(54) **ARTIFICIAL TURF FILAMENTS, AND ARTICLES MADE THEREFROM**

(57)   An artificial turf filament comprising one or more ethylene/alpha-olefin copolymers having a density of from 0.900 to 0.955 g/cc and a melt index, I2, as measured in accordance with ASTM D1238 (at 190°C. and 2.16 kg), of from 0.1 g/10 min to 20 g/10 min; an ethoxylated alcohol having the formula, $R_1(OCH_2CH_2)_xOH$, where x is an integer from 2 to 10 and R1 is a straight or branched chain alkyl of 20 to 50 carbon atoms; and a chemical foaming agent.

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Description

FIELD

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[0001] Embodiments of the present disclosure generally relate to artificial turf filaments, articles incorporating artificial turf filaments, and their manufacture.

BACKGROUND

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[0002] Synthetic or artificial turfs are increasingly being used as an alternative to natural grass turf for use on sport athletic fields, playgrounds, landscaping, and in other leisure applications. Unlike natural grass turf, synthetic or artificial turfs can absorb heat from the sun. In hotter climates, this may cause the surface of synthetic or artificial turfs to become very warm and uncomfortable for players. A major contributor to heat generation are the components exposed to the sun, such as, the turf yarn and the infill.

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[0003] Watering of synthetic or artificial turfs has been used as a solution to decrease the surface temperature of synthetic or artificial turfs via evaporative cooling. The evaporation of the water from the surface of the synthetic or artificial turf yarns is endothermic and provides the cooling effect. However, many synthetic or artificial turf yarns are produced from nonpolar polymers, which have a low affinity to water. Limited evaporative cooling may occur due to lower amounts of water remaining on the surface of a synthetic or artificial turf yarn. In addition, the industry desires the
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use of less water for heat management of synthetic or artificial turfs.

[0004] Accordingly, alternative artificial turf filaments and/or artificial turfs having improved water retention is desired.

SUMMARY

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[0005] Disclosed in embodiments herein are artificial turf filaments. The artificial turf filaments comprise one or more ethylene/alpha-olefin copolymers having a density of from 0.900 to 0.955 g/cc and a melt index, I2, as measured in accordance with ASTM D1238 (at 190°C. and 2.16 kg), of from 0.1 g/10 min to 20 g/10 min; an ethoxylated alcohol having the formula, $R_1(OCH_2CH_2)_xOH$, where x is an integer from 2 to 10 and R1 is a straight or branched chain alkyl of 20 to 50 carbon atoms; and a chemical foaming agent. The artificial turf filaments may be manufactured by providing
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a formulation comprising one or more ethylene/alpha-olefin copolymers having a density of from 0.900 to 0.955 g/cc and a melt index, I2, as measured in accordance with ASTM D1238 (at 190°C. and 2.16 kg), of from 0.1 g/10 min to 20 g/10 min; an ethoxylated alcohol having the formula, $R_1(OCH_2CH_2)_xOH$, where x is an integer from 2 to 10 and R1 is a straight or branched chain alkyl of 20 to 50 carbon atoms; and a chemical foaming agent; and extruding the formulation to form an artificial turf filament.

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[0006] Disclosed in embodiments herein are artificial turf filaments. The artificial turf filaments comprising two or more layers, wherein at least one layer comprises one or more ethylene/alpha-olefin copolymers having a density of from 0.900 to 0.955 g/cc and a melt index, I2, as measured in accordance with ASTM D1238 (at 190°C. and 2.16 kg), of from 0.1 g/10 min to 20 g/10 min; an ethoxylated alcohol having the formula, $R_1(OCH_2CH_2)_xOH$, where x is an integer from 2 to 10 and R1 is a straight or branched chain alkyl of 20 to 50 carbon atoms; and a chemical foaming agent.

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[0007] Also disclosed in embodiments herein are artificial turfs. The artificial turfs comprise a primary backing having a top side and a bottom side; and at least one artificial turf filament as described herein; wherein the at least one artificial turf filament is affixed to the primary backing such that the at least one artificial turf filament provides a tufted face extending outwardly from the top side of the primary backing.

[0008] Additional features and advantages of the embodiments will be set forth in the detailed description which follows,
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and in part will be readily apparent to those skilled in the art from that description or recognized by practicing the embodiments described herein, including the detailed description which follows, the claims, as well as the appended drawings.

[0009] It is to be understood that both the foregoing and the following description describe various embodiments and are intended to provide an overview or framework for understanding the nature and character of the claimed subject
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matter. The accompanying drawings are included to provide a further understanding of the various embodiments, and are incorporated into and constitute a part of this specification. The drawings illustrate the various embodiments described herein, and together with the description serve to explain the principles and operations of the claimed subject matter.

BRIEF DESCRIPTION OF THE DRAWINGS

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[0010]

FIG. 1 pictorially depicts an exemplary monofilament extrusion line that may be used to produce the artificial turf

filaments according to one or more embodiments shown and described herein.

FIG. 2 pictorially depicts a cutaway view of an artificial turf according to one or more embodiments shown and described herein.

DETAILED DESCRIPTION

Artificial Turf Filaments

[0011] Reference will now be made in detail to embodiments of artificial turf filaments, artificial turfs incorporating artificial turf filaments, method of making artificial turf filaments and artificial turfs, films (monolayer or multilayer), and method of making films, characteristics of which are illustrated in the accompanying drawings. As used herein, "filament" refers to monofilaments, multifilaments having two or more layers, extruded films, fibers, yarns, such as, for example, tape yarns, fibrillated tape yarn, slit-film yarn, continuous ribbon, and/or other fibrous materials used to form synthetic grass blades or strands of an artificial turf field. The artificial turf filaments or films described herein comprise an ethylene/alpha-olefin copolymer, an ethoxylated alcohol, and a chemical foaming agent, each of which are further described herein. In some embodiments, the artificial turf filaments comprise two or more layers wherein at least one layer comprises an ethylene/alpha-olefin copolymer, an ethoxylated alcohol, and a chemical foaming agent, each of which are further described herein. In some embodiments, the films comprise two or more layers wherein at least one layer comprises an ethylene/alpha-olefin copolymer, an ethoxylated alcohol, and a chemical foaming agent, each of which are further described herein. The at least one layer may comprise between 50% and 90% of the overall structure.

