasticity Retention Index (PRI) | 57 |
| 3.1.2.3. Nitrogen content | 58 |
| 3.1.2.4. Volatile matter | 58 |
| 3.2.3. Viscoelastic behaviour of MMT clay filled SNR composites..... | 59 |
| 3.2.3.1. Mooney viscosity | 59 |
| 3.2.3.2. Mooney stress relaxation | 60 |
| 3.2.3.3. Mooney peak analysis of MMT filled SNR series | 61 |
| 3.2.3.4. Measuring Thixotropic behaviour of the MMT filled SNR composites | 61 |
| 3.2.4. Green strength analysis | 62 |
| 3.2.5. Melt blending of NR/SNR containing MMT clay | 63 |
| 3.2.4. Characterization and evaluation of melt blended NR/SNR-MMT blend series..... | 65 |
| 3.2.4.1. Vulcanization / curing parameters of NR/SNR-MMT blend series | 65 |
| 3.2.4.2. Structure properties relationship using X-ray diffraction. | 68 |
| 3.2.4.3. Physico-mechanical properties of NR/SNR-MMT blend series and NR/SNR blends | 70 |

| | PAGE |
|--|-------------|
| 4.0 RESULTS AND DISCUSSION | 76 |
| 4.1. Characterization of MMT filled SNR composite series | 76 |
| 4.1.1. Key observations of preparing MMT clay filled SNR through latex compounding..... | 76 |
| 4.1.2. Raw rubber properties of MMT filled SNR composite..... | 77 |
| 4.1.2.1. Initial Plasticity and PRI | 77 |
| 4.1.2.2. Nitrogen Content | 80 |
| 4.1.2.3. Volatile matter content | 82 |
| 4.1.3. Low shear strain rate rheological properties: | 83 |
| 4.1.3.1. Effect of clay on Mooney viscosity of SNR. | 83 |
| 4.1.3.2. Effect of temperature on Mooney viscosity of MMT filled SNR in different | 85 |
| 4.1.3.3. Stress relaxation of MMT filled SNR series | 86 |
| 4.1.3.4. Mooney peak analysis of MMT filled SNR composite | 89 |
| 4.1.3.5. Thixotropic behaviour of MMT filled SNR nanocomposites | 90 |
| 4.1.4. Effect of MMT clay on green strength of SNR..... | 92 |
| 4.1.5. Mechanism of MMT and non-rubbers in SRLX to deliver value added properties | 96 |
| 4.1.5.1. SNR structure and non rubbers | 96 |
| 4.1.5.2. Protein adsorption mechanism on MMT in aqueous solution. | 97 |
| 4.1.5.3. Proteins –ammine groups adsorption on MMT | 100 |
| 4.1.5.4. Fatty acids –carboxylic group adsorption on MMT | 101 |
| 4.1.6. Identification of suitable MMT loading level for bulk trail..... | 105 |
| 4.2. RESULT AND DISCUSSION 2: Preparation and characterization blend of MMT filled SNR and NR | 106 |
| 4.2.1. Curing/vulcanization parameters of NR/SNR - MMT blend | 106 |
| 4.2.1.1. Scorch time (t_{s1}) | 106 |
| 4.2.1.2. Cure rate | 108 |
| 4.2.1.3. Thermoplasticity | 110 |
| 4.2.2. Structure properties relationship using X-ray diffraction (XRD) | 112 |

| | Page |
|--|------------|
| 4.2.3. Evaluation of physico-mechanical properties of NR/SNR –MMT blend series | 117 |
| 4.2.4. Aging properties of NR/SNR-MMT | 130 |
| 4.2.5. Factors of MMT and rubber reinforcement..... | 134 |
| 4.2.6. Performance evaluation of NR/SNR blend series | 138 |
| | |
| 5.0 CONCLUSION | 139 |
| 5.1. Characterization of MMT filled SNR composites | 139 |
| 5.2. Characterization of MMT filled SNR and RSS blends | 140 |
| 5.3. Industrial implementation | 142 |
| | |
| 6.0 FUTURE WORK | 143 |
| | |
| 7.0 PUBLICATIONS | 144 |
| 7.1. IRRDB , International Rubber Conference 2015 | 144 |
| 7.2. IIUPST 2015 , Abstract number 23, Advances in Polymer materials | 155 |
| | |
| 8.0 REFERENCES | 157 |

