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- (71) Applicant: **RELIANCE INDUSTRIES LIMITED** [IN/IN]; 3rd Floor, Marker Chamber-IV, 222, Nariman Point, Mumbai 400021, Maharashtra (IN).
- (72) Inventors: **MAITI MADHUCHHANDA**; 302-Kalindi Flat, 11/A Vrundavan Park Soc., New Sama Road, Vadodara 390 024, Gujarat (IN). **JASRA RAKSH VIR**; B-245, Sundervan Housing Society, New Sama Road, Vadodara -390 008, Gujarat (IN). **SRIVASTAVA VIVEK KUMAR**; 645(A)/896 Janki Vihar, Jankipuram, Vistar, Lucknow 226 021, Uttar Pradesh (IN). **BASAK GANESH CHANDRA**; 17/2, Nobin Chandra Das Road, Kolkata 700 090, West Bengal (IN).
- (74) Agents: **DEWAN Mohan** et al.; R. K. Dewan & Company, Trade Mark & Patent Attorneys, Podar Chambers, S.A.Brelvi Road, Fort, Mumbai 400 001, Maharashtra (IN).

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(54) Title: A RUBBER BLEND COMPOSITION

(57) Abstract: A rubber blend composition that comprises a blend of styrene butadiene rubber, polybutadiene rubber and a modified EPDM rubber is disclosed in the present disclosure wherein the rubber blend composition is suitably used as a potential alternative to the existing rubber blend compositions in different rubber field applications.



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A RUBBER BLEND COMPOSITION

FIELD

The present disclosure relates to a rubber blend composition with improved properties.

BACKGROUND

Rubber compositions are used in a variety of applications, including tire components such as tread, sidewall, belts, hoses and the like. The development of various tire components with improved properties such as high abrasion resistance, low heat build-up and cut and chip resistance is continuously in demand. The development of a new polymeric material, in order to meet each and every specific requirement in the polymer industry, is not feasible. Instead of envisaging a new polymer to meet the requirement for a new material bestowed with the desired properties, blending of various polymer components to obtain a material with significantly improved properties as compared to their individual counterparts is one of the highly preferred techniques in the rubber industry.

The blending of polymers/elastomers is a well-known procedure for modifying and improving the properties of the individual polymers. The judicious selection of individual polymers, their weight proportions and proper blending procedures help in achieving a polymer blend composition with the desired properties.

Conventionally, natural rubber is blended with synthetic rubber with a grade of abrasion resistant carbon black to provide abrasion resistant rubber blend. Chloroprene (CR), styrene butadiene (SBR), acrylonitrile butadiene rubber (NBR) and EPDM (ethylene-propylene-diene monomers) rubbers are some of the examples of synthetic rubbers. Rubber blend has many advantages over natural rubber, like better ageing characteristics, improve hysteresis, cut growth resistance of tire treads, good abrasion resistance, more resistant to oil and certain chemicals, and resilience over a wider temperature range. US4,257,934 suggests a composition comprising a blend of EPDM, styrene-butadiene rubber (SBR) and styrene-butadiene resin (SB) that has

greatly improved modulus value by the incorporation of about 1 to 20 parts of a tackifier resin per hundred parts of the blend composition. The tackifier resin as disclosed in the aforementioned US patent includes coumarone-indene resin, phenolic modified terpene resin, styrene-acrylic copolymer resin and alpha-methyl styrene resin. The aforementioned US patent document suggests the use of non-reinforcing tackifier to improve the modulus value of the vulcanizates containing EPDM/SBR/SB. US3,622,652 mentions a method to improve the abrasion resistance of EPM and EPDM polymers by grafting onto these polymers as backbones, side chain polymers comprising units formed by the graft polymerization of alkyl acrylic monomers. The graft polymers as disclosed in the aforementioned US patent are sulfur curable and have superior abrasion resistance as compared to the non-grafted ethylene-propylene-diene elastomers.

EP0508169 suggests a tire tread composition that contains a sulfonamide modified EPDM terpolymer. The sulfonamide modified EPDM terpolymer imparts improved abrasion resistance, improved ozone resistance and improved hysteresis properties to the tire tread composition.

EP0282153 recites a molded compositions having good water resistance, impact resistance and heat sag resistance, made from blends of polyamide resins, polyester resins and EPDM rubber modified with maleic anhydride.

However, the above described compositions have only specific and limited properties with respect to tire tread applications..

Therefore, there is felt a need to provide a rubber blend composition which has significantly wider scope and which is suitably used as a potential alternative to the existing rubber blend compositions in different rubber field applications.

DEFINITIONS:

As used in the present disclosure, the following words and phrases are generally intended to have the meaning as set forth below, except to the extent that the context in which they are used indicates otherwise.

The term “Cut and Chip resistance” in the context of the present disclosure refer to a property of the tire tread composition and provides an idea about relative cut resistance and chipping or tearing of the tread when subjected to off the road surfaces.

The term “heat build-up” in the context of the present disclosure refers to the temperature rise within a rubber blend composition due to hysteresis and low thermal conductivity. The heat build-up is used also used to compare the fatigue characteristics and rate of heat generation of different rubber vulcanizates when they are subjected to dynamic compressive strains.

The term “abrasion resistance” in the context of the present disclosure refers to an ability of a rubber blend composition to resist damage that can lead to visible, deep or wide trenches. The measurement of abrasion resistance of rubbers is basically a subject to abrasive/frictional wear in actual service.

The term “tensile strength” in the context of the present disclosure refers to the maximum longitudinal stress of a rubber blend composition which can withstand without any fracture or permanent deformation.

The term “hardness” in the context of the present disclosure refers to measure of the indentation resistance of a rubber blend composition based on the depth of penetration of a ball indenter.

The term “un-vulcanized rubber blend composition” in the context of the present disclosure refers to a rubber blend composition without any chemical crosslinking induced by vulcanizates.

The term “vulcanized rubber blend composition” in the context of the present disclosure refers to a rubber blend composition having chemical crosslinking in the presence of vulcanizates.

The term “ASTM compound” in the context of the present disclosure refers to the rubber standards depicted by an instrument in specifying, testing, and assessing the physico-mechanical and chemical properties of diversified materials and the products that are made of rubber and its elastomeric derivatives.

The term “sidewall compound method” in the context of the present disclosure refers that, the sidewall compound is formulated for resistance to weathering, ozone, abrasion, tear, radial and circumferential cracking, excellent flex property and for good fatigue life of a tire. The sidewall is an essential component of the tire and hence an indispensable part of the tire industry.

OBJECTS:

Some of the objects of the present disclosure, which at least one embodiment is able to achieve, are discussed herein below.

It is an object of the present disclosure to ameliorate one or more problems of the prior art or to at least provide a useful alternative.

Another object of the present disclosure is to provide a rubber blend composition for use in the potential applications of pneumatic tires.

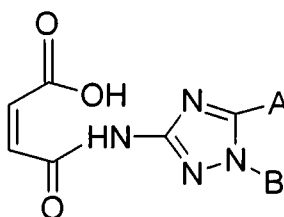
Still another object of the present disclosure is to provide a rubber blend composition with improved properties including, but not limiting to, high abrasion resistance, cut and chip resistance, low heat build-up, fatigue to failure properties, hardness and ageing as compared to the standard blend compositions available in the market.

Yet another object of the present disclosure is to provide a rubber blend composition with improved self- healing property, thereby repairing itself in the gum state under ambient conditions.

Other objects and advantages of the present invention will be more apparent from the following description when read in conjunction with the accompanying figures, which are not intended to limit the scope of the present invention.

SUMMARY:

In accordance with the present disclosure, there is provided a rubber blend composition, said composition comprising, based on parts per hundred of rubber (phr), 60 to 95 phr of a styrene-butadiene rubber (SBR), 4 to 24 phr of a polybutadiene rubber (BR) and 1 to 16 phr of a modified ethylene-alpha-olefin-diene rubber (modified EPDM); said modified EPDM rubber is a graft copolymer comprising ethylene-alpha-olefin-diene rubber (EPDM) as a polymer backbone having grafted thereon a compound of the following formula (I),



Formula (I)

wherein A is H, SCH₃, OH, SH, COOCH₃ and B is H or CH₃.

