SUITABLE COMPOSITION OF NR/EPDM BLEND TO ACHIEVE NON STAINING, OZONE RESISTANCE FOR THE TYRE SIDE WALL APPLICATION

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Declaration

I hereby declare that this project was conducted by me at the Samson Rubber Industries (Pvt) Limited, DSI – Samson Group, under the supervision of Prof.Sudantha Liyanage, Dean, Faculty of Applied Science, University of Sri Jayewardenepura, Sri Lanka. I also certify that this thesis does not include, without acknowledgement, any material previously published by any other person and to the best of my knowledge, this research has not been conducted by any other person or an institution.

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Table of Contents

LIST OF TABLES

LIST OF FIGURE

LIST OF ABBREVIATIONS

6PPD	-	N-(1,3-Dimethylbutyl)-N'-phenyl-p-phenylenediamine
BR	-	Butadiene Rubber
CR	-	Polychloroprene Rubber
E/B	-	Elongation at Break
ENB	-	Ethlidene norbornene
EPDM	-	Ethylene Propylene Diene Monomer
EPM	-	Ethylene Propylene Monomer
LCB	-	Long Chain Branching
MBTS	-	dibenzthiazyl disulphide
MDR	-	Moving Die Rheometer
MWD	-	Molecular Weight Distribution
NR	-	Natural Rubber
ODR	-	Oscillating Disk Rheometer
Phr	-	parts per hundred rubber
PPDM	-	p-Phenylendiamine
PPDs	-	Para – Phenylene Diamines
RSS III	-	Ribbed Smoked Sheet no: 3
SBR	-	Styrene Butadiene Rubber
T/S	-	Tensile Strength
TBBS	-	N-tert-Butyl-2-Benzothiazolesulphenamide
TMQ	-	2, 2, 4-Trimethyl -1, 2-dihydroquinoline, polymerized

ABSTRACT

The tyre side wall is the outer surface of the tyre between the bead and the tread. It consists of a set of casing plies covered with a thin layer of rubber; the outer surface should protect the casing against weathering.

The side wall generally consist of blends of natural rubber (NR), Butadiene rubber (BR) and Styrene butadiene rubber (SBR), containing a high concentration of antiozonants to provide ozone resistance, and also use strong PPDs to get better flexing properties too.

There are lots of color side wall bicycle tyres, but when consider motor cycle or other two wheeler tyres almost all are full black tyres rather than color wall tyres. Reason behind that is discoloration of color side wall. This is mainly due to strain characteristic of PPDs. Black sidewall surface also discoloration by the formation of a thin brown film of ozone/PPD reaction product is unacceptable to many customers as well.

Ozone aging is mainly due to ozone present in atmosphere reacts with olefinically unsaturated elastomers. By this reaction polymer decompose via chain scission. Therefore saturated polymers like EPDM is used most ozone resist applications.

The main objective of this project is find the most suitable composition of NR/EPDM blend to achieve non staining, ozone resistance of the tyre side wall applications without affecting other physical properties.

For this study 11 different NR/EPDM blends prepared in different ratios and those were denoted as S1 to S11. S1 is 100% NR and S11 is 100% EPDM, in-betweens change the NR/EPDM ratios as 90:10, 80:20, 70:30, 60:40, 50:50, 40:60, 30:70,20:80 and 10:90. Blends were carried out in open mill and followed same mixing cycle. NR was initially masticated in the mixer to avoid viscosity mismatch.

Mixed compounds vulcanized for different tests according to rheological properties. Test results are evaluated under six categories of Tensile Properties, Ageing Properties, Flexing, Ozone resistance, DIN Abrasion and Curing.

This study clearly shows when considering weather-ability, most unstable compound is S1 that is 100% NR and most stable compound is 100% EPDM. Tensile properties of 100% NR

are higher than that of 100% EPDM. Special marking systems have to use to evaluate the result and to get the final conclusion since the combination showed different values.

