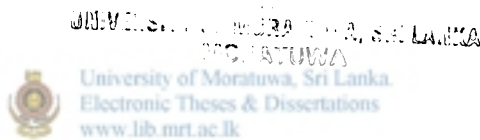


**INCORPORATION OF ACTIVATED CARBON
IN NATURAL RUBBER LATEX FOAM
FOR IMPROVEMENT IN SORPTION PROPERTY**

BY

A. R. M. RAJAKARUNA



**A dissertation submitted as partial fulfillment of the requirements for the
award of the degree of MASTER OF SCIENCE in Polymer Technology,
University of Moratuwa.**

**Department of Chemical and Process Engineering
University of Moratuwa
Sri Lanka.**

66 "06"

678(043)

May 2006

University of Moratuwa



87134

87134

87134

DECLARATION

I certify that this dissertation does not incorporate without any acknowledgement any material previously submitted for a Degree or a Diploma in any University or Institution and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due references are made in the text.

UOM Verified Signature

A. R. M. Rajakaruna

Approved for submission

UOM Verified Signature

University of Moratuwa, Sri Lanka
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

Dr. Shantha Walpolage

Course Coordinator - M.Sc in Polymer Technology,
Senior Lecturer,
Department of Chemical and Process Engineering,
Faculty of Engineering,
University of Moratuwa.

ACKNOWLEDGEMENT

I wish to express my heartfelt gratitude to Dr. Shantha Walpolage, the Course Coordinator - MSc in Polymer Technology, University of Moratuwa, as well as my project supervisor, for providing me the guidelines and the necessary facilities to carry out this research study. I acknowledge with deepest gratitude for his constant guidance, timely advice and consultative encouragement extended to me throughout the study.

I am indebted to my employer, Mr. Rohana Silva, former General Manager - Richard Pieris Natural Foams Ltd, Biyagama and Arpico Natural Latexfoams Ltd, Avissawella, sanctioning me leave and providing facilities to follow the MSc in Polymer Technology course.

I owe a sense of gratitude to Mr. Wasantha Abeysirigunawardena, General Manager - Group Research and Development, R&D Centre, Richard Pieris and Company, for providing me the opportunity to carry out this research study successfully and backing me up with advice, suggestions and assistance whenever I needed.

My sincere thanks should also go to Manjula, Susantha and Chandika at Arpico Natural Latexfoams Ltd for their kind assistance given to me to carry out laboratory testing and experimental work. I would also like to thank Lelwela, Indika and the technical staff of R&D Centre, who helped me in many ways.

I wish to record my sincere appreciation for the assistance given by Mr. Sisira de Silva, Mr. Hemachandra and the technical staff of Latex laboratory of Chemical and Process Engineering department, University of Moratuwa.

I wish to thank J.B Activators, Silvermill Group and Heycarb International for providing me with samples of activated carbon free of charge to carry out this study.

Last but not least, I would like to dedicate a very special word of thanks to my late father, my mother, my husband Rasika and my parents-in-law for being with me throughout the study.

ABSTRACT

Natural Rubber (NR) latex is a colloidal dispersion of NR polymer which is predominantly cis 1,4 -Polyisoprene in an aqueous medium. Various chemicals are added to NR latex mainly as dispersions, at compounding stage to enhance processing characteristics and to obtain desired properties of the final product. The properties of chemicals in dry form or as dispersions are critical for latex compounding for maintaining the overall colloidal stability of the latex mix. Addition of chemical dispersions into latex for compounding are basically governed by particle or droplet size, physical nature, viscosity, pH and stability of the dispersion. Hence, properties of raw materials (compounding chemicals) are very important for making good dispersions for latex compounding and producing desired latex products.

In this study, an attempt was made to use activated carbon as a compounding ingredient to enhance the sorption properties of NR latex foam product. From this study it was found that activated carbon powder which had particle size below 10μ and pH (in 1% solution) having a basic pH or a pH towards neutrality can be made to a stable dispersion of 36% Total Solids Content by ball milling for 18 hours in the presence of a dispersing agent. This dispersion had proper dispersion characteristics such as low particle size (3μ), a pH greater than 7 and low viscosity value. From mechanical and chemical stability studies on latex compound, it was found that up to 2.0% (on dry weight of latex) of activated carbon, the latex compound had good mechanical and chemical stability. At 2.0% activated carbon, the cellular structure of the foam was satisfactory. From physical property testing of foam with activated carbon on compression set and tensile strength, it was found that good foam properties were obtained with the chemical formula for optimum vulcanizing condition consisting of phr 2.55 Sulphur, 1.10 ZDC and 0.85 ZMBT.

