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Research Paper

EFFECTS OF USING SILICA FILLER IN TREAD COMPOUND

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Compounding is the mixing of specified ingredients in such a way as to achieve different objectives, depending on the intended use of the tire, the objective may be to optimize performance, to maximize traction in both wet and dry conditions, or to achieve superior rolling resistance. The desired objective can be achieved through the careful selection of one or more types of rubber, along with the type and amount of filler to blend with the rubber. The aim of the investigations described in this paper is to obtain a better understanding of the reaction between silica, and rubber. A better understanding of this reaction might help the understanding of the reinforcement mechanism for silica filled rubbers, which in turn may help developing tyres with an even better balance of properties. Further, it may potentially lead to a broader application base for silica reinforcement also in other (dynamic) rubber applications.The prepared compound was tested rheometric parameters, physical and dynamic properties. It was found that formulation includes varying carbon block and silica phr(per hundred rubber) is showing better properties.

Keywords: Compounding, Compound formulation, Fillers

INTRODUCTION

A tyre is a ring-shaped covering that fits around a wheel rim to protect it and enable better vehicle performance by providing a flexible cushion that absorbs shock while keeping the wheel in close contact with the ground. The word itself may be derived from the word “tie”, referring to the outer steel ring part of a wooden cart wheel that ties the wood segments together.

The fundamental materials of modern tires are rubber and fabric along with other compound chemicals. They consist of a tread and a body. The tread provides traction while the body ensures support. Before rubber was invented, the first versions of tires were simply bands of metal that fitted around wooden wheels in order to prevent wear and tear. Today, the vast majority of tires are pneumatic, comprising a doughnut-shaped body of cords and wires encased in rubber and generally filled with compressed air form an inflatable cushion. Pneumatic tires are used on many types of vehicles, such as

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bicycles, motorcycles, cars, trucks, earth-movers and aircraft.

THE IMPORTANCE OF COMPOUNDING

The first reason for compounding is to incorporate the ingredient and ancillary substance necessary for vulcanization. The second reason is to adjust the hardness and modulus of the vulcanized product to the values required. The viscoelastic material new consisting of polymer and fillers has to be processed and formed to shape. Its rheological properties may need to be adjusted by the addition of oils, esters, waxes etc. The other reason for compounding is to prevent or delay degradative failure of the rubber by oxygen, ozone, light, head and others by influences. Also to ensure adhesion to textile and metals to develop electrical conductivity special compounding technologies are necessary.

PREPARATION OF SILICA BASED TREAD COMPOUND

This work was done in two stages. In the first stage I've prepared stock compound. The recipe of stage 1 is shown below.

In the second stage final compound preparation with varying antioxidants/antiozonants with the vulcanizing agents and prevulcanizing inhibitor total formulation done into 02 different way.

OBSERVATIONS

In this current work 06 formulations of tread compound was been mixed mentioned TRIAL-A (standard), TRIAL-B, TRIAL-C, TRIAL-D, TRIAL-E & TRIAL-F.

Table 1: Recipe of Stage-01

RAW MATERIALS	PREPARATION WEIGHT					
	TRIAL -A	TRIAL -B	TRIAL -C	TRIAL -D	TRIAL -E	TRIAL -F
NATURAL RUBBER RMA44	14.625	14.625	14.625	14.625	14.625	14.625
STYRENE BUTADIENE RUBBER-SBR1705	13.65	13.65	13.65	13.65	13.65	13.65
RENACIT/PEPTIZER	.0325	.0325	.0325	.0325	.0325	.0325
BR-1200/CISAMER	6.5	6.5	6.5	6.5	6.5	6.5
ZINCE OXIDE	1.17	1.17	1.17	1.17	1.17	1.17
STEARIC ACID	.65	.65	.65	.65	.65	.65
CI RESIN	.26	.26	.26	.26	.26	.26
MICRO CRYSTALLINE WAX	.325	.325	.325	.325	.325	.325
6PPD	.325	.325	.325	.325	.325	.325
TMQ	.325	.325	.325	.325	.325	.325
ZINCOLETRN-44	.820	.812	.812	1.137	13	1.463
PRECIPITATED SILICA	0	1.62	2.5	3.25	4.0625	4.875
TREAD CRUMB	1.68	1.62	1.625	1.625	1.625	1.625
CARBON BLACK HAF	21.3	19.6	18.5	17.9	17.1	16.3
AROMATIC OIL	3.37	3.58	3.75	3.9	4.063	4.225
TOTAL	65	65.1	65.5	65.67	65.975	66.30

