A NEW DEVELOPMENT OF MODIFIED DIPPING PROCESS OF THE PREVULCANIZED NATURAL RUBBER LATEX FILMS : INVESTIGATION ON THE TENSILE AND SWELLING PROPERTIES

by

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APPROVAL AND DECLARATION SHEET

This project report titled A New development Of Modified Dipping Process Of The Prevulcanized Natural Rubber Latex Films : Investigation on The Tensile And Swelling Properties was prepared and submitted by Noor Marlyna binti Ismail (Matrix Number: 0831620288) and has been found satisfactory in terms of scope , quality and presentation as partial fulfillment of the requirement for the Master of Science (Polymer Engineering) in Universiti Malaysia Perlis (UniMAP).

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LIST OF ABBREVIATIONS

ASTM	American Standard Testing Manual
$CaCO_3$	Calcium carbonate
CV	Conventional vulcanization
DRC	Dry rubber content
EV	Efficient vulcanization
HA	High ammonia
ISO	International Standard Organization
KOH	Potassium hydroxide
LA	Low ammonia
MST	Mechanical stability test
NR	Natural Rubber
PCC	Precipitated calcium carbonate
pH	Alkalinity
phr	Part per hundred rubber
RRIM	Rubber Research Institute of Malaysia
SEM	Scanning electron microscopy
TMTD	Tetramethylthiuram Disulfide
TSC	Total solid content
VFA	Volatile fatty acid
ZDEC	Zinc Diethyl Dithiocarbamate
ZnO	Zinc oxide

PEMBANGUNAN TERBARU PROSES PENCELUPAN TERUBAHSUAI BAGIFILEM-FILEM LATEKS GETAH ASLI TERUBAHSUAI: PENYIASATAN KE ATAS SIFAT-SIFAT TEGANGAN DAN PEMBENGKAKAN

ABSTRAK

Filem-filem lateks getah asli tervulkan dihasilkan dengan proses pencelupan terubahsuai dan sifat-sifat tegangan dan pembengkakannya dikaji. Dua jenis lateks getah asli digunakan iaitu lateks ammonia tinggi (HA) dan lateks ammonia rendah (LA). Kajian ini dibahagikan kepada tiga bahagian utama. Bahagian pertama bagi kajian ini adalah untuk tentukan masa pematangan paling sesuai bagi sebatian lateks tersebut. Oleh yang demikian, setiap jenis lateks dimatangkan kepada tiga masa yang berbeza iaitu 1 jam, 3 jam dan 24 jam. Sebatian lateks dimatangkan seterusnya di dalam bekas mandian pada suhu 70°C sehingga nombor kloroform 3 dicapai, yang mana menunjukkan koagulum adalah aglomerat yang tak melekit. Pada tahap ini, sebatian lateks dianggap telah sederhana tervulkan. Kemudian, sebatian-sebatian lateks tersebut dijalankan proses pencelupan koagulasi dan diikuti dengan pematangan/ pengeringan pada suhu bilik, pelucutan dan pengujianan. Keputusan-keputusan ujian tegangan menunjukkan bahawa kekuatan tegangan dan modulus tegangan (M100 dan M300) adalah meningkat manakala pemanjangan pada takat putus menurun denagn pertambahan pembebanan pengisi, dengan parameter pematangan pada 24 jam menunjukkan nilai tertinggi bagi kesemua sifat-sifat tensil diikuti dengan 3 jam dan 1 jam. Pada pembebanan pengisi yang sama, lateks HA menunjukkan sifat-sifat tegangan yang lebih baik daripada lateks LA. Bahagian yang kedua melibatkan penyiasatan ke atas masa dan suhu pematangan berbeza bagi lateks. Sebatian lateks disediakan sama kaedah seperti di bahagian pertama dengan masa pematangan adalah 3 jam. Masa pematangan 3 jam tersebut dipilih kerana proses menjadi lebih berkesan dari segi penggunaan masa. Selepas itu, sebatiap tercelup di divulkankan di dalam oven pada dua proses berbeza. Oven pertama disetkan pada suhu yang lebih rendah daripada oven yang kedua, dan dipelbagaikan dengan masa. Daripada keputusan-keputusan ujian tegangan, bahagian ini menerangkan bahawa suhu pematangan pada 70°C dan 80°C bagi Oven A dan Oven B, setiap satunya menunjukkan sifat-sifat yang lebih baik daripada parameter-parameter pematangan yang lain. Untuk bahagian terakhir, setiap sampel di bahagian pertama dan kedua dijalankan proses pelarutresapan. Sampel terlarutresap kemudiannya diuji sifat-sifat tegangannya. Pada masa yang sama, latek tervulkan juga disediakan denagn process pencelupan terubahsuai yang mana sebatian-sebatian tercelup divulkankan di dalam oven dan kemudian diteruskan dengan pemvulkanan di dalam bekas mandian. Akhirnya, sampel-sampel lateks termatang-terlarutresap dikeringkan pada suhu bilik selama 24 jam sebelum dilakukan pengujianan. Keputusan bagi sampel-sample pencelupan terubahsuai menunjukkan sifat-sifat tegangan yang lebih baik daripada sampel-sampel di bahagian pertama (divulkankan pada suhu bilik) dan bahagian kedua (divulkankan di dalam oven). Secara keseluruhan, ketumpatan sambung silang meningkat/ lebih tinggi dengan peningkatan pembebanan pengisi, masa pematangan dan dengan penggunaan lateks HA. Ketumpatan sambung silang juga adalah tinggi bagi sampel-sampel yang divulkankan dengan proses pencelupan terubahsuai berbanding divulkankan pada suhu bilik dan di dalam oven.

