STUDY ON

ETHEPHON (2-CHLOROETHYLPHOSPHONIC ACID) STIMULATION OF NATURAL RUBBER LATEX ON PHYSIO-CHEMICAL AND MECHANICAL PROPERTIES OF RUBBER

by

Anusha Priyanthi Attanayake

Ph.D **2016**

STUDY ON

ETHEPHON (2-CHLOROETHYLPHOSPHONICACID) STIMULATION OF NATURAL RUBBER LATEX ON PHYSIO-CHEMICAL AND MECHANICAL PROPERTIES OF RUBBER

By

Anusha Priyanthi Attanayake

Thesis submitted to the University of Sri Jayewardenepura

For the award of the

Degree of Doctor of Philosophy in Chemistry

2016

STUDY ON

ETHEPHON (2-CHLOROETHYLPHOSPHONICACID) STIMULATION OF NATURAL RUBBER LATEX ON PHYSIO-CHEMICAL AND MECHANICAL PROPERTIES OF RUBBER

By

Anusha Priyanthi Attanayake

Thesis submitted to the University of Sri Jayewardenepura

For the award of the

Degree of Doctor of Philosophy in Chemistry

CERTIFICATION OF SUPERVISORS

"We certify that the candidate has incorporated all corrections, additions and amendments recommended by the examiners to this final version of the PHD thesis"

.....

Professor L.Karunanayake

Department of Chemistry

University of Sri Jayewardenepura

Nugegoda

Sri Lanka

.....

Dr. A.H.L.R. Nilmini

Polymer Chemistry Department

Rubber Research Institute of Sri Lanka

Rathmalana

DECLARATION

The work described in this thesis was carried out by me under the supervision of Professor L.Karunanayake of the University of Sri Jayewardenepura and Dr. A.H.L.R Nilmini, Rubber Research Institute of Sri Lanka and a report on this has not been submitted in whole or in part to any university or any institution for another Degree/Diploma.

Signature:.....

Name :Anusha Priyanthi Attanayake

Date :2017/07/24

SUPERVISORS' CERTIFICATION

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

Professor L.Karunanayake

Department of Chemistry

University of Sri Jayewardenepura

Nugegoda

Sri Lanka

Dr A.H.L.R Nilmini

Polymer Chemistry Department

Rubber Research Institute of Sri Lanka

Ratmalana

Sri Lanka

Dedicated to my dear Husband

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABRIVATIONS

S/2 d 2	-	Half spiral cut once in two days frequency
S/2 d3	-	Half spiral cut once in three days frequency
DRC	-	Dry Rubber Content
TSC	-	Total Solid Content
NRC	-	Non rubber content
ET	-	Ethephon
NRL	-	Natural Rubber Latex
VFA	-	Volatile Fatty Acid
ISO	-	International Standard Organization
NR	-	Natural Rubber
EB%	-	Percentage elongation at break
MW	-	Molecular weight
MWD	-	Molecular weight distribution
P_0	-	Plasticity Number
PRI	-	Plasticity Retention Index
HFA	-	Higher Fatty Acid
FTIR	-	Fourier transform Infrared spectroscopy
CLD	-	Cross link density
IPP	-	Isopentenyl pyrophosphate
SRPs	-	Small rubber particles
LRPs	-	Large rubber particles

ACKNOWLEDGEMENT

I owe a sense of gratitude to Prof. Laleen Karunanayake and Dr.A.H.R.L Nilmini, my supervisors for their guidance, encouragement and advice throughout this study. Apart from I am very much grateful to Prof. Asoka Nugawela, former Director, Rubber Research Institute, Sri Lanka for giving me this opportunity to carry out this study. I would like to express my heartiest gratitude to the Chairman, RRB and Director, RRISL Dr. Gamini Seneviratne and Dr.Susantha Siriwardena, Deputy director(Technology) permitting me permission to carry out this project. Every support given by all the staff of Raw Rubber and Chemical Analysis Department is sincerely acknowledged. I offer my heartiest thanks to Ms.Champa Lokuge and Mr.Pradeep for giving their fullest support throughout the study. I wish to give my special thanks to Dr.Wasana Wijesuriya and Mr.Vitharana for statistical analysis and staffs of Biochemistry department & Plant Pathology department for extend their support to sample analysis.

My special respect goes to my dear friends, Dr.Sagari and Dr.Sarojani who greatly helped and encouraged me to complete this project successfully. Finally I wish to express my since gratitude to my husband Eranga and my mother for being strength throughout the study. Last I would like to express my appreciation to those who helped me to complete this project successfully.

Study on Ethephon (2-Chloroethylphosphonicacid) stimulation of Natural Rubber Latex on Physio-chemical and Mechanical Properties of Rubber

Anusha Priyanthi Attanayake

ABSTRACT

Low frequency harvesting systems were introduced as a solution for key challenges faced by the rubber industry, such as lack of skilled tappers, high cost of production and declining rubber prices in international market. So far in-depth comprehensive technological analysis on effect of ethephon concentration has not been done. Therefore, the aim of the present investigation was to identify the effect of stimulation on raw rubber and latex properties. Further, physico-mechanical properties and ultimate processability were studied. The results of the study revealed that the maximum rubber yield as well as optimum physico-mechanical properties could be achieved with 3% ethephon concentration and higher doses of stimulant did not further improve the production. Total solid content, dry rubber content and latex viscosity were reduced with the increased ethephon concentration with simultaneous increase of non-rubber content. Viable count of bacteria increased significantly; as a result of high non rubber and sugar content in more diluted latex. Packing efficiency of latex enhanced by the production of small rubber particles with the increase of ethephon concentration, which leads to superior green strength for latex casting film. Therefore, stimulated latex could be recommended for the applications such as gloves, balloons and exercise belts.Extremely high plasticity retention index value and high ageing resistance were reported with rather low Mooney viscosity

and elasticity value which would be of advantage in-terms of product manufacturer's perspective. Lovibond colour index improved up to 3% due to retardation of enzymatic discolouration by thiol compounds. However, higher doses of ethephon lead to discoloration of rubber. Stimulation enhanced the production of short polyisoprene chains, with significant reduction in plasticity number, viscosity averaged molecular weight and increased the storage hardening and gel formation. However, above properties were at an acceptable level up to 3% ethephon concentration.End to end linkage of linear polymer of relatively long chains with very short chains create highly cross linked network which can tolerate the applied stress. Outstanding properties i.e.high tear strength, percentage elongation at break and elastic modulus were attributed to the bimodality in chain length. Relatively long chains serving to retard rupture while limited extensibility of very short chains improve the elastic modulus and ultimate strength. 3% ethephon concentration could be recommended as the best in terms of cure characteristics of unfilled compound rubber with maximum scorch safety time, maximum cure time and highest cure rate index. Due to vulcanization accelerator activator effect of decomposition products of proteins stimulated rubber imparts high cure rate than the control. Latex and raw rubber properties with the application of 3% ethephon revealed that, maximum effective time was 15 days after stimulation which would be a drawback of stimulation. Application of recommended dosage may only provide the optimum properties and higher doses may deteriorate the expected results. Dynamic and Physico-mechanical properties of stimulated rubber prepared with different filler loadings and application of glutathione in latex stage to replace or reduce the dosage of bleaching agent are among the future interests.