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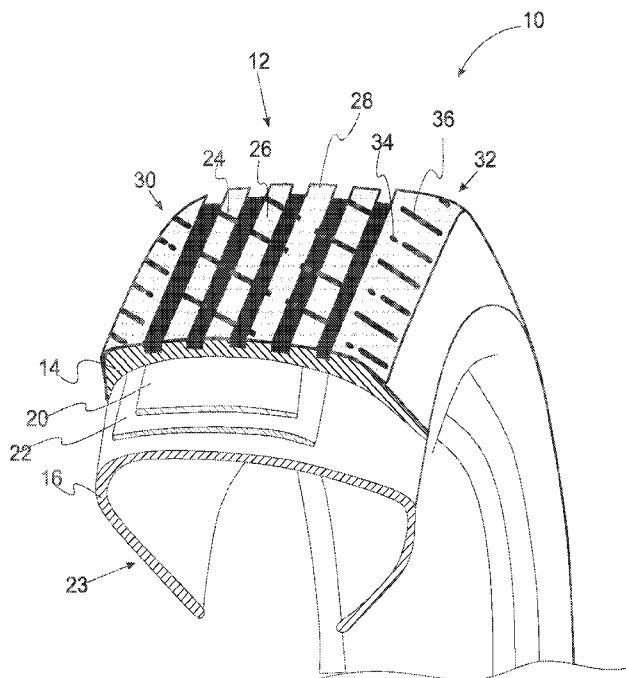


Fig. 1

(57) Abstract: A tire tread composition includes a styrene-butadiene rubber and a butadiene rubber. Characteristically, the weight ratio of the styrene-butadiene rubber to the butadiene rubber is from 2:1 to 4:1. The tire tread composition also includes a polyolefin component selected from the group consisting of silane-grafted polyolefins, non-silane grafted polyolefins, and combinations thereof. The tire tread composition also includes a filler selected from the group consisting of carbon black, silica, and combinations thereof and an additive composition.



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COMPOSITIONS FOR LOW ROLLING RESISTANCE TIRES

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. provisional application Serial No. 63/523,768 filed June 28, 2023, the disclosure(s) of which is(are) hereby incorporated in its(their) entirety by reference herein.

TECHNICAL FIELD

[0002] In at least one aspect, compositions and additives for making tire treads are provided.

BACKGROUND

[0003] Current state-of-the-art tire tread compounds can offer good abrasion and low rolling resistance but guidelines to improve fuel economy and reduce emissions continue to be particularly challenging. Existing tire treads are typically made from sulfur-cured blends of butadiene rubber, styrene-butadiene rubber, and other polymers such as natural rubber. These polymers, along with other additives, can provide good handling and abrasion resistance along with low rolling resistance. However, demand for higher treadwear resistance and higher fuel economy continues to grow. In addition, the new electric vehicles demand higher mileage per charge, higher wear resistance, and reduced stopping distance.

[0004] Accordingly, there is a need for tread compositions that allow for lower rolling resistance with improved fuel economy.

SUMMARY

[0005] In at least one aspect, a tire composition for forming tire treads is provided. The tire tread composition includes a styrene-butadiene rubber and a butadiene rubber. Characteristically, the weight ratio of the styrene-butadiene rubber to the butadiene rubber is from 2:1 to 4:1. The tire tread composition also includes a polyolefin component selected from the group consisting of silane-grafted polyolefins, non-silane grafted polyolefins, and combinations thereof. The tire tread composition also

includes a filler selected from the group consisting of carbon black, silica, and combinations thereof and an additive composition.

[0006] In another aspect, a tread section for a tire is provided. The tread section is formed from the tire tread composition described herein. Characteristically, the tread section includes a plurality of tire treads.

[0007] In another aspect, a tire tread composition is provided. The tire tread composition includes a base composition for tire treads and a tread additive elastomeric composition including a component selected from the group consisting of a silane-grafted polyolefin, a non-silane-grafted polyolefin, and combinations thereof.

[0008] The foregoing summary is illustrative only and is not intended to be in any way limiting. In addition to the illustrative aspects, embodiments, and features described above, further aspects, embodiments, and features will become apparent by reference to the drawings and the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] For a further understanding of the nature, objects, and advantages of the present disclosure, reference should be had to the following detailed description, read in conjunction with the following drawings, wherein like reference numerals denote like elements and wherein:

[0010] FIGURE 1. Schematic illustration of a pneumatic tire having a tread block made with a tire tread composition.

[0011] FIGURE 2. Spider graph summarizing the tire properties for treads made with the tire tread compositions.

DETAILED DESCRIPTION

[0012] Reference will now be made in detail to presently preferred compositions, embodiments and methods of the present invention, which constitute the best modes of practicing the

invention presently known to the inventors. The Figures are not necessarily to scale. However, it is to be understood that the disclosed embodiments are merely exemplary of the invention that may be embodied in various and alternative forms. Therefore, specific details disclosed herein are not to be interpreted as limiting, but merely as a representative basis for any aspect of the invention and/or as a representative basis for teaching one skilled in the art to variously employ the present invention.

[0013] Except in the examples, or where otherwise expressly indicated, all numerical quantities in this description indicating amounts of material or conditions of reaction and/or use are to be understood as modified by the word "about" in describing the broadest scope of the invention. Practice within the numerical limits stated is generally preferred. Also, unless expressly stated to the contrary: all R groups (e.g. R_i where i is an integer) include hydrogen, alkyl, lower alkyl, C_{1-6} alkyl, C_{6-10} aryl, C_{6-10} heteroaryl, $-NO_2$, $-NH_2$, $-N(R'R'')$, $-N(R'R'R''')^+L^-$, Cl , F , Br , $-CF_3$, $-CCl_3$, $-CN$, $-SO_3H$, $-PO_3H_2$, $-COOH$, $-CO_2R'$, $-COR'$, $-CHO$, $-OH$, $-OR'$, $-O^+M^-$, $-SO_3^-M^+$, $-PO_3^-M^+$, $-COO^-M^+$, $-CF_2H$, $-CF_2R'$, $-CFH_2$, and $-CFR'R''$ where R' , R'' and R''' are C_{1-10} alkyl or C_{6-18} aryl groups M is a metal atom (e.g., Na , K , Li , etc.) and L^- is a negative counter ion (e.g., halide); single letters (e.g., "n" or "o") are 1, 2, 3, 4, or 5; in the compounds disclosed herein including compounds described by formula or by name, a CH bond can be substituted with alkyl, lower alkyl, C_{1-6} alkyl, C_{6-10} aryl, C_{6-10} heteroaryl, $-NO_2$, $-NH_2$, $-N(R'R'')$, $-N(R'R'R''')^+L^-$, Cl , F , Br , $-CF_3$, $-CCl_3$, $-CN$, $-SO_3H$, $-PO_3H_2$, $-COOH$, $-CO_2R'$, $-COR'$, $-CHO$, $-OH$, $-OR'$, $-O^+M^-$, $-SO_3^-M^+$, $-PO_3^-M^+$, $-COO^-M^+$, $-CF_2H$, $-CF_2R'$, $-CFH_2$, and $-CFR'R''$ where R' , R'' and R''' are C_{1-10} alkyl or C_{6-18} aryl groups M is a metal atom (e.g., Na , K , Li , etc.) and L^- is a negatively charge counter ion (e.g., Cl^- , Br^- , tosylate, etc.); percent, "parts of," and ratio values are by weight; the term "polymer" includes "oligomer," "copolymer," "terpolymer," and the like; molecular weights provided for any polymers refers to weight average molecular weight unless otherwise indicated; the description of a group or class of materials as suitable or preferred for a given purpose in connection with the invention implies that mixtures of any two or more of the members of the group or class are equally suitable or preferred; description of constituents in chemical terms refers to the constituents at the time of addition to any combination specified in the description, and does not necessarily preclude chemical interactions among the constituents of a mixture once mixed; the first definition of an acronym or other abbreviation applies to all subsequent uses herein of the same abbreviation and applies mutatis mutandis to normal grammatical variations

