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(54) Title: IMPROVED PROPERTIES OF PEROXIDE-CURED ELASTOMER COMPOSITIONS

(57) Abstract: An elastomeric composition and method for making the same are provided. The composition can include a rubber component comprising one or more ethylene-propylene elastomers, one or more peroxide curing agents and one or more non-functionalized plasticizers having a viscosity index of 120 or more.

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IMPROVED PROPERTIES OF PEROXIDE-CURED ELASTOMER COMPOSITIONS

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] Embodiments of the present invention generally relate to peroxide cured elastomer systems.

Description of the Related Art

[0002] Crosslinked elastomer formulations based on ethylene-propylene (EP) and/or ethylene-propylene-diene (EPDM) elastomers are useful in a variety of applications that are exposed to high (> 150°C) and/or low (< -20°C) temperatures during the product life time. Such applications include automotive parts like under-hood belts and hoses. To improve flexibility and/or workability of such crosslinked polyolefin elastomer formulations, a substantial amount of process oil, which acts as both a processing aid and a plasticizer, is added. To maintain the mechanical integrity (and therefore performance) of the manufactured part, it is desirable to minimize the gradual loss of the process oil over time.

[0003] Permanence is especially challenging when the part is exposed to high temperatures over long times and can be a problem when a low molecular weight oil is used. On the other hand, the parts should also stay flexible to very low temperatures. This presents a need for an oil with a low pour point, which improves as molecular weight is lowered. Thus, the choice of process oil is a balance between permanence (favoring high molecular weight) and low-temperature performance (favoring low molecular weight) and defines a practical temperature window of utility for the formulation (i.e., from the onset of brittleness on the low end to the onset of unacceptable oil loss at the high end).

[0004] When under-hood temperature requirements are high, a peroxide cure system is increasingly used for EP and EPDM compounds because traditional sulfur-cured compounds have an upper use temperature of about 130-150°C. This presents another problem for mineral oils, since most contain chemical moieties (cyclic or aromatic structures, unsaturation, and heteroatoms) that can interfere with peroxide cure systems and can compromise the cure rate and final cure state (degree of crosslinking). This also presents a challenge for conventional mineral oils in terms of the permanence/pour-point balance.

[0005] WO 02/31044 describes mono-olefinic polyalphaolefin (PAO) oils having molecular weights between 400 and 1,000 g/mol, as plasticizers for vulcanized or unvulcanized olefin elastomers such as EP, EPDM, natural, butyl, and polybutadiene rubbers. U.S. 4,645,791 describes vulcanized elastomer compositions of sulfur cured EP and EPDM rubbers; a

reinforcing particulate filler; and a synthetic hydrocarbon basestock lubricating oil with a molecular weight of between 250 and 1,500 g/mol. EP 0315363 describes vulcanized elastomer compositions of sulfur cured EP and EPDM rubbers; a reinforcing particulate filler; a PAO oil or blend of PAO oils with a kinematic viscosity at 100°C of 2 to 200 cSt; and a naphthenic and/or paraffinic mineral oil. U.S. 4,833,195 describes pelletizable polyolefin compositions of an EP, EPDM, polybutadiene, polyisoprene, and polyisobutylene rubbers; and a PAO oligomer of C_2 to C_6 olefins having a molecular weight of less than 15,000 g/mol; and optionally a thermoplastic polyolefin such as polyethylene or polypropylene. EP 1028145 describes vulcanized ethylene/propylene/ethylidene-norbornene compositions comprising 300 to 700 phr of a softener that has a low pour point (-40°C or less) and a solubility parameter of 6 to 8 (units are unstated), such as low molecular weight EP copolymers, mineral oils, or liquid polybutene or polyisoprene. WO 02/18487 and WO 03/048252 describe thermoplastic elastomer compositions with phenolic resin cured EP, EPDM, ethylene/alpha-olefin, butyl, and butadiene rubbers; 10 to 90 wt% of a thermoplastic polyolefin; and a PAO oil with a molecular weight of 1,000 g/mol or less. Mineral oils are added to the composition if at least 25 wt% of the total oil is PAO. WO 04/09699 describes compositions of EPDM rubber and a Fischer-Tropsch derived paraffinic process oil with a kinematic viscosity at 100°C of between 8 and 30 cSt. Additional references include U.S. 6451915; U.S. 2005/222861, and JP 07292167.

[0006] Based on the above, there is a need for an oil of highly paraffinic structure that minimizes interference with peroxide cure systems, is thermally stable, is of sufficient molecular weight to increase retention of the oil at high temperatures, and has a low pour point to ensure flexibility at low temperatures.

SUMMARY OF THE INVENTION

[0007] An elastomeric composition and method for making the same are provided. In at least one specific embodiment, the composition includes a rubber component comprising one or more ethylene-propylene elastomers, one or more peroxide curing agents and one or more non-functionalized plasticizers having a viscosity index of 120 or more, a kinematic viscosity @100°C of 20 cSt or more, and an Mn of 1100 g/mole or more.

[0008] In yet another specific embodiment, the composition includes a rubber component comprising one or more ethylene-propylene elastomers, one or more peroxide curing agents and one or more non-functionalized plasticizers having a viscosity index of 120 or more, wherein the one or more non-functionalized plasticizers are selected from the group consisting of Group III mineral oils and wax isomerate lubricant base stocks or oils.

[0009] In yet another specific embodiment, the composition includes at least one rubber component comprising ethylene-propylene rubber, at least one rubber component comprising ethylene-propylene-diene (EPDM) rubber and two or more non-functionalized plasticizers where at least a first non-functionalized plasticizer has a kinematic viscosity @100°C of 300 cSt or more and at least a second non-functionalized plasticizer has a kinematic viscosity @100°C of 150 cSt or less.

[0010] In yet another specific embodiment, the composition includes a rubber component comprising one or more ethylene-propylene elastomers, one or more peroxide curing agents and one or more non-functionalized plasticizers having a viscosity index of 120 or more, wherein polypropylene and polyethylene are both substantially absent from the composition.

[0011] In at least one specific embodiment, the method for preparing an elastomer composition comprises mixing at least one a rubber component comprising a blend of ethylene-propylene (EP) rubber and ethylene-propylene-diene (EPDM) rubber, peroxide and one or more non-functionalized plasticizers having a viscosity index of 120 or more, a pour point of -18 °C or less and kinematic viscosity @100°C of 40 cSt or more, and an Mn of 700 or more.

DETAILED DESCRIPTION OF THE INVENTION

[0012] A detailed description will now be provided. Each of the appended claims defines a separate invention, which for infringement purposes is recognized as including equivalents to the various elements or limitations specified in the claims. Depending on the context, all references below to the "invention" can in some cases refer to certain specific embodiments only. In other cases it will be recognized that references to the "invention" will refer to subject matter recited in one or more, but not necessarily all, of the claims. Each of the inventions will now be described in greater detail below, including specific embodiments, versions and examples, but the inventions are not limited to these embodiments, versions or examples, which are included to enable a person having ordinary skill in the art to make and use the inventions, when the information in this patent is combined with available information and technology.

[0013] Elastomer compositions with unexpectedly high flexibility after prolonged heat-aging above 100°C and/or upon cooling below 0°C, and surprisingly high oil retention, are provided. In one or more embodiments, the elastomer composition includes a rubber component comprising one or more at least partially cured ethylene-propylene elastomer and one or more non-functionalized plasticizer ("NFP"). In one or more embodiments, the one or more ethylene-propylene elastomer is at least partially peroxide-cured.

[0014] Not wishing to be bound by theory, mineral oils traditionally used as elastomer process oils typically contain a significant fraction of aromatic and/or naphthenic moieties. Even

so-called "paraffinic" mineral oils have compositions such that large fraction of carbons are in naphthenic moieties, and can contain a few percent of carbon-carbon unsaturation (olefinic and aromatic moieties) and/or heteroatoms like sulfur and nitrogen, which can interact with a peroxide cure system resulting in undesirable side reactions. The same is not true for one or more NFPs described herein. It is believed that such difference in structure gives NFPs superior thermal and oxidative stability.

[0015] NFPs are also available in a broader range of viscosities (molecular weights) than mineral oils. In particular, the maximum viscosity of commercially available mineral oil is about 35 cSt (kinematic viscosity at 100°C), while NFPs are available up to 1000 cSt or more. It is believed that the higher molecular weights combined with higher thermal and oxidative stability allow NFPs to retain their plasticizing effect in elastomer compounds exposed to high temperatures for long times.

[0016] The term "mineral oil" refers to any hydrocarbon liquid of lubricating viscosity (i.e., a kinematic viscosity at 100°C of 1 cSt or more) derived from petroleum crude oil and subjected to one or more refining and/or hydroprocessing steps (such as fractionation, hydrocracking, dewaxing, isomerization, and hydrofinishing) to purify and chemically modify the components to achieve a final set of properties. Such "refined" oils are in contrast to "synthetic" oils, which are manufactured by combining monomer units into larger molecules using catalysts, initiators, and/or heat. In the lubricant industry, refined "basestocks" (which are mineral oils) are commonly divided into three categories based on their properties, as follows:

Category	Saturates		Sulfur		Viscosity Index
Group I	< 90 wt%	and/or	> 0.03 wt%	and	80 – 119
Group II	≥ 90 wt%	and	≤ 0.03 wt%	and	80 – 119
Group III	≥ 90 wt%	and	≤ 0.03 wt%	and	≥ 120

[0017] However, even if a mineral oil is not explicitly identified as a Group I, II, or III basestock, it is still possible to categorize it using this scheme. Accordingly, herein, a "Group III Mineral Oil" is defined to be any mineral oil having a viscosity index of 120 or more, whereas a "Group III basestock" is defined according to the more limiting specifications given above; therefore, any Group III basestock will also be a Group III Mineral Oil, but the opposite is not necessarily true.

[0018] In the polymer industry, mineral oils are often called "process oils" (or "extender oils"). A common classification system for process oils is to identify them as either "paraffinic", "naphthenic", or "aromatic" mineral or process oils based on the relative content of paraffinic, naphthenic, and aromatic moieties (see *Typical* heading in the table below). Herein, the three

common classes are defined based on the compositions described under *Definitions* heading in the table below:

Mineral Oil	*Typical*			*Definitions*		
Type	C_P	C_N	C_A	C_P	C_N	C_A
Paraffinic	60-80%	20-40%	0-10%	≥ 60%	< 40%	< 20%
Naphthenic	40-55%	40-55%	6-15%		≥ 40%	< 20%
Aromatic	35-55%	10-35%	30-40%			≥ 20%

where C_P, C_N, and C_A indicate the percentage of carbons in paraffinic chain-like (i.e., isoparaffinic and normal paraffinic) structures, naphthenic (i.e., saturated ring) structures, and aromatic (i.e., unsaturated ring) structures, respectively.

[0019] Illustrative paraffinic process oils are listed in the table below; each has a viscosity index less than 120, so none are Group III Mineral Oils. All have less than 80% carbons in paraffinic chain-like structures (C_P < 80%), meaning they have more than 20% carbons in aromatic and/or naphthenic ring-like structures (C_A+C_N). Paraffinic process oils have relatively low viscosity and/or relatively high pour points.

Illustrative Paraffinic Process Oils

	KV40°C, cSt	KV100°C, cSt	VI	Pour Point, °C	Specific gravity	Flash Point °C	C_P, %
Drakeol 34 [(1)]	76	9	99	-12	0.872	254	68
Paralux 2401R [(2)]	43	6	101	-12	0.866	234	66
Paralux 6001R [(2)]	118	12	102	-21	0.875	274	70
Sunpar 120 [(3)]	41	6	106	-15	0.872	228	68
Sunpar 150 [(3)]	94	11	97	-12	0.881	245	65
Sunpar 2280 [(3)]	475	31	95	-9	0.899	305	67
Plastol 135 [(4)]	24	5	104	-9	0.865	210	67
Plastol 537 [(4)]	103	11	97	-3	0.880	240	66
Plastol 2105 [(4)]	380	30	110	-15	0.885	270	
Flexon 843 [(4)]	30	5	91	-12	0.869	218	65
Flexon 865 [(4)]	106	11	93	-3	0.879	252	69
Flexon 815 [(4)]	457	32	101	-9	0.895	310	67
Shellflex 210 [(5)]	19	4	95	-18	0.860	216	66
Shellflex 330 [(5)]	70	9	95	-10	0.875	256	68
Shellflex 810 [(5)]	501	33	95	-9	0.896	324	69
Diana PW32 [(6)]	31	5	104	-18	0.862	226	67
Diana PW90 [(6)]	90	11	105	-22	0.872	262	71
Diana PW380 [(6)]	376	26	106	-19	0.877	293	73

[(1)] Available from Penreco (USA). [(2)] Available from Chevron (USA). [(3)] Available from Sunoco (USA). [(4)] Available from ExxonMobil (USA). [(5)] Available from Royal Dutch Shell (UK/Netherlands). [(6)] Available from Idemitsu (Japan).

Rubber Component

[0020] The "rubber component" can include one or more ethylene-propylene elastomers. The "ethylene-propylene elastomer" can be any cross-linkable polyolefin copolymer containing ethylene, propylene, and optionally one or more diene. Illustrative ethylene-propylene elastomers include but are not limited to ethylene-propylene bipolymer (EP) and ethylene-propylene-diene terpolymer (EPDM) elastomers. The term "copolymer" can include any polymer having two or more different monomers in the same chain, and encompasses random copolymers, statistical copolymers, interpolymers, and block copolymers.

[0021] A suitable EP elastomer can have an ethylene content of 40 to 80 wt% (preferably 45 to 75 wt%, preferably 50 to 70 wt%). A suitable EP elastomer can also have an ethylene content of 5 to 25 wt% (preferably 10 to 20 wt%).

[0022] A suitable EPDM elastomer can have an ethylene content of 40 to 80 wt% (preferably 45 to 75 wt%, preferably 50 to 70 wt%) and a diene content of less than 15 wt% (preferably 0.5 to 15 wt%, preferably 1 to 12 wt%, preferably 2 to 10 wt%, preferably 3 to 9 wt%). In one or more embodiments, a suitable EPDM elastomer can have an ethylene content of 5 to 25 wt% (preferably 10 to 20 wt%). In other embodiments, a suitable EPDM elastomer can have a diene content of 0.1 to 3 wt% (preferably 0.3 to 2 wt%), or 0.3 to 10 wt% (preferably 1 to 5 wt%). Suitable dienes can have at least two unsaturated bonds, at least one of which can be incorporated into a polymer, and can be straight chained, branched, cyclic, bridged ring, bicyclic, etc.; preferably the unsaturated bonds are nonconjugated. Preferred dienes include 5-ethylidene-2-norbornene (ENB), 5-vinyl-2-norbornene (VNB), divinyl benzene (DVB), dicyclopentadiene (DCPD), and 1,4-hexadiene.

