

LB/DON/16/02 (16) ✓

LATEX BLENDS OF NATURAL RUBBER AND NITRILE RUBBER
WITH CHLOROPRENE RUBBER

Improvement in Compatibility and Properties

by

Wathudura Nishendra Lakmal De Silva



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

A dissertation submitted in partial fulfilment of the requirements for the
degree of Master of Science in Polymer Technology

ප්‍රඥප්තිය
කොටුව විශ්ව විද්‍යාලය, ශ්‍රී ලංකාව
කොටුව.

Polymer Technology Division
Department of Chemical Engineering
University of Moratuwa
Sri Lanka

66 "99"
678.4

October 1999

.074351



University of Moratuwa

74351



TH

74351

Certificate of Originality

This dissertation contains no material which has been submitted for the award of any degree or diploma in any university, or any material previously published by another person unless due reference to the material is made.

W. N. Lakmal De Silva



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

CONTENTS

	Page
List of Tables	i
List of Figures	iv
List of Chemicals	v
Acknowledgements	vi
Abstract	vii
Chapter 1 INTRODUCTION	1
1.1 Polymer Blends	1
1.1.1 Purposes of blending two or more polymers together	2
1.1.2 Factors which can have an effect on polymer blend properties	2
1.1.3 Methods of making polymer blends	3
1.2 Miscibility of Polymers	4
1.3 Compatibility of Polymers	5
1.4 Solubility Parameter (δ) of Polymers	6
1.5 Latex	7
1.5.1 Natural rubber (NR) latex	9
1.5.1.1 Proteins in NR latex	10
1.5.1.2 Protein assay	10
1.5.1.3 Predicted properties of NR related to the chemical structure	11
1.5.2 Acrylonitrile Butadiene Rubber (NBR) latex	12
1.5.2.1 Predicted properties of NBR related to the chemical structure	13

1.5.3 Chloroprene Rubber (CR) latex	14
1.5.3.1 Predicted properties of CR related to the chemical structure	14
1.5.4 Selection of a latex for product manufacture	15
1.5.5 Latex blends	16
1.5.6 Compounding of latex	18
1.5.7 Dipping processes of latex	19
1.6 Tensile Strength and Elongation	21
1.6.1 Interpretation of test data of tensile strength and elongation	21
1.6.2 Standard test pieces to determine the tensile strength and elongation of rubbers	22
1.6.3 Factors which can have an effect on tensile test results	23
1.7 Fourier Transform Infrared Spectroscopy (FT-IR Spectroscopy)	24
1.7.1 Analysis of polymer blends using FT-IR spectrophotometer	24
1.7.2 Characteristic infrared absorption related to functional groups of NR, CR, and NBR	26
1.8 Objective	27
Chapter 2 METHODOLOGIES USED	28
2.1 Determination of the Properties of NR, CR, and NBR Latex	28
2.1.1 Total solids content (TSC)	28
2.1.2 Dry rubber content (DRC)	29
2.1.3 Alkalinity	29
2.1.4 Density (ρ)	30

2.2	Preparation of Test Films of NR, CR, NBR Latex and Their Blends	30
2.2.1	Films of NR, CR, and NBR latex	30
2.2.2	Effect of CR latex on FT-IR spectra of the films of NR / NBR latex blends	31
2.2.3	Effect of mixing temperature on the FT-IR spectra of the films of NR/CR/NBR latex blends	32
2.3	Analysis of the Films Using FT-IR Spectroscopy	32
2.3.1	Observation of FT-IR spectra	32
2.3.2	Analysis of the films of NR/NBR and NR/CR/NBR latex blends	33
2.3.3	Analysis of the films of NR, CR, and NBR latex	33
2.3.4	Identification of shifted absorption bands of NR and NBR in NR/NBR latex blends, due to the presence of CR latex	33
2.4	Determination of Tensile Strength and Elongation at Break of the Films of Vulcanized NR/NBR, NR/CR/NBR Latex Blends and NR Latex	34
2.4.1	Compounding	34
2.4.2	Coagulant dipping	36
2.4.3	Measuring of tensile strength and elongation at break	38
2.5	Determination of Swelling Resistance of Vulcanized Films of NR/NBR, NR/CR/NBR Latex Blends and NR latex	38
2.6	Determination of Water Extractable Protein Content of the Films of Vulcanized NR/NBR, NR/CR/NBR Latex Blends and NR Latex	39
2.6.1	Preparation of standard calibration curve	39
2.6.2	Determination of water extractable protein content	40



