

Fragrant Rubber Sole with New Formulation Employing EVA Crump

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Abstract The invention provides improvement over the entire physical properties of rubber soles like tensile strength, modulus strength, shore A. Oil 205 and 541 have a very good lubricating effect on their microcellular structure, breakability and resilience. An aroma was introduced to mask the rubber smell and the shore A was further investigated employing the naphthenic oil that was added in higher and lower dosages in the formulations. The cost factor of the soles was bit high that compare to other oils like 205 and 541. Their physical evaluation at FDDI was found to be compatible from customers' point of view. Tensile strength was from 104-146 Kg/cm² and the elongation was 680-850%. Hardness shore A was from 33-68 and volume loss was from 190-265%.

Keywords Rubber sole, naphthenic oil, oil 205, oil 541, Aroma

1. Introduction

We aimed at manufacturing the rubber soles with the use of SBR, RMA and PBR and making it rubber odour free employing an aroma of vanilla base. Our investigation was successful from the compatibility point of view that the hardness, specific gravity, tensile strength Kg/cm², modulus Kg/cm², elongation at break %, abrasion resistance and spilt tear strength. All these physical parameters were good from market business.

The broadest categories of latex polymers are natural rubber latexes and synthetic latexes. Natural rubber latexes include high ammonia latex, low ammonia latex and graft polymer latex.

In the *Hevea Brasiliensis* (rubber) tree, the latex is stabilized by protein. Once it is tapped from the tree, the natural protein is susceptible to attack by bacteria upon exposure to oxygen in the atmosphere. This degradation of the protein and subsequent coagulation of the latex renders the "field latex" putrid and rancid.¹⁻¹⁵

Field latex contains approximately 30% rubber, 5% of natural protein, fatty acids and impurities, and 65% water. In this state, it would not be economically efficient for industrial use or for transportation. Centrifuging is the major means by which the solids concentration is increased from 30% to 60% and higher. Creaming, another method of layer separation, is also used, but to a lesser extent.

High ammonia latex is the result of increased stabilization

by the addition of further ammonia following concentration of the latex. The additional ammonia raises the pH of the latex to approximately 11 to 12.

Low ammonia latex was developed because manufacturers objected to the noxious ammonia odor in their factories. A popular method to minimize the amount of ammonia in latex is to replace part of it with a combination of zinc oxide and the accelerator tetramethythyuramdisulfide (METHYL TUADS® (TMTD)).

The pH of this latex is approximately 10 to 11. Graft polymer latex is a copolymer of natural rubber latex (polyisoprene) and polymethylmethacrylate. It is used primarily in the adhesives industry. The poly methylmethacrylate contributes specific adhesion as well as high modulus (immediate strength) to the natural latex.

Due to its superior physical properties, which are unmatched by any synthetic latex, the applications of natural latex are numerous. They include medical devices like condoms, surgeon and examination gloves, lineman gloves, thread used in clothing and undergarments, balloons, molded goods and novelties.

However, the recent awareness that the natural protein stabilizer can cause allergic reactions has limited its use. Because of this consideration, natural rubber latex products have been replaced to some degree by synthetic rubber products, especially in unsupported examination gloves.

Synthetic rubber latexes include styrene butadiene rubber (SBR), acrylonitrile butadiene rubber (NBR), polychloroprene rubber (CR), butyl rubber (IIR), and synthetic polyisoprene rubber (IR). There are other specialized synthetic rubber latexes, such as HYPALON® latex and EPDM latex, but they will not be discussed because of their limited application.

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Published online at <http://journal.sapub.org/ajps>

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SBR latex finds its main applications in foam, paper and coatings. While the carboxylated versions of SBR (XSBR) are supplanting conventional SBR latex because of their faster cure rate, the resilience, processing ease and economy of SBR latex keeps it a viable commodity. SBR is very compatible with natural rubber latex, and is frequently blended with it for use in the carpet backing and Rug underlay industry. The ratio of rigid styrene to flexible butadiene can be adjusted to alter the physical properties of the latex.

NBR latex was for many years limited to solvent- and grease-resistant applications like paper coatings and non-woven gasketing materials. Due to the allergy concerns mentioned above, carboxylated NBR or XNBR latex is today the most popular synthetic latex alternative for unsupported examination gloves.¹⁻¹⁵

Poly chloroprene (NEOPRENE) latex is the second most popular synthetic alternative to natural latex for unsupported examination gloves, and is increasingly used in household gloves. Weather balloons and medical breather bags are made from poly chloroprene latex because of its good weather and aging resistance. It is also used in many types of coatings and adhesives.