of the initially defined abbreviation; and, unless expressly stated to the contrary, measurement of a property is determined by the same technique as previously or later referenced for the same property.

[0014] The term “alkyl” refers to C₁₋₂₀ inclusive, linear (*i.e.*, “straight-chain”), branched, saturated or at least partially and in some cases fully unsaturated (*i.e.*, alkenyl and alkynyl) hydrocarbon chains, including for example, methyl, ethyl, propyl, isopropyl, butyl, isobutyl, *tert*-butyl, pentyl, hexyl, octyl, ethenyl, propenyl, butenyl, pentenyl, hexenyl, octenyl, butadienyl, propynyl, butynyl, pentynyl, hexynyl, heptynyl, and allenyl groups. “Branched” refers to an alkyl group in which a lower alkyl group, such as methyl, ethyl or propyl, is attached to a linear alkyl chain. “Lower alkyl” refers to an alkyl group having 1 to about 8 carbon atoms (*i.e.*, a C₁₋₈ alkyl), *e.g.*, 1, 2, 3, 4, 5, 6, 7, or 8 carbon atoms. “Higher alkyl” refers to an alkyl group having about 10 to about 20 carbon atoms, *e.g.*, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, or 20 carbon atoms.

[0015] It is also to be understood that this invention is not limited to the specific embodiments and methods described below, as specific components and/or conditions may, of course, vary. Furthermore, the terminology used herein is used only for the purpose of describing particular embodiments of the present invention and is not intended to be limiting in any way.

[0016] It must also be noted that, as used in the specification and the appended claims, the singular form “a,” “an,” and “the” comprise plural referents unless the context clearly indicates otherwise. For example, reference to a component in the singular is intended to comprise a plurality of components.

[0017] The term “comprising” is synonymous with “including,” “having,” “containing,” or “characterized by.” These terms are inclusive and open-ended and do not exclude additional, unrecited elements or method steps.

[0018] The phrase “consisting of” excludes any element, step, or ingredient not specified in the claim. When this phrase appears in a clause of the body of a claim, rather than immediately following the preamble, it limits only the element set forth in that clause; other elements are not excluded from the claim as a whole.

[0019] The phrase “consisting essentially of” limits the scope of a claim to the specified materials or steps, plus those that do not materially affect the basic and novel characteristic(s) of the claimed subject matter.

[0020] With respect to the terms “comprising,” “consisting of,” and “consisting essentially of,” where one of these three terms is used herein, the presently disclosed and claimed subject matter can include the use of either of the other two terms.

[0021] It should also be appreciated that integer ranges explicitly include all intervening integers. For example, the integer range 1-10 explicitly includes 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10. Similarly, the range 1 to 100 includes 1, 2, 3, 4, . . . 97, 98, 99, 100. Similarly, when any range is called for, intervening numbers that are increments of the difference between the upper limit and the lower limit divided by 10 can be taken as alternative upper or lower limits. For example, if the range is 1.1 to 2.1 the following numbers 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, and 2.0 can be selected as lower or upper limits. In the specific examples set forth herein, concentrations, temperature, and reaction conditions (e.g. pressure, pH, etc.) can be practiced with plus or minus 50 percent of the values indicated rounded to three significant figures. In a refinement, concentrations, temperature, and reaction conditions (e.g., pressure, pH, etc.) can be practiced with plus or minus 30 percent of the values indicated rounded to three significant figures of the value provided in the examples. In another refinement, concentrations, temperature, and reaction conditions (e.g., pH, etc.) can be practiced with plus or minus 10 percent of the values indicated rounded to three significant figures of the value provided in the examples.

[0022] In the examples set forth herein, concentrations, temperature, and reaction conditions (e.g., pressure, pH, flow rates, etc.) can be practiced with plus or minus 50 percent of the values indicated rounded to or truncated to two significant figures of the value provided in the examples. In a refinement, concentrations, temperature, and reaction conditions (e.g., pressure, pH, flow rates, etc.) can be practiced with plus or minus 30 percent of the values indicated rounded to or truncated to two significant figures of the value provided in the examples. In another refinement, concentrations, temperature, and reaction conditions (e.g., pressure, pH, flow rates, etc.) can be practiced with plus

or minus 10 percent of the values indicated rounded to or truncated to two significant figures of the value provided in the examples.

[0023] Throughout this application, where publications are referenced, the disclosures of these publications in their entireties are hereby incorporated by reference into this application to more fully describe the state of the art to which this invention pertains.

[0024] Abbreviations:

[0025] “BR” means butadiene rubber.

[0026] “SBR” means styrene-butadiene rubber.

[0027] “LSBR” means liquid styrene-butadiene rubber.

[0028] “SSBR” means solution styrene-butadiene rubber.

[0029] “phr” means parts per 100 parts by weight of rubber.

[0030] Figure 1 provides a schematic illustration of a pneumatic tire having a tread section that is formed from a tread composition with improved rolling resistance. Pneumatic tire 10 includes tread block 12 disposed over undertread 14, which is disposed over carcass 16. Cap piles 20 and belts 22 are interposed between the undertread 14 and carcass 16. Sidewall 23, which abuts tread block 12, is also depicted. The tire tread compositions set forth herein are used for forming tread section 14.

[0031] Tread block 12 includes treads 24 defined by the tread rubber and interposed between blocks 26. Tread block 12 can also include ribs 28, which is a pattern of tread features aligned around the circumference of the tire. Tread block 12 also includes shoulder sections 30 and 32 which have dimples 34 and sipes 36 defined by the tread rubber therein.