A NEW DEVELOPMENT OF MODIFIED DIPPING PROCESS OF THE PREVULCANIZED NATURAL RUBBER LATEX FILMS: INVESTIGATION ON THE TENSILE AND SWELLING PROPERTIES

ABSTRACT

Prevulcanized natural rubber latex films were produced by modified dipping process and their tensile and swelling properties were investigated. Two type of natural rubber latex which is high ammonia (HA) and low ammonia (LA) latex. This research study is divided into three main parts. The first part of this research is mainly to determine the most suitable maturation time for the latex compound. Therefore, each type of latex was matured into three different maturation time, i.e., 1 hour, 3 hour and 24 hour. The latex compounds were further matured in water bath at temperature of 70°C until chloroform number 3 is achieved, in which indicates that coagulum is a non-tacky agglomerates. At this stage, the latex compound is considered moderately vulcanized. Then, the latex compounds were underwent coagulant dipping process and followed by curing/ drying at room temperature, stripping and testing. Results of the tensile test show that tensile strength and tensile modulus (M100 and M300) is increase whereas elongation at break decrease with increasing filler loading, with maturation parameter at 24 hour has shown the highest value for all tensile properties, followed by 3 hour and 1 hour. At similar filler loading, HA latex shows better tensile properties than LA latex. The second part involves the investigation on different curing time and temperature of the latex. The latex compounds were prepared as same method as in the part one with maturation time is 3 hour. The 3 hour maturation was chosen because the process is become more effective in term of time consuming. After that, the dipped compounds were vulcanized in the oven at two different processes. The first oven was set at lower temperature than the second oven, and variables with time. From the tensile test results, this part exhibits that the curing temperature at 70°C and 80°C for Oven A and Oven B, respectively, with curing time of 10 minutes for each oven shows better properties than other curing parameters. For last part, every sample in part one and two were underwent leaching process. The leached latex samples were then tested their tensile properties. At the same time, the vulcanized latex also prepared by modified dipping process in which the dipped compounds were vulcanized in the oven and then proceed with the vulcanization in the water bath. Finally, the cured-leached latex samples were dried at room temperature for 25 hours before testing. The results of modified dipping process latex samples show better tensile properties than samples in part one (vulcanized at room temperature) and part two (vulcanized in oven). Overall, crosslink density increases/ higher with increasing filler loading, maturation time and by using HA latex. The crosslink density is also higher for samples that vulcanized by modified dipping process than vulcanized at room temperature and in the oven.

CHAPTER 1

INTRODUCTION

1.1 Research Background and Problem Statement

Malaysia is the largest latex based product manufacturer in the world, especially in manufacturing gloves. Malaysia is also the largest worldwide exporter of rubber gloves whereas Thailand accounts for less than half of the Malaysian market share. The global demand for rubber gloves has increased due to recent regulations on occupational safety. The demand for rubber gloves is expected to grow by 10% per annum. Table 1.1 shows the statistics of demand for natural rubber latex in Malaysia from year 2000 to mid of 2005 (www.lgm.gov.my), while Table 1.2 shows the export demand on latex glove in Malaysia for the year 2004 and 2005 (www.margma.com.my). They are many other products made from natural rubber latex such as condoms, catheters, baby teats, swimming suits, etc. Most of the products listed here having their own former which is specially designed according to the final application of the products.