Poly isoprene latex, having been experimental for many years, is gaining popularity in the glove dipping industry.

Butyl latex finds its greatest use in chemical-resistant applications, especially in supported chemical handling gloves and adhesives.

1.1. Stabilizers

Ionic stabilization cannot be discussed without an understanding of coagulation. The tiny droplets of rubber (the oil phase) that are suspended in a water medium (water phase) are kept separated by ionic charges in most cases.

When the surface of the droplets is negatively charged, for instance, they will never coalesce, because "like charges" repel each other. When the ionic charges are intact and the droplets remain suspended and separated from each other, the latex is stabilized. When the ionic equilibrium is upset and the droplets coalesce or amalgamate, the latex is coagulated. Coagulation is not reversible.¹⁻¹⁵

Latexes can be stabilized anionically, as described above, cationically, by positive charges, or even nonionically. Anionic latexes are predominant in the latex industry. When an anionic stabilizer like DARVAN WAQ is dissolved in water, the negatively charged anions are of greater magnitude than the positively charged cations, and surround the rubber droplets so that they repel each other. Cationically stabilized latex would be just the opposite, but is no longer common.

Latexes can also be protected physically with nonionic stabilizers that are normally long chain alcohols. They simply form physical barriers between the droplets of rubber.

There is a fourth type of latex stabilizer called amphoteric. Its positive and negative ionic charges are of equal strength. It is an auxiliary rather than a primary stabilizer, reinforcing

the charge that already exists on the droplet, whether positive or negative.

It is important to remember that being able to produce coagulation on demand is an essential processing property. Without it, no latex product could be manufactured. The degree of stability in latex must therefore be appropriate to withstand the rigors of mechanical and chemical processing, but not so as to prevent coagulation from taking place at a time and under conditions of the compounder's choosing.

During storage, mixing, and processing, latex stabilization is challenged by both physical and chemical outside forces: time, temperature, phase separation, pH drift, shear in mixing, pumping and coating techniques, addition of incompatible materials like some electrolytes, particles of a substantially different diameter, and dissimilar stabilization systems.

Natural rubber latex is stabilized by natural protein and the soaps formed when the added ammonia combines with the fatty acids in the latex. When the high ammonia content of natural rubber latex is undesirable, low ammonia latex can be substituted, in which part of the ammonia is replaced by an auxiliary stabilizer such as a combination of zinc oxide and tetramethyl thiuram disulfide (METHYL TUADS (TMTD)).¹⁶⁻²¹

Synthetic latex is primarily stabilized with anionic soaps of the fatty acid and rosin acid type. These are added during the polymerization stage of manufacture to protect the newly formed latex rubber particles against the shear forces of mixing and processing. This is a major characteristic of synthetic latexes versus natural rubber latexes: they are highly stabilized.

In the coatings industry, the migration of water-soluble soaps to the film surface makes it difficult to overcoat or to coat successive layers of synthetic latex. The successive latex films do not "knit" together. The interlayer of stabilizer prevents the latex from becoming an amalgamated unit. The layers of latex film can frequently be peeled away from each other. This same migration of soap also prevents good surface bonding in adhesives.

In the dipped goods industry, it is often necessary to use an excess of external coagulants in order to overcome the effect of the synthetic latex stabilizers and build a suitable film thickness. In so doing, another problem is created, in that leaching times must be extended to remove the water-soluble stabilizer and additional coagulant.

Frequently, additional stabilizers are added to both natural and synthetic latex before compounding. An example is sodium lauryl sulfate. It is added when severe plant processing is anticipated: shear mixing, pumping, fabric impregnation. It is sometimes added when the holding or dipping tanks are large and the latex compound will remain in them for a long time, or to latex that will be pre vulcanized, in order to protect against the increased temperature. Usually, the need for additional stabilizers to control the mixing of special ingredients into the latex has to be resolved in the laboratory.

Sulfated methyl oleate (DARVAN SMO) is a special stabilizer. It not only reinforces the ionic charges protecting the droplets of rubber in the latex, but has come to be recognized for its more specialized purpose use as a film conditioner.¹⁶⁻²¹

1.2. Cross linkers

Vulcanization creates a “memory” in a rubber polymer. After the stress or strain of distortion or stretching is removed, the polymer returns to its original shape. This is what distinguishes a rubber from a thermoplastic. It is accomplished by connecting the molecular chains of the polymer to each other.