The results of sorption property investigations of this study reveal that NR latex foam with 2.0% activated carbon has a significantly higher sorption property compared to standard NR latex foam. Therefore, activated carbon can be incorporated to a NR latex compound in dispersion form at 2.0% dosage to produce a latex foam pillow having higher sorption property.

CONTENTS

	Page
Declaration	ii
Acknowledgement	iii
Abstract	iv
List of tables	viii
List of figures	xi
List of abbreviations	xiii
1.0 INTRODUCTION	
1.1 Natural Rubber (NR) latex foam	1
1.2 Activated carbon and latex foam	3
1.3 Objectives of the project	3
2.0 LITERATURE REVIEW	
2.1 Latex	5
2.2 NR Latex	5
2.3 Manufacture of NR latex foam	7
2.4 Activated carbon	25
2.5 Method of approach for developing NR latex foam with activated carbon	32
2.6 Method of incorporation of activated carbon into NR latex compound	33
2.7 Uses of activated carbon in NR latex foam	33

3.0 EXPERIMENTAL DESIGN

3.1	An outline of the proposed experimental design	35
3.2	Testing of activated carbon powder	36
3.3	Methods of preparation of activated carbon dispersion	37
3.4	Preparation of activated carbon dispersion with maximum T.S.C% and investigation of dispersion properties	38
3.5	Determination of the best activated carbon dispersion for making a stable NR latex compound	41
3.6	Determination of the effect of dosage of activated carbon dispersion for making a stable foam from NR latex	45
3.7	Optimizing the vulcanizing system	48
3.8	Production of pillows with activated carbon	50
3.9	Investigation of sorption property of NR latex foam having activated carbon	52

4.0 RESULTS AND DISCUSSION

4.1	Selection of activated carbon powder	54
4.2	Preparation of activated carbon dispersion	55
4.3	Properties of activated carbon dispersion with maximum T.S.C %	60
4.4	Selection of best activated carbon dispersion at 36% T.S.C in NR latex compound	63
4.5	Effect of dosage of activated carbon for making a stable foam of NR latex	68

4.6	Optimizing the vulcanizing system- chemical formulation	73
4.7	Compression set and tensile strength values for pillows with activated carbon	77
4.8	Measurement of sorption property of NR latex foam having activated carbon	78
5.0	CONCLUSIONS AND SUGGESTIONS FOR FUTURE WORK	
5.1	Conclusions	80
5.2	Suggestions for future work	80
	Appendix I	81
	Appendix II	82
	Appendix III	83
	Appendix IV	84
	List of references	



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

LIST OF TABLES

Table No.		Page
2.1	A typical composition of field latex	6
2.2	Composition of centrifuged latex concentrate	7
2.3	A typical formulation for initial latex compound	16
2.4	Formulation for second stage addition of chemicals for latex compound	16
2.5	Formulation for addition of gelling agents for latex compound	17
2.6	Solubilities and equilibrium pH values of various silicofluoride salts	20
3.1	Different preparation methods of AC dispersion	38
3.2	Formula for activated carbon dispersion preparation	39
3.3	Formula for preparation of chemical dispersions for latex compounding	41
3.4	Formula for 20% soap (potassium oleate) solution preparation	42
3.5	A basic formulation for white latex compound	42
3.6	Formula for latex compounds with varying AC dosages from S2-D dispersion	46
3.7	Formulation for compound preparation with varying sulphur	48
3.8	Formulation for compound preparation with varying ZDC	48
3.9	Formulation for compound preparation with varying ZMBT	48
3.10	Formulation for production of pillows with activated carbon	51
3.11	Dimensions of foam pieces for sorption test	52
4.1	Results related to raw material testing of different activated carbon samples	54