The weight ratio of the SBR, BR and modified EPDM rubbers can be 60:38:02.

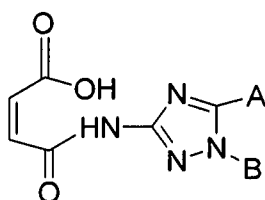
The modified EPDM rubber can comprise from 0.002 to 0.025 mole percent of the compound of the formula (I) with respect to the 100 mole % of constituent monomer of the EPDM rubber. The EPDM rubber can be a terpolymer of 20 to 75 wt% of ethylene, 80 to 25 wt% of alpha-olefin and 1 to 15 wt% of diene monomers.

The rubber blend composition in accordance with the present disclosure has a self-healing nature and exhibits a tensile strength in the range of 10 to 22 MPa, as measured in accordance with ASTM-D-412; abrasion resistance in the range of 0.07

to 0.14 g, as measured in accordance with DIN 53516; and fatigue to failure in the range of 100 to 500 kc, measured in accordance with ASTM D4482.

In accordance with the present disclosure there is provided a process for preparing a rubber blend composition, said process comprising the following steps:

- (i) providing a styrene butadiene rubber (SBR) and a polybutadiene rubber;
- (ii) preparing a modified ethylene-alpha-olefin-diene rubber (modified EPDM) by the graft copolymerization of an ethylene-alpha-olefin-diene rubber and a compound of the following formula (I),



Formula (I)

wherein A is H, SCH₃, OH, SH, COOCH₃ and B is H or CH₃; and

- (iii) mixing said SBR, polybutadiene rubber (BR) and modified EPDM rubbers to obtain a rubber blend composition.

The method step of mixing can be accomplished by using a two-roll mixer at a rotor speed varying between 40 rpm and 60 rpm at a temperature varying between 140 °C and 160 °C and for a time period varying between 2 minutes and 10 minutes.

The styrene butadiene, polybutadiene rubbers and the modified EPDM rubber can be mixed in amounts, based on parts per hundred of rubber, varying between 60 phr and 95 phr, 4 phr and 24 phr and 1phr and 16 phr, respectively.

The process in accordance with the present disclosure further comprises a method step of adding at least one additive selected from the group consisting of fillers, antioxidants, antiozonants, plasticizers, vulcanizing agents, and processing aids.

In accordance with the present disclosure, there is provided a tire, characterized in that at least a portion of said tire is produced from the rubber blend composition of the present disclosure.

BRIEF DESCRIPTION OF THE ACCOMPANYING FIGURES

Figure 1 of the accompanying drawings shows a schematic diagram for the process of preparation of a modified ethylene-alpha-olefin-diene rubber (modified EPDM), in accordance with an embodiment of the present disclosure;

Figure 2 of the accompanying drawings shows a schematic diagram for the process of preparation of a rubber blend composition, in accordance with the present disclosure;

Figure 3 of the accompanying drawings shows a schematic diagram for the process of preparation of a modified EPDM of the present disclosure and a plausible reaction mechanism for an increased cross-linking density in the modified EPDM rubber that leads to improved mechanical and self-healing properties in the rubber blend composition of the present disclosure; and

Figure 4 of the accompanying drawings shows a self-healing characteristic of the rubber blend composition of the present disclosure, as seen through Polarized optical microscope image, wherein Figure 4(a) demonstrates two cracks/cuts which are deliberately made on the rubber blend composition in gum form at room temperature; and Figure 4(b) demonstrates that the cracks/cuts as demonstrated in Figure 4(a) almost heal themselves at around 60 °C without changing the overall morphology of the rubber blend composition.

DETAILED DESCRIPTION

The description herein after, of the specific embodiments will so fully reveal the general nature of the embodiments herein that others can, by applying current knowledge, readily modify and/or adapt for various applications such specific

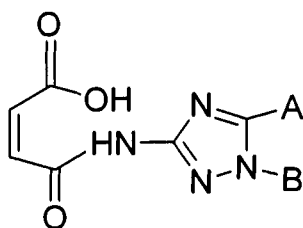
embodiments without departing from the generic concept, and, therefore, such adaptations and modifications should and are intended to be comprehended within the meaning and range of equivalents of the disclosed embodiments. It is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation. Therefore, while the embodiments herein have been described in terms of preferred embodiments, those skilled in the art will recognize that the embodiments herein can be practiced with modification within the spirit and scope of the embodiments as described herein.

The various disadvantages allied with the above described and other related prior-art references are obviated in the present disclosure by providing a rubber blend composition having a unique blend of self-healing property and an unexpected balance of properties like improved tensile strength, higher cut & chip resistance, lower heat build-up, improved fatigue to failure properties and improved ageing properties.

In one aspect, the present disclosure provides a rubber blend composition for use in the potential applications of the rubber industry, said rubber blend composition comprising, based on parts per hundred of rubber (phr),

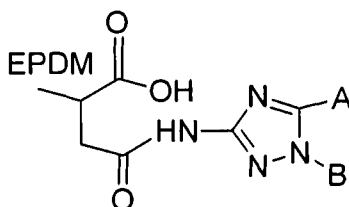
- (i) styrene-butadiene rubber (SBR) in an amount varying from 60 to 95 phr;
- (ii) poly-butadiene rubber (BR) in an amount varying from 4 to 24 phr; and
- (iii) modified ethylene-alpha-olefin-diene rubber (modified EPDM) in an amount varying from 1 to 16 phr.

The modified ethylene-alpha-olefin-diene rubber (modified EPDM) used in the rubber blend composition of the present disclosure is a graft copolymer comprising ethylene-alpha-olefin-diene rubber (EPDM) as a polymer backbone having grafted thereon a compound of the following formula (I),

**Formula (I)**

wherein A is H, SCH₃, OH, SH, COOCH₃, and B is H or CH₃.

The compound of the formula (I) is attached to the EPDM backbone through the carbon atom of the carbonyl group containing moiety (refer to **formula (II)**):

**Formula (II)**

The inventors of the present disclosure have advantageously optimized the rubber blend composition of the present disclosure in order to achieve the desired end properties in the rubber blend composition. In accordance with one of the embodiments of present disclosure, the optimized rubber blend composition comprises SBR, BR and the modified EPDM elastomer in the weight ratio of 60:38:02. The modified EPDM elastomer comprises from 0.002 to 0.025 mole percent of the compound of the formula (I) with respect to the 100 mole % of constituent monomer of the EPDM elastomer.

The styrene-butadiene rubber (SBR) used in the rubber blend composition of the present disclosure is a copolymer of styrene and butadiene, and is advantageously used as an abrasion resistant replacement for natural rubber. The styrene-butadiene rubber can be conventionally prepared by the solution polymerization and by emulsion polymerization. The commercially available styrene-butadiene rubber can also be used. The styrene-butadiene rubber has a molecular weight ranging between

320,000-400,000 (M_v). It has good abrasion resistance and good aging stability when protected by additives, and is widely used in car tires, where it may be blended with other rubber.

The polybutadiene rubber used in the rubber blend composition of the present disclosure is a synthetic rubber formed from the polymerization of 1,3-butadiene monomers and is advantageously used to provide high resistance wear property to the rubber blend composition of the present disclosure. Similar to the styrene butadiene rubber, the polybutadiene rubber can be conventionally prepared, for example, by solution polymerization and by emulsion polymerization or can be procured from the market. The polybutadiene rubber having molecular weight of 50,000 to 100,000 (M_v) is preferred. Polybutadiene is widely used in truck and passenger tires, where its very low glass transition temperature gives excellent resilience and excellent abrasion resistance.