[0023] Preferred ethylene-propylene elastomers can have one or more of the following properties: a density of 0.885 g/cm^3 or less (preferably 0.88 g/cm^3, preferably 0.87 g/cm^3 or less, preferably 0.865 g/cm^3 or less, preferably 0.86 g/cm^3 or less, preferably 0.855 g/cm^3 or less); and/or a heat of fusion (H_f) of less than 70 J/g (preferably less than 60 J/g, preferably less than 50 J/g, preferably less than 40 J/g, preferably less than 30 J/g, preferably less than 20 J/g, preferably less than 10 J/g, preferably less than 5 J/g, preferably indiscernible); and/or an ethylene or propylene crystallinity of less than 15 wt% (preferably less than 10 wt%, preferably less than 5 wt%, preferably less than 2 wt%, preferably undetectable); and/or a melting point (T_m) of 120°C or less (preferably 100°C or less, preferably 80°C or less, preferably 70°C or less, preferably 60°C or less, preferably 50°C or less, preferably 40°C or less, preferably 35°C or less, preferably undetectable); and/or a glass transition temperature (T_g) of -20°C or less (preferably -30°C or less, preferably -40°C or less, preferably -50°C or less, preferably -60°C or less); and/or a M_w of 50 to 5,000 kg/mol (preferably 100 to 3,000 kg/mol, preferably 150 to 2,000 kg/mol, preferably 200 to 1,000 kg/mol); and/or a M_w/M_n of 1.5 to 40 (preferably 1.6 to 30, preferably 1.7 to 20, preferably 1.8 to 10); and/or a Mooney viscosity, ML(1+4) at 125°C of 1 to 100 (preferably 5 to 95, preferably 10 to 90, preferably 15 to 85, preferably 20 to 80).

[0024] In one or more embodiments, the ethylene-propylene elastomers can be functionalized. For example, the ethylene-propylene elastomers can be functionalized by reacting with organic compounds with polar moieties, such as amine-, carboxy-, and/or epoxy-moieties. Examples include maleated EP and EPDM elastomers.

[0025] The ethylene-propylene elastomers can be made by any suitable process, including slurry, solution, gas-phase, and high-pressure processes, using a catalyst system appropriate for the polymerization of polyolefins, such as vanadium, Ziegler-Natta, and metallocene catalyst systems, or combinations thereof. In one or more embodiments, synthesis involves a vanadium-based catalyst system in a solution or slurry process. In one or more embodiments, one or more elastomers in the rubber component are produced using a single-site catalyst system, such as a metallocene catalyst, in a solution, slurry, or gas-phase process, and have a M_w/M_n of 1.5 to 2.5. Suitable ethylene-propylene elastomers include those available from ExxonMobil Chemical under the Vistalon®, Vistamaxx™, and Exxelor™ tradenames.

[0026] In one or more embodiments, the rubber component is a blend of two or more EP elastomers. In other embodiments, the rubber component is a blend of one or more EP elastomers and one or more EPDM elastomers. In other embodiments, the rubber component is a blend of two or more EPDM elastomers. In further embodiments, the rubber component is a blend of functionalized and unfunctionalized elastomers.

Non-Functionalized Plasticizer (NFP) Component

[0027] The elastomer compositions can include at least one non-functionalized plasticizer ("NFP"). The classes of materials described herein that are useful as NFPs can be utilized alone or admixed with other NFPs described to obtain desired properties.

[0028] A NFP is a hydrocarbon liquid, that is a liquid compound comprising carbon and hydrogen, which does not include to an appreciable extent functional groups selected from hydroxide, aryls and substituted aryls, halogens, alkoxys, carboxylates, esters, carbon unsaturation, acrylates, oxygen, nitrogen, and carboxyl. By "appreciable extent", it is meant that these groups and compounds comprising these groups are not deliberately added to the NFP, and if present at all, are present at less than 5 wt% by weight of the NFP (preferably less than 3 wt%, more preferably less than 1 wt%, more preferably less than 0.5 wt%, more preferably less than 0.3 wt%, more preferably less than 0.1 wt%, more preferably less than 0.05 wt%, more preferably less than 0.01 wt%, based upon the weight of the NFP.

[0029] In one or more embodiments, aromatic moieties (including any compound whose molecules have the ring structure characteristic of benzene, naphthalene, etc.) are substantially absent from the NFP. In one or more embodiments, naphthenic moieties (including any compound whose molecules have a saturated ring structure such as would be produced by hydrogenating benzene, naphthalene, etc.) are substantially absent from the NFP. By "substantially absent", it is meant that these compounds are not added deliberately to the compositions and, if present at all, are present at less than 0.5 wt%, preferably less than 0.1 wt%.

[0030] In one or more embodiments, the NFP is a hydrocarbon that does not contain olefinic unsaturation to an appreciable extent. By "appreciable extent of olefinic unsaturation" it is meant that the carbons involved in olefinic bonds account for less than 10% (preferably less than 5%, more preferably less than 3%, more preferably less than 1%, more preferably less than 0.5%, more preferably less than 0.3%, more preferably less than 0.1%, more preferably less than 0.05%, more preferably less than 0.01%) of the total number of carbons.

[0031] In one or more embodiments, the NFP comprises C_{20} to C_{1500} paraffins, preferably C_{25} to C_{500} paraffins, preferably C_{25} to C_{500} paraffins, preferably C_{30} to C_{500} paraffins, preferably C_{40} to C_{500} paraffins, preferably C_{40} to C_{250} paraffins. Particularly preferred NFPs include oligomers of C_5 to C_{24} alpha-olefins (PAOs), Group III basestocks, and high purity hydrocarbon fluids derived from so-called Gas-To-Liquids processes.

Polyalphaolefins

[0032] In one or more embodiments, the NFP comprises a polyalphaolefin (PAO) liquid with a pour point of -10°C or less and a kinematic viscosity at 100°C (KV100°C) of 3 cSt or more. PAO liquids are described in, for example, U.S. Patent Nos. 3,149,178; 4,827,064; 4,827,073; 5,171,908; and 5,783,531 and in Synthetic Lubricants and High-Performance Functional Fluids (Leslie R. Rudnick & Ronald L. Shubkin, ed. Marcel Dekker, Inc. 1999), p. 3-52.

[0033] PAOs are high purity hydrocarbons, with a fully paraffinic structure and a high degree of branching. PAO liquids can be conveniently prepared by the oligomerization of an alpha-olefin in the presence of a polymerization catalyst, such as a Friedel-Crafts catalyst (including, for example, $AlCl_3$, BF_3, and complexes of BF_3 with water, alcohols, carboxylic acids, or esters), a coordination complex catalyst (including, for example, the ethylaluminum sesquichloride + $TiCl_4$ system), or a homogeneous or heterogeneous (supported) catalyst more commonly used to make polyethylene and/or polypropylene (including, for example, Ziegler-Natta catalysts, metallocene or other single-site catalysts, and chromium catalysts).

[0034] In one or more embodiments, the PAO comprises C_{15} to C_{1500} (preferably C_{20} to C_{1000}, preferably C_{30} to C_{800}, preferably C_{35} to C_{400}, most preferably C_{40} to C_{250}) oligomers (such as dimers, trimers, etc) of C_3 to C_{24} (preferably C_5 to C_{18}, preferably C_6 to C_{14}, preferably C_8 to C_{12}) alpha-olefins, preferably linear alpha-olefins (LAOs), provided that C_3 and C_4 alpha-olefins are present at 30 wt% or less (preferably 20 wt% or less, preferably 10 wt% or less, preferably 5 wt% or less). Suitable LAOs include propylene, 1-butene, 1-pentene, 1-hexene, 1-heptene, 1-octene, 1-nonene, 1-decene, 1-undecene, 1-dodecene, 1-tridecene, 1-tetradecene, 1-pentadecene, 1-hexadecene, and blends thereof.

[0035] In one or more embodiments, a single LAO is used to prepare the oligomers. A preferred embodiment involves the oligomerization of 1-octene or 1-decene, preferably 1-decene.

[0036] In one or more embodiments, the PAO comprises oligomers of two or more C_3 to C_{18} LAOs, to make 'bipolymer' or 'terpolymer' or higher-order copolymer combinations, provided that C_3 and C_4 LAOs are present 30 wt% or less (preferably 20 wt% or less, preferably 10 wt% or less, preferably 5 wt% or less). A preferred embodiment involves oligomerization of a mixture of LAOs selected from C_6 to C_{18} LAOs with even carbon numbers. Another preferred embodiment involves oligomerization of 1-octene, 1-decene, and 1-dodecene.

[0037] In one or more embodiments, the PAO comprises oligomers of a single alpha-olefin species having a carbon number of 5 to 24 (preferably 6 to 18, more preferably 8 to 12, most preferably 10). In one or more embodiments, the NFP comprises oligomers of mixed alpha-olefins (i.e., two or more alpha-olefin species), each alpha-olefin having a carbon number of 5 to 24 (preferably 6 to 18, preferably 8 to 12). In one or more embodiments, the PAO comprises oligomers of mixed alpha-olefins (i.e., involving two or more alpha-olefin species) where the weighted average carbon number for the alpha-olefin mixture is 6 to 14 (preferably 8 to 12, preferably 9 to 11).

[0038] In one or more embodiments, the PAO comprises oligomers of one or more alpha-olefin with repeat unit formulas of $-[CHR-CH_2]-$ where R is a C_3 to C_{18} saturated hydrocarbon branch. In one or more embodiments, R is constant for all oligomers. In one or more embodiments, there is a range of R substituents covering carbon numbers from 3 to 18. Preferably, R is linear, i.e., R is $(CH_2)nCH_3$, where n is 3 to 17, preferably 4 to 11, and preferably 5 to 9. Optionally, R can contain one methyl or ethyl branch, i.e., R is $(CH_2)m[CH(CH_3)](CH_2)zCH_3$ or R is $(CH_2)x[CH(CH_2CH_3)](CH_2)yCH_3$, where (m + z) is 1 to 15, preferably 1 to 9, preferably 3 to 7, and (x + y) is 1 to 14, preferably 1 to 8, preferably 2 to 6. Preferably m > z; more preferably m is 0 to 15, more preferably 2 to 15, more preferably 3 to 12, more preferably 4 to 9; and n is 0 to 10, preferably 1 to 8, preferably 1 to 6, preferably 1 to 4. Preferably x > y; more preferably x is 0 to 14, more preferably 1 to 14, more preferably 2 to 11, more preferably 3 to 8; and y is 0 to 10, preferably 1 to 8, preferably 1 to 6, preferably 1 to 4. Preferably, the repeat units are arranged in a head-to-tail fashion with minimal head-to-head connections.

[0039] The PAO can be atactic, isotactic, or syndiotactic. In one or more embodiments, the PAO has essentially the same population of meso and racemic dyads, on average, making it atactic. In one or more embodiments, the PAO has more than 50% (preferably more than 60%, preferably more than 70%, preferably more than 80%, preferably more than 90%) meso dyads

(i.e., [m]) as measured by ^{13}C-NMR. In one or more embodiments, the PAO has more than 50% (preferably more than 60%, preferably more than 70%, preferably more than 80%, preferably more than 90%) racemic dyads (i.e., [r]) as measured by ^{13}C-NMR. In one or more embodiments, [m]/[r] determined by 13C-NMR is between 0.9 and 1.1 In one or more embodiments, [m]/[r] is greater than 1 In one or more embodiments, and [m]/[r] is less than 1 in yet another embodiment.

[0040] The PAO liquid can include one or more distinct PAO components. In one or more embodiments, the NFP is a blend of one or more PAOs with different compositions (e.g., different alpha-olefin(s) were used to make the oligomers) and/or different physical properties (e.g., kinematic viscosity, pour point, and/or viscosity index).

[0041] In one or more embodiments, the PAO or blend of PAOs has a number-average molecular weight (M_n) of from 400 to 15,000 g/mol (preferably 400 to 12,000 g/mol, preferably 500 to 10,000 g/mol, preferably 600 to 8,000 g/mol, preferably 800 to 6,000 g/mol, preferably 1,000 to 5,000 g/mol). In one or more embodiments, the PAO or blend of PAOs has a M_n greater than 1,000 g/mol (preferably greater than 1,500 g/mol, preferably greater than 2,000 g/mol, preferably greater than 2,500 g/mol).

[0042] In one or more embodiments, the PAO or blend of PAOs has a KV100°C of 3 cSt or more (preferably 4 cSt or more, preferably 5 cSt or more, preferably 6 cSt or more, preferably 8 cSt or more, preferably 10 cSt or more, preferably 20 cSt or more, preferably 30 cSt or more, preferably 40 cSt or more, preferably 100 or more, preferably 150 cSt or more). In one or more embodiments, the PAO has a KV100°C of 3 to 3,000 cSt (preferably 4 to 1,000 cSt, preferably 6 to 300 cSt, preferably 8 to 150 cSt, preferably 8 to 100 cSt, preferably 8 to 40 cSt). In one or more embodiments, the PAO or blend of PAOs has a KV100°C of 10 to 1000 cSt (preferably 10 to 300 cSt, preferably 10 to 100 cSt). In yet another embodiment, the PAO or blend of PAOs has a KV100°C of 4 to 8 cSt. In yet another embodiment, the PAO or blend of PAOs has a KV100°C of 25 to 300 cSt (preferably 40 to 300 cSt, preferably 40 to 150 cSt). In one or more embodiments, the PAO or blend of PAOs has a KV100°C of 100 to 300 cSt.

[0043] In one or more embodiments, the PAO or blend of PAOs has a Viscosity Index (VI) of 120 or more (preferably 130 or more, preferably 140 or more, preferably 150 or more, preferably 170 or more, preferably 190 or more, preferably 200 or more, preferably 250 or more, preferably 300 or more). In one or more embodiments, the PAO or blend of PAOs has a VI of 120 to 350 (preferably 130 to 250).

[0044] In one or more embodiments, the PAO or blend of PAOs has a pour point of -10°C or less (preferably -20°C or less, preferably -25°C or less, preferably -30°C or less, preferably

-35°C or less, preferably -40°C or less, preferably -50°C or less). In one or more embodiments, the PAO or blend of PAOs has a pour point of -15 to -70°C (preferably -25 to -60°C).

[0045] In one or more embodiments, the PAO or blend of PAOs has a glass transition temperature (T_g) of -40°C or less (preferably -50°C or less, preferably -60°C or less, preferably -70°C or less, preferably -80°C or less). In one or more embodiments, the PAO or blend of PAOs has a T_g of -50 to -120°C (preferably -60 to -100°C, preferably -70 to -90°C).

[0046] In one or more embodiments, the PAO or blend of PAOs has a flash point of 200°C or more (preferably 210°C or more, preferably 220°C or more, preferably 230°C or more), preferably between 240°C and 290°C.

[0047] In one or more embodiments, the PAO or blend of PAOs has a specific gravity (15.6°C) of 0.86 or less (preferably 0.855 or less, preferably 0.85 or less, preferably 0.84 or less).

[0048] In one or more embodiments, the PAO or blend of PAOs has a molecular weight distribution (M_w/M_n) of 2 or more (preferably 2.5 or more, preferably 3 or more, preferably 4 or more, preferably 5 or more, preferably 6 or more, preferably 8 or more, preferably 10 or more). In one or more embodiments, the PAO or blend of PAOs has a M_w/M_n of 5 or less (preferably 4 or less, preferably 3 or less) and a KV100°C of 10 cSt or more (preferably 20 cSt or more, preferably 40 cSt or more, preferably 60 cSt or more).

[0049] In one or more embodiments, the PAO or blend of PAOs has a Noack volatility of less than N* where $N^* = 60e^{-0.4(KV100°C)}$ with N* in units of % and KV100°C of the fluid in question in units of cSt. In an additional embodiment, KV100°C of the fluid in question is less than 1000 cSt, preferably less than 300 cSt, preferably less than 150 cSt, preferably less than 100 cSt, preferably less than 40 cSt, preferably less than 25 cSt, preferably less than 10 cSt, preferably less than 8 cSt.

[0050] In one or more embodiments, the PAO or blend of PAOs has a solubility parameter at 25°C of 8 or more (preferably 8 to 10) $cal^{1/2}cm^{3/2}$.