[0032] In another aspect, a tire tread composition used to form the tread section of Figure 1 is provided. The tire tread composition includes a styrene-butadiene rubber and a butadiene rubber. Characteristically, the weight ratio of the styrene-butadiene rubber to the butadiene rubber is from 2:1 to 4:1. The tire tread composition also includes a polyolefin component selected from the group

consisting of silane-grafted polyolefins, non-silane grafted polyolefins, and combinations thereof. The tire tread composition includes a filler selected from the group consisting of carbon black, silica, and combinations thereof and an additive composition.

[0033] In another aspect, the silica is present in an amount from about 20 weight percent to 40 weight percent of the total weight of the tire tread composition. In a refinement, the carbon black is present in an amount from about 1 weight percent to 40 weight percent of the total weight of the tire tread composition. In a further refinement, the carbon black is present in an amount from about 1 weight percent to 4 weight percent of the total weight of the tire tread composition.

[0034] In another aspect, the additive composition includes one or more additives. In a refinement, the one or more additives include a component selected from the group consisting of a nucleating agents (e.g., talc), a plasticizer, one or more process aids, a curative agent (e.g., peroxide, sulfur), one or more accelerators, one or more activators, one or more antioxidants, a wax, and combinations thereof. Process aids are agents that improve flow and processability. Examples of process aids include but are not limited to, stearic acid, zinc oxide, octadecanoic acid, and polyethylene glycol. Accelerators are compounds that increase the reaction rate. In a refinement, the tire tread composition includes a plasticizer in an amount from about 5 weight percent to 20 weight percent of the total weight of the tire tread composition. In further refinements, the plasticizer is present in an amount of at least 1 weight percent, 3 weight percent, 5 weight percent, 7 weight percent, or 10 weight percent of the total weight of the tire tread composition. In some further refinements, the plasticizer is present in an amount of at most 25 weight percent, 20 weight percent, 18 weight percent, 15 weight percent, or 10 weight percent of the total weight of the tire tread composition.

[0035] In another aspect, the additive composition includes a coupling agent. In a refinement, the coupling agent is an organosilane with disulfide groups or tetrasulfide groups. Examples of such coupling agents include, but are not limited to, bis(triethoxysilylpropyl)tetrasulfide, bis(triethoxysilylpropyl)disulfide, 3-thiocyanatopropyltriethoxysilane, and the like. In a refinement, the coupling agent is present in an amount from about 1 weight percent to 5 weight percent of the total weight of the tire tread composition. In further refinements, the coupling agent is present in an amount of at least 0.5 weight

percent, 1 weight percent, 1.5 weight percent, 2 weight percent, or 3 weight percent of the total weight of the tire tread composition. In some further refinements, the coupling agent is present in an amount of at most 8 weight percent, 7 weight percent, 6.5 weight percent, 6 weight percent, or 5 weight percent of the total weight of the tire tread composition.

[0036] In another aspect, the additive composition includes an activator is selected from the group consisting of stearic acid, zinc oxide, and combinations thereof. In a refinement, the additive composition includes stearic acid in an amount from 0.1 to 1.5 weight percent of the total weight of the tire tread composition. In a further refinement, the additive composition includes zinc oxide in an amount from 0.3 to 3 weight percent of the total weight of the tire tread composition.

[0037] In another aspect, the additive composition includes a wax. In a refinement, the wax in an amount from 0.3 to 3 weight percent of the total weight of the tire tread composition. In some refinements, the wax in an amount of at least 0.1 weight percent, 0.2 weight percent, 0.3 weight percent, 0.5 weight percent, or 1 weight percent of the total weight of the tire tread composition. In some further refinements, the wax in an amount of at most 5 weight percent, 4 weight percent, 3 weight percent, 2.5 weight percent, or 2 weight percent of the total weight of the tire tread composition.

[0038] In another aspect, the additive composition includes antioxidants. In a refinement, the antioxidant can be based on p-phenylenediamine. A specific example is *N*¹-(4-Methylpentan-2-yl)-*N*⁴-phenylbenzene-1,4-diamine. In another refinement, the antioxidant is a sterically hindered amine. A specific example of this type of antioxidant is 2,2,4-trimethyl-1,2-dihydroquinoline. In a further refinement, the antioxidants are present in an amount from 0.3 to 4 weight percent of the total weight of the tire tread composition.

[0039] In another aspect, the additive composition includes a curative or combinations of curatives. In a refinement, the curative is sulfur (e.g., a sulfur curing agent or sulfur curing system) which can form crosslinking involving disulfide links or sulfide links, typically, after a silane-grafted polyolefin and/or a non-silane-grafted polyolefin is added to the tire tread composition. a further refinement, the sulfur curative is present in an amount from 0.1 to 2 weight percent of the total weight of the tire tread composition. In a refinement, the curative is a peroxide, and in particular, an

organoperoxide. Peroxide promotes crosslinking of polymer chains by C-C bond. In a further refinement, the peroxide curative is present in an amount from 0.1 to 5 weight percent of the total weight of the tire tread composition. In a refinement, Peroxide can be added to contribute to crosslinking of grafted or non-grafted polyolefins. (see Table 2 below). For example, the polyolefins can be grafted and then added to tire tread composition. In another refinement, the curative includes both a peroxide and sulfur to provide a dual curing system. In some refinements, the outsole composition allows for a dual curing system. In this instance, the sulfur formed sulfur bridges within the polymer in the base composition. The presence of peroxide forms carbon-carbon bonds (C-C bonds) in the polymers in the outsole composition and in the polymer in the base composition.

[0040] In another aspect, the additive composition includes accelerators in an amount from 0.1 to 2 weight percent of the total weight of the tire tread composition. Examples of accelerators include but are not limited to, N-cyclohexyl-2-benzothiazole sulfenamide, diphenyl guanidine, thiazole, and sulfenamide boosters. In a refinement, the accelerators are present in an amount from 0.1 to 2 weight percent of the total weight of the tire tread composition.

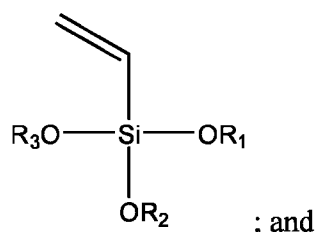
[0041] In another aspect, the polyolefin component includes a silane-grafted olefin block copolymer and/or a non-silane-grafted olefin block copolymer.

[0042] In another aspect, the polyolefin component is a non-silane grafted polyolefins. In one refinement, the non-silane grafted polyolefins is an olefin block copolymer. In a refinement, the olefin block copolymer is present in an amount from about 2 weight percent to 8 weight percent of the total weight of the tire tread composition. In some refinements, the non-silane-grafted polyolefin includes a polyethylene, polybutylene, polystyrene, a styrene block copolymer, an ethylene α -olefin copolymer, or combinations thereof. In a refinement, the non-silane-grafted polyolefin includes a low-density polyethylene, a high-density polyethylene, an ultrahigh molecular polyolefin, or combinations thereof. In another refinement, the non-silane-grafted polyolefin is selected from the group consisting of ethylene/ α -olefin copolymers, olefin block copolymers, and combinations thereof.