Ethylene/Alpha-Olefin Copolymer

[0012] One or more ethylene/alpha-olefin copolymers may be present in the artificial turf filament or film. The one or more ethylene/alpha-olefin copolymers may be present in the artificial turf filament or film, or in the at least one layer of an artificial turf filament or film, in an amount of at least 50 wt.%. All individual values and subranges of at least 50 wt.% are included and disclosed herein. For example, in some embodiments, the artificial turf filament or film, or at least one layer of an artificial turf filament or film, comprises at least 75 wt.%, at least 80 wt.%, at least 85 wt.%, or at least 90 wt.% of the ethylene/alpha-olefin copolymer.

[0013] The ethylene/alpha-olefin copolymer comprises greater than or equal to 70 wt.% of the units derived from ethylene and less than or equal to 30 wt.% of the units derived from one or more alpha-olefin comonomers. In some embodiments, the ethylene/alpha-olefin copolymer comprises (a) greater than or equal to 75%, greater than or equal to 80%, greater than or equal to 85%, greater than or equal to 90%, greater than or equal to 92%, greater than or equal to 95%, greater than or equal to 97%, greater than or equal to 98%, greater than or equal to 99%, greater than or equal to 99.5%, from 70% to 99.5%, from 70% to 99%, from 70% to 97% from 70% to 94%, from 80% to 99.5%, from 80% to 99%, from 80% to 97%, from 80% to 94%, from 80% to 90%, from 85% to 99.5%, from 85% to 99%, from 85% to 97%, from 88% to 99.9%, 88% to 99.7%, from 88% to 99.5%, from 88% to 99%, from 88% to 98%, from 88% to 97%, from 88% to 95%, from 88% to 94%, from 90% to 99.9%, from 90% to 99.5% from 90% to 99%, from 90% to 97%, from 90% to 95%, from 93% to 99.9%, from 93% to 99.5% from 93% to 99%, or from 93% to 97%, by weight, of the units derived from ethylene; and (b) less than or equal to 25 percent, or less than or equal to 20 percent, less than or equal to 18%, less than or equal to 15%, less than or equal to 12%, less than or equal to 10%, less than or equal to 8%, less than or equal to 5%, less than or equal to 4%, less than or equal to 3%, less than or equal to 2%, less than or equal to 1%, from 0.1 to 20 %, from 0.1 to 15 %, 0.1 to 12%, 0.1 to 10%, 0.1 to 8%, 0.1 to 5%, 0.1 to 3%, 0.1 to 2%, 0.5 to 12%, 0.5 to 10%, 0.5 to 8%, 0.5 to 5%, 0.5 to 3%, 0.5 to 2.5%, 1 to 10%, 1 to 8%, 1 to 5%, 1 to 3%, 2 to 10%, 2 to 8%, 2 to 5%, 3.5 to 12%, 3.5 to 10%, 3.5 to 8%, 3.5% to 7%, or 4 to 12%, 4 to 10%, 4 to 8%, or 4 to 7%, by weight, of units derived from an alpha-olefin comonomer. The comonomer content may be measured using any suitable technique, such as techniques based on nuclear magnetic resonance ("NMR") spectroscopy, and, for example, by 13C NMR analysis as described in U.S. Patent 7,498,282, which is incorporated herein by reference.

[0014] Suitable alpha-olefin comonomers may include alpha-olefin comonomers having no more than 20 carbon atoms. The one or more alpha-olefins may be selected from the group consisting of C3-C20 acetylenically unsaturated monomers and C4-C18 diolefins. For example, the alpha-olefin comonomers may have 3 to 10 carbon atoms, or 3 to 8 carbon atoms. Exemplary alpha-olefin comonomers include, but are not limited to, propylene, 1-butene, 1-pentene, 1-hexene, 1-heptene, 1-octene, 1-nonene, 1-decene, and 4-methyl-1-pentene. The one or more alpha-olefin comonomers may, for example, be selected from the group consisting of propylene, 1-butene, 1-hexene, and 1-octene; or in the alternative, from the group consisting of 1-butene, 1-hexene and 1-octene. In some embodiments, the ethylene/alpha-olefin copolymer comprises greater than 0 wt.% and less than 30 wt.% of units derived from one or more of octene, hexene, or butene comonomers.

[0015] The ethylene/alpha-olefin copolymer may be made according to any suitable polymerization process, including but not limited to solution, slurry, or gas phase polymerization processes in the presence of a metallocene, constrained geometry catalyst systems, Ziegler-Natta catalysts, or bisphenyl phenol catalyst systems. The solution, slurry, or gas phase polymerization may occur in a single reactor, or alternatively, in a dual reactor system wherein the same product is produced in each of the dual reactors. Information on preparation and use of the multimetallic catalysts are found in U.S. Patent No. 9,255,160, the disclosure of which is incorporated herein by reference in its entirety.

[0016] Suitable polymers may include, for example, high density polyethylene (HDPE), linear low density polyethylene (LLDPE), ultra-low density polyethylene (ULDPE), homogeneously branched linear ethylene polymers, and homogeneously branched substantially linear ethylene polymers (that is, homogeneously branched long chain branched ethylene polymers). In some embodiments, the ethylene/alpha-olefin copolymer is an LLDPE. Commercial examples of suitable ethylene/alpha-olefin copolymers include those sold under the trade names ATTANE™, AFFINITY™, DOWLEX™, ELITE™, ELITE AT™, and INNATE™ all available from The Dow Chemical Company (Midland, MI); LUMICENE® available from Total SA; and EXCEED™ and EXACT™ available from Exxon Chemical Company.

[0017] In embodiments herein, the ethylene/alpha-olefin copolymer is characterized by a density of 0.900 g/cc to 0.955 g/cc. All individual values and subranges of at least 0.900 g/cc to 0.955 g/cc are included and disclosed herein. For example, in some embodiments, the ethylene/alpha-olefin copolymer is characterized by a density of 0.910 g/cc to 0.940 g/cc, 0.915 g/cc to 0.940 g/cc, 0.915 to 0.935 g/cc, 0.915 to 0.930 g/cc, 0.915 to 0.925 g/cc, 0.920 g/cc to 0.940 g/cc, 0.920 to 0.935 g/cc, or 0.920 to 0.930 g/cc. Density may be measured in accordance with ASTM D792.