[0051] Particularly preferred PAOs and blends of PAOs are those having A) a flash point of 200°C or more (preferably 210°C or more, preferably 220°C or more, preferably 230°C or more); and B) a pour point less than -20°C (preferably less than -25°C, preferably less than -30°C, preferably less than -35°, preferably less than -40°C) and/or a KV100°C of 10 cSt or more (preferably 35 cSt or more, preferably 40 cSt or more, preferably 60 cSt or more).

[0052] Further preferred PAOs or blends of PAOs have a KV100°C of at least 3 cSt (preferably at least 4 cSt, preferably at least 6 cSt, preferably at least 8 cSt, preferably at least 10 cSt); a VI of at least 120 (preferably at least 130, preferably at least 140, preferably at least 150); a pour point of -10°C or less (preferably -20°C or less, preferably -30°C or less, preferably -40°C

or less); and a specific gravity (15.6°C) of 0.86 or less (preferably 0.855 or less, preferably 0.85 or less, preferably 0.84 or less).

[0053] Preferred blends of PAOs include blends of two or more PAOs where the ratio of the highest KV100°C to the lowest KV100°C is at least 1.5 (preferably at least 2, preferably at least 3, preferably at least 5). Also preferred are blends of two or more PAOs wherein at least one PAO has a Noack volatility of less than N* as defined above; preferably all the PAOs in a blend have a Noack volatility of less than N*. In an additional embodiment, KV100°C of the PAOs are less than 1000 cSt, preferably less than 300 cSt, preferably less than 150 cSt, preferably less than 100 cSt, preferably less than 40 cSt, preferably less than 25 cSt, preferably less than 10 cSt, preferably less than 8 cSt.

[0054] Preferred blends of PAO also include: blends of two or more PAOs where at least one PAO has a KV100°C of 300 cSt or more and at least one PAO has a KV100°C of less than 300 cSt (preferably 150 cSt or less, preferably 100 cSt or less, preferably 40 cSt or less); blends of two or more PAOs where at least one PAO has a KV100°C of 150 cSt or more and at least one PAO has a KV100°C of less than 150 cSt (preferably 100 cSt or less, preferably 40 cSt or less); blends of two or more PAOs where at least one PAO has a KV100°C of 100 cSt or more and at least one PAO has a KV100°C of less than 100 cSt (preferably 40 cSt or less, preferably 25 cSt or less, preferably 10 cSt or less); blends of two or more PAOs where at least one PAO has a KV100°C of 40 cSt or more and at least one PAO has a KV100°C of less than 40 cSt (preferably 25 cSt or less, preferably 10 cSt or less, preferably 8 cSt or less); blends of two or more PAOs where at least one PAO has a KV100°C of 10 cSt or more and at least one PAO has a KV100°C of less than 10 cSt (preferably 8 cSt or less, preferably 6 cSt or less, preferably 4 cSt or less); blends of two or more PAOs where at least one PAO has a KV100°C of 8 cSt or more and at least one PAO has a KV100°C of less than 8 cSt (preferably 6 cSt or less, preferably 4 cSt or less); and blends of two or more PAOs where at least one PAO has a KV100°C of 6 cSt or more and at least one PAO has a KV100°C of less than 6 cSt (preferably 4 cSt or less).

[0055] Desirable PAOs are commercially available as SpectraSyn™ and SpectraSyn Ultra™ from ExxonMobil Chemical (USA), some of which are summarized in Table A. Other useful PAOs include those available as Synfluid™ from ChevronPhillips Chemical (USA), as Durasyn™ from Innovene (USA), as Nexbase™ from Neste Oil (Finland), and as Synton™ from Chemtura (USA). For PAOs, the percentage of carbons in chain-type paraffinic structures (C_P) is close to 100% (typically greater than 98% or even 99%).

TABLE A – SpectraSyn™ Series Polyalphaolefins

	KV40°C, cSt	KV100°C, cSt	M_n, g/mol	M_w/M_n	VI	Pour Point, °C	Specific gravity	Flash Point,°C	Noack, %	S.P., $cal^{1/2}cm^{3/2}$
SpectraSyn 4	19	4	450	<1.1	126	-66	0.820	220	14	8.09
SpectraSyn Plus 4	17	4	440	<1.1	126	-60	0.820	228	12	8.12
SpectraSyn 6	31	6	540	<1.1	138	-57	0.827	246	6.4	8.14
SpectraSyn Plus 6	30	6	560	<1.1	143	-54	0.827	246	5.0	8.15
SpectraSyn 8	48	8	640	<1.1	139	-48	0.833	260	4.1	8.15
SpectraSyn 10	66	10	720	<1.1	137	-48	0.835	266	3.2	8.17
SpectraSyn 40	396	39	1,700	~1.5	147	-36	0.850	281	1.6	8.30
SpectraSyn 100	1240	100	2,800	~2.5	170	-30	0.853	283	1.1	8.33
SpectraSyn Ultra 150	1,500	150	3,700	~2.5	218	-33	0.850	> 265	0.4	8.38
SpectraSyn Ultra 300	3,100	300	4,900	~2.5	241	-27	0.852	> 265	0.3	8.38
SpectraSyn Ultra 1000	10,000	1,000	11,000	~2.5	307	-18	0.855	> 265	0.3	8.38

KV40°C = kinematic viscosity at 40°C. KV100°C = kinematic viscosity at 100°C S.P. = solubility parameter.

High Purity Hydrocarbon Fluids

[0056] In one or more embodiments, the nonfunctionalized plasticizer (NFP) is a high purity hydrocarbon fluid of lubricating viscosity comprising a mixture of C_{20} to C_{120} paraffins, 50 wt% or more being isoparaffinic hydrocarbons and less than 50 wt% being hydrocarbons that contain naphthenic and/or aromatic structures. Preferably, the mixture of paraffins comprises a wax isomerate lubricant base stock or oil, which includes: (A) hydroisomerized natural and refined waxes, such as slack waxes, deoiled waxes, normal alpha-olefin waxes, microcrystalline waxes, and waxy stocks derived from gas oils, fuels hydrocracker bottoms, hydrocarbon raffinates, hydrocracked hydrocarbons, lubricating oils, mineral oils, polyalphaolefins, or other linear or branched hydrocarbon compounds with carbon number of about 20 or more; and (B) hydroisomerized synthetic waxes, such as Fischer-Tropsch waxes (i.e., the high boiling point residues of Fischer-Tropsch synthesis, including waxy hydrocarbons); or mixtures thereof. Most preferred are lubricant base stocks or oils derived from hydrocarbons synthesized in a Fischer-Tropsch process as part of an overall Gas-to-Liquids (GTL) process.

[0057] In one or more embodiments, the mixture of paraffins has a naphthenic content of less than 40 wt%, preferably less than 30 wt%, preferably less than 20 wt%, preferably less than 15 wt%, preferably less than 10 wt%, preferably less than 5 wt%, preferably less than 2 wt%, preferably less than 1 wt% (based on the total weight of the hydrocarbon mixture); and/or a normal paraffins content of less than 5 wt%, preferably less than 4 wt%, preferably less than 3 wt%, preferably less than 1 wt% (based on the total weight of the hydrocarbon mixture); and/or an aromatic content of 1 wt% or less, preferably 0.5 wt% or less; and/or a saturates level of 90 wt% or higher, preferably 95 wt% or higher, preferably 98 wt% or higher, preferably 99 wt% or higher; and/or the percentage of carbons in chain-type paraffinic structures (C_P) of 80% or more, preferably 90% or more, preferably 95% or more, preferably 98% or more; and/or a branched paraffin:normal paraffin ratio greater than about 10:1, preferably greater than 20:1, preferably greater than 50:1, preferably greater than 100:1, preferably greater than 500:1, preferably greater than 1000:1; and/or sidechains with 4 or more carbons making up less than 10% of all sidechains, preferably less than 5%, preferably less than 1%; and/or sidechains with 1 or 2 carbons making up at least 50% of all sidechains, preferably at least 60%, preferably at least 70%, preferably at least 80%, preferably at least 90%, preferably at least 95%, preferably at least 98%; and/or a sulfur content of 300 ppm or less, preferably 100 ppm or less, preferably 50 ppm or less, preferably 10 ppm or less (where ppm is on a weight basis); and/or a nitrogen content of 300 ppm or less, preferably 100 ppm or less, preferably 50 ppm or less, preferably 10 ppm or less (where ppm is on a weight basis); and/or a number-average molecular weight of 300 to 1800 g/mol,

preferably 400 to 1500 g/mol, preferably 500 to 1200 g/mol, preferably 600 to 900 g/mol; and/or a kinematic viscosity at 40°C of 10 cSt or more, preferably 25 cSt or more, preferably between about 50 and 400 cSt; and/or a kinematic viscosity at 100°C ranging from 2 to 50 cSt, preferably 3 to 30 cSt, preferably 5 to 25 cSt, preferably 6 to 20 cSt, more preferably 8 to 16 cSt; and/or a viscosity index (VI) of 80 or greater, preferably 100 or greater, preferably 120 or greater, preferably 130 or greater, preferably 140 or greater, preferably 150 or greater, preferably 160 or greater, preferably 180 or greater; and/or a pour point of -5°C or lower, preferably -10°C or lower, preferably -15°C or lower, preferably -20°C or lower, preferably -25°C or lower, preferably -30°C or lower; and/or a flash point of 200°C or more, preferably 220°C or more, preferably 240°C or more, preferably 260°C or more; and/or a specific gravity (15.6°C/15.6°C) of 0.86 or less, preferably 0.85 or less, preferably 0.84 or less; and/or an aniline point of 120°C or more.

[0058] In one or more embodiments, the mixture of paraffins comprises a GTL base stock or oil. GTL base stocks and oils are fluids of lubricating viscosity that are generally derived from waxy synthesized hydrocarbons, that are themselves derived via one or more synthesis, combination, transformation, and/or rearrangement processes from gaseous carbon-containing compounds and hydrogen-containing compounds as feedstocks, such as: hydrogen, carbon dioxide, carbon monoxide, water, methane, ethane, ethylene, acetylene, propane, propylene, propyne, butane, butylenes, and butynes. Preferably, the feedstock is "syngas" (synthesis gas, essentially CO and H2) derived from a suitable source, such as natural gas and/or coal. GTL base stocks and oils include wax isomerates, comprising, for example, hydroisomerized synthesized waxes, hydroisomerized Fischer-Tropsch (F-T) waxes (including waxy hydrocarbons and possible analogous oxygenates), or mixtures thereof. GTL base stocks and oils can further comprise other hydroisomerized base stocks and base oils. Particularly preferred GTL base stocks or oils are those comprising mostly hydroisomerized F-T waxes and/or other liquid hydrocarbons obtained by a F-T synthesis process.

[0059] The synthesis of hydrocarbons, including waxy hydrocarbons, by F-T can involve any suitable process known in the art, including those involving a slurry, a fixed-bed, or a fluidized-bed of catalyst particles in a hydrocarbon liquid. The catalyst can be an amorphous catalyst, for example based on a Group VIII metal such as Fe, Ni, Co, Ru, and Re on a suitable inorganic support material, or a crystalline catalyst, for example a zeolitic catalyst. The process of making a lubricant base stock or oil from a waxy stock is characterized as a hydrodewaxing process. A hydrotreating step, while typically not required for F-T waxes, can be performed prior to hydrodewaxing if desired. Some F-T waxes can benefit from removal of oxygenates while others can benefit from oxygenates treatment prior to hydrodewaxing. The hydrodewaxing

process is typically conducted over a catalyst or combination of catalysts at high temperatures and pressures in the presence of hydrogen. The catalyst can be an amorphous catalyst, for example based on Co, Mo, W, etc. on a suitable oxide support material, or a crystalline catalyst, for example a zeolitic catalyst such as ZSM-23 and ZSM-48 and others disclosed in U.S. patent 4,906,350, often used in conjunction with a Group VIII metal such as Pd or Pt. This process can be followed by a solvent and/or catalytic dewaxing step to lower the pour point of the hydroisomerate. Solvent dewaxing involves the physical fractionation of waxy components from the hydroisomerate. Catalytic dewaxing converts a portion of the hydroisomerate to lower boiling hydrocarbons; it often involves a shape-selective molecular sieve, such as a zeolite or silicoaluminophosphate material, in combination with a catalytic metal component, such as Pt, in a fixed-bed, fluidized-bed, or slurry type process at high temperatures and pressures in the presence of hydrogen.

[0060] Useful catalysts, processes, and compositions for GTL base stocks and oils, Fischer-Tropsch hydrocarbon derived base stocks and oils, and wax isomerate hydroisomerized base stocks and oils are described in, for example, U.S. Patents 2,817,693; 4,542,122; 5,545,674; 4,568,663; 4,621,072; 4,663,305; 4,897,178; 4,900,407; 4,921,594; 4,923,588; 4,937,399; 4,975,177; 5,059,299; 5,158,671; 5,182,248; 5,200,382; 5,290,426; 5,516,740; 5,580,442; 5,885,438; 5,935,416; 5,935,417; 5,965,475; 5,976,351; 5,977,425; 6,025,305; 6,080,301; 6,090,989; 6,096,940; 6,103,099; 6,165,949; 6,190,532; 6,332,974; 6,375,830; 6,383,366; 6,475,960; 6,620,312; and 6,676,827; European Patents 324528, 532116, 532118, 537815, 583836, 666894, 668342, 776959; WPO patent applications 97/31693, 99/20720, 99/45085, 02/64710, 02/64711, 02/70627, 02/70629, and 03/33320; and British Patents 1,350,257; 1,390,359; 1,429,494; and 1,440,230. Particularly favorable processes are described in European Patent Applications 464546 and 464547. Processes using Fischer-Tropsch wax feeds are described in U.S. Patent Nos. 4,594,172; 4,943,672; 6,046,940; 6,103,099; 6,332,974; 6,375,830; and 6,475,960.

[0061] Desirable GTL-derived fluids are expected to become broadly available from several commercial sources, including Chevron (USA), ConocoPhillips (USA), ExxonMobil (USA), Sasol (South Africa), Shell (UK), Statoil (Russia), and Syntroleum (USA).

[0062] The GTL-derived fluid can include one or more distinct GTL-derived fluid components. For example, the NFP can be a blend of one or more GTL-derived fluids with different physical properties (e.g., kinematic viscosity, pour point, viscosity index, and/or glass transition temperature).

[0063] In one or more embodiments, the GTL-derived fluid or blend of GTL-derived fluids have a KV100°C of at least 4 cSt (preferably at least 6 cSt, preferably at least 8 cSt, preferably at

least 10 cSt, preferably at least 12 cSt); a VI of at least 120 (preferably at least 130, preferably at least 140, preferably at least 150); a pour point of -10°C or less (preferably -15°C or less, preferably -20°C or less, preferably -25°C or less); and a specific gravity (15.6°C) of 0.85 or less (preferably 0.84 or less, preferably 0.83 or less).

[0064] In one or more embodiments, the NFP is a blend of at least one GTL-derived fluid and one or more PAOs. Preferably, the KV100°C of the GTL-derived fluid or blend of GTL-derived fluids is at least 1.2 (preferably 1.5, preferably 2.0, preferably 2.5, preferably 3.0) times the KV100°C of the PAO or blend of PAOs; or the KV100°C of the PAO or blend of PAOs is at least 1.2 (preferably 1.5, preferably 2.0, preferably 2.5, preferably 3.0) times the KV100°C of the GTL-derived fluid or blend of GTL-derived fluids. Particularly preferred are blends of a PAO having a KV100°C of 25 cSt or more (preferably 40 cSt or more, preferably 100 cSt or more) and a GTL-derived fluid having a KV100°C of less than 25 cSt (preferably 15 cSt or less, preferably 10 cSt or less).