Table 2: Recipes of Stage-02

RAW MATERIALS	PREPARATION Wt FOR TRIALS
STOCK COMPOUND	63.78
TBBS	0.42
SULFUR	0.68
PV1	0.13

Rheometric Properties

The Rheometric properties are done at two different temperatures,

- Rheometric properties scorch time and cure rates at 185°C for 4 min
- Rheometric property Mooney at 100°C for 4 min

RHEOMETRIC PROPERTIES AT 100°C FOR 4 MIN

The Table 3 shows the rheometric properties of tread compound formulation at 100°C of various batches of Mooney Viscosity. The representation consists of viscosity in Mooney Units (MU) and viscosity in ML (1+4). The term "ML" indicates a large standard rotor was used. The "1" represents the preheat time before the rotor start to run. The "4" indicates the running time of actual rotation of rotor before the final Mooney viscosity measurement is made.

Table 3: Rheometric properties at 100°C for 4 min

BATCH NO'S	T-A	T-B	T-C	T-D	T-E	T-F
MOONY VISCOSITY (MU)	97.5	68.8	67.5	65.4	62.8	60.4
MOONY VISCOSITY ML(1+4) AT 100°C	94.5	66.8	65.2	63.3	60.1	57.8

RHEOMETRIC PROPERTIES AT 185°C FOR 4 MIN

The Table 4 shows the rheometric properties of tread compound formulation at 185?C of various batches. This table gives clear idea about curing characteristics such as scorch time(Ts1), time taken to cure 50% (Tc50), time taken to cure 90% (Tc90), Maximum torque (Max TQ) and Minimum torque (Min TQ).

Table 4: Rheometric Properties at 185°C

BATCH NO'S	T-A	T-B	T-C	T-D	T-E	T-F
MIN TQ(DN.M)	8.75	8.09	9.12	9.68	9.83	10.34
MAX TQ(DN.M)	36.02	36.11	33.24	29.36	29.31	29.47
TS1 (MIN)	1.02	0.94	0.98	1.06	1.04	1.21
TC50 (MIN)	1.87	2.06	2.02	1.96	1.98	2.04
TC90 (MIN)	2.38	2.57	2.35	2.36	2.46	2.54

In the Table 4 the minimum torque values are range from 8.09 to 10.34(dn.min) and maximum torque from 29.31 to 36.11 (dn.min) there is no significant changes. This is because of all formulations are used to mix in specified time 6 min). From torque results evident that consistency in mixing or good mannered and mixed formulation can be further process.

The Table 5 shows the physical properties of tread compound formulation cured at 165 ± 5°C for 09 min of various batches.

PHYSICAL AND DYNAMIC PROPERTIES

The hardness of T-A is 64 shore-A and all other batches are shows range from 62 to 59.2 shore-A. This is because hardness of rubber products is determined by the amount and type of filler, as well as the degree of dispersion and cross-link density in all the prepared formulations filler content is not varied. Any small variation observed in table Due to degree of dispersion while mixing and cross-links density.

The hardness of an automotive tire tread typically ranges from 50 to 70 shores-A depending on the application.

