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(54) Title: ARTIFICIAL TURF HAVING SILOXANE POLYMER CONTAINING TURF INFILL AND COMPOSITIONS FOR MAKING SUCH TURF INFILL

(57) Abstract: Disclosed herein is an artificial turf comprising a substrate having a plurality of filiform formations extending from the substrate and a particulate filling material between the filiform formations to maintain the filiform formations in a substantially upright position wherein the particulate filling material comprises an elastomeric polymer, at least one of an inorganic filler or a hard thermoplastic, a siloxane polymer, and, optionally, an oil.



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ARTIFICIAL TURF HAVING SILOXANE POLYMER CONTAINING TURF INFILL AND COMPOSITIONS FOR MAKING SUCH TURF INFILL

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Application No. 19382004.0, filed on January 3, 2019, which is incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

[0001] The field of this invention is infill for artificial turf and compositions useful in making such infill.

BACKGROUND

[0002] Artificial turf is often used to provide ground coverings for sports facilities, such as football or soccer fields, and sometimes for decorative use. A common structure for this artificial turf, particularly for sports fields, includes a sheet-like substrate with a plurality of filiform formations (i.e., synthetic grass blades or turf yarn or turf blade of grass) extending from the substrate for simulating the grassy sward of natural turf and a particulate filling material, or infill, dispersed between the filiform formations so as to keep the filiform formations themselves in a substantially upright condition. Specifically, the above synthetic-grass covering is characterized in that the particulate filling material (infill) is constituted by a substantially homogeneous mass of a granular material chosen in the group constituted by polyolefin-based materials and by vinyl polymer-based materials.

[0003] Various materials have been used for the infill including recycled rubber, elastomeric materials, polyolefins or vinyl polymers, and thermoplastic polyurethanes. See e.g. EP1371779B1, EP1647577, US7585555, and US 7754308. Fillers may be included to lower cost or even to help with temperature control of the artificial turf (see e.g. WO2010/025868A1).

[0004] CN 105295284 discloses a turf blade of grass formed from a PP pipe compound comprising SEBS rubber, softening plasticizer, polyolefin elastomer, ethylene propylene diene rubber, acrylic resin, calcium carbonate, antioxidant, light stabilize and processing aids. The processing aid is at least one of low molecule esters, polysiloxane-based, metal soap, the compound esters of stearic acid, amides.

[0005] A main concern of artificial turf is the ability of the pitch to withstand environmental and playing factors while maintaining its original performance and quality. In

particular the infill granules are subjected to constant abrasion and degradation. This can lead to a loss of granulation and therefore shock absorption and dimensional stability over time.

[0006] Thus, a need exists for artificial turf and turf infill having high rebound with good durability and abrasion resistance.

SUMMARY OF THE INVENTION

[0007] Disclosed herein is a simulated grass structure comprising a substrate having a plurality of filiform formations extending from the substrate and having a particulate filling material (or infill) between the filiform formations wherein the particulate filling material comprises an elastomeric polymer, a siloxane polymer, at least one of an inorganic filler and a hard thermoplastic polymer. The particulate filling material can further comprise an oil.

[0008] Also disclosed herein are compositions useful in making artificial turf infill comprising an elastomeric polymer, a siloxane polymer, at least one of an inorganic filler and a hard thermoplastic polymer. The composition and/or particulate filling material can further comprise an oil. Also, disclosed herein is particulate filling materials comprising such composition.

[0009] The above composition surprisingly shows improved abrasion resistance at similar hardness compared to compositions not including the siloxane polymer. Thus, these compositions will be uniquely useful as turf infill.

DETAILED DESCRIPTION OF THE INVENTION

[0010] Disclosed herein are artificial turf having a specific turf infill and the composition useful in making that turf infill.

[0011] Unless stated to the contrary, implicit from the context, or customary in the art, all parts and percents are based on weight, all temperatures are in ° C, and all test methods are current as of the filing date of this disclosure.

[0012] The term “composition,” as used herein, refers to a mixture of materials which comprises the composition, as well as reaction products and decomposition products formed from the materials of the composition.

[0013] “Polymer” means a polymeric compound prepared by polymerizing monomers, whether of the same or a different type. The generic term polymer thus embraces the term homopolymer (employed to refer to polymers prepared from only one type of monomer, with the understanding that trace amounts of impurities can be incorporated into

the polymer structure), and the term interpolymer as defined hereinafter. Trace amounts of impurities (for example, catalyst residues) may be incorporated into and/or within the polymer. A polymer may be a single polymer, a polymer blend or a polymer mixture, including mixtures of polymers that are formed *in situ* during polymerization.

[0014] The term “interpolymer,” as used herein, refers to polymers prepared by the polymerization of at least two different types of monomers. The generic term interpolymer thus includes copolymers (employed to refer to polymers prepared from two different types of monomers), and polymers prepared from more than two different types of monomers.