[0065] In one or more embodiments, the crosslinked elastomer composition can include one or more EP and/or EPDM elastomers and one or more NFP where at least one NFP is a high purity hydrocarbon fluid derived from a GTL process comprising a mixture of paraffins of carbon number ranging from about C_{20} to C_{100}, a molar ratio of isoparaffins:n-paraffins greater than about 50:1, the percentage of carbons in paraffinic structures (C_P) of 98% or more, a pour point ranging from about -20 to -60°C, and a kinematic viscosity at 100°C ranging from about 6 to 20 cSt.

[0066] As used herein, the following terms have the indicated meanings: "naphthenic" describes cyclic (mono-ring and/or multi-ring) saturated hydrocarbons (i.e., cycloparaffins) and branched cyclic saturated hydrocarbons; "aromatic" describes cyclic (mono-ring and/or multi-ring) unsaturated hydrocarbons and branched cyclic unsaturated hydrocarbons; "hydroisomerized" describes a catalytic process in which normal paraffins and/or slightly branched isoparaffins are converted by rearrangement into more branched isoparaffins (also known as "isodewaxing"); "wax" is a hydrocarbonaceous material existing as a solid at or near room temperature, with a melting point of 0°C or above, and consisting predominantly of paraffinic molecules, most of which are normal paraffins; "slack wax" is the wax recovered from petroleum oils such as by solvent dewaxing, and can be further hydrotreated to remove heteroatoms.

Group III Mineral Oils

[0067] In one or more embodiments, the NFP comprises a Group III Mineral Oil (i.e., a mineral oil with VI of 120 or more). Preferably the Group III Mineral Oil has a saturates levels

of 90% or more (preferably 92% or more, preferably 94% or more, preferably 95% or more, preferably 98% or more); and a sulfur content less than 0.03% (preferably between 0.001 and 0.01%).

[0068] The Group III Mineral Oil can include one or more distinct Group III Mineral Oil components. For example, the NFP can be a blend of one or more Group III Mineral Oils with different physical properties (e.g., kinematic viscosity, pour point, viscosity index, and/or glass transition temperature).

[0069] In one or more embodiments the Group III Mineral Oil or blend of Group III Mineral Oils have a VI of 130 or more, a KV100°C of 3 to 50 (preferably 4 to 40 cSt, preferably 6 to 30 cSt, preferably 8 to 20 cSt), and a number average molecular weight of 300 to 5,000 g/mol (preferably 400 to 2,000 g/mol, more preferably 500 to 1,000 g/mol). Preferably the Group III Mineral Oil or blend of Group III mineral oils has a pour point of -10°C or less, a flash point of 200°C or more, and a specific gravity (15.6°C) of 0.86 or less.

[0070] In one or more embodiments, the Group III Mineral Oil or blend of Group III Mineral Oils have a VI of 125 or more (preferably 130 or more), a KV100°C of at least 4 cSt (preferably at least 6 cSt, preferably at least 8 cSt, preferably at least 10 cSt, preferably at least 12 cSt); a pour point of -10°C or less (preferably -15°C or less); and a specific gravity (15.6°C) of 0.85 or less (preferably 0.84 or less).

[0071] Preferably the Group III mineral oil is a Group III basestock. Desirable Group III basestocks are commercially available from a number of sources and include those described in Table B. The percentage of carbons in chain-type paraffinic structures (C_P) in such liquids is greater than 80%.

TABLE B – Commercially Available Group III Basestocks

	KV100°C, cSt	VI	Pour Point, °C	Specific gravity	Flash Point, °C
UCBO 4R [1]	4.1	127	-18	0.826	216
UCBO 7R [1]	7.0	135	-18	0.839	250
Nexbase 3043 [2]	4.3	124	-18	0.831	224
Nexbase 3050 [2]	5.1	126	-15	0.835	240
Nexbase 3060 [2]	6.0	128	-15	0.838	240
Nexbase 3080 [2]	8.0	128	-15	0.843	260
Yubase YU-4 [3]	4.2	122	-15	0.843	230
Yubase YU-6 [3]	6.5	131	-15	0.842	240
Yubase YU-8 [3]	7.6	128	-12	0.850	260
Ultra-S 4 [4]	4.3	123	-20	0.836	220
Ultra-S 6 [4]	5.6	128	-20	0.839	234
Ultra-S 8 [4]	7.2	127	-15	0.847	256
VHVI 4 [5]	4.6	128	-21	0.826	
VHVI 8 [5]	8.0	127	-12	0.850	248
Visom 6 [6]	6.6	148	-18	0.836	250

[1] Available from ChevronTexaco (USA). [2] Available from Neste Oil (Finland). [3] Available from SK Corp (South Korea). [4] Available from ConocoPhillips (USA). [5] Available from PetroCanada (Canada). [6] Available from ExxonMobil (USA).

[0072] In one or more embodiments, the NFP is a blend of at least one Group III Mineral Oil and one or more PAOs. Preferably, the KV100°C of the Group III Mineral Oil or blend of Group III Mineral Oils is at least 1.2 (preferably 1.5, preferably 2.0, preferably 2.5, preferably 3.0) times the KV100°C of the PAO or blend of PAOs; or the KV100°C of the PAO or blend of PAOs is at least 1.2 (preferably 1.5, preferably 2.0, preferably 2.5, preferably 3.0) times the KV100°C of the Group III Mineral Oil or blend of Group III Mineral Oils. Particularly preferred are blends of a PAO having a KV100°C of 10 cSt or more (preferably 20 cSt or more, preferably 40 cSt or more) and a Group III Mineral Oil having a KV100°C of less than 10 cSt (preferably 8 cSt or less, preferably 6 cSt or less).

General Characteristics of Useful NFPs

[0073] In one or more embodiments, the NFP has a KV100°C of 3 cSt or more, preferably 4 cSt or more, preferably 5 cSt or more, preferably 6 to 5000 cSt, preferably 8 to 3000 cSt, preferably 10 to 1000 cSt, preferably 12 to 500 cSt, preferably 15 to 350 cSt, preferably 35 to 300 cSt, preferably 40 to 200 cSt, preferably 50 to 150 cSt, preferably 60 to 100 cSt, wherein a desirable range can be any combination of any lower KV100°C limit with any upper KV100°C limit described herein.

[0074] In one or more embodiments, the NFP has a pour point of -10°C or less, preferably -15°C or less, preferably -20°C or less, preferably -30°C or less, preferably -40°C or less, preferably -45°C or less, preferably -50°C or less, preferably greater than -120°C, preferably greater than -100°C, preferably greater than -80°C, wherein a desirable range can be any combination of any lower pour point limit with any upper pour point limit described herein. In one or more embodiments, the NFP has a pour point of less than -30°C when the kinematic viscosity at 40°C is from 0.5 to 200 cSt.

[0075] In one or more embodiments, the NFP has a glass transition temperature (T_g) of -40°C or less (preferably -50°C or less, preferably -60°C or less, preferably -70°C or less, preferably -80°C or less, preferably greater than -120°C, preferably greater than -90°C, wherein a desirable range can be any combination of any lower T_g limit with any upper T_g limit described herein.

[0076] In one or more embodiments, the NFP has a Viscosity Index (VI) of 90 or more, preferably 100 or more, preferably 110 or more, preferably 115 or more, preferably 120 or more, preferably 130 or more, preferably 135 or more, preferably less than 350, preferably less than 300, preferably less than 250, wherein a desirable range can be any combination of any lower VI limit with any upper VI limit described herein.

[0077] In one or more embodiments, the NFP has a flash point of 200°C or greater, preferably 210° or greater, preferably 220°C or greater, preferably 230°C or greater, preferably

less than 350°C, preferably less than 300°C, wherein a desirable range can be any combination of any lower flash point limit with any upper flash point limit described herein.

[0078] In one or more embodiments, the NFP has a specific gravity of 0.86 or less, preferably 0.855 or less, preferably 0.85 or less, preferably 0.84 or less, preferably 0.78 or more, preferably 0.79 or more, preferably 0.80 or more, preferably 0.81 or more, preferably 0.82 or more, wherein a desirable range can be any combination of any lower specific gravity limit with any upper specific gravity limit described herein.

[0079] In one or more embodiments, the NFP has a number-average molecular weight (M_n) of 250 g/mol or more, preferably 300 g/mol or more, preferably 400 g/mol or more, preferably 500 g/mol or more, preferably 20 kg/mol or less, preferably 10 kg/mol or less, preferably 5 kg/mol or less, preferably 3 kg/mol or less, preferably 2 kg/mol or less, preferably 1 kg/mol or less, wherein a desirable range can be any combination of any lower M_n limit with any upper M_n limit described herein.

[0080] In one or more embodiments, the NFP has a low degree of color, such as typically identified as "water white", "prime white", "standard white", or "bright and clear," preferably an APHA color of 100 or less, preferably 80 or less, preferably 60 or less, preferably 40 or less, preferably 20 or less.

[0081] Any of the NFP's can be described by any embodiment described herein, or any combination of the embodiments described herein. For example, the NFP can include C_{25} to C_{1500} paraffins and have a flash point of 200°C or more, a pour point of -10°C or less, and a VI of 120 or more. Alternately the NFP can include C_{25} to C_{1500} paraffins and have a flash point of 200°C or more and a pour point of -20°C or less. Alternately the NFP can include C_{25} to C_{1500} paraffins and have a flash point of 200°C or more and a KV100°C of 35 cSt or more.

[0082] In one or more embodiments the NFP has a KV100°C of 3 to 3000 cSt (preferably 6 to 300 cSt, more preferably 8 to 100 cSt) and a M_n of 300 to 10,000 g/mol (preferably 500 to 5,000 g/mol, more preferably 600 to 3,000 g/mol).

[0083] In one or more embodiments, the NFP has a KV100°C of 3 cSt or more (preferably 5 cSt or more, preferably 6 cSt or more, preferably 8 cSt or more, preferably 10 cSt or more), a specific gravity (15.6°C) of 0.86 or less (preferably 0.855 or less, preferably 0.85 cSt or less), and a flash point of 200°C or more (preferably 220°C or more, preferably 240°C or more).

[0084] In one or more embodiments, the NFP has a KV100°C of 4 cSt or more (preferably 5 cSt or more, preferably 6 cSt or more, preferably 8 cSt or more, preferably 10 cSt or more), a pour point of -10°C or less (preferably -15°C or less, preferably -20°C or less, preferably -25°C or less), a VI of 100 or more (preferably 120 or more, preferably 135 or more), a specific gravity

(15.6°C) of 0.86 or less (preferably 0.855 or less, preferably 0.85 or less), and a flash point of 200°C or more (preferably 220°C or more, preferably 240°C or more).

[0085] In one or more embodiments, the NFP has (a) a KV100°C of 3 cSt or greater (preferably 6 cSt or greater, more preferably 8 cSt or greater) and one or more of the following properties: (b1) a pour point of -10°C or less (preferably -20°C or less, preferably -30°C or less, preferably -40°C or less); and/or (b2) a VI of 120 or greater (preferably 130 or greater); and/or (b3) an APHA color of 100 or less (preferably 80 or less, preferably 60 or less, preferably 40 or less, preferably 20 or less, preferably 15 or less); and/or (b4) a flash point of 200°C or more (preferably 220°C or more, preferably 240°C or more); and/or (b5) a specific gravity (15.6°C) of less than 0.86.

[0086] In one or more embodiments, the NFP has a KV100°C of 35 cSt or more (preferably 40 cSt or more, preferably 50 cSt or more, preferably 60 cSt or more) and a specific gravity (15.6°C) of 0.87 or less (preferably 0.865 or less, preferably 0.86 or less, preferably 0.855 or less) and a flash point of 200°C or more (preferably 230°C or more).

[0087] In one or more embodiments, the NFP has a KV100°C of 35 cSt or more (preferably 40 or more), a specific gravity (15.6°C) of 0.86 or less (preferably 0.855 or less), a flash point of 200°C or more (preferably 220°C or more, preferably 240°C or more), and a pour point of -10°C or less (preferably -15°C or less, preferably -20°C or less, preferably -25°C or less).

[0088] In one or more embodiments, the NFP has a flash point of 200°C or more (preferably 210°C or more, preferably 220°C or more, preferably 230°C or more) and a pour point of -10°C or less (preferably -20°C or less, preferably -25°C or less, preferably -30°C or less, preferably -35°C or less, preferably -45°C or less, preferably -50°C or less).

[0089] In one or more embodiments, the NFP has a flash point of 200°C or more (preferably 210°C or more, preferably 220°C or more), a pour point of -10°C or less (preferably -20°C or less, preferably -30°C or less), and a KV100°C of 6 cSt or more (preferably 8 cSt or more, preferably 10 cSt or more, preferably 15 cSt or more).

[0090] In one or more embodiments, the NFP has (a) a flash point of 200°C or more, (b) a specific gravity of 0.86 or less, and one or more of the following properties: (c1) a pour point of -10°C or less and a viscosity index of 120 or more; and/or (c2) a pour point of -20°C or less; and/or (c3) a KV100°C of 35 cSt or more.

[0091] In one or more embodiments, the NFP has a specific gravity (15.6°C) of 0.85 or less, a KV100°C of 3 cSt or more (preferably 4 or more, preferably 5 cSt or more, preferably 8 cSt or more, preferably 10 cSt or more, preferably 15 cSt or more, preferably 20 cSt or more), and/ a M_n of at least 280 g/mol.

[0092] In one or more embodiments, the NFP has a specific gravity (15.6°C) of 0.86 or less (preferably 0.855 or less, preferably 0.85 or less), a KV100°C of 5 cSt or more (preferably 6 or more, preferably 8 cSt or more, preferably 10 cSt or more, preferably 12 cSt or more, preferably 15 cSt or more), and a M_n of at least 420 g/mol.

[0093] In one or more embodiments, the NFP has a specific gravity (15.6°C) of 0.87 or less (preferably between 0.82 and 0.87) and a KV100°C of 10 cSt or more (preferably 12 cSt or more, preferably 15 cSt or more, preferably 20 cSt or more, preferably 30 cSt or more, preferably 40 cSt or more) and/or a M_n of at least 700 g/mol.

[0094] In one or more embodiments, the NFP has a specific gravity (15.6°C) of 0.88 or less (preferably 0.87 or less) and a KV100°C of 15 cSt or more (preferably 20 cSt or more, preferably 25 cSt or more, preferably 30 cSt or more, preferably 40 cSt or more) and/or a M_n of at least 840 g/mol.

[0095] In one or more embodiments, the NFP has (a) a specific gravity (15.6°C) of 0.86 or less (preferably 0.855 or less, preferably 0.85 or less) and one or more of the following: (b1) a VI of 120 or more (preferably 135 or more, preferably 140 or more); and/or (b2) a flash point of 200°C or more (preferably 220°C or more, preferably 240°C or more).

[0096] In one or more embodiments, the NFP has (a) a pour point of -10°C or less (preferably -15°C or less, preferably -20°C or less, preferably -25°C or less) and one or more of the following: (b1) a VI of 120 or more (preferably 135 or more, preferably 140 or more); and/or (b2) a flash point of 200°C or more (preferably 220°C or more, preferably 240°C or more).

[0097] In one or more embodiments, the NFP has (a) a pour point of -20°C or less (preferably -25°C or less, preferably -30°C or less, preferably -40°C or less) and one or more of the following: (b1) a flash point of 200°C or more (preferably 220°C or more, preferably 240°C or more); and/or (b2) a VI of 120 or more (preferably 135 or more, preferably 140 or more); and/or (b3) a KV100°C of 4 cSt or more (preferably 6 cSt or more, preferably 8 cSt or more, preferably 10 cSt or more); and/or (b4) a specific gravity (15.6°C) of 0.86 or less (preferably 0.855 or less, preferably 0.85 or less).

