DOI : 10.31357/fapsmst.1999.00753

DEVELOPMENT OF A TYRE TREAD COMPOUND IN COMBINATION WITH SILICA/CARBON BLACK TO ENHANCE THE PHYSICAL PROPERTIES

BY

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M.Sc. (Polymer Science & Technology)

SEPTEMBER 1999

DECLARATION

The work described in this thesis was carried out by me under the supervision of Dr. Sudantha Liyanage & Mr Lal Motha and a report on this has not been submitted to any university for another degree.

Date: 03.09.1999

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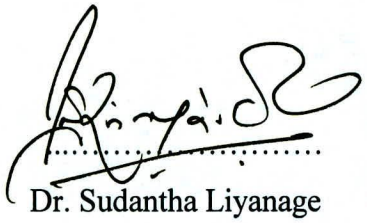
D.Lalith Leelarathna

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

Lal Motha



Dr. Sudantha Liyanage

Date: 16/11/99

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Thesis submitted to the University of Sri Jayawardenapura for the award of the degree of Master of Science on Polymer Science and Technology.

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Acknowledgement

First of all I owe a special word of thanks to my supervisors Dr. Sudantha Liyanage, University of Sri Jayawardenapura and Mr. Lal Motha of Industrial Technology Institute for their guidance, understanding and invaluable support extended to me during the preparation of this thesis.

I wish to express my sincere thanks to Dr Sudantha Liyanage for the keen interest taken in coordinating the M.Sc program in Polymer Science and Technology and making arrangement for me to undertake this project.

I extend my deepest gratitude towards Dr. Jayathissa - Director of the ITI and the other staff members of the Rubber and Plastic Technology division, who stood by me in different situations and problems I faced.

I am in debt to Dr.Gamini Senevirathna, his kind guidance and encouragement improved my knowledge in preparation of this thesis. In addition to that, I also wish to express my appreciation to Mr. A.A.Jayawardena Director - Chemical Industries (Colombo) LTD and Dr Gupta, Imperial Chemical Industries (ICI) Rubber Chemicals - India.

I also express my thanks to my colleagues Mr. Lalith Wicramasinghe and Mr. Upul Silva For their invaluable, help.

Last, but not least, I wish to convey my special remembrances to my wife Chinta for her great help, in organizing this report in short period of time and valuable encouragement and helping hand extended to me to achieve this grate task.

ABBREVIATIONS

ISO	- International Organization for Standardization
ASTM	- American Standard Test Methods
SBR	- Styrene Butadiene Rubber
NR	- Natural Rubber
BR	- Butyl Rubber
NBR	- Nitrile Rubber
EVA	- Ethyl Vinyl Acetate
PVC	- Polyvinyl Chloride
DPG	- Diphenyl Guanidine
MBTS	- Mercapto Benzo Thiozole
DEG	- Diethylene Glycol
PEG	- Polyethylene Glycol
TESPT	- Silane coupling agent

VI

Development of A Tyre Tread Compound in Combination with Silica/Carbon Black to Enhance the Physical Properties

By

Don Lalith Leelerathna

ABSTRACT

Five tread compounds were prepared by using combination of carbon black and precipitate silica such as HAF black and Ultrasil VN 3. The first formulation was done only with carbon black, the test was followed by replacement of silica by increments to the first formulation, and the physical properties were checked.

Internal banbury mixture and the two-roll mill were used for mixing and compounding then followed by the vulcanization at 120C for 27 minutes. Monsanto Rheometer curves were used as a control.

Finally, the physical properties in all tread compounds were checked using Instron 1122 for tensile strength measurement & elongation at break at speed of 100MPa for half an hour. Hardness measured with the shore A Instrument. Abrasion resistance was determined by Rotating abrasion disc method.

It was observed that the physical properties improved slightly when using the carbon black/silica combination in comparison with pure carbon black. The physical properties studied in this text were tensile strength, abrasion, hardness and elongation at break. In pure Carbon black formulation (F1) hardness values are slightly less and also the tensile property and the elongation at break is less when compared with the combination of carbon black / Silica filler formulae. Resistance to abrasion also showed better results in combine formulae.