Latex dipping techniques, i.e., simple/ straight dipping, coagulant dipping, heat-sensitized dipping are the most famous and suitable method to produce products from latex, as mentioned earlier in the previous paragraph. The processing stage can be varied, depends upon the size of the production of certain companies. As for example, Top Glove company in Johor is practicing their own manufacturing flow process, as can be seen in Figure 1.1. This processing may be involved the high cost production since it is involves a very long process. Because of that concerns, this research interest is to develop a new processing method which is simpler than the conventional one. The process is involves a modification curing method by combining the oven prevulcanization stage with prevulcanization in the water bath/ steam bath, and thus the leaching process at the end of the processing stage is no more needed.

However, the biggest challenges for the latex manufacturing company, especially in manufacturing natural rubber latex gloves is on the protein allergy that causes allergy reaction to the human being who suffered from skin allergy diseases. This disease is more attack peoples who worked in hospitals, children with spinal bifida, workers in the rubber industry, etc. Many attempts have been made to reduce the effect of protein allergy caused by protein in the latex gloves. The latest is (since 1999-2000), local manufacturers began mass production of polymer-coated powder-free examination gloves that are similar in concept as the Biogel surgical gloves. After several years of intensive R & D spearheaded by the Rubber Research Institute of Malaysia (RRIM), the manufacturers are now able to produce top-notched polymer-coated examination gloves as a viable alternative to their chlorinated counterpart (www.mrepc.com/publication/stretch_pdf/stretch_0201.pdf). Another famous method is by practicing leaching technique, whereby the latex gloves were immersed in the water-based medium, i.e., distilled water or pipe water. During leaching, some of the proteins and other water-soluble substances present in the latex glove will be removed as far as possible.

Table 1.1 : Demand of NR latex in Malaysia (2000 – until mid year 2005)

Year	Amount of NR (million tone)	Glove used (million tone)	% of glove used
2000	363, 715	201, 159	55.3
2001	400, 888	224, 430	60.0
2002	407, 884	224, 644	51.1
2003	420, 776	216, 589	51.5
2004	415, 961	230, 448	55.4
Until middle year 2005	413, 218	219, 812	53.8

Table 1.2 : Demand of latex glove from Malaysia (quantity is in pair (million) and value is in Ringgit Malaysia)

Month	Total of glove			
	2004		2005	
	Quantity	Value	Quantity	Value
January	1,816.5	239.7	2,930.3	333.9
February	1,958.4	271.7	3,068.8	328.4
March	2,066.6	264.9	3,444.7	379.5
April	2,168.8	300.5	3,233.7	368.6
Mei	2,107.8	276.3	2,584.9	363.9
June	2,053.6	287.6	3,234.3	366.1
July	2,521.1	319.2	3,049.0	385.9
August	2,545.6	310.5	3,098.40	447.3
September	2,188.1	266.2	3,085.0	469.2
October	2,674.4	316.2	-	-
November	2,720.3	252.5	-	-
December	2,612.3	303.2	-	-
Total	27,433.3	3,408.5	27,428.7	3,442.8