LIST OF FIGURES

| | Page |
|--|------|
| Figure 2.1: Industrial centrifuging machine | 22 |
| Figure 2.2: Top most collection as concentrated latex | 22 |
| Figure 2.3: Specification for centrifuged or creamed ammonia preserved natural rubber latex [ISO 2004-1979 (E)] | 23 |
| Figure 2.4: Particle size distribution of concentrated and skim lattices (Sakdapipanich & Rojruthai, 2012) | 25 |
| Figure 2.5: Molecular weight distribution of the rubber from concentrated and skim lattices (Sakdapipanich & Rojruthai, 2012) | 25 |
| Figure 2.6: Classification of Composites (Jose, et al., 2012) | 31 |
| Figure 2.7: MMT clay T-O-T structure (Koo J. H., 2006) | 36 |
| Figure 2.8: Emulsion blending process of MMT clay (Galimberti, Rubber Clay Nanocomposites, 2012) | 38 |
| Figure 2.9: Melt blending process of organophilic clay | 39 |
| Figure 2.10: Solution blending process of rubber and clay | 39 |
| Figure 2.11: In-situ polymerization of rubber and layered clay minerals | 40 |
| Figure 2.12: Different nanocomposites arrangement can be obtained through the process (Camargo, Satyanarayana, & Fernando, 2009) | 42 |
| Figure 2.13: Schematic of WAXD patterns of different morphologies of layered Silicates. (Causin, 2013) | 44 |
| Figure 2.14: Typical Rheograph of a rubber compound .ts ₂ , ML, tc ₉₀ and MHF are significant readings | 47 |
| Figure 2.15: Stress strain curve of a rubber compound | 48 |
| | |
| Figure 3.1: Step 1-Preparation of MMT aqueous dispersion | 55 |
| Figure 3.2: Step 2 - Mixing MMT Coagulation | 55 |
| Figure 3.3: Step 3 - Recovery of filled composite | 55 |
| Figure 3.4: Step 4 - Milling and removing excess water | 56 |
| Figure 3.5: Step 5- Air drying and labelling | 56 |
| Figure 3.6: Typical Mooney and relaxation curve | 59 |
| Figure 3.7: Stress relaxation interpretation using logarithm | 61 |
| Figure 3.8: Time extended Mooney curve | 62 |
| Figure 3.9: General rheograph of a rubber compound (Dick, 2003) | 66 |
| Figure 3.10: Reversion Rheograph – indicate material degradation (Dick, 2003) | 67 |
| Figure 3.11: Marching Rheograph – indicate material further crosslinking (Dick, 2003) | 67 |
| Figure 3.12: Bragg's law interpretation of crystal sites | 68 |
| Figure 3.13: X-ray diffractometer | 70 |
| Figure 3.14: Stress strain curve of a Rubber compound | 71 |
| Figure 3.15: Device for compression set | 73 |
| | |
| Figure 4.1: P ₀ and PRI of MMT filled SNR nanocomposites | 77 |
| Figure 4.2: MMT influence in O ₂ diffusion | 79 |
| Figure 4.3: Nitrogen content of SNR and MMT filled SNR series | 80 |
| Figure 4.4: Volatile matter content of SNR and MMT filled SNR series | 82 |
| Figure 45: Mooney viscosity and Mooney stress relaxation curve of MMT filled SNR series | 83 |

| | Page |
|---|------|
| Figure 4.6: Mooney viscosity of MMT filled SNR series at 100 ⁰ C. | 84 |
| Figure 4.7: Mooney viscosity behaviour of MMT filled SNR series in different temperatures | 85 |
| Figure 4.8: Lamella and amorphous segments in rubber. | 86 |
| Figure 4.9: Stress relaxation behaviour of MMT filled SNR series | 87 |
| Figure 4.10: Shows the effect of MMT on Mooney peak value | 89 |
| Figure 4.11: Time Extended Mooney curve of SNR –MMT filled SNR | 90 |
| Figure 4.12: Thixotropic behaviour of SNR –MMT filled series | 91 |
| Figure 4.13: Tensile properties of MMT filled SNR series –Tensile strength | 93 |
| Figure 4.14: Green strength based on tensile properties –Tensile strength | 94 |
| Figure 4.15: Green strength based on tensile properties –Tensile modulus | 94 |
| Figure 4.16: Presumed structure for α and ω terminal group for NR (Sakdapipanich & Rojruthai, 2012) | 96 |
| Figure 4.17: Condensed (non-hydrated) MMT structure (Galimberti, Rubber Clay Nanocomposites, 2012) | 97 |
| Figure 4.18: Hydrated, structure of MMT in an aqueous solution (Galimberti, Rubber Clay Nanocomposites, 2012) | 97 |
| Figure 4.19: Chemisorption between ammine compounds (proteins and amino acids) and MMT structural active groups. (Yariv, 2002). H bond is represented as H •••N | 100 |
| Figure 4.20: Possible reaction with long chain fatty acid oxygen sheet of TOT structure. (Yariv, 2002) | 102 |
| Figure 4.21: Linkage formation fatty acids with exchangeable cation through water bridge . (Yariv, 2002) | 102 |
| Figure 4.22: Direct linkage with exchangeable cation (Yariv, 2002) | 103 |
| Figure 4.23: Linkage between COO- group and an exchangeable cation through a water bridge. (Yariv, 2002) | 103 |
| Figure 4.24: Direct linkage between COO- group and an exchangeable cation. (Yariv, 2002) | 103 |
| Figure 4. 25: Total performance of MMT -SNR filled series | 105 |
| Figure 4.26: t_{s1} of the NR/SNR – MMT blend series and NR/SNR blend. | 106 |
| Figure 4.27: Heat dependency of sulphur transition. | 107 |
| Figure 4.28: Cure rates of NR/SNR-MMT blend series and NR/SNR blend series | 108 |
| Figure 4.29: Energy requirement of sulphur crosslinking. | 109 |
| Figure 4.30: Energy requirement of sulphur crosslinking with presence of MMT. | 109 |
| Figure 4.31: Thermoplasticity of NR/SNR –MMT series and NR/SNR series. | 110 |
| Figure 4.32: X-ray diffraction of MMT(Cloesite Na, 30A) (Galimberti, 2012) | 112 |
| Figure 4.33: X-ray diffraction of 80NR20SNR-2 | 113 |
| Figure 4.34: X-ray diffraction of 60NR40SNR-4 | 114 |
| Figure 4.35: X-ray diffraction of NR40SNR60-6 | 114 |
| Figure 4.36: X-ray diffraction of NR20SNR80-8 | 115 |
| Figure 4.37: X-ray diffraction of SNR-10 | 115 |
| Figure 4.38: Stress strain curves of NR, SNR and NR/SNR -MMT blend series | 117 |
| Figure 4.39: Tensile Strength of NR/SNR –MMT blend series and NR/SNR blend series | 118 |
| Figure 4.40: Tensile modulus of NR/SNR –MMT blend series and NR/SNR series | 119 |
| Figure 4.41: Elongation at break NR/SNR-MMT series and NR/SNR blends series | 119 |