Chapter 3 RESULTS AND DISCUSSION	41
3.1 Properties of NR, CR, and NBR Latex	41
3.1.1 Total Solids Content (TSC)	41
3.1.2 Dry Rubber Content (DRC)	42
3.1.3 Alkalinity	43
3.1.4 Density (ρ)	44
3.1.5 Solubility parameter (δ)	44
3.2 Effect of CR Latex on NR/NBR Latex Blends	46
3.3 Best Composition of NR/CR/NBR Latex Blends	51
3.4 Identification of Shifted Absorption Bands of NR and NBR Spectra Corresponding to their Main Groups, Due to the Effect of CR	51
3.4.1 Identification of absorption bands corresponding to main groups of NR, CR, and NBR	51
3.4.2 Shifted absorption bands of NR and NBR spectra, corresponding to their main groups	54
3.4.3 Unshifted absorption bands of NR and NBR spectra, corresponding to their main groups	54
3.4.4 Effect of mixing temperature on NR/CR/NBR latex blends	54
3.5 Comparison of Properties of the Films of Vulcanized NR/NBR, NR/CR/NBR Latex Blends and NR Latex	55
3.5.1 Tensile strength and elongation at break	55
3.5.2 Oil resistance	57
3.5.3 Extractable protein content	59



University of Kelaniya, Sri Lanka.

Electronic Theses & Dissertations

www.lib.mrt.ac.lk

Chapter 4 CONCLUSIONS AND SUGGESTIONS FOR FUTURE WORK	61
4.1 Conclusions	61
4.2 Suggestions For Future Work	62
References	63



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

List of Tables

Table no.	Page	
1.1	Group molar attraction constants at 25 ⁰ C (according to Small)	7
1.2	Standard dimensions of ring test piece	22
1.3	Standard dimensions of dumb-bell test piece	23
1.4	Functional groups and infrared absorption related to NR, CR, and NBR	26
2.1	Blend compositions of NR/CR/NBR latex blends	31
2.1	Preparation of the diluted BSA standard	39
3.1	Results related to TSC of NR latex	41
3.2	Results related to TSC of CR latex	41
3.3	Results related to TSC of NBR latex	42
3.4	Results related to DRC of NR latex	42
3.5	Results related to DRC of CR latex	42
3.6	Results related to DRC of NBR latex	43
3.7	Results related to alkalinity of NR latex	43
3.8	Results related to alkalinity of CR latex	43
3.9	Results related to alkalinity of NBR latex	44
3.10	Densities of NR, CR, and NBR latex	44
3.11	Data related to solubility parameter of NR latex	45
3.12	Data related to solubility parameter of CR latex	45
3.13	Data related to solubility parameter of NBR latex	45
3.14	Wave numbers related to the significant absorption bands of Figure-3.1	50

3.15	Wave numbers of the spectra of NR/NBR latex blends (closer to the shifted absorption bands of A_0 in Figure-3.1) prepared according to the Table-2.1 without CR latex	50
3.16	Wave numbers related to significant absorption bands of NR, CR, and NBR spectra (closer to the shifted absorption bands of A_0 in Figure-3.1	54
3.17	Results related to tensile strength of films of vulcanized NR latex	55
3.18	Results related to tensile strength of films of vulcanized NR/NBR latex blend	55
3.19	Results related to tensile strength of films of vulcanized NR/CR/NBR latex blend	56
3.20	Results related to elongation at break of films of vulcanized NR latex	57
3.21	Results related to elongation at break of films of vulcanized NR/NBR latex blend	57
3.22	Results related to elongation at break of films of vulcanized NR/CR/NBR latex blend	57
3.23	Swell resistance of vulcanized NR/NBR, NR/CR/NBR latex blends and NR latex for Hydraulic Break Fluid (SAE J 1703 f FMSS 116 DOT 3)	58
3.24	Swell resistance of vulcanized NR/NBR, NR/CR/NBR latex blends and NR latex for Gear Oil (SAE 90)	58
3.25	Swell resistance of vulcanized NR/NBR, NR/CR/NBR latex blends and NR latex for Kerosene Oil	58
3.26	Swell resistance of vulcanized NR/NBR, NR/CR/NBR latex blends and NR latex for Coconut Oil	58

3.27	Extractable protein content of films of vulcanized NR latex	59
3.28	Extractable protein content of films of vulcanized NR/NBR latex blend	59
3.29	Extractable protein content of films of vulcanized NR/CR/NBR latex blend	60