Cross linkers are the chemicals that connect these molecular chains. Since the chains are linked, a force is required to pull them apart. The strength of this force is a measure of the efficiency and number of connectors or cross links. The force required to stretch a cross linked polymer to a specified elongation is called a modulus. The force required to completely separate a cross linked polymer is called the tensile strength.¹⁻¹⁵

Sulfur is the primary cross linker for most natural and synthetic rubbers. In poly chloroprene (NEOPRENE), however, sulfur is the secondary cross linker.

Zinc chloride (zinc from zinc oxide and chlorine from the polymer) constitutes the primary cross linker.

There is other cross linking or vulcanizing systems. Carboxylated polymers are cross linked with metal oxides.⁴ in peroxide curing⁵; free radicals are formed on the carbon chains by the excitation of decomposing peroxides. The free radicals formed connect with each other to create carbon to carbon cross links.¹⁶⁻²¹

1.3. Activators

Sulfur alone will vulcanize (cure or crosslink) rubber latexes. However, at elevated temperatures, the process will theoretically take days, during which time oxidation would destroy the polymer before sufficient cross linking could take place. Zinc oxide activates the cross linking action of the sulfur. A sulfur/zinc oxide cure of rubber latex can take place in a matter of hours at elevated temperatures, subject to the degrading effects of oxidation.

1.4. Accelerators

Accelerators have made latex a viable industry, and have made latex products readily available worldwide by reducing their cure time to minutes. Most accelerators for sulfur cures are nitrogen-bearing. They fall into classes called dithiocarbamates (BUTYL ZIMATE®, SETSIT thiurams (METHYL TUADS (TMTD), SULFADS® (DPTT)), sulfonamides (MORFAX®), and thiazoles (CAPTAX® (MBT), ZETAX®). The xanthates (PROPYL ZITHATE®) are an exception because they do not contain nitrogen. Guanidines (VANAX® DPG and VANAX DOTG) and thioureas (THIATE® U and THIATE EF) accelerate the zinc Chloride cross linking of poly chloroprenes. Accelerators for metal

oxide cross linking in a carboxylic polymer are not necessary unless a dual system of metal oxide and sulfur vulcanization is required for optimum properties.¹⁶⁻²¹

The combination of cross linkers, activators and accelerators not only determines the rate of cure, as mentioned, but the state of cure. It is the responsibility of the latex chemist to optimize the desired physical properties of the finished article by manipulating the levels of the cross linker, the activator, and the accelerator. In the case of natural rubber latex, vulcanization can take place in the colloidal state; rapid cures may therefore not always be desirable.

The more preferred organic polymers employable in this study are the conventional vulcanisable unsaturated rubber polymers used to prepare vulcanisable rubber compounds. Illustrative of such vulcanisable rubber polymers are natural rubber and synthetic rubber polymers as disclosed, e.g. in The Elastomeric Manual (1972 Edition) published by International Institute of Synthetic Rubber Producer, Inc., such as styrene-butadiene rubber polymers, butadiene rubber polymers, ethylene-propylene rubber terpolymers, chloroprene rubber polymers, nitrile rubber polymers, bromo- and chloro- butyl rubber polymers, poly isoprene rubber polymers, and the like. Especially preferred are the conventional sulphur vulcanisable rubber polymers such as natural rubber, styrene-butadiene rubber polymers, butadiene rubber polymers, and poly isoprene rubber polymers.¹⁶⁻²¹