CHAPTER 1

INTRODUCTION

1. INTRODUCTION

1.1. Fillers

Fillers are mainly classified as reinforcing and non-reinforcing as a function. Many researchers have tried to find the theory behind for this reinforcement and finally found that there can be both physical and chemical interactions involved. (Robert B. Sosman - *The Properties of Silica)*

In classifying dry fillers used in rubber to increase its usefulness or make a cost competitive product, it is convenient to divide them into black and non-black fillers.

1.1 .1. Carbon Black

Except sulphur, no material has increased the usefulness of rubber as much as carbon black. Most of the carbon black produced is used in rubber products. The black is used as a fluffy powder. The primary purpose for using carbon black with rubber is to reinforce it. This is to increase the tensile strength, modulus, abrasion and tear resistance etc, obtained by adding it. (Robert B. Sosman - *The Properties of Silica*, Berhard and Mansour - *Effect of Carbon Black on the mechanical properties of Elastomers)*

Physical properties of carbon blacks affect both the rubber processing and vulcanizate properties significantly. Because of the fine-ness of this material and the variety of conditions under which is produced, precise description of its morphology are hard to make.

Properties that have the most influence on rubber processing and vulcanizates are particle size, surface area, character and structure. When formed in the furnace carbon black particles are spherical. Other blacks specially the popular furnace black largely form chains or networks of the particles link together.

1.1.2. Non-black Fillers

Non black fillers are chosen over carbon blacks for one or more of these reasons.

1. To obtain a white or light colored product.
2. Certain unique properties are required by the use of zinc oxide.
3. Cost - It is hard to get less costly materials than natural products like clay or ground lime stone.

Non black fillers have certain features in common compared to certain blacks. They have higher specific gravities. At the same loading by weight, they have lower tensile value

than blacks. Simply there is not the chemical and physical interaction between filler and polymer that exists with carbon black. For the same reason, modulus is lower at the same hardness. In as much as high tensile and modulus are considered vital components of abrasion resistance, non-black fillers are less abrasion resistant. *(*Edmond Marshall -*The Colloidal Chemistry of the Silicate Minerals,* Rubber Chemistry and Technology Journal - *Binder Filler Interaction and the Nonlinear Behavior of highly filled Elastomers)*

1.1.2.1. Clay

Clay is one of the most widely used non-black fillers for rubbers. Its use is based on its low comparative cost, versatility and stiffening properties. This type of clay used in rubber is called Kaolin Clay and has been derived from the weathering of aluminous minerals such as Mica and Feldspar. The closest approach to its chemical composition would probably be $Al_2O_3.2SiO_2.2H_2O$

1.1.2.2. Calcium Carbonate

This is also a widely used white filler. It occurs naturally as calcite and aragonite and any rock containing over 50% by weight $CaCO_3$ is called lime stone. The natural product is quarried or mined, then crushed and ground with the whiting, being used in rubber like clays, $CaCO_3$ are used at higher loadings than blacks. These are of little reinforcing value but are economical and their compounds are quite rubbery.

1.1.3. Synthetic Silica

Silica or silicon dioxide (SiO_2) is the most frequently occurring inorganic compound on earth and the most important oxide of the element is silicon. In nature, silicon dioxide can be found in different modifications, quartz being the most common and best known. Silicas occurring in nature have been applied successfully since the middle of the nineteenth century (For example, Kieselguhr as an absorption agent for nitro - glycerin).

However during the past 50 years, new techniques have been conceived for the production of synthetic silicas, and these have been replaced with natural silicas mainly for the following reasons. *(*A. Thomas - *Synthetic Silica,* A.R. Payne, G.Kraus *Reinforcements of Elastomers)*

- Synthetic silicas are much more uniform and contain less contamination.
- The characteristics of synthetic silicas can be modified to suit specific applications: and ,
- Synthetic silicas are X-ray amorphous (non- - crystalline), so there is no risk of silicosis.

The world production of synthetic silica is currently more than 500,000 tonnes per year. The proportion of fumed silicas about one- tenth of the total synthetic silicas