[0018] In addition to density, the ethylene/alpha-olefin copolymer is characterized by melt index, I2, as measured in accordance with ASTM D1238 (at 190°C. and 2.16 kg), of from 0.1 g/10 min to 20 g/10 min. All individual values and subranges of at least 0.1 g/10 min to 20 g/10 min are included and disclosed herein. For example, in some embodiments, the ethylene/alpha-olefin copolymer is characterized by a melt index, I2, of 0.1 g/10 min to 10.0 g/10 min, 0.5 g/10 min to 10.0 g/10 min, 1.0 g/10 min to 10.0 g/10 min. In other embodiments, the ethylene/alpha-olefin copolymer is characterized by a melt index, I2, 1.0 g/10 min to 7.0 g/10 min, 1.0 g/10 min to 5.0 g/10 min, or 1.0 g/10 min to 4.0 g/10 min. Melt index, I2, is measured in accordance with ASTM D1238 (at 190°C. and 2.16 kg).

[0019] In addition to density and melt index, I2, the ethylene/alpha-olefin copolymer may be characterized by a melt flow ratio, I10/I2, of 6.0 to 10.0. All individual values and subranges of 6.0 to 10.0 are included and disclosed herein. For example, in some embodiments, the ethylene/alpha-olefin copolymer may be characterized by a melt flow ratio, I10/I2, of 6.5 to 9.0. In other embodiments, the ethylene/alpha-olefin copolymer may be characterized by a melt flow ratio, I10/I2, of 7.0 to 8.5. Melt index, I10, is measured in accordance with ASTM D1238 (190°C. and 10.0 kg).

[0020] In addition to density, melt index, I2, and melt flow ratio, I10/I2, the ethylene/alpha-olefin copolymer may be characterized by a molecular weight distribution (Mw/Mn) of from 1.9 to 6.0. All individual values and subranges of from 1.9 to 6.0 are included and disclosed herein. For example, the ethylene/alpha-olefin copolymer may be characterized by a molecular weight distribution (Mw/Mn) of from 2.0 to 4.5. In some embodiments, the ethylene/alpha-olefin copolymer may be characterized by a molecular weight distribution (Mw/Mn) of from 2.0 to 3.0 or from 3.0 to 4.3. The Mw/Mn ratio may be determined by conventional gel permeation chromatography (GPC) as outlined below.

Ethoxylated Alcohol

[0021] The ethoxylated alcohol may be present in the artificial turf filament or film, or in the at least one layer of an artificial turf filament or film, in an amount of from 0.05 wt.% to 10 wt.%. All individual values and subranges of from 0.05 wt.% to 10 wt.% are included and disclosed herein. For example, in some embodiments, the artificial turf filament or film, or at least one layer of an artificial turf filament or film, comprises from 0.05 wt.% to 7.5 wt.%, from 0.05 wt.% to 5.0 wt.%, or from 0.05 wt.% to 3.0 wt.% of the ethoxylated alcohol.

[0022] The ethoxylated alcohol has the formula, $R_1(OCH_2CH_2)_xOH$, where x is an integer from 2 to 10 and R_1 is a linear or branched alkyl group of 20 to 50 carbon atoms. The chain length of R_1 and the number (x) of monomer units of the hydrophilic oligomer may be discrete values, or alternatively, may be average values. In one embodiment, R_1 is a straight chain alkyl with an average of 30 carbon atoms and x has an average value of 2.5, and the ethoxylated alcohol may have the following formula: $CH_3CH_2(CH_2CH_2)_{13}CH_2CH_2(OCH_2CH_2)_{2.5}OH$. Examples of suitable ethoxylated alcohols that are commercially available may include Unithox™ ethoxylates, available from Baker Petrolite Corporation (Tulsa, Oklahoma). In embodiments described herein, the ethoxylated alcohol may also include mixtures of two or more compounds of the formula, $R_1(OCH_2CH_2)_xOH$, where x is an integer from 2 to 10 and R_1 is a straight or branched chain alkyl of 20 to 50 carbon atoms.

[0023] The ethoxylated alcohol may have a melting point, as determined according to ASTM D-127, of from 60 to 110°C. All individual values and subranges of from 60 to 110°C are included and disclosed herein. For example, in some embodiments, the ethoxylated alcohol may have a melting point, as determined according to ASTM D-127, of from 65 to 110°C, from 70 to 110°C, from 80 to 110°C, from 80 to 100°C, or from 85 to 95°C.

[0024] The ethoxylated alcohol may have a hydroxyl number, as determined according to ASTM E-222, of from 10 to

90 mg KOH/g sample. All individual values and subranges of from 10 to 90 mg KOH/g sample are included and disclosed herein. For example, in some embodiments, the ethoxylated alcohol may have a hydroxyl number, as determined according to ASTM E-222, of from 15 to 90 mg KOH/g sample, from 25 to 90 mg KOH/g sample, from 35 to 90 mg KOH/g sample, from 45 to 90 mg KOH/g sample, or from 60 to 90 mg KOH/g sample.

Chemical Foaming Agent

[0025] In embodiments herein, the artificial turf filaments or films further comprise chemical foaming agents. The chemical foaming agent may be present in the artificial turf filament or film, or in at least one layer of an artificial turf filament or film, in an amount of from 0.05 wt.% to 10 wt.%. All individual values and subranges of from 0.05 wt.% to 10 wt.% are included and disclosed herein. For example, in some embodiments, the artificial turf filament or film, or the at least one layer of an artificial turf filament or film, comprises from 0.05 wt.% to 7.5 wt.%, from 0.05 wt.% to 5.0 wt.%, or from 0.05 wt.% to 3.0 wt.% of the chemical foaming agent.

[0026] Suitable chemical foaming agents may include sodium bicarbonate, ammonium carbonate and ammonium hydrogen carbonate, citric acid or citrates, such as sodium citrate, sodium glutaminate, phthalic anhydride, benzoic acid, benzoates, such as aluminum benzoate, azodicarbonamide, azoisobutyronitrile and dinitropentamethylene. The use of chemical foaming agents is exemplified by the teachings to processes of making ethylenic polymer foam structures and processing them in Chapter 9 of the "Handbook of Polymeric Foams and Technology" entitled "Polyolefin Foam", written by C. P. Park, edited by D. Klempner and K. C. Frisch, Hanser Publishers, Munich, Vienna, New York Barcelona (1991), which is herein incorporated in reference. Examples of commercially available chemical foaming agents may be obtained from Bergan International under their FOAMAZOL™ brand name, Clariant under their HYDROCEROL™ brand name, or Lehmann&Voss&Co under their LUVOBATCH™ brand name.