[0098] In one or more embodiments, the NFP has a pour point of -25°C or less, a kinematic viscosity at 40°C of 20 to 5000 cSt, and a M_n of 400 g/mol or greater.

[0099] In one or more embodiments, the NFP has a pour point of -40°C or less (preferably -50°C or less) and a specific gravity of 0.84 or less (preferably 0.83 or less).

[00100] In one or more embodiments, the percentage of carbons in chain-type paraffins (C_P) in the NFP is at least 80% (preferably at least 85%, more preferably at least 90%, even more preferably at least 95%, even more preferably at least 98%, most preferably at least 99%).

[00101] In one or more embodiments, the compositions can be characterized in that the weight of the composition decreases less than 3% (preferably less than 2%, preferably less than 1%) when permanence of the NFP is determined on an 0.25 mm thick sheet subjected to 300 hours in a dry 70°C oven. Weight loss here refers to the reduction in weight in excess of that measured for the unplasticized composition under the same test conditions.

[00102] In one or more embodiments, the NFP's can be characterized in that, when blended with the elastomer to form a plasticized composition, there is no change in the number of tan-delta peaks in an Dynamic Mechanical Thermal Analysis (DMTA) trace for the plasticized composition as compared to the DMTA trace for the unplasticized composition (the DMTA trace is the plot of tan-delta vs temperature).

Component Concentrations

[00103] In one or more embodiments, the rubber component is present in an amount of from a low of 10 wt% (preferably 15 wt%, preferably 20 wt%, preferably 30 wt%) to a high of 90 wt% (preferably 80 wt%, preferably 70 wt%, preferably 60 wt%) based on total weight of the elastomer composition, wherein a desirable range can be any combination of any lower wt% limit with any upper wt% limit described herein. In one or more embodiments, the composition includes at least one EP or EPDM elastomer in the amount of 20 to 90 wt% (preferably 30 to 75 wt%, preferably 40 to 60 wt%) based on the total weight of the composition.

[00104] In one or more embodiments, the NFP is present in an amount of from a low of 10 wt% (preferably 15 wt%, more preferably 20 wt%, even more preferably 25 wt%) to a high of 80 wt% (preferably 70 wt%, more preferably 60 wt%, even more preferably 50 wt%, even more preferably 40 wt%) based on total weight of the composition, wherein a desirable range can be any combination of any lower wt% limit with any upper wt% limit described herein. In one or more embodiments, the composition includes at least one NFP in an amount of about 1 to 60 wt% (preferably 5 to 50 wt%, more preferably 10 to 30 wt%) based on the total weight of the composition. In one or more embodiments, the NFP is present at 50 to 300 parts (preferably 60 to 250 parts, preferably 70 to 200 parts, preferably 80 to 150 parts) per 100 parts rubber component (by weight).

[00105] In one or more embodiments, the composition contains essentially no mineral oil with a VI of less than 120 (i.e., paraffinic, naphthenic, and/or aromatic mineral oils). By that, it is meant that no mineral oil is intentionally added to the composition as a processing aid or oil. Accordingly, in one or more embodiments, the compositions comprise less than 10 wt% (preferably less than 5 wt%, preferably less than 2 wt%, preferably less than 1 wt%) of mineral oils based on the total weight of all mineral oils and NFPs present in the composition.

[00106] In one or more embodiments, the composition contains less than 10 wt%, preferably less than 7 wt %, preferably less than 5 wt %, preferably less than 4 wt %, preferably less than 3 wt %, preferably less than 2 wt %, preferably less than 1 wt %, based upon the weight of the composition. Thermoplastic polymer is defined be a polymer having a melting point of 40°C or more. Accordingly, in one or more embodiments, the compositions comprise less than 10 wt% (preferably less than 5 wt%, preferably less than 4 wt%, preferably less than 3 wt%, preferably less than 2 wt%, preferably less than 1 wt%) of a propylene polymer having a melting point of 40°C or more. In preferred embodiments, the composition the compositions comprise less than 10 wt% (preferably less than 5 wt%, preferably less than 4 wt%, preferably less than 3 wt%, preferably less than 2 wt%, preferably less than 1 wt%) of a thermoplastic polymer (such as a propylene polymer) having a melting point of 30 °C or more, preferably 25 ° C or more. A propylene polymer is a polymer having at least 50 mole% propylene.

Cure System

[00107] Any curative that is capable of curing or crosslinking the rubber component can be used. Illustrative curatives include, but are not limited to, peroxides and other free-radical generating curatives, sulfur and sulfur-containing curatives, phenolic curatives, hydrosilane and alkoxysilane curatives, silicon-containing curatives, and blends thereof. Such curing, or vulcanization, systems for elastomers are well known in the art.

[00108] In one or more embodiments, the curing agent is one or more peroxide compound, preferably one or more organic peroxide compound. Peroxide cross-linking is possible without the presence of unsaturated moieties in the polymer backbone but can be accelerated by the presence of such moieties. Useful organic peroxides include but are not limited to: diaryl peroxides, ketone peroxides, peroxydicarbonates, peroxyesters, dialkyl peroxides, hydroperoxides, benzoyl peroxides, lauroyl peroxides, di-t-butyl peroxide, dicumyl peroxide, t-butylcumyl peroxide, t-butyl peroctoate, p-di(t-butylperoxy)diisopropylbenzene, 2,5-dimethyl-2,5-di(t-butylperoxy)hexane, 1,1-di(t-butylperoxy)-3,3,5-trimethylcyclohexane, 2,5-dimethyl-2,5-di(t-butylperoxy)hexene-3, t-butyl-peroxy-(cis-3-carboxy)propenoate, 1,1-di(t-amylperoxy)cyclohexane, t-amyl-(2-ethylhexyl)peroxycarbonate, t-butylperoxy-3,5,5-trimethylhexanoate, t-butyl peroxybenzoate, and mixtures thereof. Peroxides having a 1 minute half-life at temperatures of less than 200°C (preferably less than 185°C, preferably less than 170°C) are preferred. Blends of peroxides having different activation temperatures can be utilized to more precisely control the curing process. In one or more embodiments, the composition comprises 0.5 to 20 parts (preferably 1 to 18 parts, preferably 1.5 to 16 parts, preferably 2 to 14 parts) of peroxide per 100 parts rubber component (by weight). Peroxides are available from a variety of commercial suppliers, including Luperox® from Arkema (France),

Trigonox® and Perkadox® from Akzo Nobel (Netherlands), and Varox® from R.T. Vanderbilt (USA), either as a liquid product or as a concentrated assay on an inorganic support. Peroxide curing agents are preferred for applications that demand excellent high-temperature performance.

[00109] In one or more embodiments, the curing agent is elemental sulfur or a sulfur-containing (sulfur donor) compound such as dithiomorpholine. Typically, sulfur cure systems also involve one or more accelerants and/or coagents. Sulfur curing agents are preferred for applications that demand excellent low-temperature performance.

[00110] Phenolic curatives are thermosetting resins, often referred to as phenolic resins. Illustrative phenolic resins are described in U.S. Patent Nos. 2,972,600; 3,287,440; and 6,433,090. These include resole resins made by condensation of alkyl substituted phenols or unsubstituted phenols with aldehydes in an alkaline medium or by condensation of bi-functional phenoldialcohols. Phenolic resins are ideally used in conjunction with a catalyst system, such as halogen donors and/or a hydrogen halide scavenger (e.g., ZnO).

[00111] Silicon-containing curatives are typically silicon hydride compounds, such as methylhydrogen polysiloxanes, methylhydrogen dimethyl-siloxane copolymers, alkyl methyl polysiloxanes, bis(dimethylsilyl)alkanes, and bis(dimethylsilyl)benzene. These compounds are typically used in conjunction with a hydrosilylation catalyst.

[00112] Cross-linking can also be enhanced through the use of "coagents" such as organic or metallic acrylates and methacrylates (for example: dimethyl acrylate, triallyl cyanurate, zinc diacrylate, or zinc dimethacrylate), especially in the case of peroxide cured articles.

Other Elastomers

[00113] In one or more embodiments, the composition can include one or more other elastomers including natural rubber, polyisoprene, polyisobutylene, polybutadiene, butyl, chlorobutyl, bromobutyl, nitrile, ethylene-vinyl acetate, chlorinated polyethylene, and chloroprene.

Fillers and Additives

[00114] In one or more embodiments, the composition can include typical additives *per se* known in the art such as antioxidants, UV stabilizers, adhesion promoters, block, antiblock, pigments/colorants/dyes, color masterbatches, processing aids (including fatty acids, esters, and paraffin wax), lubricants, neutralizers, metal deactivators, surfactants, nucleating agents, waxes, tackifiers (including aliphatic and alicyclic hydrocarbon resins), calcium stearate, slip agents, dessicants, and flame retardants (including aluminum hydroxide and antimony trioxide). Preferred antioxidants include those commonly used in the elastomer industry, such as quinolines (e.g., trimethylhydroxyquinolein), imidazoles (e.g., zinc mercapto toluyl imidazole), and

phenylamines; and conventional antioxidants, such as organic phosphites, hindered amines (including hindered amine light stabilizers), phenolics, and lactones. Examples of organic phosphites that are suitable are tris(2,4-di-tert-butylphenyl)phosphite (IRGAFOS 168) and di(2,4-di-tert-butylphenyl)pentaerithritol diphosphite (ULTRANOX 626). Examples of hindered amines include poly[2-N,N'-di(2,2,6,6-tetramethyl-4-piperidinyl)-hexanediamine-4-(1-amino-1,1,3,3-tetramethylbutane)sym-triazine] (CHIMASORB 944) and bis(1,2,2,6,6-pentamethyl-4-piperidyl)sebacate (TINUVIN 770). Examples of phenolic antioxidants include substituted phenols such as 2,6-di-t-butylphenol in which a hydrogen atom at 2 and/or 6 position is substituted by an alkyl residue, pentaerythrityl tetrakis(3,5-di-tert-butyl-4-hydroxyphenyl)propionate (IRGANOX 1010); and 1,3,5-tri(3,5-di-tert-butyl-4-hydroxybenzyl-isocyanurate (IRGANOX 3114). The amount of antioxidants used can be within the range of 0.001 to 10 parts per 100 parts rubber component (by weight). Examples of adhesion promoters are polar acids, polyaminoamides, urethanes, coupling agents (such as silane or titanate esters), reactive acrylate monomers, metal acid salts, polyphenylene oxide, oxidized polyolefins, acid modified polyolefins, and anhydride modified polyolefins.

[00115] In one or more embodiments, the composition can include one or more fillers. Suitable fillers include reinforcing fillers such as carbon black, talc, carbon fibers, or silica, which can improve the mechanical and wear properties of the compositions, as well as non-reinforcing fillers such as calcium carbonate or titanium dioxide. Other suitable fillers include inorganic particulate fillers, conductive fillers, magnesium carbonate, magnesium dioxide, barium sulfate, silicates, silicon dioxide, graphite, mica, sand, glass beads or fibers, clay, mineral aggregates, wollastonite, and zinc oxide. Inorganic fillers can include particles less than 1 mm in diameter, rods/fibers less than 1 cm in length, and plates less than 0.2 cm^2 in surface area. The amount of inorganic filler used can exceed 300 phr; preferably inorganic filler is present at less than 300 phr (preferably less than 200 phr, preferably less than 100 phr) where phr is parts per 100 parts rubber component (by weight). This only includes only the rubber component as defined by the claims and does not include any additional rubber that is added that does not fall within the scope of the rubber component as defined by the claims. In some embodiments, the composition contains no inorganic filler. The filler can also be an organoclay, such as montmorillonite, nontronite, beidellite, volkonskoite, laponite, hectorite, saponite, sauconite, magadite, kenyaite, sobockite, svindordite, stevensite, vermiculite, halloysite, aluminate oxides, hydrotalcite, illite, rectorite, tarosovite, ledikite, and the like, and functionalized derivatives thereof. Filler is preferably present at between 1 and 80 wt% (preferably between 5 and 60 wt%, preferably between 10 and 40 wt%) based on the total weight of the composition. In one or more embodiments, the compound contains no filler.

[00116] While certain classes of fillers/additives and preferred amounts of specific fillers/additives have been suggested above, more generally (absent specific directions otherwise given herein) the compositions can optionally have one or more fillers/additives, preferably in the amount of less than 80 wt%, or less than 70 wt%, or less than 60 wt%, or less than 50 wt%, or less than 40 wt%, or less than 30 wt%, or less than 20 wt%, or less than 10 wt%, or in other embodiments less than 5 wt%, or less than 2 wt%, or less than 1 wt%, based upon the total weight of the composition. While not critical to the characterization of a "composition comprising a filler/additive", which means that one or more fillers and/or additives are added, a lower limit can be 100 ppm, 500 ppm, 1000 ppm, or similar amounts. In some cases it can be preferable for there to be no fillers/additives, or in other cases preferred embodiments can be directed to the absence of specific fillers/additives, e.g., some preferred embodiments have no carbonates, no inorganic fillers, and so on. Filler/additives in the nature of unavoidable impurities can of course be present in the case where no filler/additives are purposefully added but in some embodiments it can be useful to further purify ingredients to avoid filler/additives as much as possible. One of ordinary skill in the art, in possession of the present disclosure, can determine the nature and amount of these optional ingredients by routine experimentation.

Properties of the Composition

[00117] In one or more embodiments, the uncured composition can have a Mooney Viscosity ML(1+4) at 125°C of from 10 to 100 (preferably from 20 to 80), a green strength as measured by the stress at 10% strain in a tensile test of from 0.5 to 20 MPa (preferably 1 to 15 MPa), and a tensile strain at break of 300% or more (preferably 400% or more, preferably 500% or more).

[00118] In one or more embodiments, the cured composition can have a degree of curing such that at least 2 wt% (preferably at least 5 wt%, preferably at least 10 wt%, preferably at least 20 wt%, preferably at least 35 wt%, preferably at least 45 wt%, preferably at least 65 wt%, preferably at least 75 wt%, preferably at least 85 wt%) of the rubber component is insoluble after 24 hours in refluxing xylene, calculated after accounting for any additives, fillers, and NFP.

Blending of the Components

[00119] In one or more embodiments, the components can be combined into an intimate mixture using conventional blending equipment and methods used in the elastomer industry. Suitable equipment includes batch mixers, internal mixers (such as Banbury mixers), roll-mills, kneaders, extruders (including combinations of a compounding extruder and a side-arm extruder used directly or indirectly downstream of a polymerization process), static mixers, impingement mixers, and combinations thereof. The components can be first "dry-blended" such as in a tumble-blender and subsequently melt-blended in the blending equipment, or can be combined

by direct addition individually into the blending equipment. Addition of one or more components can involve a masterbatch wherein the concentration of the component in a carrier is higher than the concentration of that component in the final composition. The blended composition can be formed into sheet, granules, flakes, bales, pellets, pastilles, and the like. The blending method *per se* would be well within the skill of the ordinary artisan.

[00120] The composition in an appropriate form can then be used in the final process, e.g., extruded into a product, such as a sheet, tube, profile, or other article. The shaped article can then be cured by raising the temperature for a period of time to allow the curing of the elastomer composition. The curing systems can be mixed into the elastomer composition prior to the shaping step of the article to be made.