Table 5: Unaged Physical Properties

PROPERTIES/BATCH NO'S		T-A	T-B	T-C	T-D	T-E	T-F
DENSITY (g/cc)		1.133	1.138	1.142	1.146	1.147	1.149
HARDNESS	SHORE-A	64	63	62	61	59.8	59.2
SAMPLE THICKNESS	MM	2.20	2.15	2.15	2.20	2.20	2.20
TENSILE	MM^2	17.1	16.4	16.0	15.8	15.4	15.1
MODULUS AT 300%	MM^2	11.8	11.2	10.5	9.8	9.4	9.6
ELONGATION %	%	522	542	555	590	605	580
BREAKING LOAD IN KGS	IN KGS	24.08	21.96	21.8	21.6	21.2	20.89
VOLUME LOSS	CC	.0756	.0763	.0783	.0792	.0807	.0812

In the volume loss table shown in the volume loss's are range from 0.0756cc (T-A) to 0.0812 cc (T-F). In T-F shows higher volume loss compare to other batches.

The tensile strengths are range from 15.1 mpa to 1.71 mpa. Tensile property of rubber depends on types of raw rubbers, fillers and crosslink density. In all prepared batches rubbers, fillers, curatives and curing time are used same. It clearly indicates that use silica 10 phr levels there is no adverse affect on tensile strength of rubber has resulted.

The modulus at 300% elongation and elongation % shown in table and there is no significant changes in none of the formulation. From the results we can concluded that use of silica to 10phr level there is no adverse effect on 300% modulus and elongation % of rubber.

COMPARISONS BETWEEN AGED AND UNAGED PHYSICAL PROPERTIES

The Table 6 shows the aged physical properties of tread compound formulation cured at 165 ± 5°C for 15 min of various batch's and aged at 24, 48,72 hours at 100°C.

Comparisons Between Aged and Unaged Physical Properties

Table 6: Comparisons Between Aged and Unaged Physical Properties

Un aged						
BATCH No's	T-A	T-B	T-C	T-D	T-E	T-F
HARDNESS (SHORE-A)	63	63	62	60	59	61
TENSILE (Mpa)	24.08	21.96	21.8	21.6	21.2	20.89
ELONGATION %	522	540	555	620	630	590
24hr aged at 100°C						
BATCH No's	T-A	T-B	T-C	T-D	T-E	T-F
HARDNESS (SHORE-A)	68	69	68	68	66	66
TENSILE (Mpa)	12.2	10.8	12.8	13.3	16.0	17.1
ELONGATION %	220	230	240	260	270	300
48hr aged at 100°C						
BATCH No's	T-A	T-B	T-C	T-D	T-E	T-F
HARDNESS (SHORE-A)	72	74	72	67	66	68
TENSILE (Mpa)	9.2	8.5	10.2	11.4	13.3	13.2
ELONGATION %	150	150	160	190	200	150
72hr aged at 100°C						
BATCH No's	T-A	T-B	T-C	T-D	T-E	T-F
HARDNESS (SHORE-A)	71	70	70	68	58	58
TENSILE (Mpa)	7.4	8.3	7.8	7.9	8.2	9.3
ELONGATION %	80	90	90	100	100	9.5

CONCLUSION

From the rheometric properties it was found that there is not much variation in all rheometric parameters they are in range, it concluded that not much effect in process and curing characteristics by silica up to 10phr From physical properties it shows that better results in T-D tensile strength, elongation % as well in modulus at 300% for specimens. From all the results the better formulation for improved physical, dynamic properties and also account with the cost consists of carbon block replaced by silica up to 10phr.

REFERENCES

1. Chandra Arup K (2007), "Tire Technology--recent Advances and Future Trends", *Publication: Rubber World*.
2. Lin Chung-Yuan (2000), "Improving Flex Fatigue and Dynamic Ozone Crack Resistance Through Antidegradants", *Publication: Rubber World*.
3. Mukhopadhyay R (2004), "The Effects of Ozone Attack", *Publication: Rubber World*.
4. N M Mathew, J R White and S K De (2003), "Rubber Technologist Handbook", *Rapra Technology Limited*, *123 U.K*.
5. Wheeler Edward L, Watertown C T, Franko, Robert J and Beacon Falls C T (1988), "Ozone Resistant Elastomeric Articles", *United States Patent :4794134, Publication*.