[0027] In embodiments herein, the artificial turf filaments or films may further include one or more polyethylene resins. For example, the artificial turf filaments or films may, optionally, comprise an ultra-low or very low density polyethylene (ULDPE or VLDPE), a low density polyethylene (LDPE), a linear low density polyethylene (LLDPE), a medium density polyethylene (MDPE), a high density polyethylene (HDPE), or combinations thereof.

[0028] In embodiments herein, the artificial turf filaments or films may further include one or more optional additives. Nonlimiting examples of suitable additives include antioxidants, pigments, colorants, UV stabilizers, UV absorbers, curing agents, cross linking co-agents, boosters and retardants, processing aids, fillers, coupling agents, ultraviolet absorbers or stabilizers, antistatic agents, nucleating agents, slip agents, plasticizers, lubricants, viscosity control agents, tackifiers, anti-blocking agents, surfactants, extender oils, acid scavengers, and metal deactivators. Additives can be used in amounts ranging from less than about 0.01 wt % to more than about 10 wt % based on the weight of the composition.

Artificial Turf Filament Process

[0029] The artificial turf filaments described herein may be made using any appropriate process for the production of artificial turf filament from polymer compositions as the artificial turf filaments described herein are process independent. Referring to FIG. 1, the following describes one such exemplary process **100** that may be used.

[0030] Artificial turf filaments may be made by extrusion. Suitable artificial turf filament extruders may be equipped with a single PE/PP general purpose screw and a melt pump ("gear pump" or "melt pump") to precisely control the consistency of polymer volume flow into the die **105.** Artificial turf filament dies **105** may have multiple single holes for the individual filaments distributed over a circular or rectangular spinplate. The shape of the holes corresponds to the desired filament cross-section profile, including for example, diamond, rectangular, dog-bone, and v-shaped. A standard spinplate has 50 to 160 die holes of specific dimensions. Lines can have output rates from 150 kg/h to 350 kg/h.

[0031] The artificial turf filaments **110** may be extruded into a water bath **115** with a die-to-water bath distance of from 16 to 40 mm. Coated guiding bars in the water redirect the filaments **110** towards the first takeoff set of rollers **120.** The linear speed of this first takeoff set of rollers **120** may vary from 15 to 70 m/min. The first takeoff set of rollers **120** can be heated and used to preheat the filaments **110** after the waterbath **115** and before entering the stretching oven **125.** The stretching oven **125** may be a heated air or water bath oven. The filaments **110** may be stretched in the stretching oven **125** to a predetermined stretched ratio. In some embodiments, the stretch ratio is at least 4. In other embodiments, the stretch ratio is at least 4.5, 4.8, 5.0, 5.2, or 5.5. The stretching ratio is the ratio between the speed of the second takeoff set of rollers **130** after the stretching oven and the speed of the first takeoff set of rollers **120** before the stretching oven (V2/V1 as shown in FIG. 1). The second takeoff set of rollers **120** may be run at a different (higher or lower) speed than the first set of rollers **130.**

[0032] After the filaments **110** are passed over the second takeoff set of rollers **130,** they are then drawn through a set of three annealing ovens **135, 140,** and **145.** The three annealing ovens **135, 140,** and **145** may be either a hot air oven with co- or countercurrent hot air flow, which can be operated from 50 to 150°C or a hot water-oven, wherein the filaments **110** are oriented at temperatures from 50 to 98°C. At the exit of the first annealing oven **135,** the filaments **110**

are passed onto a third set of rollers **150** that may be run at a different (higher or lower) speed than the second set of rollers **130.** The linear velocity ratio of the third set of rollers **150** located after the oven to the second set of rollers **130** located in front of the oven may be referred to as either a stretching or relaxation ratio. At the exit of the second annealing oven **140,** the filaments **110** are passed onto a fourth set of rollers **155** that may be run at a different (higher or lower) speed than the third set of rollers **150.** At the exit of the third annealing oven **145,** the filaments **110** are passed onto a fifth set of rollers **160** that may be run at a different (higher or lower) speed than the fourth set of rollers **155.**

[0033] In some embodiments, a method of manufacturing an artificial turf filament comprises providing a formulation comprising of one or more ethylene/alpha-olefin copolymers as previously described herein, an ethoxylated alcohol as previously described herein, and a chemical foaming agent as previously described herein, and extruding the formulation into an artificial turf filament. The artificial turf filament may be extruded to a specified width, thickness, and/or cross-sectional shape depending on the physical dimensions of the extruder. As mentioned above, the artificial turf filament can include a monofilament, a multifilament, a film, a fiber, a yarn, such as, for example, tape yarn, fibrillated tape yarn, or slit-film yarn, a continuous ribbon, and/or other fibrous materials used to form synthetic grass blades or strands of an artificial turf field.

[0034] The artificial turf filament may optionally undergo further post-extrusion processing (e.g., annealing, cutting, etc.).

Artificial Turf

[0035] One or more embodiments of the artificial turf filaments described herein may be used to form an artificial turf field. Referring to FIG. 2, depicted is a cutaway view of an artificial turf field **200** according to one or more embodiments shown and/or described herein. The artificial turf field **200** comprises a primary backing **205** having a top side **210** and a bottom side **215;** and at least one artificial turf filament **220** as previously described herein. The at least one artificial turf filament **220** is affixed to the primary backing **205** such that the at least one artificial turf filament **220** provides a tufted face **225** extending outwardly from the top side **210** of the primary backing **205.** As used herein, "affix," "affixed," or "affixing" includes, but is not limited to, coupling, attaching, connecting, fastening, joining, linking or securing one object to another object through a direct or indirect relationship. The tufted face **225** extends from the top side **210** of the primary backing **205,** and can have a cut pile design, where the artificial turf filament loops may be cut, either during tufting or after, to produce a pile of single artificial turf filament ends instead of loops.