End-Uses

[00121] The elastomer composition can be useful for the fabrication of shaped articles and parts made by using standard elastomer processing techniques like extrusion, calendaring, and molding (e.g., injection or compression molding). Such articles include seals (such as used in building construction or appliances), roofing, tubing, hoses, strips, joints, isolators, wire and cable jackets, medical device components (including syringe parts and catheters), packaging, trays, toys, sporting equipment, furniture, kitchen devices, handles, belts (including power transmission and conveyor belts) and appliance components. Also included are articles for transportation vehicles such as cars, trucks, trains, airplanes, and boats, including weather seals, noise and/or vibration insulation seals and mounts, disks, diaphragms, cups, joints, tubing, hoses, gaskets, o-rings, belts (including synchronous, asynchronous, serpentine, and V belts), wiper blades, mud flaps, skins, mats, boots, bellows, and trim.

[00122] In one or more embodiments, the elastomer composition can be at least partially adhered or otherwise at least partially attached to a second component or substrate to form a composite structure. The second component can be, or include, another elastomeric composition according to one or more embodiments described, an unplasticized elastomeric composition, a thermoset rubber, a thermoplastic resin or plastic, a thermoplastic vulcanizate, or a metal. In one or more embodiments, the two or more structures are at least partially adhered or otherwise at least partially attached to one another to form a composite structure. Illustrative composite structures include, but are not limited to, molded corners, molded end caps, glass run channels, trunk seals, tailgate seals, cowl seals, gap fillers, glass encapsulation, cut line seals, door seals, hood-to-radiator seals, roof line seals, rocker panels, sashes, and belt-line seals.

Experimental Methods

[00123] For purpose of this invention and the claims herein, unless otherwise noted, physical and chemical properties described are measured using the following test methods.

Elastomer Properties

Density	ASTM D 1505
Ethylene content of EP(DM) Polymers	ASTM D 3900 (A)
Diene content of EPDM Polymers	ASTM D 6047
Mooney Viscosity (MH, ML, Rh)	ASTM D 1646
Tensile Properties (Modulus, Break)	ASTM D 412
Flexural Modulus, 1% Secant	ASTM D 790 (A)
Compression Set	ASTM D 395 (B)
Tension Set	ASTM D 412
Hardness (Durometer)	ASTM D 2240

[00124] Dynamic Mechanical Thermal Analysis (DMTA) provides information on the small-strain mechanical response (relaxation behavior) of a sample as a function of temperature over a temperature range that includes the glass transition region. Appropriate DMTA instrumentation is readily available from several commercial vendors. Samples are tested in a three point bending configuration at a frequency of 1 Hz and amplitude of 20 μm, from -130°C to 100°C at 3°C/min. The output is the storage modulus (E') and loss modulus (E") as a function of temperature. Tan-delta is the ratio of E"/E' and gives a measure of the damping characteristics of the material. The glass transition, associated with the so-called beta-relaxation mode, is characterized by the peak temperature (herein identified as T_g) and the area under the peak.

[00125] Differential Scanning Calorimetry (DSC) is used to measure crystallization temperature (T_c) and melting temperature (T_m). Appropriate DSC instrumentation is readily available from several commercial vendors. Typically, 2 to 10 mg of a sample is sealed in an aluminum pan and loaded into the DSC at room temperature. Melting data (first heat) is acquired by heating the sample to at least 30°C above its melting temperature at a heating rate of 10°C/min. The sample is held for at least 5 minutes at this temperature to destroy its thermal history. Crystallization data is acquired by cooling the sample from the melt to at least 50°C below the crystallization temperature at a cooling rate of 20°C/min. The sample is held at this temperature for 5 minutes, and then heated at 10°C/min to acquire additional melting data (second heat). The endothermic melting transition (first and second heat) and exothermic crystallization transition are analyzed for peak temperatures; T_m is reported as the peak melting temperature from the second heat unless otherwise specified. For polymers displaying multiple peaks, T_m is defined to be the peak melting temperature associated with the largest endothermic response; likewise, T_c is defined to be the peak crystallization temperature associated with the largest exothermic response. The total peak area associated with the second heat endothermic response is the heat of fusion, H_f, which is used to calculate the degree of crystallinity (in weight percent) by [H_f (in J/g) / H° (in J/g)] * 100, where H° is the ideal heat of fusion for the homopolymer of the major monomer component. A value of 300 J/g is used for H° of polyethylene, and 200 J/g is used for H° of polypropylene.

[00126] Size-Exclusion Chromatography (SEC) is used to measure the weight-average molecular weight (M_w), number-average molecular weight (M_n), and molecular weight distribution (M_w/M_n or MWD) of polymers. Appropriate SEC instrumentation is readily available from several commercial vendors. The following experimental conditions are employed: differential refractive index (DRI) detector; column set of 3 Polymer Laboratories PLgel 10mm Mixed-B columns; flow rate of 0.5 mL/min; injection volume of 300 μL; carrier solvent of 1,2,4-trichlorobenzene (TCB) containing 1.5 g/L of butylated hydroxy toluene. The columns, DRI detector, and transfer lines are contained in a 135°C oven. The carrier solvent is filtered online through a 0.7 μm glass pre-filter then a 0.1 μm Teflon filter, and degassed with an online degasser. Polymer solutions are prepared by placing dry polymer in a glass container, adding the desired amount of TCB, then heating the mixture at 160°C with continuous agitation for about 2 hours. All quantities are measured gravimetrically. The TCB densities used to express polymer concentration in mass/volume units are 1.463 g/ml at room temperature and 1.324 g/ml at 135°C. The injection concentration ranges from 1.0 to 2.0 mg/ml, with lower concentrations being used for higher molecular weight samples. Prior to running a set of samples, the DRI detector and the injector are purged, the flow rate increased to 0.5 ml/minute, and the DRI allowed to stabilize for 8-9 hours. The relative concentration of polymer at each point in the chromatogram (i.e., the plot of DRI signal as a function of elution volume) is calculated from the baseline-subtracted DRI signal. The molecular weight associated with a given elution volume is determined by calibrating the column set using known narrow MWD polystyrene standards, run under identical experimental conditions. Commercially available SEC analysis software is used to calculate M_n and M_w from the chromatogram using this "polystyrene" calibration curve. This approach yields the "polystyrene-equivalent" M_n and M_w values, which are used herein.

[00127] Polymer microstructure can be determined by ^{13}C-NMR spectroscopy, including the concentration of isotactic and syndiotactic diads ([m] and [r]), triads ([mm] and [rr]), and pentads ([mmmm] and [rrrr]). Samples are dissolved in d_2-1,1,2,2-tetrachloroethane. Spectra are recorded at 125°C using a 100 MHz NMR. Polymer resonance peaks are referenced to mmmm = 21.8 ppm. Calculations follow the work of F. A. Bovey in "Polymer Conformation and Configuration" (Academic Press, 1969) and J. Randall in "Polymer Sequence Determination, ^{13}C-NMR Method" (Academic Press, 1977). The percent of dimer methylene sequences, $\%(CH_2)_2$ = the integral for methyl carbons between 14-18 ppm divided by the sum of the integral for lone methylene carbons between 45-49 ppm and the integral for methyl carbons between 14-

18 ppm, times 100. Assignments were based on H. N. Cheng and J. A. Ewen, Makromol. Chem. 190, p. 1931 (1989).

Fluid Properties

Kinematic Viscosity (KV)	ASTM D 445
Viscosity Index (VI)	ASTM D 2270
Pour Point	ASTM D 97
Specific Gravity and Density	ASTM D 4052 (15.6/15.6°C)
Flash Point	ASTM D 92
Noack (evaporative loss)	ASTM D 5800
Glass Transition Temperature (T_g)	ASTM 1356
Branch Paraffin: N-paraffin ratio	^{13}C-NMR
% mono-methyl species	^{13}C-NMR
% side chains with X number of carbons	^{13}C-NMR
Saturates Content	ASTM D 2007
Sulfur Content	ASTM D 2622
Nitrogen Content	ASTM D 4629
Aniline Point	ASTM D 611

[00128] Color can be determined on the APHA scale by ASTM D 1209. Note that an APHA color of 100 corresponds to a Saybolt color (ASTM D 156) of about +10; an APHA color of 20 corresponds to a Saybolt color of about +25; and an APHA color of 0 corresponds to a Saybolt color of about +30.

[00129] Carbon type composition can be determined by ASTM D 2140, and gives the percentage of aromatic carbons (C_A), naphthenic carbons (C_N), and paraffinic carbons (C_P) in the fluid. Specifically, C_A is the wt% of total carbon atoms in the fluid that are in aromatic ring-type structures; C_N is the wt% of total carbon atoms in the fluid that are in saturated ring-type structures; and C_P is the wt% of total carbon atoms in the fluid that are in paraffinic chain-type structures. ASTM D 2140 involves calculating a "Viscosity Gravity Constant" (VGC) and "Refractivity Intercept" (RI) for the fluid, and determining the carbon type composition from a correlation based on these two values. However, this method is known to fail for highly paraffinic oils, because the VGC and RI values fall outside the correlation range. Therefore, the following protocol can be used: If the calculated VGC (ASTM D 2140) for a fluid is 0.800 or greater, the carbon type composition including C_P is determined by ASTM D 2140. If the calculated VGC (ASTM D 2140) is less than 0.800, the fluid is considered to have C_P of at least 80%. If the calculated VGC (ASTM D 2140) is less than 0.800 but greater than 0.765, then ASTM D 3238 is used to determine the carbon type composition including C_P. If application of ASTM D 3238 yields unphysical quantities (e.g., a negative C_A value), then C_P is defined to be 100%. If the calculated VGC (ASTM D 2140) for a fluid is 0.765 or less, then C_P is defined to be 100%.

[00130] The number-average molecular weight (M_n) can be determined by one of two methods. For samples having KV100°C of 10 cSt or less, Gas Chromatography (GC) with a mass spectrometer detector is used. Suitable GC methods are generally described in "Modern Practice

of Gas Chromatography", 3rd Ed., R.L. Grob and E.F. Barry (Wiley-Interscience, 1995). For samples having KV100°C of more than 10 cSt, Gel Permeation Chromatography (GPC) is used and "polystyrene-equivalent" M_n values are reported. Suitable GPC methods involving a DRI detector are generally described in "Modern Size Exclusion Liquid Chromatographs", W.W. Yan, J.J. Kirkland, and D.D. Bly (J. Wiley & Sons, 1979).

Permanence

[00131] Permanence of the NFP can be determined following ASTM D 1203, by measuring the weight loss from the plasticized composition in the form of a 0.25 mm thick sheet, after 300 hours in dry 70°C oven. Permanence is 100% minus the Corrected %weight loss, where Corrected %weight loss = (%weight loss for the plasticized composition) - (%weight loss for the unplasticized composition under the same test conditions), and % weight loss = $100x(W-W_o)/W_o$, where W = weight after drying and W_o is the weight before drying. The unplasticized composition is the same composition as the plasticized composition but without NFP added; both are tested in the cured state.

NFP Content

[00132] In the absence of knowledge of the specific formulation of the plasticized composition, the NFP content (wt% basis) in the cured composition can be determined by Soxhlet extraction in cyclohexane for 16 hours. Preferably, the base composition (i.e., cured but without NFP) is subjected to the same analysis, since low molecular weight material can be present in both compositions that is soluble in the extraction solvent; the NFP content is then more accurately determined by correcting the extractables level for the plasticized composition by that for the base composition. The presence of NFP in the extract can be verified by traditional gas chromatography methods using mass-spectrometer detection.

EXAMPLES

[00133] The foregoing discussion can be further described with reference to the following non-limiting examples. The following examples illustrate the surprising and significant effect from presence of one or more non-functionalized plasticizers in elastomer compositions. Such elastomer compositions exhibited unexpectedly high flexibility after prolonged heat-aging above 100°C and/or upon cooling below 0°C, and surprisingly high oil retention.

[00134] The blend components used to prepare the examples are listed in Tables 1.1 to 1.5 below. Each example was prepared by batch compounding on a 3.2 L Banbury mixer, operated at 50 rpm. The startup temperature was between 48 and 55°C. All components were added and allowed to mix for 30 sec before putting the ram down. The Banbury was swept at 90°C, and dumped after mixing for an additional 3.5 to 4.5 minutes, at which point the temperature had

reached between 112 and 150°C. The peroxide cure system was added on a roll mill. Test specimens were compression molded and evaluated using standard testing protocols. Tensile specimens were cured for 20 min at 180°C.

[00135] From Ex. 1 and 2, substituting PAO for mineral oil resulted in more efficient plasticization of the compound and a higher cure state despite having a higher viscosity (KV100°C of 100 vs 31 cSt). Superior plasticization efficiency is judged by a lower compound Mooney viscosity, ML (1+4 @ 100°C). Superior cure state is judged by changes in properties correlated with crosslink density, such as a higher tensile hardness, higher stress at break, higher strain at break, lower compression set, and higher Mooney MH-ML values. Upon aging, the PAO formulations (Ex. 2-7) retained their tensile properties to a greater extent than the mineral oil formulation (Example 1) and maintained a higher level of elasticity (lower compression set)– both due to superior permanence of the PAO.

[00136] High viscosity PAO (KV100°C of 300 cSt or more) is generally difficult to homogenously blend into the elastomer compound, even at reduced PAO loadings (10 phr vs 50 phr above) and extended mixing times. Surprisingly, however, blending a high viscosity PAO and a low viscosity PAO (KV100°C of less than 300 cSt, or 100 cSt or less) allows all the PAO to be well incorporated into the compound. Thus, while 10 phr of SpectraSyn 300 could not be homogeneously added to a formulation using the disclosed mixing conditions, a combination of 10 phr SpectraSyn 300 and 40 phr SpectraSyn 100 (50 phr total) was readily incorporated. Similarly, while 10 phr of SpectraSyn 1000 could not be homogeneously added to a formulation using the mixing conditions, a combination of 10 phr SpectraSyn 1000 and 40 phr SpectraSyn 100 was readily incorporated. It is believed that the low viscosity PAO acted as a "carrier" in order to facilitate the mixing and incorporation of the high viscosity PAO.

[00137] Ex. 3-6 show the effects of blending a high viscosity PAO (SpectraSyn 300) with a low viscosity PAO (SpectraSyn 100) at various levels (10/90, 20/80, 40/60 and 60/40), as well as results for a 20/80 blend of SpectraSyn 150 with SpectraSyn 100. The data shows the synergistic effect of combining a low viscosity PAO with a high viscosity PAO, resulting in superior plasticization and superior permanence.

[00138] Ex. 8-11 compare formulations made with a paraffinic oil (Flexon 815) to those made with a PAO (SpectraSyn 40) of nearly the same KV100°C. Comparing Ex. 8 and 9, the use of the PAO in place of the paraffinic mineral oil resulted in significantly improved high temperature hot air aging resistance and high temperature compression set, which are important performance parameters for rubber parts exposed to a high temperature environment during their service life. The cure state (reflected in Mooney MH-ML) and the cure rate (reflected in Mooney Rh) were also higher for the formulation with PAO compared to the same formulation with mineral oil, due

to the lower interaction of PAO with the peroxide curing agent. At the same time, the Mooney viscosity (ML 1+4 @ 100°C) was lower for the PAO formulation, despite the slightly higher viscosity of SpectraSyn 40 vs Flexon 815 (KV100°C of 40 vs 32 cSt).

[00139] Comparing Examples 10 and 11, the use of the PAO in place of the paraffinic mineral oil resulted in a significant improvement in low temperature flexibility. The cure state (MH-ML) and the cure rate (Rh) were again higher for the PAO based formulation due to the lower interaction of the PAO with the peroxide curing agent. This reflects a higher crosslink density that, in turn, results in higher tensile modulus. This tensile modulus increase is an important improvement for rigid part applications such as wiper blades. Low temperature compression set and tension set were also reduced when PAO is used in place of mineral oil.