Figure 1. Rubber Kneading Machine



Figure 2. Rubber Rolling/Milling Machine

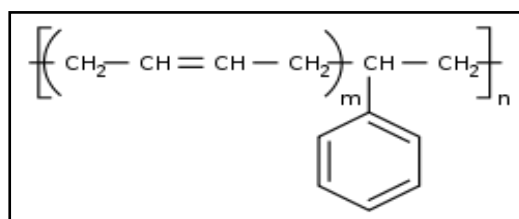


Figure 3. Styrene-butadiene rubbers

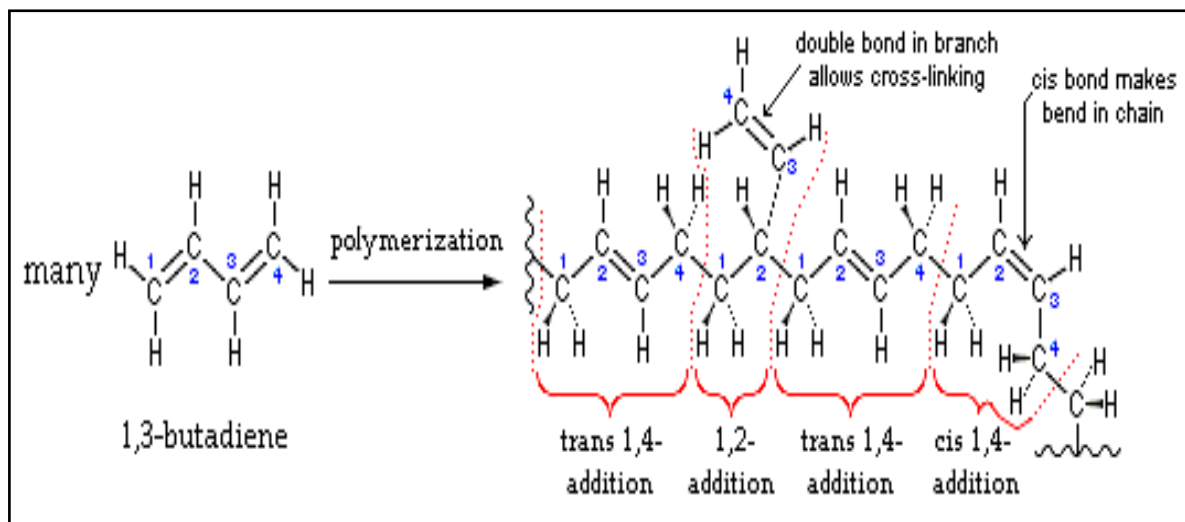


Figure 4. Poly butadiene rubbers

Some rubber compounds, such as those used in shoe soles, rubber bands, etc, need to be transparent or translucent. Unfortunately, ordinary zinc oxide by itself impairs transparency and/or translucency. For example, French process zinc oxide will render a cured rubber compound white and non-transparent at concentrations even as low as 1.5 phr (parts per hundred parts of rubber). Zinc carbonate may be used instead of zinc oxide in rubber compounding at somewhat higher concentrations. However, at 5 phr, good commercial zinc carbonate still does not render the rubber compound totally non-transparent.¹⁶⁻²¹

into pieces weighing 250-300 g, it was introduced to the moulds, and the moulds were clipped and operated for the casting at 180 °C. To avoid the burning of the soles 60-75 seconds of each hard pressing round were allowed to repeat for five to six times. Once that was done then the moulds were pulled out and de moulded while spraying the silicon releasing agent to free it from the casting. The casted rubber soles then taken for quality control testing.

The testing covers hardness Shore A, specific gravity, tensile strength Kg/cm², modulus at 300% Kg/cm², elongation at break %; volume loss % and split tear strength Kg/cm².¹⁶⁻²¹

2. Materials and methods

The kneader machine and roll mill was locally purchased. The manual operating moulding machine was imported from China. The ingredients SBR 1502, RMA IX, PBR, ZnO, Stearic acid, VN3 silica, Oil 205, Vulcanit G(PVI) (FB), HS/LG (TMQ), PEG #4000, Carbon black, EVA crump and naphthenic oil were imported from China and few were purchased at India. Master batch raw materials, MBT, MBTS, TMTD, Sulphur and curing agent were resourced from India.

2.1. Kneading of Rubber

It was of 200 Kg capacity and each time, 150 Kg of rubber was admixed with the ingredient mentioned earlier and was kneaded for 1 h to 2 h until the ingredients get mixed well.