[0015] The terms “olefin-based polymer” or “polyolefin”, as used herein, refer to a polymer that comprises, in polymerized form, a majority amount of olefin monomer, for example ethylene or propylene (based on the weight of the polymer), and optionally may comprise one or more comonomers.

[0016] The term, “ethylene/ α -olefin interpolymer,” as used herein, refers to an interpolymer that comprises, in polymerized form, a majority amount (>50 mol %) of units derived from ethylene monomer, and the remaining units derived from one or more α -olefins. Typical α -olefins used in forming ethylene/ α -olefin interpolymers are C₃-C₁₀ alkenes.

[0017] The term, “ethylene/ α -olefin copolymer,” or “ethylene/ α -olefin” as used herein, refers to a copolymer that comprises, in polymerized form, a majority amount (>50 mol%) of ethylene monomer, and an α -olefin, as the only two monomer types.

[0018] The term “ α -olefin”, as used herein, refers to an alkene having a double bond at the primary or alpha (α) position.

[0019] The terms “comprising,” “including,” “having,” and their derivatives, are not intended to exclude the presence of any additional component, step or procedure, whether or not the same is specifically disclosed. In order to avoid any doubt, all compositions claimed through use of the term “comprising” may include any additional additive, adjuvant, or compound, whether polymeric or otherwise, unless stated to the contrary. In contrast, the term, “consisting essentially of” excludes from the scope of any succeeding recitation any other component, step or procedure, excepting those that are not essential to operability. The term “consisting of” excludes any component, step or procedure not specifically delineated or listed. The compositions discussed herein as comprising may can be compositions consisting essentially of or consisting of the components listed.

[0020] “Polyethylene” or “ethylene-based polymer” shall mean polymers comprising a majority amount (>50 mol %) of units which have been derived from ethylene monomer. This includes polyethylene homopolymers or copolymers (meaning units derived from two or

more comonomers). Common forms of polyethylene known in the art include Low Density Polyethylene (LDPE); Linear Low Density Polyethylene (LLDPE); Ultra Low Density Polyethylene (ULDPE); Very Low Density Polyethylene (VLDPE); single-site catalyzed Linear Low Density Polyethylene, including both linear and substantially linear low density resins (m-LLDPE); Medium Density Polyethylene (MDPE); and High Density Polyethylene (HDPE). These polyethylene materials are generally known in the art; however, the following descriptions may be helpful in understanding the differences between some of these different polyethylene resins.

[0021] The term “LDPE” may also be referred to as “high pressure ethylene polymer” or “highly branched polyethylene” and is defined to mean that the polymer is partly or entirely homo-polymerized or copolymerized in autoclave or tubular reactors at pressures above 14,500 psi (100 MPa) with the use of free-radical initiators, such as peroxides (see for example US 4,599,392, which is hereby incorporated by reference). LDPE resins typically have a density in the range of 0.916 to 0.935 g/cm³.

[0022] The term “LLDPE”, includes both resin made using the traditional Ziegler-Natta catalyst systems and chromium-based catalyst systems as well as single-site catalysts, including, but not limited to, bis-metallocene catalysts (sometimes referred to as “m-LLDPE”) and constrained geometry catalysts, and includes linear, substantially linear or heterogeneous polyethylene copolymers or homopolymers. LLDPEs contain less long chain branching than LDPEs and includes the substantially linear ethylene polymers which are further defined in U.S. Patent 5,272,236, U.S. Patent 5,278,272, U.S. Patent 5,582,923 and US Patent 5,733,155; the homogeneously branched linear ethylene polymer compositions such as those in U.S. Patent No. 3,645,992; the heterogeneously branched ethylene polymers such as those prepared according to the process disclosed in U.S. Patent No. 4,076,698; and/or blends thereof (such as those disclosed in US 3,914,342 or US 5,854,045). The LLDPEs can be made via gas-phase, solution-phase or slurry polymerization or any combination thereof, using any type of reactor or reactor configuration known in the art.

[0023] The term “HDPE” refers to polyethylenes having densities greater than about 0.935 g/cm³ and up to about 0.970 g/cm³, which are generally prepared with Ziegler-Natta catalysts, chrome catalysts or single-site catalysts including, but not limited to, bis-metallocene catalysts and constrained geometry catalysts.

[0024] “Blend”, “polymer blend” and like terms mean a composition of two or more polymers. Such a blend may or may not be miscible. Such a blend may or may not be phase separated. Such a blend may or may not contain one or more domain configurations, as

determined from transmission electron spectroscopy, light scattering, x-ray scattering, and any other method known in the art. Blends are not laminates, but one or more layers of a laminate may contain a blend. Such blends can be prepared as dry blends, formed *in situ* (e.g., in a reactor), melt blends, or using other techniques known to those of skill in the art.