[0036] The primary backing **205** can include, but is not limited to, woven, knitted, or nonwoven fibrous webs or fabrics made of one or more natural or synthetic fibers or yarns, such as polypropylene, polyethylene, polyamides, polyesters, and rayon. The artificial turf field **200** may further comprise a secondary backing **230** bonded to at least a portion of the bottom side **215** of the primary backing **205** such that the at least one artificial turf filament **220** is affixed in place to the bottom side **215** of the primary backing **205.** The secondary backing **230** may comprise polyurethane (including, for example, polyurethane supplied under the name ENFORCER™ or ENHANCER™ available from The Dow Chemical Company) or latex-based materials, such as, styrene-butadiene latex, or acrylates.

[0037] The primary backing **205** and/or secondary backing **230** may have apertures through which moisture can pass. The apertures may be generally annular in configuration and are spread throughout the primary backing **205** and/or secondary backing **230.** Of course, it should be understood that there may be any number of apertures, and the size, shape and location of the apertures may vary depending on the desired features of the artificial turf field **200.**

[0038] The artificial turf field **200** may be manufactured by providing at least one artificial turf filament **220** as described herein and affixing the at least one artificial turf filament **220** to a primary backing **205** such that that at least one artificial turf filament **220** provides a tufted face **225** extending outwardly from a top side **210** of the primary backing **205.** The artificial turf field **200** may further be manufactured by bonding a secondary backing **230** to at least a portion of the bottom side **215** of the primary backing **205** such that the at least one artificial turf filament **220** is affixed in place to the bottom side **215** of the primary backing **205.**

[0039] The artificial turf field **200** may optionally comprise a shock absorption layer underneath the secondary backing of the artificial turf field. The shock absorption layer can be made from polyurethane, PVC foam plastic or polyurethane foam plastic, a rubber, a closed-cell crosslinked polyethylene foam, a polyurethane underpad having voids, elastomer foams of polyvinyl chloride, polyethylene, polyurethane, and polypropylene. Non- limiting examples of a shock absorption layer are DOW® ENFORCER™ Sport Polyurethane Systems, and DOW® ENHANCER™ Sport Polyurethane Systems.

[0040] The artificial turf field **200** may optionally comprise an infill material. Suitable infill materials include, but are not limited to, mixtures of granulated rubber particles like SBR (styrene butadiene rubber) recycled from car tires, EPDM (ethylene-propylene-diene monomer), other vulcanised rubbers or rubber recycled from belts, thermoplastic elastomers (TPEs) and thermoplastic vulcanizates (TPVs).

[0041] The artificial turf field **200** may optionally comprise a drainage system. The drainage system allows water to be removed from the artificial turf field and prevents the field from becoming saturated with water. Nonlimiting examples of drainage systems include stone-based drainage systems, EXCELDRAIN™ Sheet 100, EXCELDRAIN™ Sheet 200, AND EXCELDRAIN™ EX-T STRIP (available from American Wick Drain Corp., Monroe, N.C.).

[0042] The embodiments described herein may be further illustrated by the following non-limiting examples.

TEST METHODS

Density

[0043] Density is measured according to ASTM D792.

Melt Index

[0044] Melt index, or I2, is measured according to ASTM D1238 at 190°C, 2.16 kg. Melt index, or I10, is measured in accordance with ASTM D1238 at 190°C, 10 kg.

Conventional Gel Permeation Chromatography (GPC)

[0045] The gel permeation chromatographic system consists of either a Polymer Laboratories Model PL-210 or a Polymer Laboratories Model PL-220 instrument. The column and carousel compartments are operated at 140°C. Three Polymer Laboratories 10-micron Mixed-B columns are used. The solvent is 1,2,4-trichlorobenzene. The samples are prepared at a concentration of 0.1 grams of polymer in 50 milliliters of solvent containing 200 ppm of butylated hydroxytoluene (BHT). Samples are prepared by agitating lightly for 2 hours at 160° C. The injection volume used is 100 microliters and the flow rate is 1.0 ml/minute.

[0046] Calibration of the GPC column set is performed with 21 narrow molecular weight distribution polystyrene standards with molecular weights ranging from 580 to 8,400,000, arranged in 6 "cocktail" mixtures with at least a decade of separation between individual molecular weights. The standards are purchased from Polymer Laboratories (Shropshire, UK). The polystyrene standards are prepared at 0.025 grams in 50 milliliters of solvent for molecular weights equal to or greater than 1,000,000, and 0.05 grams in 50 milliliters of solvent for molecular weights less than 1,000,000. The polystyrene standards are dissolved at 80°C. with gentle agitation for 30 minutes. The narrow standards mixtures are run first and in order of decreasing highest molecular weight component to minimize degradation. The polystyrene standard peak molecular weights are converted to polyethylene molecular weights using the following equation (as described in Williams and Ward, J. Polym. Sci., Polym. Let., 6, 621 (1968)): $M_{polyethylene}=0.4316 \times (M_{polystyrene})$. Polyethylene equivalent molecular weight calculations are performed using Viscotek TriSEC software Version 3.0.

[0047] Number-, weight- and z-average molecular weights are calculated according to the following equations:

$$M_n = \frac{\sum^i Wf_i}{\sum^i \left(Wf_i \middle/ M_i \right)}$$

$$M_w = \frac{\sum^i \left(Wf_i * M_i \right)}{\sum^i Wf_i}$$

$$M_z = \frac{\sum^i \left(Wf_i * M_i^2 \right)}{\sum^i Wf_i * M_i}$$

wherein Mn is the number average molecular weight, Mw, is the weight average molecular weight, Mz is the z-average molecular weight, Wf_i is the weight fraction of the molecules with a molecular weight of M_i.

Water Capture and Water Retention

[0048] Drying rate test method was performed in Sartorius Moisture Analyzer MA100, based on an adaptation of the standard work instruction PORTAR-FIBER 89.00. Film samples were cut into discs of 5 cm diameter and submerged in distilled water for at least 15 minutes (no difference in water adsorption was observed when watering for 15 minutes and overnight). Subsequently, specimens were held in air for 30 seconds and then they were introduced in an infrared heating oven with a weighing device for 12 minutes. The heating program was defined as a constant temperature of 80°C. Weight loss, due to water evaporation, was recorded during the 12 minutes. Performance is evaluated through the following parameters:

[0049] *Water Adsorption*. It reflects the amount of water that the film is able to capture, which should correlate to the amount of water present in the pitch just after watering. The index is weighted per gram of polymer, as shown in Equation 1, since samples are slightly different in weight. The calculation takes into account the weight of water after watering for 15 minutes (difference between the total weight at the beginning of the drying test, i.e. t=0, and the dry weight) and the polymer dry weight.

