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(54) **THERMOPLASTIC ROOFING MEMBRANES FOR FULLY-ADHERED ROOFING SYSTEMS**

THERMOPLASTISCHE DACHHÄUTE FÜR VOLLSTÄNDIG VERKLEBTE DACHSYSTEME

MEMBRANES DE TOITURE THERMOPLASTIQUES POUR SYSTÈMES DE TOITURE À
ADHÉRENCE TOTALE

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to fully-adhered roofing systems comprising thermoplastic roofing membranes; the overall membranes are characterized by an advantageously low stiffness. One or more layers of the membranes include an ethylene-based olefinic block copolymer.

BACKGROUND OF THE INVENTION

[0002] Thermoplastic roofing membranes, especially those membranes engineered to cover flat or low-sloped roofs, are known in the art. Many of these membranes are engineered to meet the industry standards defined in ASTM D790. Among the performance requirements provided in this industry standard, thermoplastic roofing membranes must meet threshold requirements for tensile strength and tear strength. Tensile strength is an indicator of seam strength, and the seam strength must withstand wind uplift forces. Tear strength is primarily important from the standpoint of fastener pull through. That is, where the membrane is mechanically attached to the roof surface, the membrane must be able to withstand threshold wind uplift forces without tear at the location of the fastener.

[0003] Many commercially-available thermoplastic roofing membranes include fabric-reinforced thermoplastic sheets. These membranes are fabricated by sandwiching a reinforcing fabric between two extruded thermoplastic sheets to provide a laminated structure. The thermoplastic extruded sheets, which can be the same or different, often include ethylene-propylene reactor copolymers (e.g. CA10A available from Lyondell-basell), together with various additives, such as inert filler, anti-weathering additives, and flame retardants. As the skilled person appreciates, the type and amount of additives employed, such as the filler, can impact the mechanical properties of the membrane including tensile and tear strength.

[0004] While industry standards for thermoplastic roofing membranes are designed with an eye toward mechanically-attached thermoplastic roofing systems, fully-adhered systems also exist. In fact, fully-adhered systems are often viewed as superior roof systems. As the skilled person appreciates, a fully-adhered system is installed by using an adhesive that attaches the membrane to the roof surface, where the adhesive substantially contacts the entire membrane surface adjacent to the roof deck. In practice, liquid bond adhesives or pressure-sensitive adhesives that are factory applied to the membrane are often used.

[0005] A problem encountered when installing fully-adhered thermoplastic roofing sheets relates to the stiffness of the roofing sheet. As the skilled person appreciates, the integrity of a fully-adhered system can hinge on the

degree to which the overall surface of the membrane is adhered. Where areas or pockets exist that are not adhered, the system can fail wind uplift tests. This is particularly true where the membrane is not fully adhered over uneven surfaces in the roof, such as fastening plates that are often used to secure underlying insulation boards. The skilled person understands that the stiffness of the sheet creates problems when attempting to evenly apply the sheet over the roof surface, especially uneven substrates. A goal often sought is the ability to view the underlying contours of the roof surface through the membrane, which is indicative of complete adhesion to the roof. Where the membrane is too stiff, the membrane will not contour to the underlying surface. A term often used in the art is telegraphing, which refers to the ability of the sheet to contour to the substrate and thereby allow the presence of the substrate to be noticed with the sheet in place.

[0006] WO 2014/105809 A1 describes a process for producing a thermoplastic polyolefin roofing membrane. The process includes directly adding components of a high-load flame retardant TPO formulation to a counter-rotating twin screw extruder. The process includes extruding the formulation with counter-rotation of the twin screws and forming a TPO roofing membrane having a tensile strength of greater than 10 MPa and a flame retardance of rating of classification D as measured in accordance with EN ISO 1 1925-2, surface exposure test.

[0007] US 5,437,923 A describes a halogen-free flame-retardant bitumen composition with improved performance characteristics. The flame-retardant bitumen composition contains at least 45 weight percent bitumen, about 2 to 25 weight percent thermoplastic polymer, and about 15 to 35 weight percent of a mixture of flame-retardant compounds. The mixture of flame-retardant compounds comprises alumina trihydrate and/or magnesium hydroxide, at least 2 weight percent zinc borate, and, optionally, about 2 to 20 weight percent calcium carbonate of the final flame-retardant bitumen composition.

[0008] WO 2014/001224 A1 relates to a polymer blend comprising propylene-based elastomer and random copolymer polypropylene. The document describes a composition comprising as the polymer base around 40 to 75% w/w of at least one polypropylene-based elastomer and around 25 to 60% w/w of at least one random copolymer polypropylene.