As per the net result, NR/EPDM, 70:30 blend combinations is the optimum combination for the tyre side wall application by achieving non staining, ozone resists properties, without affecting other physical properties.

1 INTRODUCTION

1.1 Background motivation

The tyre side wall is the outer surface of the tyre between the bead and the tread as shown in figure 1.1. It provides a physical link between the wheel and the tyre tread in transmitting power and braking forces to the tyre tread. The tyre side wall also plays a significant role in a vehicle's suspension and in the general handling of the vehicle on the road. As it undergoes distortion from the load bearing down on the tyre, one of the most significant properties of the sidewall is its flexibility[1].

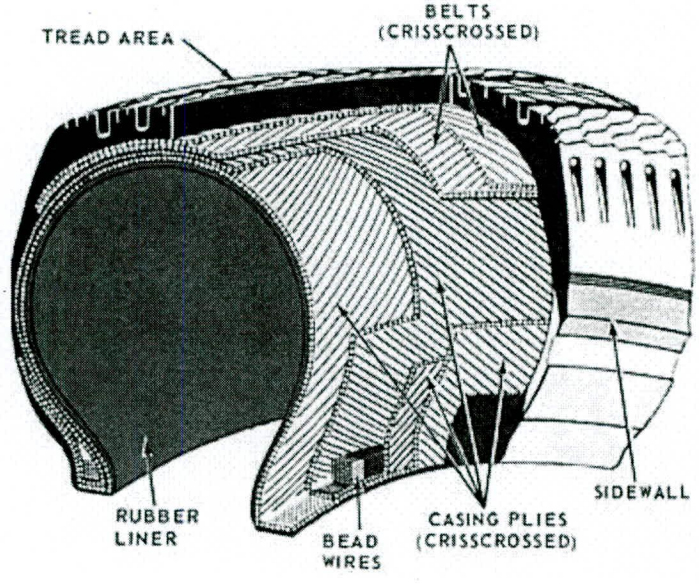

Figure 1.1 Tyre side wall

Since the side wall consists of a set of casing plies covered with a thin layer of rubber, the outer surface should protect the casing against weathering. It is formulated for resistance to weathering, ozone aging, tearing and cracking and for good fatigue life[2].

The side wall generally consist of blends of natural rubber (NR), Butadiene rubber (BR) and Styrene butadiene rubber (SBR), containing a high concentration of antiozonants to provide ozone resistance.

It is normal practice in rubber compounding to use waxes and antiozonants in the formulation for effective ozone protection under both static and dynamic conditions. Waxes exert their

protection by blooming and forming "physical" protective layers on the surface, which is impermeable to ozone. Wax offers effective protection in applications that are static or have a critical strain less than 30%. The formation of the waxes film is based on the ability of wax to migrate to the surface.

The governing factor for migration is its insolubility in the rubber matrix, which is a function of both the structure of the wax and temperature. Another important factor is the speed at which the protective film is formed. This depends on the solubility dependant migration and mobility of the molecules excessive migration or bloom occurs when the concentration of the wax greatly exceeds the solubility in the rubber. Blends of paraffinic and microcrystalline waxes are generally used to guarantee protection over the widest possible temperature range.

There are several classes of chemical antiozonants that are used to protect tyre side wall. However, the addition of antiozonants has some inherent disadvantages. Firstly, the protection by an antiozonant of the rubber once it is mixed into the compound, does not last forever. The antiozonant is continually depleted from the tyre sidewall surface by reaction with ozone and by physical mechanisms such as curb scuffing and washing. One can easily imagine that as a result of this phenomenon, there will be a certain moment that the concentration of antiozonants is too low to provide the necessary protection.

Secondly, para-phenylene diamines (PPDs) are highly toxic materials, Therefore, from an environmental point of view it is worth to search for alternatives.