The ethylene-alpha-olefin-diene rubber (EPDM) used in the rubber blend composition of the present disclosure is a terpolymer of ethylene, alpha-olefin monomers and diene monomers. Examples of alpha-olefin monomers useful for the present disclosure include propylene, 1-butene, 1-pentene, and 1-hexene. The preferred alpha-olefin monomer is propylene. Examples of diene monomers useful for the present disclosure include ethylidene, norbornene, dicyclopentadiene, 1,4-hexadiene and the like. The EPDM rubber, in un-modified form, contains 20 to 75 wt% of ethylene, 80 to 25 wt% of alpha-olefin and 1 to 15 wt% of diene monomers. The EPDM rubber has a molecular weight ranging from 1×10^5 to 2×10^5 .

The use of EPDM rubber as a synthetic rubber in the rubber blend compositions is well-known in the art due to their potential low cost and high resistance to weather, age, heat and ozone. A major deficiency of the EPDM rubber is their poor abrasion resistance as compared to other rubbers such as SBR. Therefore, several modifications in the EPDM rubbers have been reported to improve their abrasion resistance property. Such modifications mainly include grafting on to these rubbers as

backbones, different side chain polymers, for example, grafting of side chain polymers of alkyl acrylates and methacrylates monomers on the backbone of EPDM rubber; sulfonamide modified EPDM polymer with improved abrasion resistance, improved ozone resistance and improved hysteresis; and a maleic anhydride modified EPDM rubber.

The modified EPDM rubber useful for the present disclosure is a graft copolymer that comprises ethylene-propylene-diene rubber as a polymer backbone having grafted thereon a compound of the **formula (I)**. The inventors of the present disclosure have emphasized on modifying the EPDM rubber in such a way which leads to increased crosslinking density in the modified EPDM rubber. The modified EPDM rubber with improved cross-linking density when used in the rubber blend composition, leads to the rubber blend composition which is self-healing in nature and has improved properties such as abrasion resistance, wear resistance and the like.

The method of producing the modified EPDM rubber of the present disclosure is not specific and any conventional methods known for the modifications of the EPDM rubbers can be employed. For example, the method for producing thermoplastic elastomer composition containing a carbonyl-containing group and a nitrogen containing group can be used, the contents of which are hereby incorporated by reference in its entirety.

The process for the preparation of the modified EPDM rubber in accordance with the present disclosure is a two-step process. In the first step, an unmodified EPDM rubber reacts with a carbonyl containing compound, such as di-carboxylic acids and derivatives thereof that include acid anhydrides, esters, ketones and the like. In accordance with one of the embodiments of the present disclosure, the carbonyl containing compound is maleic anhydride. A toluene solution of maleic anhydride and EPDM rubber react together in the presence of a free radical initiator at room temperature or under heating in a nitrogen atmosphere to obtain a maleic anhydride modified EPDM rubber (refer to **Figure-1** and **figure-3** of the accompanying drawings). The EPDM rubber and the maleic anhydride are reacted in a weight

portion suitable for obtaining the maleic anhydride modified EPDM rubber having maleic anhydride in a mole percent varying from 0.005 to 0.05 based on 100 mole % of the constituent monomers of the EPDM rubber.

The amount of the maleic anhydride that reacts with the EPDM rubber is in the range of 2 to 5 wt% with respect to total weight of the EPDM rubber. The functionalization of EPDM rubber with maleic anhydride in presence of peroxide initiator such as benzoyl peroxide, dicumyl peroxide etc. is carried out in a Brabender Plasticorder under the following reaction conditions: rotor speed: 40-60 rpm; temperature: 140-160 °C; and residence time: 3-5 minutes.

Subsequently, the maleic anhydride modified rubber is reacted with a nitrogen containing heterocyclic compound in the same brabender and the conditions employed are: maleic anhydride: nitrogen bearing heterocyclic compound in a weight ratio of : 1:10 to 10:1; rotor speed: 40-60 rpm; temperature: 140-160 °C; residence time: 3-5 minutes.

The maleic anhydride of the maleic anhydride modified EPDM rubber, when reacted with the nitrogen containing compound, for example, 3-amino-1, 2, 4-triazole, forms an open ring structure (refer to **figure-3** of the accompanying drawings). During the reaction, either a part or a total amount of the maleic anhydride grafted onto the EPDM rubber reacts with the nitrogen containing compound, for example, 3-amino-1,2,4-triazole. The amount of the nitrogen containing compound, for example 3-amino-1,2,4-triazole, that reacts with the modified EPDM rubber typically ranges between 0.1 to 1 mole % with respect to 100 mol % of the carbonyl containing group.

Ring-opening polymerization is a form of chain-growth polymerization in which the terminal end of a polymer acts as a reactive center, where further cyclic monomers join to form a larger polymer chain through ionic propagation. The treatment of some cyclic compounds with catalysts brings about cleavage of the ring followed by polymerization to yield high-molecular-weight polymers.

The rubber blend composition in accordance with the present disclosure further comprise various additives such as antioxidants, antiozonants, fillers, plasticizers, vulcanizing agents, and the like for further improving the desired properties of the rubber blend composition. The use of various additives as herein above described is well known in the art and accordingly those additives may be used in the rubber blend composition of the present disclosure.

Fillers useful for the rubber blend composition of the present disclosure includes one or more filler selected from the group consisting of black, non-black and nano-fillers; The fillers are small spherical particles or rod shaped objects and flakes with at least one critical dimension below 100 nm. Examples of suitable black fillers are: carbon black N326, carbon black N134 and the like; Examples of suitable non-black fillers are calcium carbonate, kaolin clay, precipitated silica and the like. The amount of the fillers typically ranges from 5 to 60 parts per hundred parts of rubbers (phr).

Plasticizer useful for the rubber blend composition of the present disclosure includes hydrocarbon plasticizer oil such as aromatic, paraffinic and naphthenic oil. Examples of suitable plasticizers are: phosphates, dialkylether diesters, and polymeric plasticizers. The amount of the plasticiser typically ranges from 2 to 10 parts per hundred parts of rubbers.

The anti-degradants useful for the rubber blend composition of the present disclosure are staining and non-staining antioxidants and antiozonants. Suitable examples of staining antioxidants/antiozonants are: monophenols, bisphenols, thiobisphenols, phophites, nickel dibutyldithiocarbamate and the like. Suitable examples of non-staining antioxidants/antiozonants are naphthylamines, diphenyl amine derivatives, para-phenylenediamine derivatives and the like. The amount of the anti-degradant mixed with the rubber blend composition typically ranges from 0.5 to 2 phr.

The rubber blend composition of the present disclosure also comprises a curative. Any curative conventionally known for the vulcanization of the rubber blend composition

may be used, for example, sulphur and non-sulphur cures. The amount of the sulphur cures ranges from 0.5 to 2 phr, depending on the type of the vulcanization system.

Examples of non-sulphur cure vulcanizing agents are metal oxides, difunctional compounds, organic peroxides and the like. The amount of the non-sulphur cure typically ranges from 0.5 to 5 phr. The rubber blend composition may also comprise curative accelerator. Examples of curative accelerator suitable for the purpose of the present disclosure include sulfenamides, thiazole and the like. The amount of the curative accelerator typically ranges from 0.2 to 2 phr.

The rubber blend composition in accordance with the present disclosure may also comprise processing aids which increase the process-ability of the rubber blend composition. Examples of suitable processing aids are: lubricants, tackifiers, homogenizers, chemicals dispersing agents, peptizers, plasticizers, flow promoter, oil and the like. The processing aids are present in an amount typically ranging from 0.5 to 25 phr.