SUMMARY OF THE INVENTION

[0009] The invention provides the roof system defined in claim 1. Preferred embodiments are defined in the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

Fig. 1 is a perspective view of a single-extrudate

membrane useful in the present invention.

Fig. 2 is a perspective view of a laminate membrane useful in the present invention.

Fig. 3 is a perspective view of laminate membrane useful in the present invention.

Fig. 4 is a cross-sectional view of a fully-adhered roofing system according to embodiments of the present invention.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0011] Embodiments of the present invention are based, at least in part, on the discovery of thermoplastic roofing membranes that can advantageously be used for fully-adhered roofing systems. The membranes of one or more embodiments include ethylene-based olefinic block copolymers as defined in claim 1. These membranes are characterized by a relatively low stiffness, which allows the membranes to be installed using fully-adhered attachment techniques while overcoming installation problems associated with stiffness. While the relatively low stiffness can provide a corresponding loss in certain mechanical properties, it has unexpectedly been discovered that the overall balance of properties is sufficient to provide technologically useful fully-adhered systems. For example, while low stiffness may be associated with a corresponding loss in fastener pull-through strength or resistance, the fact that the membrane systems are fully adhered diminishes the deleterious impact caused by this loss in property.

MEMBRANE CONSTRUCTION

[0012] Membranes used in the roof system of one or more embodiments of the present invention can be described with reference to Fig. 1. In this embodiment, the membrane includes planar body 11, which also may be referred to as sheet 11 or panel 11. In one or more embodiments, panel 11 is a planar body that consists of a single extrudate. In one or more embodiments, planar body 11 may be compositionally homogeneous or, in other embodiments, planar body 11 may include one or more compositionally distinct layers 13 and 15. For example, compositionally distinct layers 13 and 15 may be formed through coextrusion techniques, and reference may therefore be made to coextruded layers 13 and 15, or first coextruded layer 13 and second coextruded layer 15.

[0013] In other embodiments, the membranes used in the roof system of one or more embodiments of the present invention may include two or more laminated layers. For example, as shown in Fig. 2, membrane 21 may include first layer 23 and second layer 25, which are laminated to one another, optionally with a reinforcing scrim 27 disposed between laminated layers 23 and 25. First

layer 23 and second layer 25 may be compositionally similar with respect to one another. Or, in other embodiments, the layers may be compositionally distinct. Additionally, layers 23 and 25 may, within themselves, be compositionally homogeneous or, in other embodiments, they may be nonhomogeneous. For example, first layer 23, second layer 25, or both layers 23 and 25, may include compositionally distinct coextruded layers. As shown in Fig. 3, first layer 23 may include compositionally distinct coextruded layers 31 and 33, and second layer 25 may include compositionally distinct coextruded layers 35 and 37.

[0014] As suggested above, one or more layers of the membranes used in this invention include ethylene-based olefinic block copolymers. With reference to Fig. 3, these one or more layers may include upper middle layer 33, as well as lower middle layer 35 and bottom layer 37. In these or other embodiments, top layer 31 may also include ethylene-based olefinic block copolymer. In certain embodiments, top layer 31 includes a propylene-based olefinic polymer such as thermoplastic polyolefin or a propylene-based elastomer. Additionally, in certain embodiments, bottom layer 37 includes a functionalized thermoplastic resin. In one or more embodiments, top layer 31 includes flame retardants and other weathering additives that provide sufficient environmental protection to the polymers, while at least one of layers 33, 35, and 37 may include fillers such as mineral fillers.

MEMBRANE CHARACTERISTICS

[0015] As discussed above, the membranes employed in the practice of this invention are advantageously characterized by a relatively high flexibility and low stiffness. This relatively high flexibility and low stiffness can be quantified through one or more physical properties of the membranes used in this invention. For example, in one or more embodiments, storage modulus, as may be measured using dynamic mechanical analysis (DMA) may be indicative of high flexibility and low stiffness. According to embodiments of the present invention, storage modulus can be determined by using, for example, a TA Instrument Q800 DMA instrument coupled with a GCA cooling unit and the use of liquid nitrogen. A rectangular specimen of about 18.5 mm in length, 5.3 mm in width, and 1.4 mm in thickness is used and can be prepared by using a 5.3 mm film cutter (TA Instrument part number 984486.901). The specimen is loaded onto a thin film clamp using a 3 pound-force inch torque. A multi-frequency strain mode can be used for all experiments. The parameters should be customized to a 1Hz single frequency and the amplitude kept at 10 μ m. The specimen should be equilibrated at -90 °C, and then ramped to 70 °C at a 2 °C/minute heating rate. In view of the fabric scrim, samples can be run in duplicates for the machine direction and cross direction.