[0025] “Polypropylene” means polymers comprising greater than 50% by weight of units which have been derived from propylene monomer. This includes polypropylene homopolymers or copolymers (meaning units derived from two or more comonomers). Common forms of polypropylene known in the art include homopolymer polypropylene (hPP), random copolymer polypropylene (rcPP), impact copolymer polypropylene (hPP + at least one elastomeric impact modifier) (ICPP) or high impact polypropylene (HIPP), high melt strength polypropylene (HMS-PP), isotactic polypropylene (iPP), syndiotactic polypropylene (sPP), and combinations thereof.

The artificial turf

[0026] The artificial turf can be of any conventional structure of such turf that uses infill or particulate material. The infill can assist in keeping blades upright. The infill can provide other performance properties such as cushioning.

[0027] For example, the artificial turf can include a substrate to which synthetic grass fibers, yarns, or blades (referred to herein as filiform) are attached. The substrate can be a sheet or film like material. It may for example be a thermoplastic material. It can be woven or non-woven or a solid film or sheet. The filiforms (i.e. synthetic grass fibers) are elongated objects, or fibers or blades attached to the substrate and protruding upward from the substrate. Synthetic grass fibers can be synthetic extruded fibers (monofilaments) or (slit-film) tapes. The fibers can be arranged in bundles, preferably in bundles of monofilaments. For example, one bundle may contain 4 to 20 fibers. The synthetic grass fibers can be manufactured from materials chosen from the list comprising polypropylene (PP); any variant of polyethylene (PE) including low density polyethylene (LDPE), linear low density polyethylene (LLDPE), and high density polyethylene (HDPE)); polyester (PET); and polyamide (PA). For example, the synthetic grass fibers manufactured from LLDPE can provide good softness and resiliency. The synthetic grass fibers used in the artificial turf of the present invention can further comprise additives selected from, but not limited to, the group of infrared reflectants, UV stabilizers, anti-oxidants, fire-retardants, matting agents, luminescent compounds (phosphorescent or fluorescent compounds), fillers (e.g. chalk, talk), processing aids. The synthetic grass fibers can have a cross-section selected from, but not limited to, a rectangular, a diamond-shape, a round, an elliptical, a multilobal (Y, X), a C-shaped, a V-shaped, a W-

shaped, a S-shaped or a Ω -shaped cross-section, and have dimensions of e.g. 50-500 micrometer thickness and 0.5-5.0 mm width. The synthetic grass fibers can further comprise a backbone nerve, and/or a micro-textured surface to resemble grass blade nerves to further improve the resemblance to natural grass blades. The synthetic grass fibers are typically in a green color e.g. a uni-color or a mixed shade of green and other colors. The synthetic grass fibers can be tufted or woven through the backing. For example, the fibers can be tufted through the backing substrate. The synthetic grass fibers can be formed in loop piles or cut piles. The filiforms can extend from the substrate for a length of about 20 or 30 to about 60 or 50 mm.

[0028] In addition to the substrate and the synthetic grass or filiforms, the artificial turf includes particulate filling material (infill). The infill can be located on the substrate. The infill can be located between the filiforms. The infill can serve to support the filiforms (e.g. in a substantially upright position to simulate grass blades). The infill can have an average particle sizes of at least 1 mm to about 5 or to about 4 or to about 3 mm. The infill can extend from the surface of the substrate for at least 5 or at least 10 mm to about 30 or to about 20 mm to support the filiform. Average particle size can be determined by "Procedure to determine the particle size distribution of granulated infill materials (FIFA method 20)".

The composition for use as turf infill

[0029] The composition disclosed herein as useful as an infill turf grass includes an elastomeric polymer, at least one of inorganic filler and a hard thermoplastic polymer and a siloxane polymer. The composition can further comprise one or more of an oil and colorant. The composition is resilient to contact with people and objects and if used outside is resilient to variations in temperature, humidity, water exposure, freezing, and sunlight.

[0030] The elastomeric polymer can be any elastomer that can be blended with other polymers and which is resilient to the conditions under which it will be used. The elastomeric polymer can be a styrene butadiene rubber, a styrene ethylene butylene rubber, a styrene ethylene propylene rubber, a thermoplastic polyolefin elastomer, a thermoplastic polyurethane, a thermoplastic copolyester, a thermoplastic polyamide or combinations thereof. For example, the elastomeric polymer can be a styrene butadiene styrene (SBS) block copolymer, a styrene ethylene butylene styrene (SEBS) block copolymer, or an ethylene/alpha-olefin polymer composition or combinations thereof.

[0031] As another more specific example, the elastomeric polymer can be an ethylene/alpha-olefin polymer composition having a density (according to ISO1183-1 Ed. 2012) less than 0.900 g/cm³ and a melt index (I2) (according to ISO1133-1 Ex. 2011) of less

than 15.0 or 10.0 or 5.0 or 3.0 g/10 min and at least 0.1 g/10 min. The ethylene/alpha-olefin polymer composition can have a crystallinity of less than 35%. The ethylene/alpha-olefin polymer composition can have a crystallinity of at least 10%. Crystallinity can be measured by dynamic scanning calorimetry (DSC) (according to ISO11357-1 Ed. 2013). The alpha olefin used in making the ethylene/alpha-olefin can be 1-octene. Commercially available examples of such ethylene/alpha-olefin polymers include INFUSE™ or ENGAGE™ polymers from The Dow Chemical Company. The amount of elastomeric polymer in the composition can at least 5, or at least 10, weight percent and no more than 50, no more than 40, or no more than 30, weight percent based on total weight of the composition.