In another aspect, the present disclosure provides a process for preparing the rubber blend composition of the present disclosure. There is no particular limitation to a method for preparing the rubber blend composition of the present disclosure. Any conventional mixing techniques can be suitably used for preparing the rubber blend composition of the present disclosure, such as kneading, extruding, rolling, and stirring and the like. The sequence of mixing various ingredients and other process conditions are well known to a person skilled in the art. A useful method for preparing the rubber blend composition of the present disclosure comprises the use of a rolling mixer wherein various components of the rubber blend composition such as styrene-butadiene rubber, poly-butadiene rubber and modified EPDM rubber are blended together for a time period and at a temperature sufficient for achieving uniform dispersion thereof. In accordance with one of the embodiments of the present disclosure, the various rubber components are blended together in a Brabender Plasticorder at a rotor speed varying from 40 to 60 rpm for a time period varying from 2 to 10 minutes at a temperature in the range of 140 to 160 °C.

The various additives as herein above described such as anti-oxidants, anti-ozonants, fillers, and processing aids are also added during the blending of the rubber components. The additives are typically added in a weight proportion based on parts per hundred of rubber (phr) i.e. parts per hundred of the sum of styrene-butadiene rubber, polybutadiene rubber and modified EPDM rubber. The rubber blend composition thus obtained is an un-vulcanized rubber blend composition. The un-vulcanized rubber blend composition is further mixed in a two roll mill and blended with a curative, such as sulphur and non-sulphur types. The vulcanized rubber blend composition thus obtained is then compression molded at 140-160 °C and under 5 MPa compressive pressure for the optimum cure time determined from Rheometer in an electrically heated press to obtain rectangular sheets of dimensions 120×120×1.5 mm³.

The compression molded rubber blend composition thus obtained is used for testing purpose. The performance evaluation of the compression molded rubber blend composition is carried out by measuring its properties that include: abrasion resistance, hardness, cut and chip resistance, tensile strength, heat build-up, ageing and self-healing property. The results are shown in tables 2-8.

As evident from table-3 that the rubber blend composition of the present disclosure shows better tensile strength as compared to the conventional standard blends such as blends of SBR/BR, SBR/EPDM, and SBR/BR/EPDM. Further, the rubber blend composition of the present disclosure demonstrates shows better or comparable properties with respect to hardness, cut and chip resistance, heat build-up and abrasion loss as compared to the conventional standard blends of blends of SBR/BR, SBR/EPDM (refer to data as provided in table-2).

Still further, the rubber blend composition of the present disclosure also demonstrates better tensile strength and ageing properties in comparison to other comparative rubber blend compositions. Further, the rubber blend composition of the present disclosure also demonstrates better self-healing characteristic as compared to the

conventional rubber blend composition, as is evident from **figure-4** of the accompanying drawings.

The improved/enhanced properties of the rubber blend composition of the present disclosure can be attributed to a number of cooperative hydrogen bonding present in the rubber blend composition of the present disclosure (refer to **figure 3** of the accompanying drawings) that leads to increased cross-linking density. The cross-link density of the rubber blend composition of the present disclosure shows higher value (1.10×10^{-4} gmol/cm³) as compared to the standard SBR/BR blend (SB1) (0.87 gmol/cm³), which indirectly reflects the generation of cooperative H-bonding in the rubber blend composition. The cooperative H-bonding is assumed to impart inherent self-healing characteristics and enhanced mechanical, ageing as well as dynamic properties to the rubber blend composition of the present disclosure.

The rubber blend composition in accordance with the present disclosure can be used in a number of applications that include, but are not limited to, the manufacturing of various automobile parts such as tire tread, sidewalls, body plies, chafer and bead compounds. The study of self healing properties of such end use application products has been carried out and shown in tables 9-15.

In accordance with still another aspect, the present disclosure provides a tire, characterized with that at least a portion of the tire is composed of the rubber blend composition of the present disclosure.

The embodiments herein and the various features and advantageous details thereof are explained with reference to the non-limiting embodiments in the following description. Descriptions of well-known components and processing techniques are omitted so as to not unnecessarily obscure the embodiments herein. The examples used herein are intended merely to facilitate an understanding of ways in which the embodiments herein may be practiced and to further enable those of skill in the art to practice the embodiments herein. Accordingly, the examples should not be construed as limiting the scope of the embodiments herein.

Examples 1 to 4 (Ex-1 to Ex-4) and comparative examples 1 to (Comp Ex-1 to Comp Ex-4)

In the rubber blend compositions as shown in table-1, various ingredients other than zinc oxide, stearic acid, sulfur and vulcanization accelerator were mixed in a brabender plasticorder, an internal mixer for 2-10 minutes at a temperature in the range of 140- 160°C. The rubber blend composition (unvulcanized) obtained was mixed with zinc oxide, stearic acid, sulfur and vulcanization accelerator in a two roll mill and thereafter molded at 140 -160 °C to obtain a vulcanized rubber blend composition.

The compression molded rubber blend composition was then evaluated for physical properties.

Table-1: Rubber blend compositions:

Components (phr)	Ex-1	Ex-2	Ex-3	Ex-4	Comp Ex-1	Comp Ex-2	Comp Ex-3	Comp Ex-4
SBR	60	60	60	60	60	60	60	60
BR	32	24	38	36	40	-	26	38
Modified EPDM	08	16	02	04	-	-	-	-
EPDM	-	-	-	-	-	40	16	02
Carbon black	60	60	60	60	60	60	60	60
Naphthenic oil	8	8	8	8	8	8	8	8
Zinc Oxide	5	5	5	5	5	5	5	5
Stearic Acid	2	2	2	2	2	2	2	2
Antioxidant (6-PPD)	2	2	2	2	2	2	2	2
Anti-oxidant (di- tert-butyl-p-cresol)	1	1	1	1	1	1	1	1
Microcrystalline wax	1	1	1	1	1	1	1	1
Sulfur	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Vulcanization accelerator (CBS)	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3

Performance evaluations of the rubber blend compositions for Example 1-4 and Comparative example 1-4:

Various compression molded rubber blend compositions, including the one produced from the method as described herein, have been tested for their mechanical properties that include: heat build-up, abrasion resistance, hardness, cut and chip resistance, tensile strength, and ageing.

1. Hardness:

The hardness (Hs) of each compression molded rubber blend composition was measured with a hardness tester at 25°C in accordance with ASTM D2240. (Shore A hardness testing). The larger the value is, the harder the composition is.

2. Abrasion resistance

The method determines the resistance of compression molded rubber blend composition to abrasion by means of a rotating cylindrical drum device. In this method, the volume loss due to the abrasive action of rubbing a test piece of the compression molded rubber blend composition over a specified grade of abrasive sheet was determined. This corresponds to the test method of DIN 53516 and to Method A (Relative volume loss) of ISO 4649:1985. The rotational frequency of the circular cutting die was approximately 1200 rpm. The center axis of the test piece holder was an angle of 3° to the perpendicular in the direction of rotation and the center of the test piece was within approximately 1mm directly above the longitudinal axis of the drum.

3. Cut and chip resistance:

It was developed to predict the service performance of passenger truck OTR, conveyor belts etc. that are subjected to contacting surfaces containing sharp objects like rocks, gravel, metal etc. It is performed on a disk shaped specimen prepared from the compression molded rubber blend composition of the examples 1-4 mounted on rotating shaft. The disk shaped specimen is impacted by a tungsten carbide knife with a precision ground cutting edge. The standard testing condition is a 10 minutes cycle time, specimen speed at 750 rpm and cut and chip cycle set at 60 rpm.

4. Heat build-up:

The Goodrich Flexometer is used to measure the heat build-up characteristics of a compression molded rubber blend composition test piece when applied test amplitude by constant strain control. This conforms to a test method of ASTM D 623. The test was carried out under the following conditions: test frequency: 20 Hz; static load: 142.9 PSI; stroke: 4.5 mm and temperature: 100 °C. A higher measured value indicates higher heat build-up. It is already reported in the literature that heat-build up of a vulcanizates increases with decreasing crosslink density. Similar kind of behavior is also seen in the rubber blend compositions of the present disclosure: crosslink density and heat build-up of vulcanizate SBR/BR (60:40) are 0.87×10^{-4} gmol/cm³ and 20 °C, respectively whereas crosslink density and heat build-up of vulcanizate SBR/BR/EPDM_m are 1.10×10^{-4} gmol/cm³ and 18 °C, respectively.