[0016] The membranes used in the roof system of the present invention are characterized by a storage modu-

lus, as determined by DMA as described herein, in the machine direction at 0 °C of less than 450 MPa, in other embodiments less than 425 MPa, in other embodiments less than 400 MPa, in other embodiments less than 375 MPa, in other embodiments less than 350 MPa, and in other embodiments less than 325 MPa. In these or other embodiments, the membranes used in one or more embodiments of the present invention are characterized by a storage modulus, as determined by DMA as described herein, in the machine direction at 0 °C, of from about 100 to about 450 MPa, in other embodiments from about 110 to about 400 MPa, and in other embodiments from about 125 to about 350 MPa.

[0017] In one or more embodiments, the membranes used in one or more embodiments of the present invention are characterized by a storage modulus, as determined by DMA as described herein, in the machine direction at -20 °C of less than 850 MPa, in other embodiments less than 800 MPa, in other embodiments less than 750 MPa, in other embodiments less than 725 MPa, in other embodiments less than 700 MPa, and in other embodiments less than 675 MPa. In these or other embodiments, the membranes used in one or more embodiments of the present invention are characterized by a storage modulus, as determined by DMA as described herein, in the machine direction at -20 °C, of from about 400 to about 850 MPa, in other embodiments from about 450 to about 800 MPa, and in other embodiments from about 500 to about 750 MPa.

[0018] In one or more embodiments, the membranes may be characterized by a flexural modulus, as determined by ASTM D790, of less than 90 MPa, in other embodiments less than 80 MPa, in other embodiments less than 70 MPa, in other embodiments less than 60 MPa, in other embodiments less than 50 MPa, in other embodiments less than 40 MPa, and in other embodiments less than 30 MPa. In these or other embodiments, the membranes may be characterized by a flexural modulus of from about 5 to about 90 MPa, in other embodiments from about 10 to about 80 MPa, and in other embodiments from about 20 to about 70 MPa.

[0019] In one or more embodiments, the membranes employed in the practice of this invention are advantageously characterized by a relatively Shore hardness (e.g. low Shore A or Shore D). In one or more embodiments, the membranes may be characterized by a Shore D hardness, as determined by ASTM D2240, of less than 40, in other embodiments less than 30, and in other embodiments less than 20. In these or other embodiments, the membranes may be characterized by a hardness of from about 70 Shore A to about 40 Shore D, in other embodiments from about 80 Shore A to about 30 Shore D, and in other embodiments from about 90 Shore A to about 20 Shore D.

MEMBRANE COMPOSITION

[0020] In one or more embodiments, the advanta-

geously low stiffness is attributable to the polymeric composition of one or more layers of the membrane. The polymeric composition of one or more layers includes ethylene-based olefinic block copolymer. More specifically, the polymeric composition of one or more layers of the membrane includes a blend of a first ethylene-based olefinic block copolymer (first EBOC), which is characterized by a relatively low melt flow rate as defined in claim 1, and a second ethylene-based olefinic block copolymer (second EBOC), which is characterized by a relatively high melt flow rate as defined in claim 1. In one or more embodiments, the one or more layers of the membrane including the blend of the first EBOC and the second EBOC also include yet another distinct thermoplastic resin.

ETHYLENE-BASED OLEFINIC BLOCK COPOLYMER

[0021] In general, the ethylene-based olefinic block copolymers include block copolymers including a first plurality of ethylene- α -olefin blocks having low α -olefin content and a second plurality of ethylene- α -olefin blocks having a high α -olefin content. For purposes of this specification, the α -olefin may be referred to as a comonomer. Also, for purposes of this specification, the first plurality may be referred to as the hard blocks since these blocks are characterized by a relatively high melt temperature, and the second plurality of blocks may be referred to as the soft blocks since these block are characterized by a low glass transition temperature. In one or more embodiments, the hard blocks are crystallizable and the soft blocks are amorphous. In one or more embodiments, the α -olefin includes C₄ or higher α -olefins. In particular embodiments, the α -olefin is selected from butane, hexene, and octene. In particular embodiments, the α -olefin is octene.