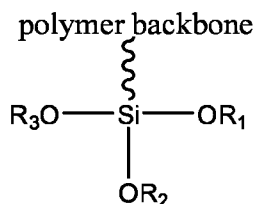
[0043] In another aspect, the polyolefin component is a silane-grafted polyolefin. In a refinement, the silane-grafted polyolefin is a silane-grafted olefin block copolymer. In a further

refinement, the olefin block copolymer is present in an amount from about 2 weight percent to 8 weight percent of the total weight of the tire tread composition. In some refinements, the silane-grafted polyolefin includes a silane-grafted polyethylene, a silane-grafted butylene, a silane-grafted styrene, a silane-grafted styrene block copolymer, a silane-grafted ethylene α -olefin copolymer, or combinations thereof. In a refinement, the silane-grafted polyolefin includes a silane-grafted low-density polyethylene, a silane-grafted high-density polyethylene, a silane-grafted ultrahigh molecular polyolefin, or combinations thereof. In another refinement, the silane-grafted polyolefin is selected from the group consisting of silane-grafted ethylene/ α -olefin copolymers, silane-grafted olefin block copolymers, and combinations thereof.

[0044] In another aspect, the silane-grafted polyolefin is formed from a blend that includes a base polyolefin and a silane crosslinker having the following formula:



wherein R_1 , R_2 , and R_3 are each independently H or lower alkyl or higher alkyl. In a refinement, R_1 , R_2 , and R_3 are each independently H or C_{1-8} alkyl. In a refinement, R_1 , R_2 , and R_3 are each methyl, ethyl, propyl, or butyl. Additional details of silane-grafted polyolefins and silane grafting are found in US Pat. Nos 10/774,168 and 10/779,608, the entire disclosures of which are hereby incorporated by reference in its entirety. In a refinement, the silane grafted silane-grafted polyolefin can be described by the following formula:



where the polymer backbone can be a polymer or copolymer backbone. In a further refinement, the silane-grafted polymer is mixed with a silanol-forming condensation catalyst and then exposed to humidity and/or heat to effect crosslinking of the copolymer in a two-step reaction. Alternatively, the composition can be cross-linked via sulfonic acid catalyst (e.g., 'Ambicat') or a tin-based catalyst where the ambient moisture is sufficient to crosslink over a longer time period (e.g., about 48 hours). First, the water hydrolyzes the silane to produce a silanol. The silanol then condenses to form intermolecular, irreversible Si-O-Si crosslink sites. Additional details of silane-grafted polyolefins and silane grafting are found in US Pat. Nos 10/774,168 and 10/779,608, the entire disclosures of which are hereby incorporated by reference in its entirety.

[0045] In another aspect, the number average molecular weight of the silane-grafted polyolefins may be in the range of from about 4,000 g/mol to about 30,000 g/mol, including from about 5,000 g/mol to about 25,000 g/mol and from about 6,000 g/mol to about 14,000 g/mol. The weight average molecular weight of the grafted polymers may be from about 8,000 g/mol to about 60,000 g/mol, including from about 10,000 g/mol to about 30,000 g/mol.

[0046] In another aspect, the density of the base polyolefin is less than 1.0 g/cm³, including less than about 0.92 g/cm³. The density may be from about 0.85 g/cm³ to about 0.96 g/cm³. In some refinements, the density is at least 0.84 g/cm³, including at least about 0.862 g/cm³.

[0047] In another aspect, the tire tread composition includes a nanofiller (i.e., at least one dimension less than 100 nm). Examples of nanofillers include carbon nanotubes, nanoclays, graphene, carbon nanofibers, cellulose nanofibers, nanoscale silica particles, and combinations thereof.

[0048] In another aspect, the tire tread composition includes a condensation catalyst when the polyolefin component includes a silane-grafted polyolefin. With such polymer, the condensation catalyst promotes the formation of silane crosslinking. The condensation catalyst can include, for example, organic bases, carboxylic acids, and organometallic compounds (e.g., organic titanates and complexes or carboxylates of lead, cobalt, iron, nickel, zinc, and tin). In other aspects, the condensation catalyst can include fatty acids and metal complex compounds such as metal carboxylates; aluminum triacetyl acetate, iron triacetyl acetate, manganese tetraacetyl acetate,

nickel tetraacetyl acetate, chromium hexaacetyl acetate, titanium tetraacetyl acetate and cobalt tetraacetyl acetate; metal alkoxides such as aluminum ethoxide, aluminum propoxide, aluminum butoxide, titanium ethoxide, titanium propoxide and titanium butoxide; metal salt compounds such as sodium acetate, tin octylate, lead octylate, cobalt octylate, zinc octylate, calcium octylate, lead naphthenate, cobalt naphthenate, dibutyltin dioctoate, dibutyltin dilaurate, dibutyltin maleate and dibutyltin di(2-ethylhexanoate); acidic compounds such as formic acid, acetic acid, propionic acid, p-toluenesulfonic acid, trichloroacetic acid, phosphoric acid, monoalkylphosphoric acid, dialkylphosphoric acid, phosphate ester of p-hydroxyethyl (meth)acrylate, monoalkylphosphorous acid and dialkylphosphorous acid; acids such as p-toluenesulfonic acid, phthalic anhydride, benzoic acid, benzenesulfonic acid, dodecylbenzenesulfonic acid, formic acid, acetic acid, itaconic acid, oxalic acid and maleic acid, ammonium salts, lower amine salts or polyvalent metal salts of these acids, sodium hydroxide, lithium chloride; organometal compounds such as diethyl zinc and tetra(n-butoxy)titanium; and amines such as dicyclohexylamine, triethylamine, N,N-dimethylbenzylamine, N,N,N',N'-tetramethyl-1,3-butanediamine, diethanolamine, triethanolamine and cyclohexylethylamine. In still other aspects, the condensation catalyst can include ibutyltindilaurate, dioctyltinmaleate, dibutyltindiacetate, dibutyltindioctoate, stannous acetate, stannous octoate, lead naphthenate, zinc caprylate, and cobalt naphthenate. Depending on the desired final material properties, a single condensation catalyst or a mixture of condensation catalysts may be utilized. The condensation catalyst(s) may be present in an amount from about 0.01 wt % to about 8 wt %, based on the total weight of the expanded polymeric polymer sheet.