| | Page |
|--|------|
| Figure 4.42: Tear strength of NR/SNR-MMT blend series and NR/SNR series | 120 |
| Figure 4.43: Hardness of NR/SNR-MMT blend series and NR/SNR series | 124 |
| Figure 4.44: Compression set of NR/SNR- MMT blend series and NR/SNR series | 125 |
| Figure 4.45: Abrasion of NR/SNR-MMT Blend series and NR/SNR series | 127 |
| Figure 4.46: Rebound resilience of NR/SNR-MMT blend series and NR/SNR series | 128 |
| Figure 4.47: Percentage tensile strength retention of NR/SNR –MMT series in comparison to NR/SNR blend | 131 |
| Figure 4.48: Retention of tensile modulus of NR/SNR-MMT blend series and NR/SNR series | 131 |
| Figure 4.49: Retention of elongation at break of NR/SNR-MMT blend series and NR/SNR series | 132 |
| Figure 4.50: Retention of tear strength of NR/SNR- MMT series and NR/SNR series | 132 |
| Figure 4.51: Formation of primary and aggregations (Samsuri, 2014) | 136 |

LIST OF TABLES

| | Page |
|--|------|
| Table 2.1: Chemical composition of fresh NR latex (Mathew, 2001) | 18 |
| Table 2.2: Chemical composition of SNR (Nithi-Uthai, et al., 1999); (Ho, 2014)..... | 27 |
| Table 2.3: Classification of clays based on surface electrical charge (Galimberti, 2012) | 34 |
| Table 2.4: SNR- MMT nanocomposite main analytical methods and testing | 43 |
| Table 2.5: Significant features of XRD..... | 45 |
| Table 2.6: Tensile test parameter and indicating properties | 49 |
| | |
| Table 3.1: Properties of RSS rubber. (Seneviratne, 2003) | 51 |
| Table 3.2: Chemicals in dry and wet solution forms used in this process | 52 |
| Table 3.3: Chemicals involved in melt blending, which were used to | 52 |
| Table 3.4: Estimation of required SRLX and MMT aqueous solution volumes for 600 g of the SNR. | 54 |
| Table 3.5: Rubber ratios of series 1 NR /SNR-MMT blend. | 63 |
| Table 3.6: Rubber ratios of series 2 NR/SNR blends. | 64 |
| Table 3.7: General formula being used | 64 |
| Table 3.8: Melt blending internal mixer (brabender) mixing circle. Chemicals are introduced as mentioned order. | 64 |
| Table 3.9: Melt blending two roll mill mixing introduced as in order of mentioned. | 65 |
| Table 3.10: Rheograph parameter and resembling properties. | 66 |
| Table 3.11: Tensile test parameter and indicating properties | 71 |
| | |
| Table 4. 1:1 +a Rate of relaxation –shows elasticity of rubber, K is viscosity of the compound after 1s of shear force removal. | 88 |
| Table 4.2: Cure characteristics of NR/SNR-MMT and NR/SNR series. | 111 |
| Table 4.3: X-ray diffraction test summery | 116 |
| Table 4.4: Performance of NR/SNR-MMT Blend series. | 138 |

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