2.2. Mill roller

The kneaded rubber was then introduced to the roll press for half an hour and then the master batch was allowed to admix thoroughly. After, almost half hour sulphur as weighed quantity was put over the flattened rubber. To make it best vulcanized calcium carbonate was powdered over it and allowed get properly distributed. After an hour then it was allowed to get cured for overnight. After 24 h it was transferred to manufacturing area. The rubber sheet was cut

3. Results and discussion

The addition of naphthenic oil has great influence on all the properties of the soles. At 8 Kg phr it yielded the soles with 68 and 33 hardness shore A, at 5 Kg phr the soles were with 45 and 58 Kg shore A. At 10 Kg phr it gave the soles of 55 and 62 shore A. But when the dose was reduced to 1.2 Kg phr then the results were comparatively good with than that of high quantity. Use of EVA crumps helped in increasing the tensile strength and modulus % of 108 and 19.42 Kg/cm² and 100 and 37 Kg/cm². In some cases the elongation test was low using EVA crumps almost of the value of 475%. High quantity of naphthenic oil along with oil 205 resulted in the soles with very poor shore A. The shore A was analysed to be 38, whereas when the quantity of naphthenic oil was reduced and oil 205 was kept out of the formulation then the shore A of the sole rose to 58. It was revealed that high content of naphthenic oil was providing too much of lubrication to the formula and the shore A was getting poor. MBT, MBTS, TMTD and sulphur were kept consistent along with sulphur. In one of the formulation when stearic acid was not include then it was found that the rubber soles were found to broken within 3-4 days. ZnO has helped in establishing a balanced network of isoprene unit that gave a firm micro-cellular structure and thus yielded the soles with firm heals.

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SBR can be produced by two basically different processes: from solution (S-SBR) or as emulsion (E-SBR). In the first instance the reaction is ionic polymerization, in the emulsion polymerization case the reaction is via free radical polymerization. In that process; Low pressure reaction vessels are required and usually charged with styrene and butadiene, the two monomers, a free radical generator and a chain transfer agent such as an alkyl mercaptan and water. Mercaptans controls molecular weight and high viscosity product from forming. The anionic polymerization process is initiated by alkyl lithium and water not involved. High styrene content rubbers are harder but less rubbery.²⁶⁻²⁹

Natural rubber (RMA 1X), also called India Rubber or caoutchouc, is an elastomeric (an elastic hydrocarbon polymer) that was originally derived from latex, a milky colloid produced by some plants. The plants would be 'tapped', that is, an incision made into the bark of the tree and the sticky, milk colored latex sap collected and refined into a usable rubber. The purified form of natural rubber is the chemical poly isoprene, which can also be produced synthetically. Natural rubber is used extensively in many applications and products, as is synthetic rubber. It is normally very stretchy and flexible and extremely waterproof.

Latex is a natural polymer of isoprene (most often *cis*-1, 4-polyisoprene) – with a molecular weight of 100,000 to 1,000,000. Typically, a small percentage (up to 5% of dry mass) of other materials, such as proteins, fatty acids, resins and inorganic materials (salts) are found in natural rubber. Poly isoprene is also created synthetically, producing what is sometimes referred to as "synthetic natural rubber".

Poly butadiene is a synthetic rubber that is a polymer formed from the polymerization process of the monomer 1, 3-butadiene. It has a high resistance to wear and is used especially in the manufacture of tires, which consumes about

70% of the production. Another 25% is used as an additive to improve the mechanical strength of plastics such as polystyrene and acrylonitrile butadiene styrene (ABS). It is also used to manufacture golf balls, various elastic objects and to coat or encapsulate electronic assemblies, offering extremely high electrical resistivity. It exhibits a recovery of 80% after stress is applied, a value only exceeded by elastin and resilin.

The butadiene molecule can be polymerized in three different ways, giving rise to three isomers called *cis*, *Trans* and *vinyl*. The properties of polybutadiene are different depending on the proportion of these isomers. For example, polybutadiene called "high *cis*" has a high elasticity and is very popular while the so-called "high *trans*" is a plastic crystal without any useful application.²⁶⁻³⁰

The polymers are linear or branched. The conjugated dienes suitable are those which ordinarily contain 4 to about 12 carbon atoms per molecule with those containing 4 to about 8 carbon atoms being preferred and are exemplified by 1,3-butadiene, isoprene, piperylene, 2,3-dimethyl-1, 3-butadiene, 3-butyl-1,3-octadiene, 2-phenyl-1,3-butadiene, and the like, and mixtures thereof. The mono vinylarenes suitable are those which ordinarily contain 8 to about 16 carbon atoms per molecule and are exemplified by styrene, alpha-methyl styrene, 3-methyl styrene, 4-n-propyl styrene, 4-p-tolyl styrene, 1-vinyl naphthalene, and the like, and mixtures thereof. The reinforcing fillers suitable for use in this invention include any type of silica-containing material which is considered to have reinforcing properties. These are often described as siliceous fillers and refer to fillers which are rubber compatible or can be worked into rubber mixtures, said fillers consisting of silicates or silica or contain silicas or silica and/or contain chemically bound silicates (or silica) in the widest sense including mixtures of two or more siliceous fillers.²⁶⁻²⁹