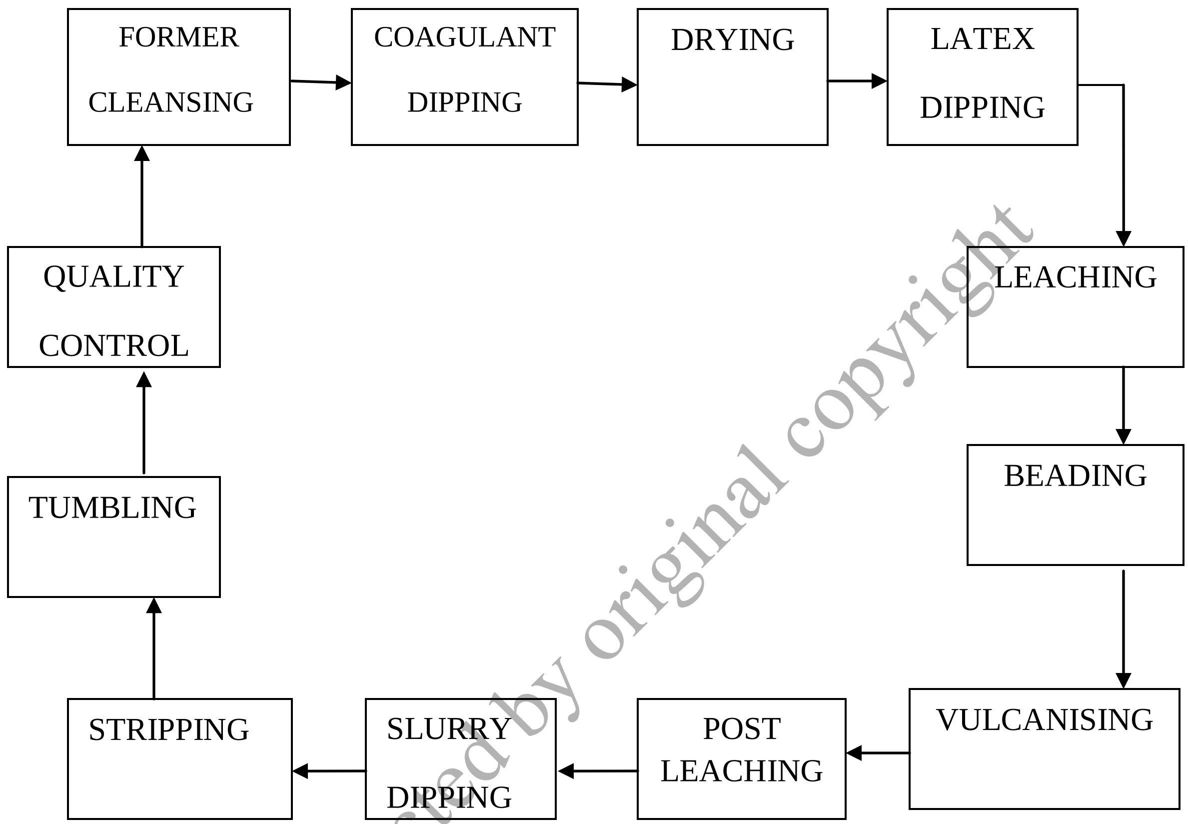

Figure 1.1 Manufacturing process flow by Top Glove Sdn Bhd.

1.2 Research objective

The aim of this research is to develop a new dipping process by combining oven curing stage with curing in water bath, in order to produce prevulcanized NR latex film. For this reason, the primary objectives of study were listed as:

1. to study the effect of maturation time and filler loading on the properties of prevulcanized NR latex;

2. to study the effect of curing parameters on the properties of prevulcanized NR latex;

3. to compare properties between conventional dipping process with modified dipping process of prevulcanized NR latex;

4. to study the effect of leaching on the properties of prevulcanized NR latex.

1.3 Outline of Thesis Structure

The thesis has been divided into ten (5) chapters and each chapter deals with an aspect of the overall problem of understanding the compressive behaviour of the prevulcanized natural rubber latex.

- Chapter 1 covers the introduction of the thesis. It provides an overall introduction for the study including a brief introduction about research background and problem statement, an objective of study and outline of the thesis;
- Chapter 2 provides a review characteristics of filler
- Chapter 3 details the materials, instruments and experimental procedures applied in this research;
- Chapter 4 discusses on the points listed in the objectives of the study (Chapter 1.3)
- Chapter 5 presents conclusions on the present work and suggestions for future work.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

2.1.1 Natural Rubber Latex

Natural rubber is an unsaturated hydrocarbon consisting of carbon and hydrogen with an empirical formula of C5H8. Natural rubber has a high average molecular weight usually between 100,000 and 500,000 daltons. Isoprene is the repeating unit of natural rubber where one double bond unit existed for each C5H8 group. It is a long chain polymer structure which almost all (90-95%) the isoprene have the cis-1,4-polyisoprene configuration. Figure 2.1 shows the chemical structure of cis-1, 4-polyisoprene (Morton, 1973). Table 2.1 shows the typical compositions of NR latex.

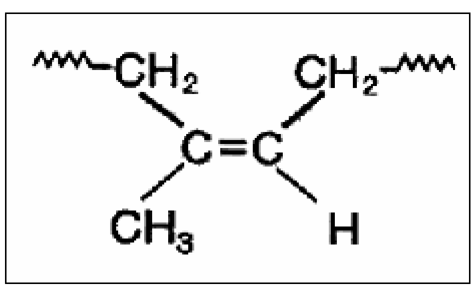

Figure 2.1: Chemical structure of cis-1,4-polyisoprene

Table 2.1: Typical compositions of NR latex

Items	Composition (%)
Total solid content	36
Dry rubber content	33
Proteineous substances	1-1.5
Resinous substances	1-2.5
Ash	< 1
Sugars	1
Water	60

The latex is collected from the trees and processed into commercial rubber latex. The low rubber content and high non-rubber solids found in NR latex has severely limits its usefulness as an industrial raw material. NR latex is normally concentrates to 60% DRC. Hence it is necessary to concentrate the field latex to increase its dry rubber content (DRC). Three concentration methods are available i.e., creaming, evaporation and centrifugation. The latex concentrates must be preserved to inhibit bacterial growth that could destabilize the latex. Therefore, ammonia is usually added to the latex as a preservative to increase the alkalinity (pH) and retard microbial growth. The additional benefit for adding ammonia is the increase in stability of the NR latex due to the increase in negative surface charge of the rubber particles (Loganathan, 1998).