[0049] As set forth above, the tread composition can include a peroxide initiator (e.g., a peroxide curing agent). In a refinement, the peroxide initiators can independently include a peroxide selected from the group consisting of hydrogen peroxide and organoperoxides such as alkyl hydroperoxides, dialkyl peroxides, and diacyl peroxides. Examples for the peroxide include, but are not limited to, an organic peroxide selected from the group consisting of di-t-butyl peroxide, t-butyl cumyl peroxide, dicumyl peroxide, 2,5-dimethyl-2,5-di(t-butyl-peroxy)hexyne-3, 1,3-bis(t-butyl-peroxy-isopropyl)benzene, n-butyl-4,4-bis(t-butyl-peroxy)valerate, benzoyl peroxide, t-butylperoxybenzoate, t-butylperoxy isopropyl carbonate, t-butylperbenzoate, bis(2-methylbenzoyl)peroxide, bis(4-methylbenzoyl)peroxide, t-butyl peroctoate, cumene hydroperoxide,

methyl ethyl ketone peroxide, lauryl peroxide, tert-butyl peracetate, di-t-amyl peroxide, t-amyl peroxybenzoate, 1,1-bis(t-butylperoxy)-3,3,5-trimethylcyclohexane, α,α' -bis(t-butylperoxy)-1,3-diisopropylbenzene, α,α' -bis(t-butylperoxy)-1,4-diisopropylbenzene, 2,5-bis(t-butylperoxy)-2,5-dimethylhexane, 2,5-Dimethyl-2,5-di-(tert-butylperoxy)-hexane, 2,5-bis(t-butylperoxy)-2,5-dimethyl-3-hexyne, 2,4-dichlorobenzoyl peroxide, and combinations thereof.

[0050] In another aspect, a tire tread composition includes a base composition for tire treads (i.e., a base tire tread composition) and a tread additive elastomeric composition. In this context, a base tire tread composition is a composition that forms tire treads even without a silane-grafted polyolefin being added. The tire additive elastomeric composition includes a component selected from the group consisting of a silane-grafted polyolefin, a non-silane-grafted polyolefin, and combinations thereof. Advantageously, the tread additive elastomeric composition is combined with the base composition for tire treads or tank track pads to achieve low rolling resistance. Details for the silane-grafted polyolefins, the non-silane-grafted polyolefins, the peroxides, and the silane crosslinkers are described above.

[0051] In another aspect, the tread additive elastomeric composition includes the silane-grafted polyolefin. As set forth above, the silane-grafted polyolefin can include a silane-grafted polyethylene, a silane-grafted butylene, a silane-grafted styrene, a silane-grafted styrene block copolymer, a silane-grafted ethylene α -olefin copolymer, or combinations thereof. In a refinement, the silane-grafted polyolefin includes a silane-grafted low density polyethylene, a silane-grafted high density polyethylene, a silane-grafted ultrahigh molecular polyolefine, or combinations thereof. In a further refinement, the first silane-grafted polyolefin is a silane-grafted olefin block copolymer. In still another refinement, the silane-grafted polyolefin is selected from the group consisting of silane-grafted olefin homopolymers, silane-grafted blends of homopolymers, copolymers of two or more olefins, silane-grafted blends of copolymers of two or more olefins, and a combination of silane-grafted olefin homopolymers blended with copolymers of two or more olefins.

[0052] In another aspect, the tread additive elastomeric composition includes a non-silane-grafted polyolefin. In a refinement, the non-silane grafted polyolefins is an olefin block copolymer. In some refinements, the non-silane-grafted polyolefin includes a polyethylene, polybutylene,

polystyrene, a styrene block copolymer, an ethylene α -olefin copolymer, or combinations thereof. In a refinement, the non-silane-grafted polyolefin includes a low-density polyethylene, a high-density polyethylene, an ultrahigh molecular polyolefin, or combinations thereof. In another refinement, the non-silane-grafted polyolefin is selected from the group consisting of ethylene/ α -olefin copolymers, olefin block copolymers, and combinations thereof.

[0053] In another aspect, the number average molecular weight of the non-silane-grafted polyolefins may be in the range of from about 4,000 g/mol to about 30,000 g/mol, including from about 5,000 g/mol to about 25,000 g/mol and from about 6,000 g/mol to about 14,000 g/mol. The weight average molecular weight of the grafted polymers may be from about 8,000 g/mol to about 60,000 g/mol, including from about 10,000 g/mol to about 30,000 g/mol.

[0054] In another aspect, the density of the non-silane-grafted polyolefins is less than 1.0 g/cm³, including less than about 0.92 g/cm³. The density may be from about 0.85 g/cm³ to about 0.96 g/cm³. In some refinements, the density is at least 0.84 g/cm³, including at least about 0.862 g/cm³.

[0055] In another aspect, the cis-to-trans ratio for the polyolefins set forth above is greater than 1 and preferably greater than 2. These polyolefins include the base polyolefins from which the silane-grafted polyolefin is formed, as well as the polyolefins for the non-silane-grafted polyolefins. In some refinements, the cis-to-trans ratio of the polyolefins set forth above is at least 0, 1, 2, 3, or 5. In further refinements, the cis-to-trans ratio of the polyolefins set forth above is at most 10, 8, 7, 6, or 5.

[0056] In another aspect, the polyolefins set forth above have a total unsaturation from 20 to 100 unsaturated bonds per 100,000 CH_n groups where n is an integer label for the number of Hs (e.g., 1 or 2). In a refinement, the polyolefins set forth above have a total unsaturation from 40 to 60 unsaturated bonds per 100,000 CH_n groups. In some refinement, the polyolefins set forth above have a total unsaturation of at least 5, 10, 20, 30, 40, 50, 60, or 70 unsaturated bonds per 100,000 CH_n groups. In further refinements, the polyolefins set forth above have a total unsaturation of at most 150, 120, 100, 90, 80, or 70 unsaturated bonds per 100,000 CH_n groups.

[0057] A typical base (standard) composition for tire treads includes synthetic rubbers, natural rubbers, sulfur, and various fillers. Examples of synthetic rubbers include polybutadiene rubbers and styrene-butadiene rubbers. In a refinement, the base composition is a tread composition that a tire manufacturer typically uses for making treads. The tread additive elastomeric composition set forth herein includes an elastomeric component and one or more additives. In a refinement, the one or more additives include a component selected from the group consisting of a polymer carrier, additives that increase tensile strength, a traction enhancer, a reinforcing filler, silane-terminated liquid polybutadiene, one or more process aids, a curative agent (e.g., sulfur), a butadiene rubber, a hydrocarbon resin, one or more accelerators, one or more activators, one or more antioxidants, a wax, and combinations thereof. Process aids are agents that improve flow and processability. Examples of process aids include but are not limited to, octadecanoic acid and polyethylene glycol. Traction enhancers improve the wet traction in tire treads formed from the tire tread composition. An example of a traction enhancer is SBR, and in particular, SBR with high styrene content. Activators assist in promoting chemical reactions. Examples of activators include but are not limited to, stearic Acid and ZnO. Accelerators are compounds that increase the reaction rate. Examples of accelerators include but are not limited to, N-cyclohexyl-2-benzothioazole sulfenamide, diphenyl guanidine, thiazole and sulfenamide boosters.