[0032] Either or both of an inorganic filler and a hard thermoplastic polymer can be useful in controlling the hardness of the particulate filling material. Examples of inorganic fillers include calcium carbonate, sodium bentonite, calcium bentonite, aluminum trihydroxide, barium sulfate, calcium carbonate, calcium sulfate, magnesium carbonate, magnesium trihydroxide, diatomaceous earth, dolomite, glass beads, ceramic beads, kaolin, mica, perlite, natural silica, synthetic silica, wollastonite, calcite, whiskers, or combinations thereof. The inorganic filler can be in substantially spherical, elliptical, plate-like or whisker form. The median particle size, D50, of the inorganic filler can at least 1, at least 5, at least 10, at least 20 up to 150, up to 130, up to 100, or up to 80 microns. Particle size can be determined, for example, by ASTM E2980-15: "Standard test methods for estimating average particle size of powders using air permeability. Test method 1: inorganic materials". The amount of inorganic filler, when used, can be at least 30 or at least 40 and no more than 80 or no more than 70 weight percent based on total weight of the composition.

[0033] The hard thermoplastic polymer can any thermoplastic that is harder than the elastomeric polymer. The hard thermoplastic polymer can be a high density polyethylene or a polypropylene. The hard thermoplastic polymer can be a polymer (preferably a polyolefin) having a density of more than 0.91 or 0.92 or 0.93 g/cm³. For example, the hard thermoplastic can be a high density polyethylene with a density of 0.940 to 0.970 g/cm³ and a melt index (I2) of 0.1 to 20 g/10 min as measured according to ASTM D1238 (at 190 °C and 2.16 kg). The amount of the hard thermoplastic polymer, when used, can be at least 0.1 or at least 1 and no more than 20 or 15 or 10% by weight based on total weight of the composition. The polysiloxane may be any siloxane which is useful in blends with other polymers. The siloxane polymer can be polydimethylsiloxane (PDMS). The PDMS can have a number average molecular weight (Mn) of at least 10,000, at least 50,000, or at least 100,000 and no more than 500,000, no more than 450,000, or no more than 400,000 g/mol as measured by

Gel Permeation Chromatography. For example, weight average molecular weight (M_w) and number average molecular weight (M_n) can be measured by GPC (Viscotek™ GPC Max) using a triple detection capability. The Viscotek™ TDA305 unit is equipped with a differential refractometer, an online differential pressure viscometer, and low angle light scattering (LALS: 7° and 90° angles of detection). The mobile phase is Toluene HPLC grade. The columns are two PL Gel Mixed C from Varian – (7.5 * 300 mm, 5 μ m particle size) and a PL Gel Guard column from Varian – (7.5 * 300 mm) 5 fractom Injection volume with a flow of 1 mL/min and a run time of 37 min. The column and detector temperature is 40°C. The software used is OmniseC 4.6.1 (Viscotek™). The detectors are calibrated by injection of a narrow polystyrene standard (M_w 68,100 g/mol) of a known concentration. Correct run parameters are checked by using a narrow molecular weight distribution polystyrene standard (PS71K). The molecular weight averages must be within the Statistical Process Control (SPC) chart in order to validate the detectors calibration. Typical GPC³ precision and accuracy (which depends on the refractive index increment) are around 2–3%.

[0034] The PDMS components can comprise an ultrahigh molecular weight (UHMW) PDMS component, a high molecular weight (HMW) PDMS component, or a blend of both. For example, the PDMS components can comprise a blend of an UHMW PDMS component and the HMW PDMS component. The UHMW PDMS component can have a M_n of from 150,000, from 200,000, or from 250,000 to 450,000, to 400,000, or to 350,000 g/mol. The HMW PDMS can have a M_n of from 10,000 to 100,000, to 50,000, to 25,000 g/mol, or to 20,000 g/mol.

[0035] The amount of the polysiloxane can be at least 0.1, at least 0.5, or at least 1 weight percent based on total weight of the composition. The amount of polysiloxane can be no more than 20, no more than 15, or no more than 10 weight percent based on total weight of the composition. The polysiloxane can for convenience be incorporated into the composition using a carrier polymer, e.g. in a master batch. For example, a polyolefin carrier polymer may be used. Examples of suitable polyolefin carriers include polyethylenes and polypropylenes. The polyethylene may be a linear low density polyethylene, a low density polyethylene, a high density polyethylene. For example, a carrier polyolefin may be compounded with the polysiloxane in weight ratios of carrier:polysiloxane of at least 20:80, at least 30:70, or at least 40:60 up to no more than 70:30 or no more than 60:40. The carrier may include other components such as polyamide.