$$Equation\ 1:\ Water\ Adsorption = \frac{W_{t=0\ min} - W_{dry}}{W_{dry}}\ (\frac{mg\ water}{g\ polymer})$$

[0050] *Evaporation Rate.* It shows the speed at which the water is released when exposed to a temperature of 80°C into the oven. As shown in Equation 2, it is defined as an average moisture loss (in percentage) during the test (from t=0 to t=12 minutes).

$$Equation\ 2:\ Evaporation\ Rate = \frac{\frac{W_{t=0\ min} - W_{t=12\ min}}{W_{t=0\ min} - W_{dry}}}{12\ min}\ x\ 100\%\ (\frac{\%\ water\ lost}{min})$$

[0051] *Residual Water.* It is a parameter reflecting the combination of amount of water captured and rate of evaporation. It is defined as the amount of water (in percentage relative to the total amount of water captured at the watering step) that is present in the film after the test (t=12 min), as shown in Equation 3. The technology that captures more water and loses it slower will have the more residual moisture after the test.

$$Equation\ 3:\ Residual\ Water = \frac{W_{t=12\ min} - W_{dry}}{W_{t=0\ min} - W_{dry}}\ x\ 100\%\ (\%\ adsorbed\ water)$$

Mechanical Evaluation

[0052] Elmendorf tear strength is measured in the machine direction (MD) and the cross direction (CD) according to ASTM D1922. Elongation at break in the tensile strength test is measured in the machine direction (MD) and the cross direction (CD) according to ISO 527-3.

EXAMPLES

Materials Used

[0053] The ethylene alpha-olefin copolymer is DOWLEX™ 2107 GC, available from The Dow Chemical Company (Midland, MI) having a density of 0.917 g/cc, a melt index, I2, of 2.3 g/10 min, an I10/I2 of 8.1, and a Mw/Mn of 3.7. The ethoxylated alcohol is UNTTHOX™ 420, available from Baker Hughes Inc. (Houston, TX), having a melting point of 91°C and a Hydroxyl Number of 85 mg KOH/g sample. The chemical foaming agent is LUVOBATCH™ PE BA 9537, available from Lehmann&Voss&Co. (Hamburg, Germany).

Table 1 - Film Formulations

	Formulation	Structure
Comparative Example 1 (CE1)	DOWLEX™ 2107 GC	Monolayer
Comparative Example 2 (CE2)	DOWLEX™ 2107 GC + 1% UNITHOX™ 420	Monolayer
Comparative Example 3 (CE3)	DOWLEX™ 2107 GC + 2% UNITHOX™ 420	Monolayer
Inventive Example 1 (IE1)	DOWLEX™ 2107 GC + 2% UNITHOX™ 420 + 1 % LUVOBATCH™ PE BA 9537	Monolayer
Inventive Example 2 (IE2)	A: DOWLEX™ 2107 GC B: DOWLEX™ 2107 GC + 2% UNITHOX™ 420 + 1 % LUVOBATCH™ PE BA 9537	A/B/A Multilayer Film 10%/80%/10%

[0054]   Multilayer film (IE2) was fabricated using the film formulations in Table 1 on a Dr. Collins GmbH cast extrusion line equipped with six extruders. Monolayer films were fabricated using the film formulation in Table 1 on a Dr. Collin GmbH cast extrusion line equipped with one extruder. UNITHOX™ 420 was pre-compounded (melt blending) with DOWLEX™ 2107 GC on a Buss Compounder line. The processing temperature was set at around 200 to 260°C with melt temperature at around 240°C. The extrudate was cooled by chilling rolls set at 30°C. The final film thickness is 200 micrometers. Additional processing parameters are shown in Tables 2 & 3 below.

Table 2 - Process Conditions for Monolayer Films

		CE1	CE2	CE3	IE1
Compounding	Kneader Speed (rpm)		85	80	80
Compounding	Motor Current (A)		3	3	3
Compounding	Output Rate (Kg/h)		9	9	9
Compounding	Screw Speed (rpm)		115	115	115
Compounding	Thermocouple K1 (°C)		120	120	120
Compounding	Thermocouple K2 (°C)		130	130	130
Compounding	Thermocouple K3 (°C)		140	140	140
Compounding	Thermocouple K5 (°C)		120	120	120
Compounding	Thermpcouple K4 (°C)		135	135	135
Extrusion Cast	Die gap (mm)	1	1	1	1
Extrusion Cast	Line Speed (m/min)	2.1	2	2	2.1
Extrusion Cast	Melt Pressure (bar)	54	54	56	53
Extrusion Cast	Melt Temperature (°C)	212	213	208	222
Extrusion Cast	Motor Current (A)	8	7.9	8	7.5
Extrusion Cast	Output Rate (Kg/h)	5	5	5	5
Extrusion Cast	Screw Speed (rpm)	50	50	50	50
Extrusion Cast	Thickness (μm)	200	200	200	200

Table 3 - Process Conditions for Multilayer Films

	Units	IE2
Amps - Extruder A (Ext. A)	A	1.8

(continued)

	Units	IE2
Amps - Extruder B (Ext. B)	A	0
Amps - Extruder C (Ext. C)	A	6.2
Amps - Extruder D (Ext. D)	A	1.5
Amps - Extruder E (Ext. E)	A	0
Corona Treatment	dyne/cm	0
Die gap	mm	0.8
Layer Percentage - Ext. A	%	10
Layer Percentage - Ext. B	%	0
Layer Percentage - Ext. C	%	80
Layer Percentage - Ext. D	%	10
Layer Percentage - Ext. E	%	0
Melt Pressure - Ext. A	bar	83
Melt Pressure - Ext. B	bar	0
Melt Pressure - Ext. C	bar	231
Melt Pressure - Ext. D	bar	79
Melt Pressure - Ext. E	bar	0
Melt Temperature - Ext. A	°C	184
Melt Temperature - Ext. B	°C	0
Melt Temperature - Ext. C	°C	229
Melt Temperature - Ext. D	°C	184
Melt Temperature - Ext. E	°C	0
RPM - Ext. A	rpm	25
RPM - Ext. B	rpm	0
RPM - Ext. C	rpm	98
RPM - Ext. D	rpm	25
RPM - Ext. E	rpm	90
Structure	-	A/B/A
Take-off speed	m/min	3.9
Total Output	kg/h	11
Total Thickness	μm	200