[00140] In Ex. 12-23, the effect of low viscosity PAO (KV100°C of 10 cSt or less) or blends of low viscosity PAOs was further examined. The room-temperature modulus and low temperature set properties (compression and tension) are superior for the PAO formulations compared to the same formulation with mineral oil.

[00141] In Ex. 18-20, an EPDM formulation containing PAO (SpectraSyn 10, KV100°C of 10 cSt) is compared to the same formulation containing either a mineral oil with a higher viscosity (Flexon 815, KV100°C of 32 cSt) or a mineral oil with a similar viscosity (Plastol 537, KV100°C of 11 cSt). Vulcanization was accomplished by extruding the compound into a flat strip shape and then moving the strip through a hot air tunnel at 220°C in 10 minutes.

[00142] Color stability was tested after exposure to UV-light in a QUV Accelerated Weathering Tester (Q-Lab Corporation, Model QUV/se), using a UVB-313 lamp (wavelength range of 280-360 nm) and an irradiance set point of 0.63. The exposure cycle was: 72 hours of alternating 2 hrs UV exposure @ 40°C/2 hrs condensation exposure @ 40°C, followed by 24 hours of alternating 4 hrs UV exposure @ 60°C/4 hrs condensation exposure @ 50°C. Color was measured using a HunterLab Colorimeter, expressed in terms of the L (white-black), a (red-green), and b (yellow-blue) color parameters. The total color change is characterized by DeltaE (the root-mean square average of the changes in L, a, and b). Surprisingly, the compound containing PAO suffered less discoloration (lower DeltaE) upon UV aging than did the compounds containing paraffinic mineral oil.

TABLE 1.1 – Elastomers

Elastomer	Mooney	wt% ethylene	wt% ENB	Source
EP				
Vistalon™ 706	42	65	--	ExxonMobil
Vistalon™ 785	30	49	--	ExxonMobil
EPDM				
Vistalon™ 3666 (1)	50	64	3.9	ExxonMobil
Vistalon™ 7500	91	56	5.7	ExxonMobil
Vistalon™ 8700 (2)	51	63	8	ExxonMobil
Vistalon™ 8800	15	73	10	ExxonMobil
Vistalon™ 9500	72	60	11	ExxonMobil

Mooney = Mooney viscosity measured as ML (1+4) at 125°C
(1) Contains 75 phr mineral oil (Sunpar 2280 or equivalent)
(2) Contains 15 phr mineral oil (Sunpar 2280 or equivalent)

TABLE 1.2 – NFPs

Identifier	KV100°C, cSt	Pour Point, °C	Flash Point, °C	Specific gravity	C_P / C_N, %	Source
Paraffinic Mineral Oils						
Flexon™ 815	32	-9	310	0.895	67 / 28	Imperial Oil
Plastol™ 537	11	-3	240	0.880	66 / 29	ExxonMobil
Sunpar® 2280	31	-9	305	0.899	69 / 29	Sunoco
PAOs						
SpectraSyn™ 4	4	-66	220	0.820	100 / 0	ExxonMobil
SpectraSyn™ 6	6	-57	246	0.827	100 / 0	ExxonMobil
SpectraSyn™ 10	10	-48	266	0.835	100 / 0	ExxonMobil
SpectraSyn™ 40	40	-36	281	0.850	100 / 0	ExxonMobil
SpectraSyn™ 100	100	-30	283	0.853	100 / 0	ExxonMobil
SpectraSyn Ultra™ 150	150	-33	> 265	0.850	100 / 0	ExxonMobil
SpectraSyn Ultra™ 300	300	-27	> 265	0.852	100 / 0	ExxonMobil

KV100°C = kinematic viscosity at 100°C

TABLE 1.3 – Fillers

Identifier	Description	Source
Durex® O	carbon black, "lamp black" type	Degussa
Mistron® Vapor	talc (particle size ~ 1.7 microns)	Luzenac
Mistron® R10C	Talc	Luzenac
CB N-550	carbon black, FEF (fast extruding furnace) type	Cabot
Omya® BSH	calcium carbonate (ground, surface treated)	Omya
Sillitin® Z 86	quartz + kaolinite mix	Hoffmann Mineral
Spheron® 5000	carbon black	Cabot
Spheron® 6000	carbon black	Cabot

TABLE 1.4 – Cure System Components

Identifier	Description	CAS #	Source
Bisomer® TMPTMA	trimethylolpropane trimethacrylate, coagent	3290-92-4	Cognis
CBS	n-cyclohexyl-2-benzothiazole sulphenamide, accelerator	95-33-0	
Luperox® F40	di(tert-butylperoxyisopropyl)benzene (40% on $CaCO_3$ carrier), organic peroxide	25155-25-3	Arkema
Perkadox® 14-40	di(tert-butylperoxyisopropyl)benzene (40% on solid carrier), organic peroxide	25155-25-3	Akzo Nobel
Rhenocure® TP/G	zinc dibutyldithiophosphate (50% on solid carrier), accelerator		Rhein Chemie
Rhenogran® CaO-80	calcium oxide (80% in EPDM/EVA binder), activator		Rhein Chemie
Rhenogran® ZAT-70	zinc dialkyldithiophosphate (activated, 70% in EPDM/EVA binder), accelerator		Rhein Chemie
Sartomer® SR-350	trimethylolpropane trimethacrylate, coagent	3290-92-4	Sartomer
Silquest® A-172	vinyl tri(2-methoxy-ethoxy)silane, coupling agent	1067-53-4	General Electric
Sulfur	elemental sulfur, vulcanization agent	7704-34-9	
TAC	2,4,6-tris(2-propenyloxy)-1,3,5-triazine (also called triallyl cyanurate), coupling agent	101-37-1	
ZnO	zinc oxide, activator	1314-13-2	

TABLE 1.5 – Other Additives

Identifier	Description	CAS #	Source
Maglite® D	magnesium oxide, acid absorber	1309-48-4	C.P. Hall
Structol® WB 212	emulsion of fatty acid esters on inorganic carrier, processing aid		Schill-Seilacher
TMQ	2,2,4-trimethyl-1,2-hydroquinoline, antioxidant	101-37-1	Nocil
stearic acid	saturated fatty acid	57-11-4	
Carbowax™ 3350	polyethylene glycol, 3000-3700 g/mol avg, lubricant	25322-68-3	Dow Chemical
Vanox® ZMTI	zinc 2-mercaptotolumimidazole, antioxidant	61617-00-3	R.T. Vanderbilt

TABLE 2 – Formulations (parts by weight) for Examples 1-7

Example	1	2	3	4	5	6	7
Vistalon 706	70	70	70	70	70	70	70
Vistalon 7500	30	30	30	30	30	30	30
CB N-550	75	75	75	75	75	75	75
Mistron Vapor	50	50	50	50	50	50	50
Sunpar 2280	50	--	--	--	--	--	--
SpectraSyn 100	--	50	45	40	30	20	40
SpectraSyn Ultra 150	--	--	--	--	--	--	10
SpectraSyn Ultra 300	--	--	5	10	20	30	--
Luperox F40	9	9	9	9	9	9	9
Bisomer TMPTMA	1	1	1	1	1	1	1
Structol WB 212	2	2	2	2	2	2	2
Vanox ZMTI	2	2	2	2	2	2	2
TMQ	1	1	1	1	1	1	1

TABLE 3 – Properties of Examples 1-7

Example	1*	2*	3	4	5	6	7
Mooney Viscosity							
ML (1+4 @ 100°C)	60.0	56.7	53.6	51.5	Rotor	Rotor	52.0
MH-ML (dNm)	10.4	13.7	13.7	13.5	Slip	Slip	12.8
Hardness	66	68	67	67	68	68	67
Tensile Stress @ Break (MPa)							
Initial value after cure	11.2	12.4	12.1	11.5	10.9	7.0	11.9
Tensile Stress @ Break (MPa) after aging							
125°C for 168 hours	11.0	12.5	12.8	11.9	10.4	6.9	12.3
150°C for 168 hours	10.7	12.3	12.1	11.8	9.8	6.1	11.6
175°C for 168 hours	4.5	6.0	6.0	6.1	2.8	3.5	7.2

150°C for 1000 hours	4.3	7.0	7.3	10.0			8.5
Tensile Strain @ Break (%)							
Initial value after cure	485	335	340	325	270	210	330
Tensile Strain @ Break (%) after aging							
125°C for 168 hours	475	335	340	330	290	205	340
150°C for 168 hours	470	345	340	325	270	185	320
175°C for 168 hours	155	180	190	190	90	100	215
150°C for 1000 hours	100	180	185	250			215
Compression Set (%) after aging							
70°C for 168 hours	26	18	17.5	18.3			17.4
125°C for 22 hours	18	11	13.2	15.2			14.8
125°C for 168 hours	29	23	25.5	25.3			24.5

*Average of three separate batches

TABLE 4 – Formulations (parts by weight) for Examples 8-11

Example	8	9	10	11
Vistalon 706	70	70	--	--
Vistalon 7500	30	30	--	--
Vistalon 8800	--	--	57.5	57.5
Vistalon 785	--	--	50	50
Mistron R10C	60	60	--	--
Spheron 6000	60	60	--	--
CB N-550	--	--	70	70
Sillitin Z 86	--	--	60	60
Flexon 815	50	--	47.5	--
SpectraSyn 40	--	50	--	47.5
Perkadox 14-40	9	9	10	10
Sartomer SR-350	1	1	--	--
Rhenogran CaO-80	--	--	5	5
TAC	--	--	3	3
Silquest A-172	--	--	1	1
Sulfur	--	--	0.1	0.1
Maglite D	5	5	--	--
Vanox ZMTI	2	2	--	--
TMQ	2	2	--	--

TABLE 5 – Properties for Examples 8-9

Example	8	9
Mooney Viscosity		
ML(1+4) @ 100°C	51.5	46.7
MH-ML (dNm)	9.0	12.0
Rh (dNm/min)	6.9	8.9
Initial (autoclave cured, 20 min @ 180°C)		
Hardness (Shore A)	59	59
Tensile strength @ Break (MPa)	7	8
Tensile elongation @ Break (%)	685	500
Compression set (%) after aging in hot air @ 150°C		
24 hr, 25% compression	42	37
70 hr, 25% compression	46	38
1000 hr, 25% compression	95	81
After aging in hot air for 6 weeks @ 150°C		
Tensile strength @ Break (MPa)	5.6	6.1
Tensile elongation @ Break (%)	165	230
After aging in hot air for 72 hours @ 175°C		
Tensile elongation @ Break (%)	410	340
After aging in an oil bath (5W30) for 168h @ 150°C		
Hardness (Shore A)	21	33

TABLE 6 – Properties of Examples 10-11

Example	10	11
Mooney Viscosity		
MH-ML (dNm)	15.5	19.7
Rh (dNm/min)	7.0	8.0
Tensile Modulus (MPa)		
50% strain	1.4	2.1
100% strain	3.3	6.4

Compression Set (%)		
-20°C	25	13
-30°C	43	21
-40°C	70	34
Tension Set (%)		
-20°C	38	20

TABLE 7 – Formulations (parts by weight) for Examples 12-23

Example	12	13	14	15	16	17	18	19	20	21	22	23
Vistalon 2502	50	50	50	--	--	--	--	--	--	--	--	--
Vistalon 7602	50	50	50	--	--	--	--	--	--	--	--	--
Vistalon 8800	--	--	--	57.5	57.5	57.5	57.5	57.5	57.5	57.5	57.5	57.5
Vistalon 785	--	--	--	50	50	50	50	50	50	50	50	50
N-550 FEF	70	70	70	70	70	70	70	70	70	70	70	70
Silitin Z 86	60	60	60	60	60	60	60	60	60	60	60	60
Flexon 815	55	--	--	47.5	--	--	--	--	--	--	--	--
SpectraSyn 4	--	55	--	--	5	10	15	20	--	--	--	--
SpectraSyn 6	--	--	55	--	--	--	--	--	5	10	15	20
SpectraSyn 10	--	--	--	--	42.5	37.5	32.5	27.5	42.5	37.5	32.5	27.5
Perkadox 14-40	10	10	10	10	10	10	10	10	10	10	10	10
Rhenogran CaO-80	5	5	5	5	5	5	5	5	5	5	5	5
TAC	3	3	3	3	3	3	3	3	3	3	3	3
Silquest A-172	1	1	1	1	1	1	1	1	1	1	1	1
Sulfur	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

TABLE 8 – Properties for Examples 12-23

Example	12	13	14	15	16	17	18	19	20	21	22	23
Mooney Viscosity												
MH-ML (dNm)	16.6	23.2	22.2	15.6	18.1	19.2	18.4	18.4	18.5	19.2	19.3	18.6
Rh (dNm/min)	8.3	10.5	10.4	7.0	8.0	8.7	8.6	7.8	8.4	8.2	8.5	8.3
Tensile Modulus (MPa)												
50% strain	1.4	2.1	2.1	1.5	1.8	2.0	1.8	1.9	1.8	1.9	1.9	1.9
100% strain	3.2	5.8	5.7	3.8	5.4	5.9	5.4	6.0	5.4	5.9	6.0	5.6
Set at -20°C (%)												
Compression set	43	13	13	33	15	14	14	14	20	15	15	16
Tension set	40	14	34	20	10	6	6	2	8	13	11	2

TABLE 9 – Formulations (parts by weight) for Examples 24-26

Example	24	25	26
Vistalon 9500	92	92	92
Vistalon 3666	15	15	15
Spheron 5000	88	88	88
Durex O	60	60	60
Omya BSH	40	40	40
Flexon 815	57	--	--
Plastol 537	--	57	--
SpectraSyn 10	--	--	57
Rhenogran CaO-80	6	6	6
ZnO	3	3	3
Rhenocure TP/G	2.5	2.5	2.5
CBS	1.2	1.2	1.2
Rhenocure ZAT-70	1	1	1
Sulfur	0.95	0.95	0.95
Carbowax 3350	3	3	3
Stearic Acid	0.5	0.5	0.5

TABLE 10 – Results for Examples 24-26

Example	24	25	26
Color, initial			
L	17.32	17.99	17.72
a	-0.17	-0.27	-0.32
b	-1.24	-1.36	-1.59
Color after QUV aging			
L	19.94	20.61	18.71
a	0.1	0.19	0.25
b	-0.19	0.34	0.28
Color Change			
DeltaE	2.8	3.2	2.2

[00143] Specific embodiments can further include:

1. An elastomeric composition comprising:

a rubber component comprising one or more ethylene-propylene elastomers;

one or more peroxide curing agents; and

one or more non-functionalized plasticizers having a viscosity index of 120 or more, a kinematic viscosity @100°C of 20 cSt or more, and a Mn of 1100 g/mole or more, wherein polypropylene and polyethylene are both substantially absent from the composition.

2. The composition of paragraph 1, wherein the rubber component is a blend of ethylene-propylene (EP) elastomer and ethylene-propylene-diene (EPDM) elastomer.

3. The composition of paragraphs 1 or 2, wherein the one or more ethylene-propylene elastomers is a blend of about 20, 30, or 40 wt% to about 50, 60, or 70 wt% of ethylene-propylene (EP) elastomer and about 50, 60, or 70 wt% to about 20, 30, or 40 wt% ethylene-propylene-diene (EPDM) elastomer, based on total weight of rubber.