[0036] Addition of an oil can be helpful in controlling the hardness of the composition. The amount of oil can be 0 or can be at least 0.1, at least 1, at least 3, or at least 5 up to 20, up to 15, or up to 12 weight percent based on total weight of the composition. Examples of suitable oils include paraffinic oil, naphthenic oil, aromatic oil and combinations thereof.

[0037] In many applications it is desirable to include a colorant. Typically these colorants will be pigments in a polymeric carrier matrix. The weight ratio of pigment to carrier can be in the range of at least 10:90, at least 20:80, or at least 30:70 up to 90:10, up to 80:20, or up to 70:30. The amount of colorant (including its carrier if any is used) may be at least 0.1, at least 0.5, at least 1, at least 2 and no more than 10, no more than 7, or no more than 5 weight percent based on total weight of the composition.

[0038] Additional optional additives can be used. Examples of such additional, optional additives include antioxidants, UV stabilizers, UV absorbers, curing agents, cross linking co-agents, boosters and retardants, processing aids, antistatic agents, nucleating agents, slip agents, plasticizers, lubricants, viscosity control agents, tackifiers, anti-blocking agents, acid scavengers, and meta deactivators. If an optional additive is used it is present in amounts less than 5, less than 4, less than 3, less than 2, or less than 1% by weight and the total amount of all the additives is less than 10, less than 8, less than 6, less than 4 or less than 2% by weight based on total weight of the composition. They can be used in amounts of at least 0.001, at least 0.01, or at least 0.1 % by weight based on total weight of the composition.

[0039] In addition the composition can comprise an additional polymer such as a polyethylene, a polypropylene, a polyamide or a polyester. The amount of this additional polymer is no more than 20, no more than 15, no more than 10, or no more than 5% by weight based on total weight of the composition. The amount of this additional optional polymer may be 0 or at least 1% by weight based on total weight of the composition.

[0040] The components of the composition may be combined and blended by known techniques such as kneading, internal mixers and extrusion blending.

[0041] The compositions disclosed herein can have density of at least 1.1, at least 1.2, at least 1.3, or at least 1.4 g/cm³. The compositions disclosed herein can have density of not more than 1.8 or not more than 1.7 g/cm³.

[0042] The compositions disclosed herein have good abrasion resistance as measured by ISO 4649 Ed. 2010 and can show weight losses of less than 530, less than 500, less than 450, or less than 400 mg.

[0043] The composition can be formed into the particulate filling material by extruding and pelletizing and/or grinding.

[0044] The particulate filling material as described herein may be mixed with other granular infill materials such as other polymeric particles, recycled rubber, sand or the like. The weight ratio of the particulate filling material as described herein to the other granular infill materials can be at least 10:90, at least 20:80, or at least 30:70 up to 95:5, up to 90:10, up to 80:20, or up to 70:30.

EXAMPLES

Formulating the composition

[0045] Components as set forth in Table 1 together with 4% by Sicolen 95-133805 colorant from BASF are compounded on a Polylab mixer chamber with Banbury Rotors. The mixer volume is 379 cubic centimeters and it is filled at 72%. All percents are weight percents based on total weight of ingredients.

Sample ID	Elastomer	HDPE ¹	Filler ⁴	Paraffinic Oil ⁵	PDMS ⁶
Comparative Example 1 (CE1)	19% (ENGAGE™ 7387) ²	5%	62%	10%	-
Comparative Example 2 (CE2)	19% (INFUSE™ 9010) ³	5%	62%	10%	-
Inventive Example 1 (IE1)	19% (ENGAGE™ 7387)	5%	57%	10%	5%
Inventive Example 2 (IE2)	19% (ENGAGE™ 7387)	5%	52%	10%	10%
Inventive Example 3 (IE3)	19% (INFUSE™ 9010)	5%	57%	10%	5%

¹The HDPE used herein is as disclosed in US 2018/0296524 (Table 1, Inventive Resin 1) and has a density of 0.950 g/cm³ and a melt index, I2 of 1.5 g/10 min.

²ENGAGE™7387 is an ethylene/alpha-olefin polymer composition from The Dow Chemical Company having a density of 0.874 g/cm³, a melt index, I2 of 0.8 g/10 min, and a DSC crystallinity of 16%.

³INFUSE™9010 is an ethylene/alpha-olefin polymer composition from The Dow Chemical Company having a density of 0.877 g/cm³, a melt index, I2 of 0.5 g/10 min.

⁴Omyalite 95T calcium carbonate, available from Omya (Basel, Switzerland)

⁵Sunpar 2280 paraffinic oil from R.E. Carroll, Inc.

⁶ This is provided in a masterbatch comprising 50 wt.% PDMS having an Mn = 300,000 g/mol and 50 wt.% of DOWLEX™ 2035G LLDPE. The DOWLEX™ 2035G has a density = 0.919 g/cc, and melt index I2 = 6.0 g/10 min.