[0058] In another aspect, the tire tread composition includes from about 30 to 95 weight percent of the base (e.g., standard) tread composition and about 70 to 5 weight percent of the tread additive composition. In a refinement, the tire tread composition includes from about 30 to 90 weight percent of the base (e.g., standard) tread composition and about 70 to 1- weight percent of the tread additive composition. In a refinement, the tire tread composition includes from about 30 to 63 weight percent of the base (e.g., standard) tread composition and about 70 to 37 weight percent of the tread additive composition. In some refinements, the tire tread composition includes 5 weight percent, 10 weight percent, at least 20 weight percent, 30 weight percent, 40 weight percent, or 50 weight percent of the base (e.g., standard) tire tread composition and/or at most 80 weight percent, 70 weight percent, 60 weight percent, or 50 weight percent of the base tire tread composition.

[0059] In another aspect, the tire tread composition includes the tread additive elastomeric composition in an amount from about 5 to 50 phr. In a refinement, the tire tread composition includes the tread additive elastomeric composition in an amount from about 5 to 30 phr. In some refinements, the tire tread composition includes the tread additive elastomeric composition in an amount of at least 1, 5, 7, 10, 12 or 15 phr and at most 60, 50, 40, 35, 30, 25, 20 or 18 phr.

[0060] In another aspect, a silane-grafted polyolefin is formed as described above with a peroxide. This silane-grafted polyolefin is added to a typical base (standard) composition, which is subsequently cured with a sulfur curing agent and/or a peroxide curing agent.

[0061] The following examples illustrate the various embodiments of the present invention. Those skilled in the art will recognize many variations that are within the spirit of the present invention and scope of the claims.

[0062] Table 1 provides examples of tire tread compositions used to make treads. Example 1 is a control sample used to compare the improvements of examples 2 and 3. Table 2 provides the composition used to form the silane-grafted olefin block copolymer. It should be appreciated that practice within (i.e., +/-), in increasing order of preference, 30%, 20%, 10%, 5%, or 2% of the amounts indicated in Tables 1 and 2 are also contemplated. Figure 2 shows the improvement in rolling resistance achieved by examples 2 and 3.

[0063] Table 1. Tire tread compositions used to make treads.

		Ex.1 (PHR)	Ex.2 (PHR)	Ex.3 (PHR)
Pass 1	SSBR polymer	96.25	96.25	96.25
	BR Polymer	30.00	30.00	30.00
	Olefin Block Copolymer			8.0
	Silane Grafted Olefin Block Copolymer		8.0	
	Carbon black filler	5.0	5.0	5.0
	Silica filler	70.0	70.0	70.0
	Oil/plasticizer	5.0	5.0	5.0
	Coupling agent	5.5	5.5	5.5
Pass 2	Activator	2.0	2.0	2.0

	Activator	3.5	3.5	3.5
	Wax	3.0	3.0	3.0
	Antioxidant	1.0	1.0	1.0
	Antiozonant	1.0	1.0	1.0
Pass 3	Curative	1.7	1.7	1.7
	Accelerator	2.0	2.0	2.0
	Accelerator	2.0	2.0	2.0
	Total PHR	227.95	235.95	235.95
	Calculated Gravity	1.163	1.150	1.151

[0064] Table 2. Silane Grafted Olefin Block Copolymer

	Wt%
Olefin Block Copolymer	97.0
VTMO	2.775
Peroxide	0.15
Antioxidant	0.015
Silicone	0.06
TOTAL	100.00

[0065] While exemplary embodiments are described above, it is not intended that these embodiments describe all possible forms of the invention. Rather, the words used in the specification are words of description rather than limitation, and it is understood that various changes may be made without departing from the spirit and scope of the invention. Additionally, the features of various implementing embodiments may be combined to form further embodiments of the invention.

WHAT IS CLAIMED IS:

1. A tire tread composition comprising:
 - a styrene-butadiene rubber;
 - a butadiene rubber, wherein a weight ratio of the styrene-butadiene rubber to the butadiene rubber is from 2:1 to 4:1;
 - a polyolefin component selected from the group consisting of silane-grafted polyolefins, non-silane-grafted polyolefins, and combinations thereof;
 - a filler selected from the group consisting of carbon black, silica, and combinations thereof; and
 - an additive composition.
2. The tire tread composition of claim 1, wherein a silane-grafted polyolefin is formed with a peroxide curing agent, the silane-grafted polyolefin is added a base tire tread composition which is subsequently cured with a sulfur curing agent and/or a peroxide curing agent.
3. The tire tread composition of claim 1, wherein the silica is present in an amount from about 20 weight percent to 40 weight percent of the total weight of the tire tread composition.
4. The tire tread composition of claim 1, wherein the carbon black is present in an amount from about 1 weight percent to 40 weight percent of the total weight of the tire tread composition.
5. The tire tread composition of claim 1, wherein the additive composition includes a plasticizer in an amount from about 5 weight percent to 20 weight percent of the total weight of the tire tread composition.
6. The tire tread composition of claim 1, wherein the additive composition includes a coupling agent that is an organosilane with disulfide groups or tetrasulfide groups.

7. The tire tread composition of claim 5, wherein the coupling agent is present in an amount from about 1 weight percent to 5 weight percent of the total weight of the tire tread composition.

8. The tire tread composition of claim 1, wherein the additive composition includes an activator is selected from the group consisting of stearic acid, zinc oxide, and combinations thereof.

9. The tire tread composition of claim 8, wherein the additive composition includes stearic acid in an amount from 0.1 to 1.5 weight percent of the total weight of the tire tread composition.

10. The tire tread composition of claim 9, wherein the additive composition includes zinc oxide in an amount from 0.3 to 3 weight percent of the total weight of the tire tread composition.

11. The tire tread composition of claim 1, wherein the additive composition includes a wax in an amount from 0.3 to 3 weight percent of the total weight of the tire tread composition.

12. The tire tread composition of claim 1, wherein the additive composition includes antioxidants in an amount from 0.3 to 4 weight percent of the total weight of the tire tread composition.

13. The tire tread composition of claim 1, wherein the additive composition includes a curative.

14. The tire tread composition of claim 13, wherein the tire tread composition is crosslinked with sulfide links and/or disulfide links after a silane-grafted polyolefin and/or a non-silane-grafted polyolefin is added to the tire tread composition.

15. The tire tread composition of claim 14, wherein the curative is sulfur.

16. The tire tread composition of claim 15, wherein the curative present in an amount from 0.1 to 2 weight percent of the total weight of the tire tread composition.

17. The tire tread composition of claim 13, wherein the tire tread composition is crosslinked with C-C bonds.

18. The tire tread composition of claim 17, wherein the curative is a peroxide.

19. The tire tread composition of claim 1, wherein the additive composition includes accelerators in an amount from 0.1 to 2 weight percent of the total weight of the tire tread composition.