Table 4 - Film Results

	Water Adsorption (mg water/g polymer)	Evaporation Rate (% water lost/min)	Residual Water (% adsorbed water)	Elmendorf MD Tear Strength (g)	Elmendorf CD Tear Strength (g)	MD Elongation at Break (%)	CD Elongation at Break (%)
CE1	43	9.0	0.5	3930	4140	731	692
CE2	176	-	-	-	-	-	-

(continued)

	Water Adsorption (mg water/g polymer)	Evaporation Rate (% water lost/min)	Residual Water (% adsorbed water)	Elmendorf MD Tear Strength (g)	Elmendorf CD Tear Strength (g)	MD Elongation at Break (%)	CD Elongation at Break (%)
CE3	308	7.3	16.6	3890	3990	773	696
IE1	329	5.5	34.4	768	4450	533	83
IE2	171	6.0	31.0	3900	4220	708	660

[0055] As shown in Table 4, the inventive film (IE1) shows higher water adsorption and lower evaporation rate. As a result, the residual water in IE1 was significantly higher than the comparative examples. Inventive film IE2 showed improved mechanical performance while maintaining the hydrophilic properties.

[0056] The dimensions and values disclosed herein are not to be understood as being strictly limited to the exact numerical values recited. Instead, unless otherwise specified, each such dimension is intended to mean both the recited value and a functionally equivalent range surrounding that value. For example, a dimension disclosed as "40 mm" is intended to mean "about 40 mm."

[0057] Every document cited herein, if any, including any cross- referenced or related patent or application and any patent application or patent to which this application claims priority or benefit thereof, is hereby incorporated herein by reference in its entirety unless expressly excluded or otherwise limited. The citation of any document is not an admission that it is prior art with respect to any invention disclosed or claimed herein or that it alone, or in any combination with any other reference or references, teaches, suggests or discloses any such invention. Further, to the extent that any meaning or definition of a term in this document conflicts with any meaning or definition of the same term in a document incorporated by reference, the meaning or definition assigned to that term in this document shall govern.

[0058] While particular embodiments of the present invention have been illustrated and described, it would be obvious to those skilled in the art that various other changes and modifications can be made without departing from the spirit and scope of the invention. It is therefore intended to cover in the appended claims all such changes and modifications that are within the scope of this invention.

Claims

1. An artificial turf filament comprising:

   one or more ethylene/alpha-olefin copolymers having a density of from 0.900 to 0.955 g/cc and a melt index, I2, as measured in accordance with ASTM D1238 (at 190°C. and 2.16 kg), of from 0.1 g/10 min to 20 g/10 min;
   an ethoxylated alcohol having the formula, $R_1(OCH_2CH_2)_xOH$, where x is an integer from 2 to 10 and R1 is a straight or branched chain alkyl of 20 to 50 carbon atoms; and
   a chemical foaming agent.

2. The filament of claim 1, wherein the filament comprises at least 75 wt.% of the one or more ethylene/alpha-olefin copolymers.

3. The filament of claims 1 or 2, wherein the filament comprises from 0.05 wt.% to 10 wt.% of the ethoxylated alcohol.

4. The filament of claims 1-3, wherein the ethoxylated alcohol is an ethoxylated aliphatic alcohol.

5. The filament of claims 1-4, wherein the filament comprises from 0.05 wt.% to 10 wt.% of the foaming agent.

6. An artificial turf filament comprising two or more layers, wherein at least one layer comprises:

   one or more ethylene/alpha-olefin copolymers having a density of from 0.900 to 0.955 g/cc and a melt index from 0.1 g/10 min to 20 g/10 min;
   an ethoxylated alcohol having the formula, R1(OCH2CH2)xOH, where x is an integer from 2 to 10 and R1 is a straight or branched chain alkyl of 20 to 50 carbon atoms; and
   a chemical foaming agent.

7. The filament of claim 6, wherein the filament comprises at least 75 wt.% of the one or more ethylene/alpha-olefin copolymers.

8. The filament of claims 6 or 7, wherein the filament comprises from 0.05 wt.% to 10 wt.% of the ethoxylated alcohol.

9. The filament of claims 6-8, wherein the ethoxylated alcohol is an ethoxylated aliphatic alcohol.

10. The filament of claims 6-9, wherein the filament comprises from 0.05 wt.% to 10 wt.% of the foaming agent.

11. An artificial turf comprising:

a primary backing having a top side and a bottom side; and
at least one artificial turf filament according to claim 1 or 6;
wherein the at least one artificial turf filament is affixed to the primary backing such that the at least one artificial turf filament provides a tufted face extending outwardly from the top side of the primary backing.