Table 1. Rubber formulations with oil grades

Sl. No.	Ingredients	Black With Oil 205	Black With Oil 541	Brown With Oil 205	Brown With Oil 541
1	SBR 1502	13.825	13.825	9.855	9.855
2	RMA 1X	10.753	10.753	14.782	14.782
3	PBR	3.072	3.072	8.212	8.212
4	ZnO	1.536	1.536	1.825	1.825
5	ST. ACID	0.845	0.845	1.004	1.004
6	VN3 SILICA	9.677	9.677	15.000	15.000
7	Oil 205 Kg	4.608	0.000	7.000	0.000
8	MC WAX	0.307	0.307	0.365	0.365
9	HS/ LG (TMQ)	0.154	0.154	0.183	0.183
10	PEG #4000	0.104	0.104	0.123	0.123
11	CARBON BLACK (N 220)	5.530	5.530	0.000	0.000
12	EVA Crump	9.670	9.670	0.000	0.000
13	Napthenic Oil (541)	0.000	2.850	0.000	5.000
14	Aroma (Perfume)	0.030	0.030	0.030	0.030
15	Pigment (Carbon Black)			0.030	0.030
16	Pigment (Red Oxide)			0.042	0.042
MASTER BATCH WT. (Kg)/ Cost		60.11	58.353	58.45	56.451
		MB Cost / Kg	MB Cost / Kg	MB Cost / Kg	MB Cost / Kg
15	MBT	0.138	0.138	0.328	0.328
16	MBTS	0.354	0.354	0.840	0.840
17	TMTD	0.039	0.039	0.091	0.091

18	SULPHUR	0.645	0.645	1.537	1.537
19	Vulcanit -G(PVI)(FB)	0.024	0.024	1.537	1.537
CURING AGENT WT. (Kg)		1.200	4.333	4.333	
TOTAL WT. (Kg)		61.311	62.686	62.784	56.451

Table 2. Rubber formulations with physical properties of the soles

Sl. No.	Ingredients	A	B	C	R & D No. 01	R & D No. 02	R & D No. 03	R & D No. 04	R & D No. 05	R & D No. 06
1	SBR 1502	50.000	50.000	50.000	50.000	50.000	50.000	50.000	50.000	50.000
2	RMA 1X	38.889	38.889	38.889	38.889	38.889	38.889	38.889	38.889	38.889
3	PBR	11.111	11.111	11.111	11.111	11.111	11.111	11.111	11.111	11.111
4	ZnO	5.556	5.556	5.556	5.556	5.556	5.556	5.556	5.556	5.556
5	ST. ACID	3.056	3.056	3.056	3.056	3.056	3.056	3.056	3.056	3.056
6	VN3 SILICA	38.889	35.000	35.000	35.000	35.000	35.000	35.000	35.000	35.000
7	Oil 205 Kg	16.667	16.667	16.667	16.667	8.333	8.333	8.333	12.083	0
8	MC WAX	1.111	1.111	1.111	1.111	1.111	1.111	1.111	1.111	1.111
9	Vulcanit -G(PVI)(FB)	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083
10	HS/ LG (TMQ)	0.556	0.556	0.556	0.556	0.556	0.556	0.556	0.556	0.556
11	PEG #4000	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375
12	CARBON BLACK	8.330	20.000	20.000	20.000	20.000	20.000	20.000	20.000	20.000
13	EVA Crump	0.000	0.000	35.000	0.000	0.000	0.000	35.000	35.000	35.000
14	Napthenic Oil	0.000	0.000	0.000	8.000	8.000	5.000	5.000	1.250	10.000
15	Aroma (Perfume)	0.000	0.000	0.000	7.980	0.300	0.300	0.300	0.300	0.300
MASTER BATCH WT. (Kg)		174.623	182.404	217.404	198.384	182.370	179.370	214.370	214.370	211.037
14	MBT	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
15	MBTS	1.278	1.278	1.278	1.278	1.278	1.278	1.278	1.278	1.278
16	TMTD	0.139	0.139	0.139	0.139	0.139	0.139	0.139	0.139	0.139
17	SULPHUR	2.333	2.333	2.333	2.333	2.333	2.333	2.333	2.333	2.333
CURING AGENT WT. (Kg)		4.250	4.250	4.250	4.250	4.250	4.250	4.250	4.250	4.250
TOTAL WT. (Kg)		178.873	186.654	221.654	202.634	186.620	183.620	218.620	218.620	215.287
Laboratory Test Report 02/07/2011					Laboratory Test Report 22/07/2011		Laboratory Test Report 03/08/2011		Laboratory Test Report 10/08/2011	
1	Hardness (Shore A)	52	58	68	33	38	45	58	55	62
2	Specific Gravity	1.02	1.03	1.03	1.02	1.02	1.00	0.99	1.01	1.02
3	Tensile Strength (Kg/cm2)	146	128	108	110	115	142	100	106	104
4	Modulus at 300% (Kg/cm2)	26.3	21.41	19.42	***	20.47	39	37	38	35
5	Elongation at Break %	815	610	475	820	850	785	690	680	850
6	Abrasion Resistance (Volume loss) %	250	265	280	260	210	140	190	180	190
7	Split Tear Strength (Kg/cm)	***	***	***	***	***	***	***		