20. The tire tread composition of claim 19, wherein the accelerators include diphenyl guanidine.

21. The tire tread composition of claim 1, wherein the polyolefin component includes a silane-grafted olefin block copolymer and/or a non-silane-grafted olefin block copolymer.

22. The tire tread composition of claim 21, wherein the silane-grafted olefin block copolymer and/or a non-silane-grafted olefin block copolymer is present in an amount from about 2 weight percent to 8 weight percent of the total weight of the tire tread composition.

23. The tire tread composition of claim 21, wherein the polyolefin component includes the silane-grafted polyolefin that is grafted via a peroxide.

24. The tire tread composition of claim 23, wherein the silane-grafted polyolefin includes a silane-grafted olefin block copolymer.

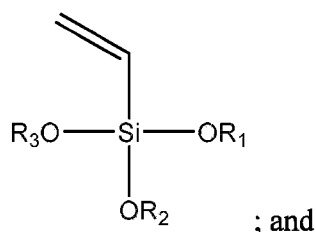
25. The tire tread composition of claim 23, wherein the silane-grafted polyolefin is present in an amount from about 2 weight percent to 8 weight percent of the total weight of the tire tread composition.

26. The tire tread composition of claim 23, wherein the silane-grafted polyolefin includes a silane-grafted polyethylene, a silane-grafted butylene, a silane-grafted styrene, a silane-grafted styrene block copolymer, a silane-grafted ethylene α -olefin copolymer, or combinations thereof.

27. The tire tread composition of claim 23, wherein the silane-grafted polyolefin includes a silane-grafted low-density polyethylene, a silane-grafted high-density polyethylene, a silane-grafted ultrahigh molecular polyolefin, or combinations thereof.

28. The tire tread composition of claim 23, wherein the silane-grafted polyolefin is selected from the group consisting of silane-grafted ethylene/ α -olefin copolymers, silane-grafted olefin block copolymers, and combinations thereof.

29. The tire tread composition of claim 23, wherein the silane-grafted polyolefin is formed from a blend that includes a base polyolefin and a silane crosslinker having the following formula:



R_1 , R_2 , and R_3 are each independently H or C_{1-8} alkyl.

30. The tire tread composition of claim 29, wherein R_1 , R_2 , and R_3 are each methyl, ethyl, propyl, or butyl.

31. The tire tread composition of claim 24, wherein tire composition includes silane crosslinking.
32. The tire tread composition of claim 31, further comprising a condensation catalyst.
33. The tire tread composition of claim 31, further comprising a nanofiller.
34. The tire tread composition of claim 33, wherein the nanofiller is selected from the group consisting of carbon nanotubes, nanoclays, graphene, carbon nanofibers, cellulose nanofibers, nanoscale silica particles, and combinations thereof.
35. A tread section for a tire formed from the tire tread composition of any of claims 1 to 34, the tread section including a plurality of tire treads.
36. A tire tread composition comprising:
a base composition for tire treads; and
a tread additive elastomeric composition including a component selected from the group consisting of a silane-grafted polyolefin, a non-silane-grafted polyolefin, and combinations thereof.
37. The tire tread composition of claim 36, wherein the tread additive elastomeric composition includes the silane-grafted polyolefin.
38. The tire tread composition of claim 37, wherein the silane-grafted polyolefin includes a silane-grafted polyethylene, a silane-grafted butylene, a silane-grafted styrene, a silane-grafted styrene block copolymer, a silane-grafted ethylene α -olefin copolymer, or combinations thereof.
39. The tire tread composition of claim 37, wherein the silane-grafted polyolefin includes a silane-grafted low density polyethylene, a silane-grafted high density polyethylene, a silane-grafted ultrahigh molecular polyolefine, or combinations thereof.

40. The tire tread composition of claim 37, wherein the silane-grafted polyolefin is a silane-grafted olefin block copolymer.

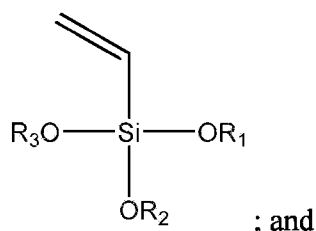
41. The tire tread composition of claim 37, wherein the silane-grafted polyolefin is selected from the group consisting of silane-grafted olefin homopolymers, silane-grafted blends of homopolymers, copolymers of two or more olefins, silane-grafted blends of copolymers of two or more olefins, and a combination of silane-grafted olefin homopolymers blended with copolymers of two or more olefins.

42. The tire tread composition of claim 36, wherein tread additive elastomeric composition includes a non-silane-grafted polyolefin.

43. The tire tread composition of claim 42, wherein tread additive elastomeric composition includes a non-silane-grafted polyolefin and a peroxide.

44. The tire tread composition of claim 42, wherein tread additive elastomeric composition includes a non-silane-grafted polyolefin, a silane crosslinker, and a peroxide.

45. The tire tread composition of claim 44, wherein the silane crosslinker has the following formula



R₁, R₂, and R₃ are each independently H or C₁₋₈ alkyl.