In order to understand the effect of blend composition, several other important properties like heat build-up, cut and chip resistance, abrasion loss and hardness were also evaluated and provided in table-2. Apart from tensile strength value, the other properties could not be directly correlated with composition. But, it can be said that some of the modified blend compositions showed better or comparable properties with respect to hardness, cut & chip resistance, heat build-up as well as abrasion loss in comparison to conventional standard blend (Comp Ex-1) which is most preferably used in tire industry.

Table-2: Mechanical properties of various rubber blend compositions:

Experiment No.	Heat Build-up (°C)	Abrasion loss (g)	Hardness (IRHD)	Cut & chip resistance(g)
Ex-1	22	0.0962	58	0.514
Ex-2	24	0.1322	67	0.225
Ex-3	18	0.0912	55	0.203
Ex-4	22	0.0984	56	0.308
Comp Ex-1	20	0.0903	59	0.214
Comp Ex-2	26	0.1351	60	0.437
Comp Ex-3	23	0.1021	58	0.271
Comp Ex-4	19	0.0962	53	0.337

5. Tensile Strength:

The tensile strength of the compression molded rubber blend compositions of the present disclosure were measured in accordance with a test method ASTM D-412 and the study is provided in table 3.

Table-3: Tensile properties of various rubber blend compositions:

Experiment No.	Composition	Tensile Strength (MPa)
Ex-1	SBR:[BR: Modified EPDM] (60:[32:8])	17.2
Ex-2	SBR:[BR: Modified EPDM] (60:[24:16])	19.1
Ex-3	SBR:[BR: Modified EPDM] (60:[38:02])	13.9
Ex-4	SBR:[BR: Modified EPDM] (60:[36:04])	14.0
Comp Ex-1	SBR:BR (60:40)	11.6
Comp Ex-2	SBR:EPDM (60:40)	12.2
Comp Ex-3	SBR:[BR:EPDM] (60:[24:16])	15.0
Comp Ex-4	SBR:[BR:EPDM] (60:[38:02])	11.2

As evidenced from table-3, the rubber blend composition containing modified EPDM rubber (Ex-1, Ex-2, Ex-3 and Ex-4) showed better tensile strength properties in comparison to the conventional standard blend (Comp Ex-1, Comp Ex-2, Comp Ex-3 and Comp Ex-4). It was observed that the tensile strength was marginally improved when SBR:BR:EPDM was used in rubber blend composition. Moreover, the improvement was more prominent in case of modified EPDM rubber in comparison to unmodified EPDM rubber which can be seen in table-3.

6. DeMattia Test:

DeMattia Flexing Fatigue Tester conforms to ASTM D-430 method "B" and ASTM D-813 standards to measure the ability of soft rubber compounds to resist dynamic fatigue. It is basically used to determine the crack growth of vulcanized rubber, leather, etc. when subjected to repeated bending strain or flexing. It is also used to measure the resistance to dynamic fatigue of vulcanized rubbers/ elastomers test specimen when subjected to repeated bending and extension.

Table 4 A: DeMattia Test Cut initiation:

Comp Ex-1	No crack up to 325,000 cycles
Ex-3	No crack up to 325,000 cycles
Ex-1	Crack after 250,000 cycles
Ex-2	Crack after 270,000 cycles
Ex-4	Crack after 130,000 cycles

Table 4 (b) DeMattia Cut-Growth (Initial Cut 2 mm)

Kilocycles	Cut propagation length, mm				
	SB-1	Ex-3	Ex-1	Ex-2	Ex-4
1	3.56	4.56	7.4	7.1	8.1
2	5.53	6.53	10.7	10.0	11.8
3	7.21	8.19	12.8	11.9	13.7
4	8.61	8.65	14.8	13.8	15.7
5	9.20	9.28	16.2	15.6	17.6

7. Fatigue to Failure Tester (FTFT):

The fatigue to failure properties of the compression molded rubber blend compositions (FTFT) were measured at 100% extension ratio in a Monsanto FTFT machine as per ASTM D4482. The fatigue life was calculated using the Japanese Industrial Standard (JIS) number average method. Specimens of the compression molded rubber blend compositions are stretched and released via a continuously rotating cam. Device records number of cycles applied to each specimen before the specimen is destroyed by fatigue. The FTFT study for example 1 to 4 has been given in table 5 below:

Table 5: FTFT Study of Ex 1-Ex 4

Sample	Comp Ex-1	Ex-1	Ex-2	Ex-3	Ex-4
FTFT (kc)	275	287	118	359	109

Since, rubber blend compositions containing modified EPDM showed outstanding improvement in tensile strength value, a comparison study of the standard blend along with modified blend composition with respect to ageing properties were carried out and the results are provided in table-6. The results indicated that Ex-3 & Ex-4 blends showed better ageing properties in terms of tensile strength as compared to standard conventional blend (Comp Ex-1).

Table-6: Ageing properties of various rubbers blend compositions:

Experiment No.	Tensile Strength (MPa)	Aged Sample
		T.S (MPa)
Ex-1	17.2	11.2
Ex-2	19.1	13.5
Ex-3	13.9	13.7
Ex-4	14.0	12.9
Comp Ex-1	11.6	13.2
Comp Ex-2	13.8	13.8
Comp Ex-3	12.2	12.6
Comp Ex-4	15.0	----

8. Self-healing properties of the blends:

It is extremely difficult to visualize the crack-healing characteristics of a blended, carbon black filled rubber composition through polarized optical microscope due to the constraint generated by carbon black present in the systems. Although, the self-

healing characteristic of the same material in *gum* form can be easily seen in the polarized optical microscopy as shown in Figure-4 of the accompanying drawings. From Figure 4, it is observed that the indentation depth has been reduced from Figure 4 (a) to 4 (b), which indicates the self-healing nature.

After incorporation of certain amount of modified EPDM rubber into the standard blend compositions (Comp Ex-1), the significant improvement of properties in FTFT and comparable to DeMattia test results was also observed. So, the maximum benefit in terms of desired properties can be accomplished by proper judicious selection of blend composition.

As evidenced from table-7, the cross-link density of the rubber blend compositions (e.g. Ex-1, Ex-2, Ex-3 and Ex-4) showed higher values as compared to the SBR/BR blend in the presence of unmodified EPDM rubber (Comp Ex-4) which indirectly reflects the generation of cooperative H-bonding in the system. It was difficult to compare the cross-link density of above stated blend with Comp Ex-1 due to their different kind of nature. All the above specified blends are ternary blend whereas Comp Ex-1 is a binary blend. From the table 7, it can be seen that the higher the cooperative H-bond in the system, higher will be the cross-link density. But, it is worth to mention that a certain composition of all the ternary systems plays a significant role to balance all the desired properties.

The cooperative H-bonding is assumed to impart inherent self-healing characteristics. Due to cooperative H-bonding present in the self-healing material, it ultimately exhibits enhanced mechanical, ageing as well as dynamic properties. Table 7 illustrates the comparison with conventional SBR, BR composition.