Testing and Results

[0046] The compounds are then compression molded into 2mm plaques according to ISO 293. Density is measured according to ISO 1183-1 (Method A, Ed. 2012), hardness shore A with 3 seconds testing time (ISO 868, Ed. 2003), abrasion resistance ISO 4649 Ed. 2010 and tensile elastomers (BS ISO 37 Ed 2012). Results are shown in Table 2.

Table 2. Summary of mechanical properties of inventive and comparative examples.

		CE1	IE1	IE2	CE2	IE3
Density	g/cm ³	1.545	1.467	1.399	1.548	1.471
Hardness	Shore A	78.8	80.3	80.5	83.2	82.8
Abrasion weight loss	mg	488	405	305	585	517
Strain at break	%	795	838	801	828	798
Stress at break	MPa	5.4	6.0	5.7	5.4	5.0
Work at break	J	3.1	3.7	3.5	3.7	3.5
Tensile Strength at 5%	MPa	1.01	1.12	1.26	1.35	1.42
Tensile Strength at 10%	MPa	1.39	1.51	1.63	1.75	1.80
Tensile Strength at 15%	MPa	1.60	1.70	1.79	1.95	1.98
Tensile Strength at 20%	MPa	1.72	1.79	1.88	2.06	2.08
Tensile Strength at 25%	MPa	1.80	1.85	1.92	2.13	2.13
Tensile Strength at 50%	MPa	1.89	1.86	1.92	2.19	1.94
Tensile Strength at 100%	MPa	1.74	1.65	1.74	1.84	1.78
Tensile Strength at 200%	MPa	1.68	1.72	1.81	1.90	1.87
Tensile Strength at 300%	MPa	1.79	1.85	2.06	2.04	2.21

[0047] The compositions and methods can alternatively comprise, consist of, or consist essentially of, any appropriate materials, steps, or components herein disclosed. The compositions, methods, and articles can additionally, or alternatively, be formulated so as to be devoid, or substantially free, of any materials (or species), steps, or components, that are otherwise not necessary to the achievement of the function or objectives of the compositions, methods, and articles.

[0048] For ranges, stated upper and lower limits can be combined to form ranges (e.g. “at least 1 or at least 2 weight percent” and “up to 10 or 5 weight percent” can be combined as the ranges “1 to 10 weight percent”, or “1 to 5 weight percent” or “2 to 10 weight percent” or “2 to 5 weight percent”). The terms “a” and “an” and “the” do not denote a limitation of quantity and are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context.

[0049] This disclosure further encompasses the following aspects.

[0050] Aspect 1. An artificial turf comprising a substrate having a plurality of filiform formations extending from the substrate and a particulate filling material between the filiform

formations wherein the particulate filling material comprises an elastomeric polymer, at least one of an inorganic filler or a hard thermoplastic, a siloxane polymer, and, optionally, an oil.

[0051] Aspect 2. The artificial turf of aspect 1 wherein the oil is used and is selected from the group consisting of paraffinic oil, naphthenic oil, aromatic oil and combinations thereof.

[0052] Aspect 3. The artificial turf of any of the preceding aspects wherein the particulate filler materials comprise the hard thermoplastic polymer which is selected from high density polyethylene and polypropylene.

[0053] Aspect 4. The artificial turf of any of the preceding aspects wherein the elastomeric polymer is selected from the group consisting of styrene-butadiene-styrene (SBS), styrene-ethylene-butadiene-styrene (SEBS), and ethylene/alpha-olefin resin having a density of less than 0.900 g/cc and a melt index (I2) of less than 15.0 g/10 min.

[0054] Aspect 5. The artificial turf of any of the preceding aspects wherein the siloxane is a polydimethylsiloxane having a number average molecular weight of 10,000 to 500,000 g/mol, preferably 100,000 to 500,000 g/mol, as measured by gel permeation chromatography.

[0055] Aspect 6. The artificial turf of any of the preceding aspects wherein the hard thermoplastic is a high density polyethylene having a density 0.940 g/c to 0.970 g/cc and a melt index (I2) of 0.1 g/10 min to 20 g/10 min as measured according to ASTM D1238 (at 190°C, 2.16 kg).

[0056] Aspect 7. The artificial turf of any of the preceding aspects wherein the inorganic filler is selected from calcium carbonate, sodium bentonite, calcium bentonite, aluminum trihydroxide, barium sulfate, calcium carbonate, calcium sulfate, magnesium carbonate, magnesium trihydroxide, diatomaceous earth, dolomite, glass beads, ceramic beads, kaolin, mica, perlite, natural silica, synthetic silica, wollastonite, calcite, whiskers, or combinations thereof.

[0057] Aspect 8. The artificial turf of any one of the preceding aspects wherein the particulate filling material comprises 0.1 to 10 % of the hard thermoplastic, 10 to 50% of the elastomeric polymer, 30-80% of the inorganic filler, 0.1 to 15% of the oil and 0.5-15% of the siloxane based on total weight of the composition.