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

List of Figures

Figure no.	Page	
1.1	Chemical structure of NR molecule	11
1.2	Reaction in NBR production	12
1.3	Chemical structure of NBR molecule	13
1.4	Chemical structure of CR molecule	14
1.5	Die of ring test piece	22
1.6	Die of dumb-bell test piece	22
1.7	FT-IR spectra of PVC/PCL blends recorded at room temperature at the range 1675-1775 cm ⁻¹	25
2.1	A cardboard piece which is cut according to the measurements of the film holder of FT-IR spectrophotometer	31
3.1	FT-IR spectra of NR/CR/NBR latex blends at 30°C (prepared according to the <i>Table-2.1</i>)	47
3.2	Enlarged FT-IR spectra of NR/CR/NBR latex blends which are related to the set of absorption bands no. (7)	48
3.3	Enlarged FT-IR spectra of NR/CR/NBR latex blends which are related to the set of absorption bands no. (13), (14), and (15)	49
3.4	Characteristic FT-IR spectra of NR	52
3.5	Characteristic FT-IR spectra of CR	53
3.6	Characteristic FT-IR spectra of NBR	53
3.7	Color response curve for BSA using the standard (RT/2hrs)	

List of Chemicals

BCA	- bicinehoninic acid
BSA	- bovine serum albumin
Cellosize QP	- hydroxy ethyl cellulose
Dispersol LR	- disodium methylene dinaphthalene sulphonate
Foam-master	- polydimethyl siloxane
SDS	- sodium dodecyl sulphonate
Teri QN-40	- trimethyl ammonium bromide
Triton X-100	- octyl phenoxy polyethoxy ethanol
Vulcastab TM	- aqueous paste of cetyl trimethyl ammonium bromide
Wettem	- non-ionic stabilizer of the ethylene oxide condensate type
ZDEC	- zinc dimethyl dithio-carbamate



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

Acknowledgements

I am much grateful to Dr. L. M. K. Tillekeratne, Director, Rubber Research Institute (RRI) of Sri Lanka, for granting laboratory facilities.

I owe a sense of gratitude to Dr. (Mrs.) K. D. Karnika De Silva, Deputy director (research-technology) and Dr. Laleen Karunanayake (raw rubber and chemical analysis department), RRI, my supervisors for their valuable advice and constructive criticism extended to me during the entire period of this project. In particular, I am indebted to Prof. (Mrs.) L. Sivagurunathan, University of Moratuwa for her patience and encouragement throughout the project.

Enormous thanks are due to Dr. A. C. M. Rizmi, Mr. W.W. Nandasena, Mrs. Sriyanthi Weeraman, Mr. H.N.K.K. Chandralal and Mr. L.P. Witharana their generosity and immeasurable support offered to me.

Many thanks and appreciation are also made to my cousin Miss. Priyanthi Silva(plant pathologist)RRI, parents and family members for their encouragement throughout the project.

Finally I wish to express my sincere thanks to the staff members of the Rubber Research Institute of Sri Lanka, Colombo Office & Laboratories, Ratmalana.

W. N. Lakmal De Silva

October 1999

Abstract

Latex is a colloidal dispersion of a polymer substance in an aqueous medium. Latex blends of natural rubber (NR) and several synthetic rubber latices (e.g. chloroprene rubber (CR), nitrile rubber (NBR), styrene butadiene rubber (SBR) etc.) have been used extensively for manufacturing various rubber products including foam rubber and gloves. In NR/NBR latex blend interfacial tension between NR and NBR is very high due to the differences in polarities of the two latices. Therefore the compatibility and hence the miscibility of NR/NBR latex blend is low.

In this study an attempt was made to use CR latex as a compatibilizing agent in NR/NBR latex blends. Using FT-IR spectra it was found that addition of CR latex to NR/NBR latex blend has caused a chemical shift. Hence the properties of NR/NBR latex blend and NR/CR/NBR latex blend were studied. It was found that the tensile strength of NR/CR/NBR latex blend is greater than NR/NBR latex blend. Further the solubility parameter of CR latex was found to be between NR and NBR. Hence it was found that CR latex can be used to improve the strength and miscibility of NR/NBR latex blends. The effect of addition of CR latex on other properties of NR/NBR latex blend (water extractable protein content and oil resistance) were studied and it was found that there was no adverse effect on those properties with the addition of CR latex to NR/NBR latex blend. Therefore it can be concluded that CR latex can be used as a suitable compatibilizing agent in NR/NBR latex blend.