Table 7: Cross-link density of various rubber blend composition:

Composition	Cross-link density (10^4 gmol/cm^3)
Ex-1	1.18
Ex-2	1.86
Ex-3	1.08
Ex-4	1.74
Comp Ex-4	0.86

9. Cure properties of rubber blends:

Cure characteristics of the Ex-1 to Ex-4 are provided in table 8 below:

Table 8: Cure properties of Rubber blend:

Moving Die Rheometer	Ex-1 SBR:[BR:EPDMm] (60:[32:8])	Ex-2 SBR:[BR:EPDMm] (60:[24:16])	Ex-3 SBR:[BR:EPDMm] (60:[38:02])	Ex-4 SBR:[BR:EPDMm] (60:[36:04])
Test Condition	45' @ 160°C	45' @ 160°C	45' @ 160°C	45' @ 160°C
M _L (dN.m)	0.68	0.72	0.65	0.67
M _H (dN.m)	7.32	7.67	6.97	7.02
TS ₂ (Minutes)	1.89	1.95	1.31	1.42
Tc ₉₀ (Minutes)	3.16	3.94	2.21	2.43
M _H -M _L	6.64	6.95	6.32	6.35

Example 5 & 6 (Ex-5 & Ex-6) and comparative example 5 & 6 (Comp Ex-5 & Comp Ex-6)

Self-healing behavior were further ascertained in the end use application product. The presence of modified elastomer in any compound shows a definite self healing characteristics. Hence the study of self healing properties of two formulation which is predominantly used in rubber industry (example 5 & 6 and comparative example 5 & 6) were carried out using ASTM compound and sidewall compound method.

The standard formulation of the rubber blend used in the rubber industry is given in Table-9

Table 9 -: Rubber blend compositions of Ex 5 and Ex 6:

ASTM			Sidewall		
	Ex-5	Comp Ex-5		Ex-6	Comp Ex -6
Ingredients	phr	phr	Ingredients	phr	phr
BR	95	100	NR (RSS-4)	50	50
Modified EPDM	5	0	BR	46.5	50
Industry Reference Black (IRB)	60	60	Modified EPDM	3.5	0
ZnO	3	3	N300	50	50
Stearic acid	2	2	Aromatic oil	8	8
Naphthenic Oil	15	15	N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine (6-PPD)	1	1
Sulfur	1.5	1.5	Micro Crystalline wax	2	2
N-tert-butyl-2-benzothiazyl sulfenamide TBBS	0.9	0.9	Polymerized 2,2,4-trimethyl-1,2-dihydroquinoline (TMQ)	1	1
			ZnO	4	4
			Stearic acid	2	2
			Coumarone Indene resin	2	2
			Sulfur	2	2
			N-Cyclohexyl-2-benzothiazole sulfenamide (CBS)	1	1

Example 5 and 6 shows remarkable improvement in flexing property after incorporation of self-healing rubber in NR blend too (in the consecutive section). This subsequently implies that blend containing modified EPDM imparts self-healing characteristic. Since there was improvement in flexing property after including self-

healing elastomer in the blend, the performance evaluation study was carried out a large number of experiments based on the end use application.

Performance evaluations of the rubber blend compositions for Ex-5 & Ex-6 and comp Ex- 5& comp Ex-6:

Various mechanical properties for Ex-5 & EX-6 and Comp Ex-5 & Comp Ex-6 were studied and described herein below. The mechanical properties that include viscosity, cure characteristics, physical properties of Unaged sample and Aged samples, Payne effect, De Mattia test and fatigue to failure test (FTFT)

Table 10: Raw and Compounded rubber viscosity:

		ASTM		Side Wall	
		Ex-5	Comp Ex-5	Ex-6	Comp Ex-6
Raw rubber MV	ML ₍₁₊₄₎	42.45	43.98	NA	NA
Master Mooney	ML ₍₁₊₄₎	63.03	57.60	68.54	67.01
	SR@120 sec	13.50	11.82	11.89	11.66
Final Mooney	ML ₍₁₊₄₎	55.88	54.98	56.32	56.04
	SR@120 sec	12.75	12.66	12.52	12.13
Mooney scorch	(t ₃₅ -t ₅) sec	228	223	90	79

Table 11: Cure characteristics:

Moving Die Rheometer	ASTM		Sidewall	
	Ex-5	Comp Ex-5	Ex-6	Comp Ex-6
Test Condition	21' @ 160°C	21' @ 160°C	45' @ 141°C	45' @ 141°C
M _L (dN.m)	2.66	2.65	2.70	2.51
M _H (dN.m)	15.01	15.28	17.11	17.14
TS ₁ (Minutes)	3.84	4.14	9.01	8.39
TS ₂ (Minutes)	4.87	5.66	9.62	8.99
Tc ₅₀ (Minutes)	6.53	7.36	11.90	11.13
Tc ₉₀ (Minutes)	10.22	11.04	19.28	17.90
M _H -M _L	12.35	12.63	14.41	14.63

Table 12 A: Physical properties of Unaged samples

	ASTM		Sidewall	
	Ex-5	Comp Ex-5	Ex-6	Comp Ex-6
Tensile strength (MPa)	16.0	15.9	21.1	21.2
Elongation at break (%)	457	450	618	588
Modulus at 100% Elongation (MPa)	1.9	1.9	2.2	2.1
Modulus at 200% Elongation(MPa)	4.8	4.8	5.2	4.9
Modulus at300% Elongation(MPa)	9.2	9.3	8.9	8.8
Hardness (IRHD)	61	60	66	65
Hardness (Shore A)	58	57	60	60
Tear Strength(N/mm)	48.55	43.69	56.71	59.82

Table 12B: Physical properties of Aged samples

	ASTM		Side Wall	
	Ex-5	Comp Ex-5	Ex-6	Comp Ex-6
% Change of TS	-25	-43	-51	-48
% Change of EB	-53	-60	-67	-53
% Change of Modulus @ 100% Elongation	111	116	91	76
% Change of Modulus @ 200% Elongation	121	NA	94	92
% Change of Modulus @ 300% Elongation	NA	NA	NA	NA
% Change in Hardness	11	11	8	6

Table 13: Payne effect

	ASTM		Side Wall	
	Ex-5	Comp Ex-5	Ex-6	Comp Ex-6
$\Delta G'$ (kPa)	181.79	185.72	154.19	143.28
Specific gravity	1.103	1.105	1.103	1.105

The core characteristic of Ex-5 shows faster cure compared to comp Ex-5 and Ex-6 indicates better Mooney scorch value than comp Ex-6 but all other rheological parameters are within +/- 10 % variation which is in the acceptable range. The raw and compounded rubber viscosity did not change significantly with incorporation of self-healing elastomer in the blend. Physical properties are comparable in all blend compounds except Tear strength which is found to be better in Ex-6 compared to comp Ex-6 (11 % higher). Moreover, the retention properties are better for Ex-6. However, the Payne effect didn't show any remarkable change (lower the $\Delta G'$, the higher would be polymer-filler interaction).

Table 14A: DeMattia cut initiation study at room temperature and higher temperature (70 °C)

Tested in RT (cycles in KC)				
	ASTM		Side Wall	
	Ex-5	Comp Ex-5	Ex-6	Comp Ex-6
Crack Initiation	>2400	1034	4545	567
Failed	>2400	1074	1714	700
Tested at 70 °C (cycles in KC)				
	ASTM		Side Wall	
	Ex-5	Comp Ex-5	Ex-6	Comp Ex-6
Crack Initiation	>1000	102	>1000	~800
Failed	>1000	108	>1000	>1000

Table 14 B: DeMattia cut propagation study at room temperature

Cycles (Nos.)	ASTM		Side Wall	
	Ex-5	Comp Ex-5	Ex-6	Comp Ex-6
1000	5.4	4.10	3.1	3.4
2000	7.2	4.88	4.3	4.9
3000	8.5	5.69	5.9	6.0
4000	9.2	6.80	7.1	7.5
5000	10.3	7.56	8.5	8.4
6000	11.4	8.34	9.5	9.8
7000	11.8	8.67	10.0	10.7
8000	12.2	9.36	11.1	11.9
9000	12.4	9.58	11.8	12.8
10000	12.5	10.02	12.5	13.9
11000	12.7	10.36	13.1	14.7
13000	12.9	10.76	14.3	15.8
15000	13.0	11.49	15.1	16.7
17000	13.2	11.83	15.9	17.9
20000	13.2	12.94	16.7	19.1
25000	13.4	13.35	17.7	19.5

Table 14 C: DeMattia cut propagation study at higher temperature (70 °C)