Table 3. Cost evaluations of rubber formulations

Sl. No.	Ingredients	Rate/ Kg	A	Cost	B	Cost	C	Cost	R & D No. 01	Cost
1	SBR 1502	222	50.000	11100.00	50.000	11100.00	50.000	11100.00	50.000	11100.00
2	RMA 1X	276	38.889	10733.36	38.889	10733.36	38.889	10733.36	38.889	10733.36
3	PBR	239	11.111	2655.53	11.111	2655.53	11.111	2655.53	11.111	2655.53
4	ZnO	115	5.556	638.94	5.556	638.94	5.556	638.94	5.556	638.94
5	ST. ACID	70	3.056	213.92	3.056	213.92	3.056	213.92	3.056	213.92
6	VN3 SILICA	56	38.889	2177.78	35.000	1960.00	35.000	1960.00	35.000	1960.00
7	Oil 205 Kg	69	16.667	1150.02	16.667	1150.02	16.667	1150.02	16.667	1150.02
8	MC WAX	95.5	1.111	106.10	1.111	106.10	1.111	106.10	1.111	106.10
9	HS/ LG (TMQ)	198.54	0.556	110.39	0.556	110.39	0.556	110.39	0.556	110.39
10	PEG #4000	128	0.375	48.00	0.375	48.00	0.375	48.00	0.375	48.00
11	CARBON BLACK (N 220)	86.73	8.330	722.46	20.000	1734.60	20.000	1734.60	20.000	1734.60
12	EVA Crump	8.5	0.000	0.00	0.000	0.00	35.000	297.50	0.000	0.00
13	Napthenic Oil	100	0.000	0.00	0.000	0.00	0.000	0.00	8.000	800.00
14	Aroma (Perfume)	400	0.000	0.00	0.000	0.00	0.000	0.00	7.980	3192.00
MASTER BATCH WT. (Kg)/ Cost			174.54	29656.51	182.321	30450.86	217.32	30748.36	198.30	34442.86
			MB Cost /	169.91	MB Cost /	167.02	MB Cost /	141.49	MB Cost /	173.69

			Kg		Kg		Kg		Kg	
15	MBT	209.57	0.500	104.79	0.500	104.79	0.500	104.79	0.500	104.79
16	MBTS	231.63	1.278	296.02	1.278	296.02	1.278	296.02	1.278	296.02
17	TMTD	154.42	0.139	21.46	0.139	21.46	0.139	21.46	0.139	21.46
18	SULPHUR	20	2.333	46.66	2.333	46.66	2.333	46.66	2.333	46.66
19	Vulcanit -G(PVI)(FB)	336.42	0.083	27.92	0.083	27.92	0.083	27.92	0.083	27.92
	CURING AGENT WT. (Kg)		4.333	496.855	4.333	496.86	4.333	496.86	4.333	496.86
	TOTAL WT. (Kg)		178.873	30153.37	186.654	30947.72	221.654	31245.22	202.634	34939.72
			FB Cost / Kg	168.57	FB Cost / Kg	165.80	MB Cost / Kg	140.96	FB Cost / Kg	172.43