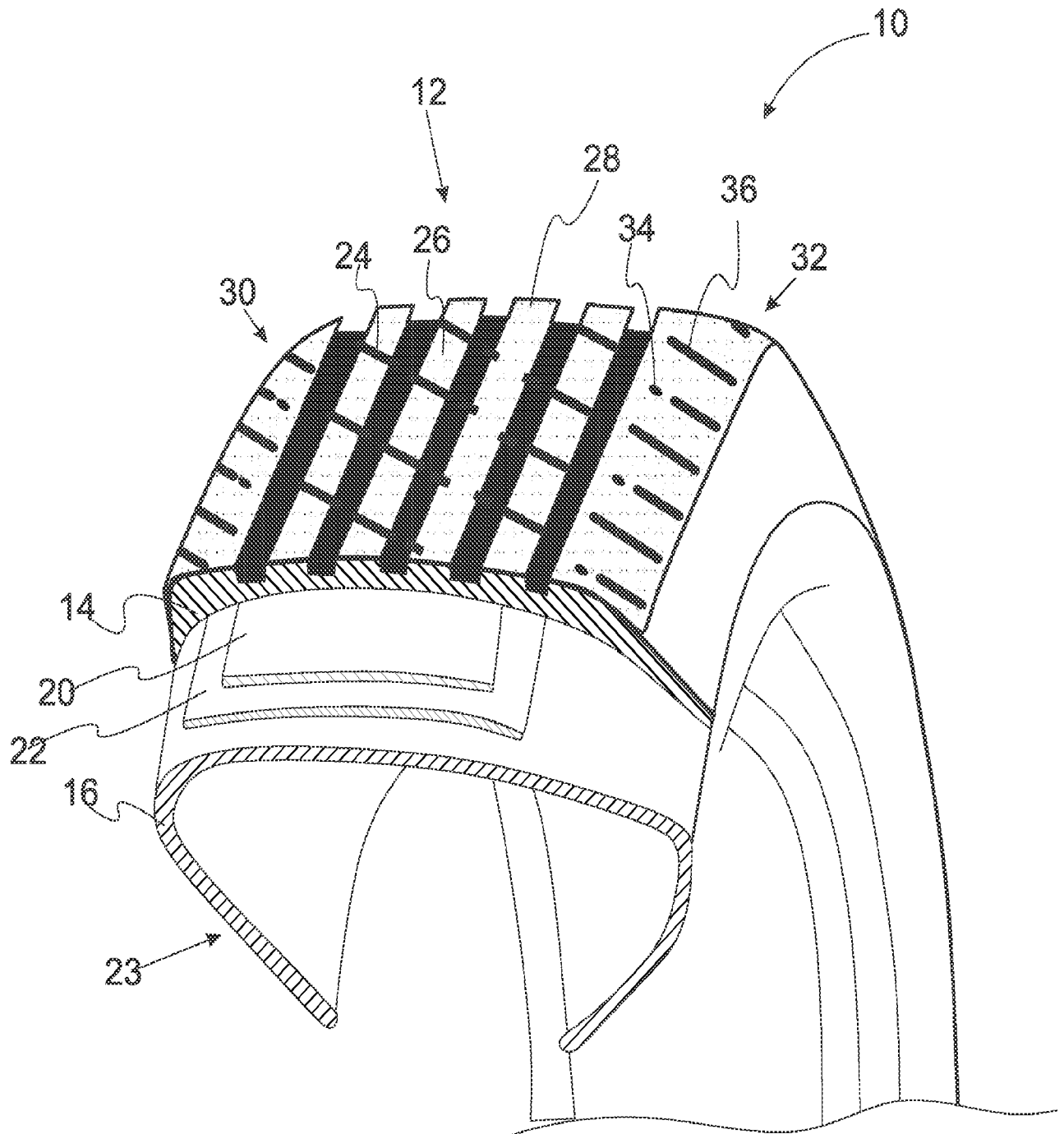
46. The tire tread composition of claim 45, wherein R_1 , R_2 , and R_3 are each methyl, ethyl, propyl, or butyl.

47. The tire tread composition of claim 42, wherein the non-silane grafted polyolefins is an olefin block copolymer.

48. The tire tread composition of claim 42, wherein the non-silane grafted polyolefins includes a polyethylene, polybutylene, polystyrene, a styrene block copolymer, an ethylene α -olefin copolymer, or combinations thereof.

49. The tire tread composition of claim 42, wherein the non-silane-grafted polyolefin includes a low-density polyethylene, a high-density polyethylene, an ultrahigh molecular polyolefin, or combinations thereof.

50. The tire tread composition of claim 42, wherein the non-silane-grafted polyolefin the non-silane-grafted polyolefin is selected from the group consisting of ethylene/ α -olefin copolymers, olefin block copolymers, and combinations thereof.

*Fig. 1*

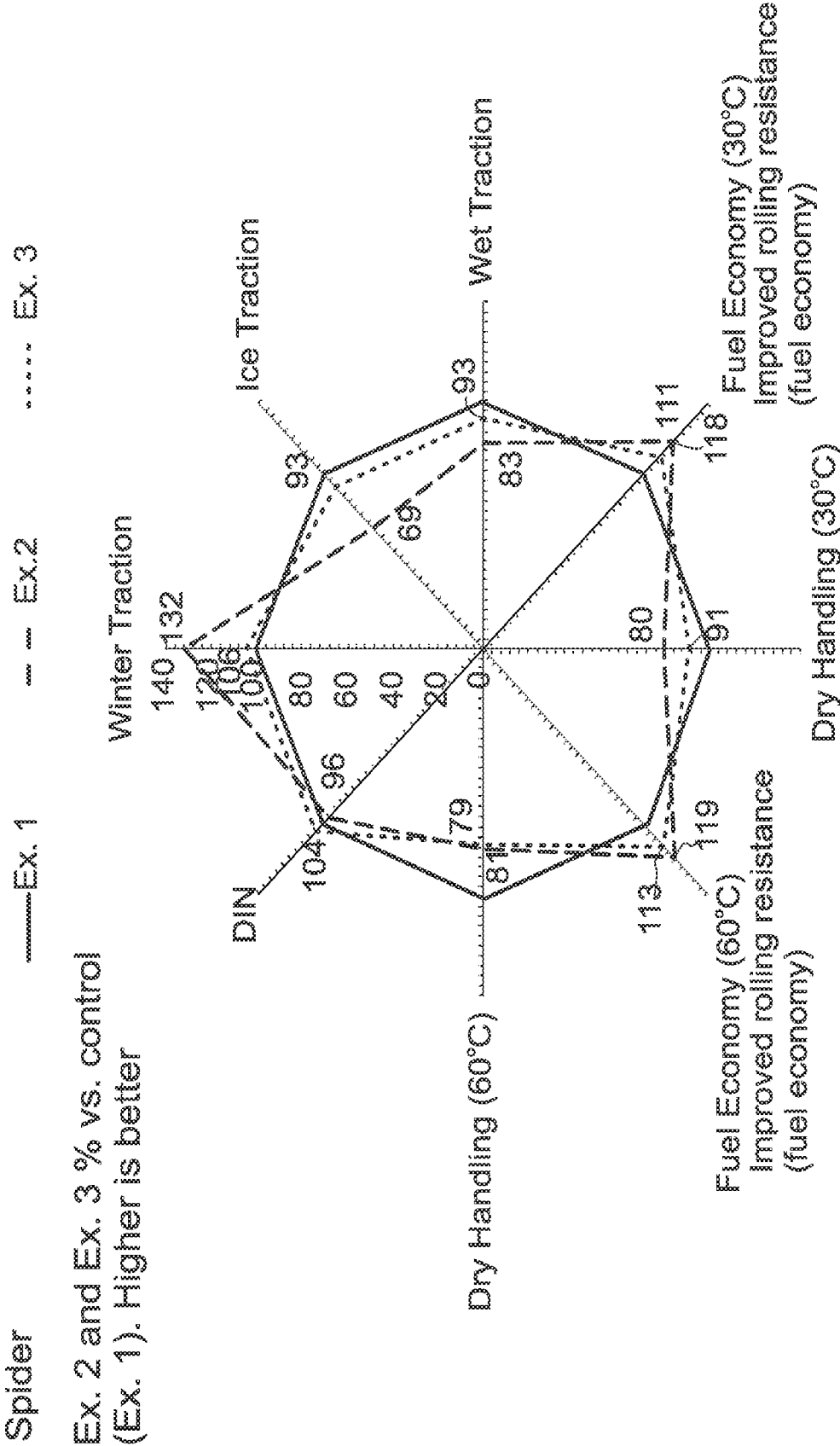


Fig. 2