4. The composition of any of paragraphs 1 to 3, wherein the one or more ethylene-propylene elastomers is a blend of about 30, 40, 45, or 50 wt% to about 70, 60, 55, or 50 wt% ethylene-propylene (EP) elastomer and about 30, 40, 45, or 50 wt% to about 70, 60, 55 or 50 wt% ethylene-propylene-diene (EPDM) elastomer, based on total weight of rubber.

5. The composition of any of paragraphs 1 to 4, wherein the rubber component is at least partially cured by the peroxide.

6. The composition of any of paragraphs 1 to 5, wherein the one or more non-functionalized plasticizers is present in an amount of about 20 to 50 phr.

7. The composition of any of paragraphs 1 to 6, wherein the one or more non-functionalized plasticizers is a blend of at least two non-functionalized plasticizers.

8. The composition of any of paragraphs 1 to 7, wherein the one or more non-functionalized plasticizers is a blend of at least two non-functionalized plasticizers, wherein two of the plasticizers have a difference in kinematic viscosity @100°C of about 100 cSt or more.

9. The composition of any of paragraphs 1 to 8, wherein the one or more non-functionalized plasticizers is a blend of at least two non-functionalized plasticizers, wherein two of the plasticizers have a difference in kinematic viscosity @100°C of about 300 cSt or less.

10. The composition of any of paragraphs 1 to 9, wherein the one or more non-functionalized plasticizers comprises at least two non-functionalized plasticizers where a first non-functionalized plasticizer has a viscosity index of 300 or more and a second non-functionalized plasticizer has a viscosity index of 150 or less.

11. The composition of any of paragraphs 1 to 10, wherein the one or more non-functionalized plasticizers has a kinematic viscosity @100°C of 40 cSt or more.

11a. The composition of any of paragraphs 1 to 11, wherein the composition comprises from 0 to less than 10 wt% of a thermoplastic polymer having a melting point of 40 ° C or more.

12. The composition of any of paragraphs 1 to 11a, wherein the one or more non-functionalized plasticizers comprises a blend of at least two plasticizers selected from the group consisting of oligomers of C_5 to C_{24} alpha-olefins (PAOs), Group III mineral oils, and wax isomerate lubricant base stocks or oils.

13. The composition of any of paragraphs 1 to 12, wherein at least one of the one or more non-functionalized plasticizers has a Noack volatility of less than N* where

$N^* = 60e^{-0.4(KV100^{\circ}C)}$ wherein N* has units of % and KV100°C has units of cSt.

14. An elastomeric composition comprising:

a rubber component comprising one or more ethylene-propylene elastomers;

one or more peroxide curing agents; and

one or more non-functionalized plasticizers having a viscosity index of 120 or more wherein the one or more non-functionalized plasticizers are selected from the group consisting of Group III mineral oils and wax isomerate lubricant base stocks or oils, wherein polypropylene and polyethylene are both substantially absent from the composition.

15. The composition of paragraph 14, wherein the rubber component is a blend of ethylene-propylene (EP) elastomer and ethylene-propylene-diene (EPDM) elastomer.

16. The composition of paragraphs 14 or 15, wherein the one or more ethylene-propylene elastomers is a blend of about 30 wt% to about 70 wt% of ethylene-propylene (EP) elastomer and about 70 wt% to about 30 wt% ethylene-propylene-diene (EPDM) elastomer.

17. The composition of any of paragraphs 14 to 16, wherein the one or more ethylene-propylene elastomers is a blend of about 45 wt% to about 65 wt% ethylene-propylene (EP) elastomer and about 45 wt% to about 55 wt% ethylene-propylene-diene (EPDM) elastomer.

18. The composition of any of paragraphs 14 to 17, wherein the rubber component is at least partially cured by the peroxide.

19. The composition of any of paragraphs 14 to 18, wherein the one or more non-functionalized plasticizers is present in an amount of about 20 to 50 phr.

20. The composition of any of paragraphs 14 to 19, wherein the one or more non-functionalized plasticizers is a blend of at least two non-functionalized plasticizers.

21. The composition of any of paragraphs 14 to 20, wherein the one or more non-functionalized plasticizers is a blend of at least two non-functionalized plasticizers, wherein two of the plasticizers have a difference in kinematic viscosity @100°C of about 100 cSt or more.

22. The composition of any of paragraphs 14 to 21, wherein the one or more non-functionalized plasticizers is a blend of at least two non-functionalized plasticizers, wherein two of the plasticizers have a difference in kinematic viscosity @100°C of about 300 cSt or less.

23. The composition of any of paragraphs 14 to 22, wherein the one or more non-functionalized plasticizers comprises at least two non-functionalized plasticizers where a first non-functionalized plasticizer has a viscosity index of 300 or more and a second non-functionalized plasticizer has a viscosity index of 150 or less.

24. The composition of any of paragraphs 14 to 23, wherein the one or more non-functionalized plasticizers has a kinematic viscosity @100°C of 40 cSt or more.

25. The composition of any of paragraphs 14 to 24, wherein the one or more non-functionalized plasticizers comprises a blend of at least two plasticizers selected from the group consisting of oligomers of C_5 to C_{24} alpha-olefins (PAOs), Group III mineral oils, and wax isomerate lubricant base stock or oil.

26. The composition of any of paragraphs 14 to 25, wherein at least one of the one or more non-functionalized plasticizers has a Noack volatility of less than N* where

$N^* = 60e^{-0.4(KV100^{\circ}C)}$ wherein N* has units of % and KV100°C has units of cSt.

27. An elastomeric composition comprising:

at least one rubber component comprising ethylene-propylene rubber;

at least one rubber component comprising ethylene-propylene-diene (EPDM) rubber; and

two or more non-functionalized plasticizers where at least a first non-functionalized plasticizer has a kinematic viscosity @100°C of 300 cSt or more and at least a second non-functionalized plasticizer has a kinematic viscosity @100°C of 150 cSt or less.

28. The composition of paragraph 27, wherein the ethylene-propylene (EP) rubber and ethylene-propylene-diene (EPDM) rubber are at least partially peroxide cured.

29. The composition of paragraphs 27 or 28, wherein a ratio of the first non-functionalized plasticizer to the second non-functionalized plasticizer based on total weight of the plasticizer is about 10:90 to about 40:60.

30. The composition of any of paragraphs 27 to 29, wherein the two or more non-functionalized plasticizers comprises between about 10 wt% and 90 wt% of the first non-functionalized plasticizer.

31. The composition of any of paragraphs 27 to 30, wherein the two or more non-functionalized plasticizers comprises between about 30 wt% and 70 wt% of the first non-functionalized plasticizer.

32. The composition of any of paragraphs 27 to 31, wherein the two or more non-functionalized plasticizers comprises between about 40 wt% and 60 wt% of the first non-functionalized plasticizer.

33. The composition of any of paragraphs 27 to 32, wherein at least one of the two or more non-functionalized plasticizers has a Noack volatility of less than N* where

$N^* = 60e^{-0.4(KV100^oC)}$ wherein N* has units of % and KV100°C has units of cSt.

34. The composition of any of paragraphs 27 to 33, wherein all of the two or more non-functionalized plasticizers have a Noack volatility of less than N*.

35. The composition of any of paragraphs 1 to 34 wherein the non-functionalized plasticizer has a pour point of -20°C or less, a specific gravity of 0.86 or less, and flash point of 200 ° C or more.

36. A method for preparing an elastomer composition, comprising:

mixing at least one a rubber component comprising a blend of ethylene-propylene (EP) rubber and ethylene-propylene-diene (EPDM) rubber; peroxide; and one or more non-functionalized plasticizers having a viscosity index of 120 or more, a kinematic viscosity @100°C of 20 cSt or more, and an Mn of 1100 g/mole or more.

[00144] Certain embodiments and features have been described using a set of numerical upper limits and a set of numerical lower limits. It should be appreciated that ranges from any lower limit to any upper limit are contemplated unless otherwise indicated. Certain lower limits, upper limits and ranges appear in one or more claims below. All numerical values are "about" or "approximately" the indicated value, and take into account experimental error and variations that would be expected by a person having ordinary skill in the art.

[00145] Various terms have been defined above. To the extent a term used in a claim is not defined above, it should be given the broadest definition persons in the pertinent art have given that term as reflected in at least one printed publication or issued patent. Furthermore, all patents, test procedures, and other documents cited in this application are fully incorporated by reference to the extent such disclosure is not inconsistent with this application and for all jurisdictions in which such incorporation is permitted.

[00146] While the foregoing is directed to embodiments of the present invention, other and further embodiments of the invention can be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

[00147] All documents described herein are incorporated by reference herein, including any priority documents and/or testing procedures to the extent they are not inconsistent with this text. As is apparent from the foregoing general description and the specific embodiments, while forms of the invention have been illustrated and described, various modifications can be made without

departing from the spirit and scope of the invention. Accordingly, it is not intended that the invention be limited thereby. Likewise, the term "comprising" is considered synonymous with the term "including" for purposes of Australian law.

CLAIMS

What is claimed is:

1. An elastomeric composition comprising:

a rubber component comprising one or more ethylene-propylene elastomers;

one or more peroxide curing agents; and

one or more non-functionalized plasticizers having a viscosity index of 120 or more, a kinematic viscosity @100°C of 20 cSt or more, and a Mn of 1100 g/mole or more, wherein polypropylene and polyethylene are both substantially absent from the composition.

2. The composition of claim 1, wherein the rubber component is a blend of ethylene-propylene (EP) elastomer and ethylene-propylene-diene (EPDM) elastomer.

3. The composition of claims 1 or 2, wherein the one or more ethylene-propylene elastomers is a blend of about 20 wt% to about 70 wt% of ethylene-propylene (EP) elastomer and about 20 wt% to about 70 wt% ethylene-propylene-diene (EPDM) elastomer, based on total weight of rubber.

4. The composition of any of claims 1 to 3, wherein at least one of the one or more non-functionalized plasticizers has a Noack volatility of less than N* where

$N^* = 60e^{-0.4(KV100^oC)}$ wherein N* has units of % and KV100°C has units of cSt.

5. The composition of any of claims 1 to 4, wherein the rubber component is at least partially cured by the peroxide.

6. The composition of any of claims 1 to 5, wherein the one or more non-functionalized plasticizers is present in an amount of about 20 to 50 phr.

7. The composition of any of claims 1 to 6, wherein the one or more non-functionalized plasticizers is a blend of at least two non-functionalized plasticizers.

8. The composition of any of claims 1 to 7, wherein the one or more non-functionalized plasticizers is a blend of at least two non-functionalized plasticizers, wherein two of the plasticizers have a difference in kinematic viscosity @100°C of about 100 cSt or more.

9. The composition of claim 8, wherein the one or more non-functionalized plasticizers is a blend of at least two non-functionalized plasticizers, wherein two of the plasticizers have a difference in kinematic viscosity @100°C of about 300 cSt or less.

10. The composition of any of claims 1 to 9, wherein the one or more non-functionalized plasticizers comprises at least two non-functionalized plasticizers where a first non-functionalized plasticizer has a viscosity index of 300 or more and a second non-functionalized plasticizer has a viscosity index of 150 or less.

11. The composition of any of claims 1 to 10, wherein the composition comprises from 0 to less than 10 wt% of a thermoplastic polymer having a melting point of 40 ° C or more.

12. The composition of any of claims 1 to 11, wherein the one or more non-functionalized plasticizers comprises a blend of at least two plasticizers selected from the group consisting of

oligomers of C_5 to C_{24} alpha-olefins (PAOs), Group III mineral oils, and wax isomerate lubricant base stocks or oils.

13. An elastomeric composition comprising:

a rubber component comprising one or more ethylene-propylene elastomers;

one or more peroxide curing agents; and

one or more non-functionalized plasticizers having a viscosity index of 120 or more wherein the one or more non-functionalized plasticizers are selected from the group consisting of Group III mineral oils and wax isomerate lubricant base stocks or oils, wherein polypropylene and polyethylene are both substantially absent from the composition.

14. The composition of claim 13, wherein the rubber component is a blend of ethylene-propylene (EP) elastomer and ethylene-propylene-diene (EPDM) elastomer.

15. The composition of claims 13 or 14, wherein the one or more ethylene-propylene elastomers is a blend of about 30 wt% to about 70 wt% of ethylene-propylene (EP) elastomer and about 70 wt% to about 30 wt% ethylene-propylene-diene (EPDM) elastomer.

16. The composition of any of claims 13 to 15, wherein at least one of the one or more non-functionalized plasticizers has a Noack volatility of less than N* where

$N^* = 60e^{-0.4(KV100^oC)}$ wherein N* has units of % and KV100°C has units of cSt.

17. The composition of any of claims 13 to 16, wherein the rubber component is at least partially cured by the peroxide.

18. The composition of any of claims 13 to 17, wherein the one or more non-functionalized plasticizers is present in an amount of about 20 to 50 phr.

19. The composition of any of claims 13 to 18, wherein the one or more non-functionalized plasticizers is a blend of at least two non-functionalized plasticizers.

20. The composition of any of claims 13 to 19, wherein the one or more non-functionalized plasticizers is a blend of at least two non-functionalized plasticizers, wherein two of the plasticizers have a difference in kinematic viscosity @100°C of about 100 cSt or more and about 300 cSt or less.

21. The composition of any of claims 13 to 20, wherein the one or more non-functionalized plasticizers comprises at least two non-functionalized plasticizers where a first non-functionalized plasticizer has a viscosity index of 300 or more and a second non-functionalized plasticizer has a viscosity index of 150 or less.

22. The composition of any of claims 13 to 22, wherein the one or more non-functionalized plasticizers comprises a blend of at least two plasticizers selected from the group consisting of oligomers of C_5 to C_{24} alpha-olefins (PAOs), Group III mineral oils, and wax isomerate lubricant base stock or oil.

23. The composition of any of claims 13 to 22, wherein the composition comprises from 0 to less than 10 wt% of a thermoplastic polymer having a melting point of 40 ° C or more.

24. The composition of any of claims 1 to 22 wherein the non-functionalized plasticizer has a pour point of -20°C or less, a specific gravity of 0.86 or less, and flash point of 200 ° C or more.

25. A method for preparing an elastomer composition of any of claims 1-24, comprising:

mixing at least one a rubber component comprising a blend of ethylene-propylene (EP) rubber and optionally ethylene-propylene-diene (EPDM) rubber; and peroxide; and one or more non-functionalized plasticizers having a viscosity index of 120 or more, a kinematic viscosity @100°C of 20 cSt or more, and an Mn of 1100 g/mole or more.

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2008/050857

A. CLASSIFICATION OF SUBJECT MATTER
INV. C08L23/16
ADD. C08L23/18 C08L91/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C08L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 080 942 A (YAU STEVEN D [US]) 14 January 1992 (1992-01-14)	1-25
Y	examples 1-5	1-25
A	WO 02/31044 A (DURABAN OY [FI]; KAARNAKARI MATTI [FI]; ALHA KARI [US]) 18 April 2002 (2002-04-18) cited in the application	1-25
Y	example 1	1-25
X	EP 1 357 150 A (MATERIALS ENGINEERING RES LAB [GB]) 29 October 2003 (2003-10-29) table XIX	1-25
X	WO 99/24506 A (UNIROYAL CHEM CO INC [US]) 20 May 1999 (1999-05-20) table II	1-25

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 April 2008	21/04/2008

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Schmidt, Helmut

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2008/050857

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2006/128646 A (EXXONMOBIL CHEM PATENTS INC [US]; EXXONMOBIL CHEMICAL LTD [GB]; JOURDA) 7 December 2006 (2006-12-07) table 1	1-25

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2008/050857

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