Cycles (Nos.)	ASTM		Side Wall	
	Ex-5	Comp Ex-5	Ex-6	Comp Ex-6
1000	4.39	8.16	4.39	4.03
2000	4.72	8.92	5.24	5.26
3000	5.60	11.19	6.40	6.52
4000	6.55	12.63	7.16	7.26
5000	6.91	13.01	8.48	8.31
6000	7.36	13.20	9.39	9.60
7000	7.65	14.11	10.16	10.70
8000	9.56	14.28	11.06	11.55
9000	10.38	14.98	12.15	12.45
10000	10.85	15.64	13.49	13.47
11000	11.67	16.01	15.51	14.72
13000	12.96	16.44	16.92	16.92
15000	14.24	17.26	18.51	19.73

Table 15: Fatigue to failure test (FTFT)

	ASTM		Side Wall	
	Ex-5	Comp Ex-5	Ex-6	Comp Ex-6
FTFT (Kilocycles)	1424	984	210	139

Crack initiation is comparatively better in both Ex-5 and Ex-6 material at RT and High Temp in comparison to its counterpart. On the other hand, Ex-6 shows improved resistance to cut propagation compared to comp Ex-6 whereas cut propagation of Ex-5 becomes comparable with comp Ex-5 on long runs. Substantial improvement in FTFT has been achieved without sacrificing any rheological and physico-mechanical properties of all Self healing elastomer compounds. The fatigue life has been increased to 44 and 51 % in Ex- 5 and Ex-6 respectively, and they are having self-healing material. This study implies that the self healing elastomer containing blend is definitely an ideal and competent material for the tire side wall application.

ECONOMIC SIGNIFICANCE AND TECHNICAL ADVANCEMENT:

The technical advancements offered by the present disclosure are as follows:

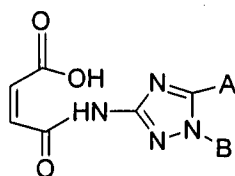
- A rubber blend composition having enhanced mechanical properties as compared to conventional rubber blends used in the tire industry, and
- A rubber blend composition having self-healing properties.

The numerical values mentioned for the various physical parameters, dimensions or quantities are only approximations and it is envisaged that the values higher/lower than the numerical values assigned to the parameters, dimensions or quantities fall within the scope of the invention, unless there is a statement in the specification specific to the contrary.

The foregoing description of the specific embodiments will so fully reveal the general nature of the embodiments herein that others can, by applying current knowledge, readily modify and/or adapt for various applications such specific embodiments without departing from the generic concept, and, therefore, such adaptations and modifications should and are intended to be comprehended within the meaning and range of equivalents of the disclosed embodiments. It is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation. Therefore, while the embodiments herein have been described in terms of preferred embodiments, those skilled in the art will recognize that the embodiments herein can be practiced with modification within the spirit and scope of the embodiments as described herein.

CLAIMS:

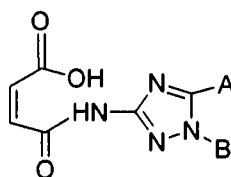
1. A rubber blend composition, said composition comprising, based on parts per hundred of rubber (phr), 60 to 95 phr of a styrene-butadiene rubber (SBR), 4 to 24 phr of a polybutadiene rubber (BR) and 1 to 16 phr of a modified ethylene-alpha-olefin-diene rubber (modified EPDM); wherein said modified EPDM rubber is a graft copolymer comprising ethylene-alpha-olefin-diene rubber (EPDM) as a polymer backbone having grafted thereon a compound of the following formula (I),

**Formula (I)**

wherein A is H, SCH₃, OH, SH, COOCH₃, and B is H or CH₃.

2. The rubber blend composition as claimed in claim 1, wherein the weight ratio of the SBR, BR and modified EPDM is 60:38:02.
3. The rubber blend composition as claimed in claim 1, wherein said modified EPDM rubber comprises from 0.002 to 0.025 mole percent of the compound of the formula (I) with respect to the 100 mole % of a constituent monomer of the EPDM rubber.
4. The rubber blend composition as claimed in claim 1, wherein the EPDM rubber is a terpolymer of 20 to 75 wt% of ethylene, 80 to 25 wt% of alpha-olefin and 1 to 15 wt% of diene monomers.

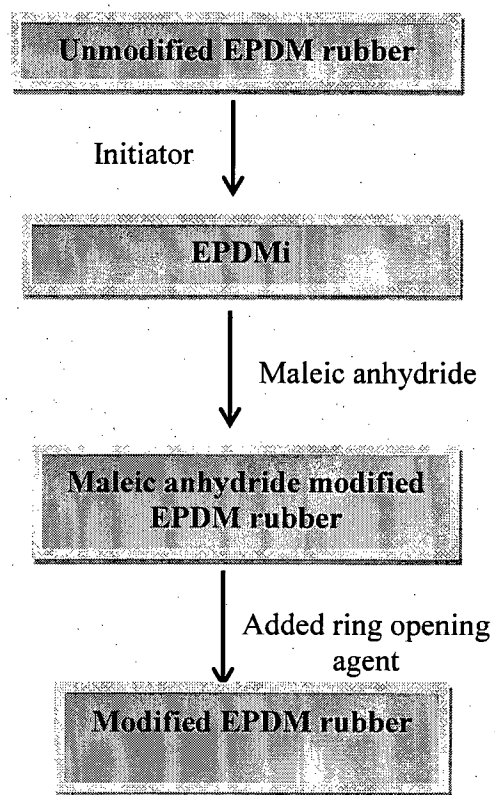
5. The rubber blend composition as claimed in claim 1, wherein the diene monomer includes at least one non-conjugated diene monomer selected from the group consisting of ethylidene, norbornene, dicyclopentadiene, and 1,4-hexadiene.
6. The rubber blend composition as claimed in claim 1, wherein the alpha-olefin includes at least one olefin selected from the group consisting of propylene, 1-butene, 1-pentene and 1-hexene.
7. The rubber blend composition as claimed in claim 1, wherein said composition further comprises at least one additive selected from the group consisting of fillers, antioxidants, antiozonants, plasticizers, vulcanizing agents, and processing-aids.
8. The rubber blend composition as claimed in claim 1, characterized in that said composition has a self-healing nature and exhibits a tensile strength in the range of 10 to 22 MPa, as measured in accordance with ASTM-D-412; abrasion resistance in the range of 0.07 to 0.14 g, as measured in accordance with DIN 53516; and fatigue to failure in the range of 100 to 500 kc, measured in accordance with ASTM D4482.
9. A process of preparing a rubber blend composition, said process comprising the following steps:
 - (i) providing a styrene butadiene rubber (SBR) and a polybutadiene rubber;
 - (ii) preparing a modified ethylene-alpha-olefin-diene rubber (modified EPDM) by the graft copolymerization of an ethylene-alpha-olefin-diene rubber and a compound of the following formula (I),

**Formula (I)**

wherein A is H, SCH₃, OH, SH, COOCH₃, and B is H or CH₃; and

(iii) mixing said SBR, polybutadiene rubber (BR) and said modified EPDM rubber to obtain a rubber blend composition.

10. The process as claimed in claim 9, wherein the method step of mixing is accomplished by using a two-roll mixer at a rotor speed varying between 40 rpm and 60 rpm at a temperature varying between 140 °C and 160 °C and for a time period varying between 2 minutes and 10 minutes.
11. The process as claimed in claim 9, wherein said styrene butadiene, polybutadiene rubber and modified EPDM rubber are mixed in amounts, based on parts per hundred of rubber (phr), varying between 60 phr and 95 phr, 4 phr and 24 phr and 1 phr and 16 phr, respectively.
12. The process as claimed in claim 9, further comprising a method step of adding at least one additive selected from the group consisting of fillers, antioxidants, antiozonants, plasticizers, vulcanizing agents, and processing aids.
13. A tire, characterized in that at least a portion of said tire is produced from the rubber blend composition as claimed in any of the preceding claims.