[0058] Aspect 9. A composition useful in turf infill comprising an elastomeric polymer, at least one of an inorganic filler or a hard thermoplastic selected from high density polyethylene and polypropylene, a polydimethylsiloxane polymer, and an oil.

[0059] Aspect 10. The composition of aspect 9 wherein both the inorganic filler and the hard thermoplastic are present, the elastomeric polymer is selected from the group consisting of styrene-butadiene-styrene (SBS), styrene-ethylene-butadiene-styrene (SEBS), and ethylene/alpha-olefin resin having a density of less than 0.900 g/cc and a melt index (I2) of less than 15.0 g/10 min, the hard thermoplastic is a high density polyethylene having a density 0.940 g/c to 0.970 g/cc and a melt index (I2) of 0.1 g/10 min to 20 g/10 min as measured according to ASTM D1238 (at 190°C, 2.16 kg), the polydimethylsiloxane has a number average molecular weight of 10,000 to 500,000 g/mol, preferably 100,000 to 500,000 g/mol, as measured by gel permeation chromatography.

[0060] Aspect 11. The composition of aspect 9 or 10 wherein the oil is selected from the group consisting of paraffinic oil, naphthenic oil, aromatic oil and combinations thereof.

[0061] Aspect 12. The composition of any one of aspects 9-11 wherein the inorganic filler is selected from calcium carbonate, sodium bentonite, calcium bentonite, aluminum trihydroxide, barium sulfate, calcium carbonate, calcium sulfate, magnesium carbonate, magnesium trihydroxide, diatomaceous earth, dolomite, glass beads, ceramic beads, kaolin, mica, perlite, natural silica, synthetic silica, wollastonite, calcite, whiskers, or combinations thereof.

[0062] Aspect 13. The composition of any one of aspects 9-12 having 0.1 to 10 % of the hard thermoplastic, 10 to 50% of the elastomeric polymer, 30-80% of the inorganic filler, 0.1 to 15% of the oil and 0.5-15% of the polydimethylsiloxane polymer based on total weight of the composition.

[0063] Aspect 14. The composition of any of aspects 9-13 having an abrasion resistance as determined by weight loss using test ISO4649 (Ed.2010) of less than 530 mg and a density greater than 1.1 g/cm³.

[0064] Aspect 15. A particulate filling material comprising the composition of any one of aspects 9-14, preferably having an average particle size of 1 to 5 mm.

What is claimed is:

1. An artificial turf comprising a substrate having a plurality of filiform formations extending from the substrate and a particulate filling material between the filiform formations wherein the particulate filling material comprises an elastomeric polymer, at least one of an inorganic filler or a hard thermoplastic, a siloxane polymer, and, optionally, an oil.
2. The artificial turf of claim 1 wherein the oil is used and is selected from the group consisting of paraffinic oil, naphthenic oil, aromatic oil and combinations thereof.
3. The artificial turf of any of the preceding claims wherein the particulate filler materials comprises the hard thermoplastic polymer which is selected from high density polyethylene and polypropylene.
4. The artificial turf of any of the preceding claims wherein the elastomeric polymer is selected from the group consisting of styrene-butadiene-styrene (SBS), styrene-ethylene-butadiene-styrene (SEBS), and ethylene/alpha-olefin resin having a density of less than 0.900 g/cc and a melt index (I2) of less than 15.0 g/10 min.
5. The artificial turf of any of the preceding claims wherein the siloxane is a polydimethylsiloxane having a number average molecular weight of 10,000 to 500,000 g/mol, preferably 100,000 to 500,000 g/mol, as measured by gel permeation chromatography.
6. The artificial turf of any of the preceding claims wherein the hard thermoplastic is a high density polyethylene having a density 0.940 g/c to 0.970 g/cc and a melt index (I2) of 0.1 g/10 min to 20 g/10 min as measured according to ASTM D1238 (at 190°C, 2.16 kg).
7. The artificial turf of any of the preceding claims wherein the inorganic filler is selected from calcium carbonate, sodium bentonite, calcium bentonite, aluminum trihydroxide, barium sulfate, calcium carbonate, calcium sulfate, magnesium carbonate, magnesium trihydroxide, diatomaceous earth, dolomite, glass beads, ceramic beads, kaolin, mica, perlite, natural silica, synthetic silica, wollastonite, calcite, whiskers, or combinations thereof.
8. The artificial turf of any one of claims 2-7 wherein the particulate filling material comprises 0.1 to 10 % of the hard thermoplastic, 10 to 50% of the elastomeric polymer, 30-80% of the inorganic filler, 0.1 to 15% of the oil and 0.5-15% of the siloxane based on total weight of the composition.
9. A composition useful in turf infill comprising an elastomeric polymer, at least one of an inorganic filler or a hard thermoplastic selected from high density polyethylene and polypropylene, a polydimethylsiloxane polymer, and an oil.