The major disadvantage of PPDs is their staining characteristic, which renders them unsuitable for light colored applications. Black sidewall surface discoloration by the formation of a thin brown film of ozone/PPD reaction product is unacceptable to many customers as well.

New developments on antiozonants have focused on non-staining and slow-migrating products which last longer in rubber compounds. Several new types of non-staining antiozonants have been developed, but none of them appeared to be as efficient as the conventional antiozonants. The most prevalent method to achieve non-staining ozone protection of the diene rubbers is to blend them with inherently ozone-resistant, saturated backbone polymers like EPDM.

1.2 Aims & Objectives

The main objective of this project is to find the most suitable composition of NR/EPDM blend to achieve non staining, ozone resistance of the tyre side wall applications without affecting other physical properties.

1.3 History of tyre

Tyres have been around since the mid 1800's and the earliest tyres were made of solid rubber. The first practical pneumatic tyre was made by John Boid Dunlop, in 1887 for his son's bicycle. Until recently, tyres were available in a variety of different constructions, including bias-ply (figure 1.2) and bias-belted. Radial tyres (figure 1.3) have pretty much replaced other varieties since their technological design offers better safety and handling, particularly at highway driving speeds.

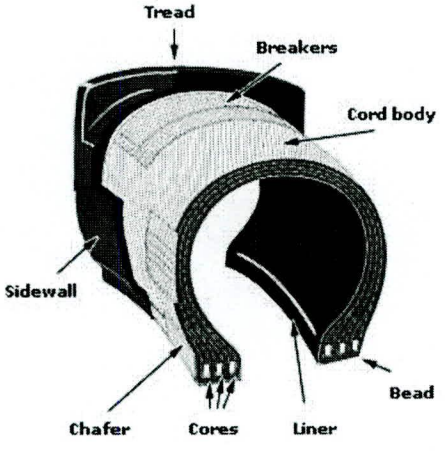

Figure 1.2 Cross ply tyre

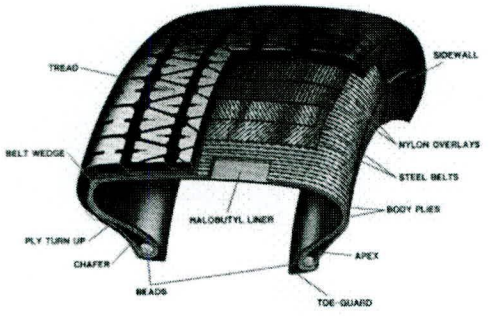

Figure .1.3 Radial tyre

1.4 Color side wall tyre

Color wall tyre means outer surface of the tyre between the bead and the tread made out of from color compounds. This compound also formulated for resistance to weathering, ozone ageing, abrasion, tearing and cracking, and for good fatigue life like black side wall does. Since this color layer lies on black layer, black compound property is very important and it should be formulated as non staining compound. Therefore the development of the non staining, ozone resistance tyre side wall compound without affecting other physical properties is very important.

1.4.1 Discoloration and Staining

In general, antioxidants/antiozonents derived from a phenolic base are non-discoloring and those derived from aromatic amines are discoloring. Staining is related to antioxidant/antiozonent migration and is determined by the chemical nature of the antioxidant/antiozonent as well as by its mobility. For light colored stocks, amine type cannot be used and therefore, phenolic derivatives must be selected. For tyre application, rubbers which are to be mixed with carbon black, discoloration is not a problem, so the more potent amine type can be used[3]. But color wall tyre applications those types of antioxidant/antiozonent not suitable.

1.5 Elastomer Blends

In a rubber blend, the factors that play significant roles for the desired properties are mentioned below[4].

- Polymer Ratio
- Molecular Architecture
- Rheological characteristics / its impact on blend morphology
- Process Aids
- Mixing hardware & processes involved
- Distribution of fillers, Plasticizers & other ingredients between the elastomers
- Cure compatibility of the constituent polymers in a blend.