4.2	Data related to different dispersion preparation methods for sample ID S-2	56
4.3	Data related to different dispersion preparation methods for sample ID S-3	57
4.4	Data related to different dispersion preparation methods for sample ID S-5	57
4.5	Properties of AC dispersions with varying T.S.C% for sample ID S- 2	60
4.6	Properties of AC dispersions prepared from selected raw material samples	62
4.7	Data related to T.S.C% of basic latex compound (white)	63
4.8	Data related to MST and pH of basic latex compound (white)	63
4.9	Results related to coagulum formation test at 1% AC dosage	64
4.10	Results related to MST test of latex compounds with different AC dispersions at 1% dosage	64
4.11	Results related to pH test of latex compounds with different AC dispersions at 1% dosage	65
4.12	Results related to chemical stability test (gel time) of latex compounds with different AC dispersions at 1% dosage	65
4.13	Data related to foaming height of latex compounds at partially foamed stage for different AC dosages	68
4.14	Gel times of latex compounds having different AC dosages	69
4.15	Data related to structure analysis of foam with varying dosages of AC	70
4.16	Compression set % for each sample and average compression set % values for 1S- 3S, 1D- 3D, 1M - 3M and 1C-2C	74

4.17	Average tensile strength values of foam of 1S-3S, 1D-3D, 1M-3M and C	75
4.18	Compression set and tensile strength of 60D black pillows	77
4.19	Weight of normal and black foam samples with time, in ammonia environment	78
4.20	Percentage sorption values of normal white foam and black foam	78



University of Moratuwa, Sri Lanka
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

LIST OF FIGURES

Figure No.		Page
2.1	Structure of isoprene (2-methyl-1, 3-butadiene)	5
2.2	A rubber tree at tapping stage	5
2.3	Various products of latex foam rubber (Mattress/ Pillow/ Sheet)	8
2.4	Structure of S ₈ ring	12
2.5	Chemical structure of ZDC	13
2.6	Chemical structure of ZMBT	13
2.7	Chemical structure of Ralox	14
2.8	Chemical structure of DPG	15
2.9	Oakes continuous mixer	18
2.10	Foam filling into a mould	19
2.11	Mattress washing	23
2.12	Horizontal slitting of foam to produce sheets	24
2.13	Schematic flow chart of Dunlop process of NR latex foam manufacture	24
2.14	Schematic flow chart of activated carbon manufacturing process	26
2.15	A view of pore structure of activated carbon – SEM view 1	28
2.16	Pore structure of activated carbon under SEM view 2	28
2.17	Surface chemistry of activated carbon - A summary of production methods of different activated carbon surfaces	29

2.18	Carbon surface chemistry; Heteroatoms and groups commonly found in activated carbons	30
2.19	Applications of activated carbons; (a) A water filter, (b) A cross section through a water filter, (c) A filter mask having activated carbon filters	31, 32
3.1	Dial type Brookfield viscometer	41
3.2	Mechanical stability tester	44
3.3	Test pieces for compression set test	49
3.4	Test piece for tensile strength test	50
3.5	Black foam test pieces for sorption test	52
3.6	A simple set up for measuring the sorption ability of foam to ammonia	53
4.1	Results related to viscosity variation of AC dispersions from sample ID S-2 at different target T.S.C%	60
4.2	Results related to MST variation of latex compounds with different AC dispersions at 1% dosage	64
4.3	Variation of chemical stability (gel times) in latex compounds with different AC dispersions at 1% dosage	65
4.4	Variation of gel times with different AC dosages	69
4.5	Photographs of different foam structures for black foam and standard white foam	70, 71
4.6	Average compression set % for different sulphur/ accelerator systems	74
4.7	Average tensile strength values of compounds 1S to C	75
4.8	A photograph of a complete pillow with activated carbon	75
4.9	Variation of sorption percentages of normal and black foam	79

LIST OF ABBREVIATIONS

NR	-	Natural Rubber
AC	-	Activated Carbon
T.S.C	-	Total Solids Content
S	-	Sulphur
ZDC	-	Zinc diethyl dithiocarbamate
ZMBT	-	Zinc mercaptobenzothiozole
ZnO	-	Zinc Oxide
SSF	-	Soldium Silico Fluoride
KCl	-	Potassium Chloride
DPG	-	Diphenylguanidine
Ralox	-	A sterically hindered phenolic type antioxidant which is a butylated reaction product of p -cresol and dicyclopentadiene
FS 4	-	A non ionic foam stabilizer
CaCO ₃	-	Calcium carbonate
NH ₃	-	Ammonia



University of Moratuwa, Sri Lanka
Electronic Theses & Dissertations
www.lib.mrt.ac.lk