10. The composition of claim 9 wherein both the inorganic filler and the hard thermoplastic are present, the elastomeric polymer is selected from the group consisting of styrene-butadiene-styrene (SBS), styrene-ethylene-butadiene-styrene (SEBS), and ethylene/alpha-olefin resin having a density of less than 0.900 g/cc and a melt index (I2) of less than 15.0 g/10 min, the hard thermoplastic is a high density polyethylene having a density 0.940 g/c to 0.970 g/cc and a melt index (I2) of 0.1 g/10 min to 20 g/10 min as measured according to ASTM D1238 (at 190°C, 2.16 kg), the polydimethylsiloxane has a number average molecular weight of 10,000 to 500,000 g/mol, preferably 100,000 to 500,000 g/mol, as measured by gel permeation chromatography.

11. The composition of claim 9 or 10 wherein the oil is selected from the group consisting of paraffinic oil, naphthenic oil, aromatic oil and combinations thereof.

12. The composition of any one of claims 9-11 wherein the inorganic filler is selected from calcium carbonate, sodium bentonite, calcium bentonite, aluminum trihydroxide, barium sulfate, calcium carbonate, calcium sulfate, magnesium carbonate, magnesium trihydroxide, diatomaceous earth, dolomite, glass beads, ceramic beads, kaolin, mica, perlite, natural silica, synthetic silica, wollastonite, calcite, whiskers, or combinations thereof.

13. The composition of any one of claims 9-12 having 0.1 to 10 % of the hard thermoplastic, 10 to 50% of the elastomeric polymer, 30-80% of the inorganic filler, 0.1 to 15% of the oil and 0.5-15% of the polydimethylsiloxane polymer based on total weight of the composition.

14. The composition of any of claims 9-13 having an abrasion resistance as determined by weight loss using test ISO4649 (Ed.2010) of less than 530 mg and a density greater than 1.1 g/cm³.

15. A particulate filling material comprising the composition of any one of claims 9-14, preferably having an average particle size of 1 to 5 mm.

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2019/067365

A. CLASSIFICATION OF SUBJECT MATTER
 INV. C08L53/02
 ADD.

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 practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 105 295 284 A (DONGGUAN JISU PLASTIC TECHNOLOGY CO LTD) 3 February 2016 (2016-02-03) claims 1,2; examples 1-3 -----	1-15
Y	US 9 540 777 B1 (TETRAULT CHRISTOPHER [US]) 10 January 2017 (2017-01-10) column 5 -----	1-15
Y	EP 2 119 829 A2 (SUMITOMO RUBBER IND [JP]) 18 November 2009 (2009-11-18) paragraph [0054] -----	1-15
Y	WO 2009/086251 A1 (DOW GLOBAL TECHNOLOGIES INC [US]; PRIETO MIGUEL A [CH] ET AL.) 9 July 2009 (2009-07-09) paragraph [0100] -----	1-15



Further documents are listed in the continuation of Box C.



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 application or patent 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

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

5 March 2020

Date of mailing of the international search report

16/03/2020

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2019/067365

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☒ Claims Nos.: 9(partially)
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
see FURTHER INFORMATION sheet PCT/ISA/210
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☒ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2019/067365

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
CN 105295284	A	03-02-2016	NONE
US 9540777	B1	10-01-2017	US 9540777 B1 10-01-2017
		US 10081919 B1	25-09-2018
EP 2119829	A2	18-11-2009	CN 101581067 A 18-11-2009
		EP 2119829 A2	18-11-2009
		JP 4623749 B2	02-02-2011
		JP 2009275370 A	26-11-2009
		KR 20090118831 A	18-11-2009
		US 2009286017 A1	19-11-2009
WO 2009086251	A1	09-07-2009	AT 513003 T 15-07-2011
		BR PI0819478 A2	05-05-2015
		CN 101959942 A	26-01-2011
		EP 2231755 A1	29-09-2010
		KR 20100108574 A	07-10-2010
		US 2009172970 A1	09-07-2009
		WO 2009086251 A1	09-07-2009

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-15(partially)

A compound according to claim 1 or 9 comprising an inorganic filler.

2. claims: 1-15(partially)

A compound according to claim 1 or 9 comprising a hard thermoplastic.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box II.2

Claims Nos.: 9(partially)

Present independent claim 9 encompasses compounds defined only by their desired function, contrary to the requirement of clarity (Art. 6 PCT), because the "result-to-be-achieved" type of definition ("useful in turf infill") does not allow the scope of the claim to be ascertained. The fact that any compound could be screened does not overcome this objection, as the skilled person would not know beforehand whether it fell within the scope claimed, except for the compounds disclosed in the description. Undue experimentation would be required to screen all combinations of the broadly defined groups of compounds ("elastomeric polymer", "inorganic filler", "siloxane polymer") randomly.

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guidelines C-IV, 7.2), should the problems which led to the Article 17(2) declaration be overcome.