In continuation

R & D No. 02	Cost	R & D No. 03	Cost	R & D No. 04	Cost	R & D No. 05	Cost	R & D No. 06	Cost
50.000	11100.00	50.000	11100.00	50.000	11100.00	50.000	11100.00	50.000	11100.00
38.889	10733.36	38.889	10733.36	38.889	10733.36	38.889	10733.36	38.889	10733.36
11.111	2655.53	11.111	2655.53	11.111	2655.53	11.111	2655.53	11.111	2655.53
5.556	638.94	5.556	638.94	5.556	638.94	5.556	638.94	5.556	638.94
3.056	213.92	3.056	213.92	3.056	213.92	3.056	213.92	3.056	213.92
35.000	1960.00	35.000	1960.00	35.000	1960.00	35.000	1960.00	35.000	1960.00
8.333	574.98	8.333	574.98	8.333	574.98	12.083	833.73	0	0.00
1.111	106.10	1.111	106.10	1.111	106.10	1.111	106.10	1.111	106.10
0.556	110.39	0.556	110.39	0.556	110.39	0.556	110.39	0.556	110.39
0.375	48.00	0.375	48.00	0.375	48.00	0.375	48.00	0.375	48.00
20.000	1734.60	20.000	1734.60	20.000	1734.60	20.000	1734.60	20.000	1734.60
0.000	0.00	0.000	0.00	35.000	297.50	35.000	297.50	35.000	297.50
8.000	800.00	5.000	500.00	5.000	500.00	1.250	125.00	10.000	1000.00
0.300	120.00	0.300	120.00	0.300	120.00	0.150	60.00	0.150	60.00
182.287	30795.82	179.287	30495.819	214.29	30793.32	214.137	30617.07	210.804	30658.34
MB Cost / Kg	168.94	MB Cost / Kg	170.09	MB Cost / Kg	143.70	MB Cost / Kg	142.98	MB Cost / Kg	145.44
0.500	104.79	0.500	104.79	0.500	104.79	0.500	104.79	0.500	104.79
1.278	296.02	1.278	296.02	1.278	296.02	1.278	296.02	1.278	296.02
0.139	21.46	0.139	21.46	0.139	21.46	0.139	21.46	0.139	21.46
2.333	46.66	2.333	46.66	2.333	46.66	2.333	46.66	2.333	46.66
0.083	27.92	0.083	27.92	0.083	27.92	0.083	27.92	0.083	27.92
4.333	496.86	4.333	496.86	4.333	496.86	4.333	496.86	4.333	496.855
186.62	31292.67	183.620	30992.67	218.62	31290.17	218.47	31113.92	215.14	31155.20
FB Cost / Kg	167.68	FB Cost / Kg	168.79	FB Cost / Kg	143.13	FB Cost / Kg	142.42	FB Cost / Kg	144.82

Highly dispersed silica (silicon dioxide) having a specified surface area in the range of about 5 to about 1,000, preferably about 20 to about 300 m²/g (determined with gaseous nitrogen according to the known BET procedure) and with primary particle sizes in the range of about 5 to about 500 nm (nano meter, 10⁻⁹ meters) which can be produced, for example, by precipitation from solution of silicates by hydrolysis and/or oxidative high temperature conversion. There can also be used flame hydrolysis of volatile silicon halides, e.g., silicon tetrachloride or electric arc processes. These silicas, in a given case, can also be present as mixed oxides or oxide mixtures with oxides of the metals aluminium (alumina), magnesium(magnesium oxide), calcium (calcium oxide), barium (barium oxide), zinc (zinc oxide), zirconium (e.g., zirconium dioxide) or titanium (e.g., titanium dioxide).²⁶⁻²⁹

4. Conclusions

The use of EVA crumps in the formulations of rubber

soles brought the cost of manufacturing quite feasible. The use of ZnO proven to be very good cross linker and the process of vulcanization was technically successful. The properties of rubber soles were found to be altered specifically softness of the soles. Nevertheless with employing 0.150 Kg of aroma found to have the masking of the rubber odour and the properties of the soles were as per specification. EVA provided the flexibility to the rubber soles. Employing the use of stearic acid in the formulations exhibited very good lubrication. The work now has successfully become the routine production of the company.

ACKNOWLEDGEMENTS

I am thankful to my technical team and quality control team for their untiring support in evaluating all the physical evaluations. FDDI also deserves a special thank for analysing the standard physical evaluations.

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