**FIGURE 1**

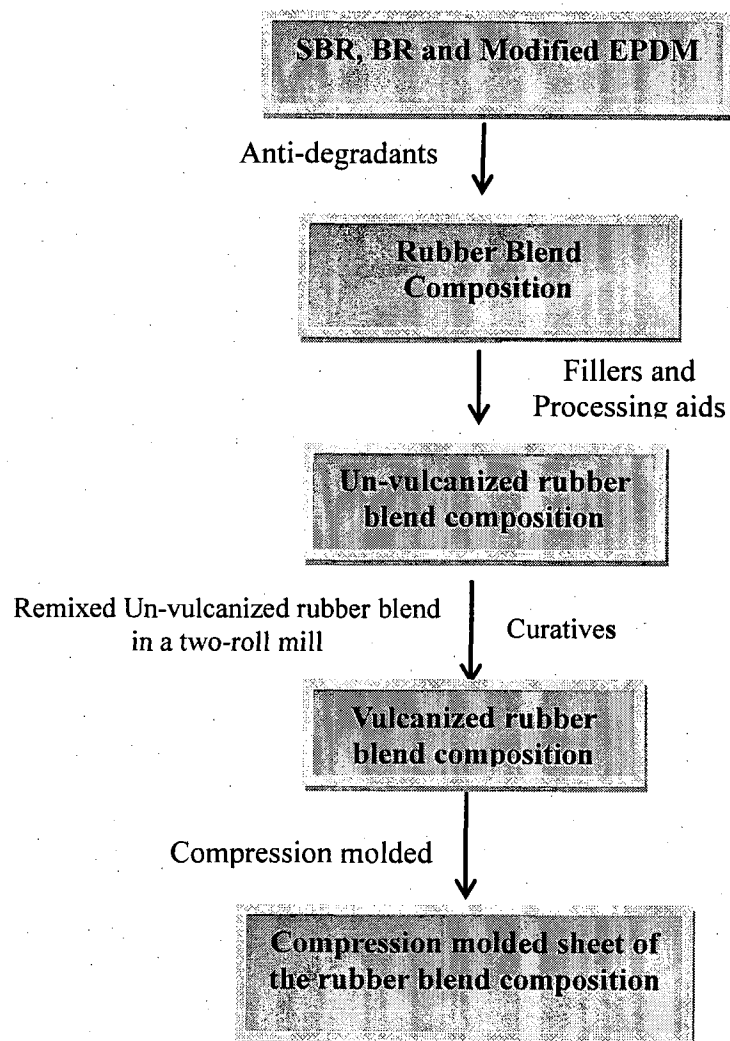


FIGURE 2

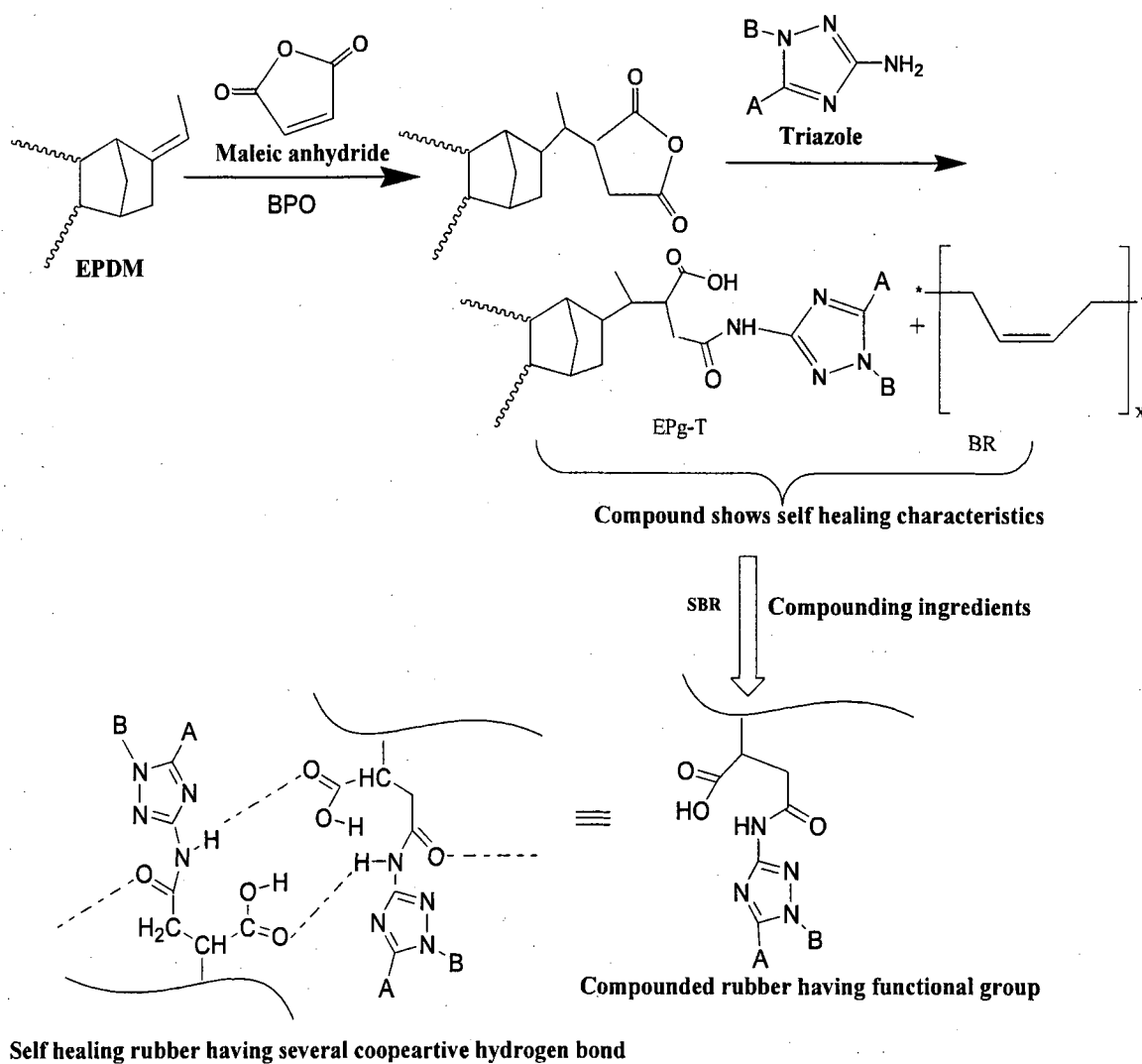
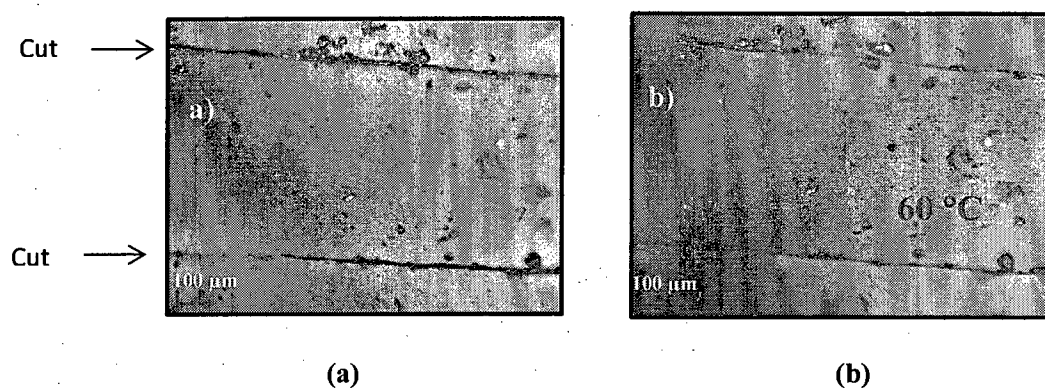


FIGURE 3

**FIGURE 4**