12. The artificial turf of claim 11, wherein the artificial turf field further comprises a secondary backing bonded to at least a portion of the bottom side of the primary backing such that the at least one artificial turf filament is affixed in place to the bottom side of the primary backing.
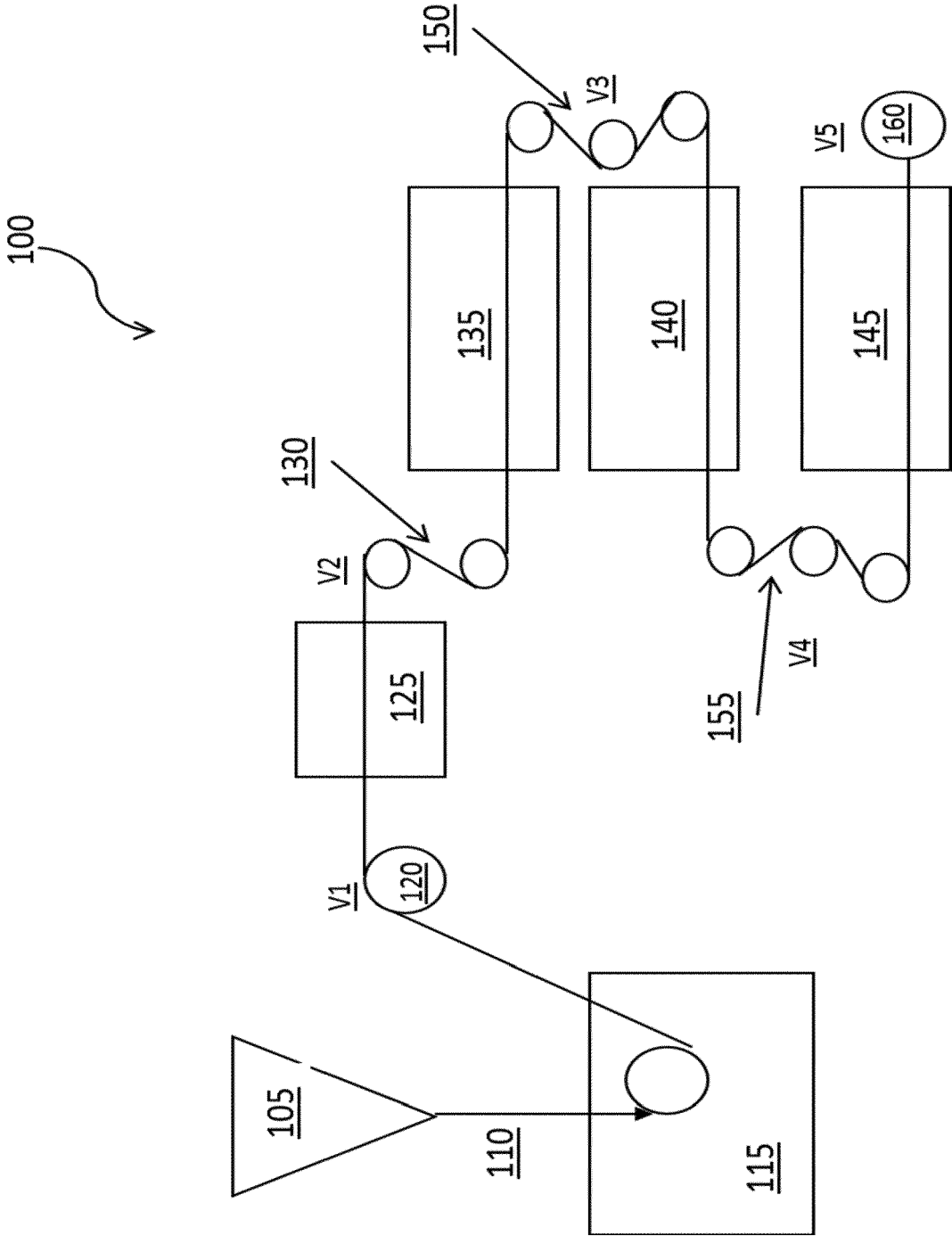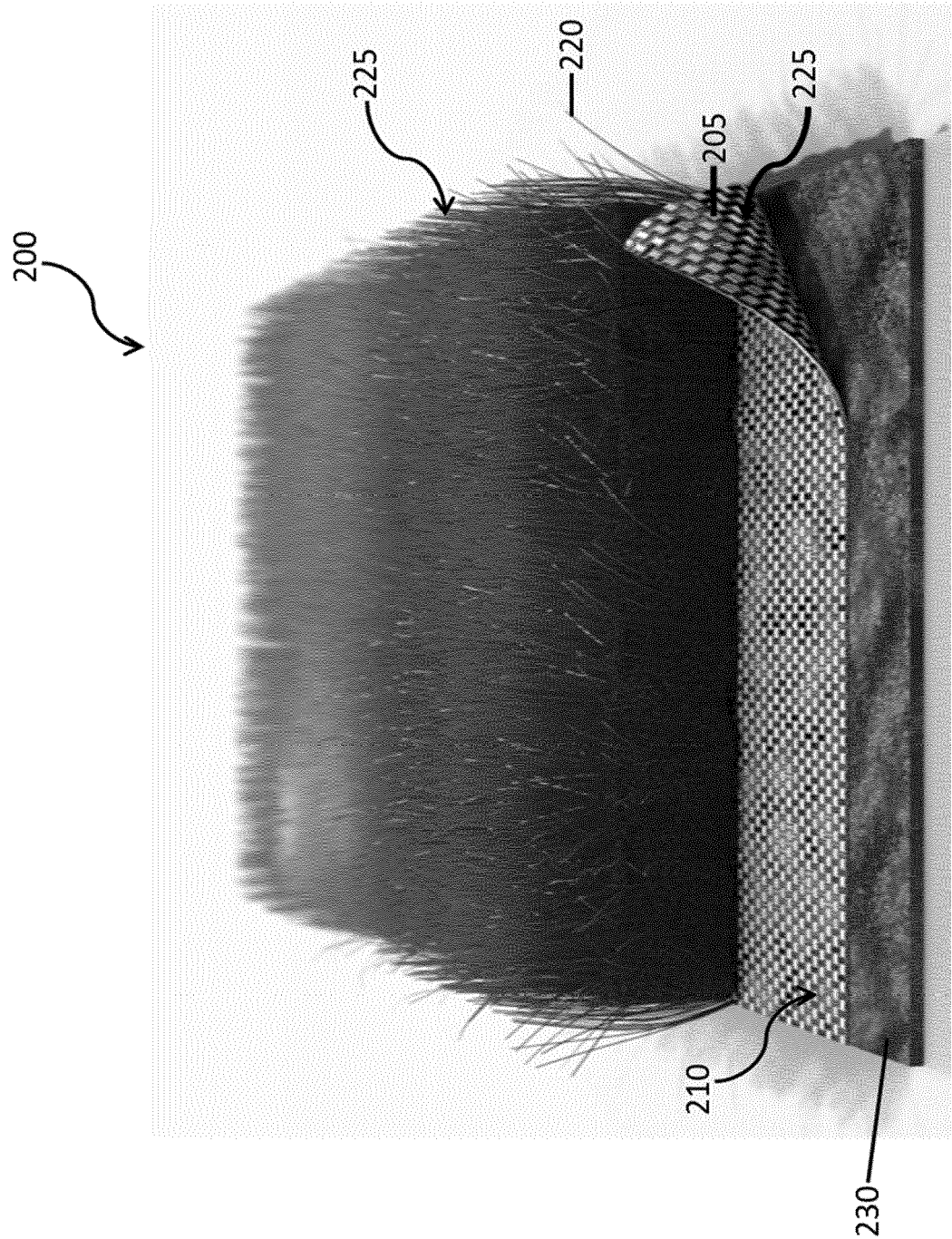
FIG. 1

FIG. 2

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EUROPEAN SEARCH REPORT

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	13 October 2017	Van Beurden-Hopkins

EPO FORM 1503 03.82 (P04C01)

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