[0022] In one or more embodiments, the ethylene-based olefinic block copolymer includes hard and soft blocks alternating in (AB)_n pattern where A is a hard block, B is a soft block, and _n is an integer greater than 1 including 2, 3, 4, 5, 10, 20, 40, 60, 80, 100, or higher.

[0023] As suggested above, the hard blocks, which may also be referred to as hard segments, have a relatively low comonomer content (i.e., α -olefin). In one or more embodiments, the comonomer content (i.e., comonomer in polymerized form) of the hard block is less than 5 wt. %, in other embodiments less than 2 wt. %, and in other embodiments less than 1 wt. %, with the balance of the polymeric units deriving from ethylene. Accordingly, the hard segments may include greater than 95 wt. %, in other embodiments greater than 98 wt. %, and in other embodiments greater than 99 wt. % polymeric units deriving from ethylene. In particular embodiments, the hard segments exclusively include or substantially include ethylene-derived units.

[0024] The soft block, which may also be referred to as soft segments, have a relatively high comonomer content (i.e., α -olefin). In one or more embodiments, the

comonomer content (i.e., comonomer in polymerized form) of the soft block is greater than 5 wt. %, in other embodiments greater than 8 wt. %, in other embodiments greater than 10 wt. %, in other embodiments greater than 15 wt. %, in other embodiments greater than 25 wt. %, in other embodiments greater than 35 wt. %, in other embodiments greater than 45 wt. %, and in other embodiments greater than 60 wt. %, with the balance including ethylene-derived units.

[0025] In one or more embodiments, the ethylene-based olefinic block copolymers employed in the present invention are characterized by a density of less than 0.9 g/cm³, in other embodiments less than 0.89 g/cm³, in other embodiments less than 0.885 g/cm³, and in other embodiments less than 0.875 g/cm³. In these or other embodiments, the density of the ethylene-based olefinic block copolymers is greater than 0.85 g/cm³ and in other embodiments greater than 0.86 g/cm³. As the skilled person appreciates, density can be determined according to ASTM D-792.

[0026] In one or more embodiments, the ethylene-based olefinic block copolymers employed in the present invention are characterized by a melt temperature, as measured by differential scanning calorimetry as described in U.S. Publ No. 2006/0199930, of at least 105, in other embodiments at least 110, in other embodiments at least 115, and in other embodiments at least 120 °C. In these or other embodiments, the ethylene-based olefinic block copolymers are characterized by a melt temperature of less than 130 and in other embodiments less than 125 °C.

[0027] The first EBOC, which is characterized by a relatively low melt index, has a melt index, as determined by ASTM D1238 or ISO 1133 (2.16 kg load at 190 °C), of less than 5 g/10 min, in other embodiments less than 2 g/10 min, and in other embodiments less than 1 g/10 min. In these or other embodiments, the melt index of the first EBOC is from about 0.1 to about 5 g/10 min, in other embodiments from about 0.3 to about 2 g/10 min, and in other embodiments from about 0.5 to about 1 g/10 min.

[0028] The second EBOC, which is characterized by a relatively high melt index, as determined by ASTM D1238 or ISO 1133 (2.16 kg load at 190 °C), has a melt index of greater than 5 g/10 min, in other embodiments greater than 15 g/10 min, and in other embodiments greater than 25 g/10 min. In these or other embodiments, the melt index of the second EBOC is from about 5 to about 50 g/10 min, in other embodiments from about 15 to about 40 g/10 min, and in other embodiments from about 25 to about 35 g/10 min.

[0029] In one or more embodiments, the ethylene-based olefinic block copolymers employed in the present invention are characterized by a glass transition temperature, as measured by differential scanning calorimetry, of at less than 0 °C, in other embodiments less than -20 °C, in other embodiments less than -30 °C, in other embodiments less than -40 °C, and in other embodiments

less than -50 °C. In these or other embodiments, the ethylene-based olefinic block copolymers are characterized by a glass transition temperature of from about -70 °C to 0 °C, or in other embodiments from about -50 °C to about 0 °C.

[0030] Useful ethylene-based olefinic block copolymers that may be employed in the present invention are known in the art as described in U.S. Patent No. 7,893,166 and 7,355,089 and U.S. Publ. No. 2010/0084158. Useful ethylene-based olefinic block copolymers are commercially available under the trade-name INFUSE (Dow Chemical Company) including those specific polymers available under the tradenames 9010 and 9900.

DISTINCT THERMOPLASTIC RESINS

[0031] As suggested above, the one or more layers of the thermoplastic membranes used in the present invention that include the ethylene-based olefinic block copolymer may also include a distinct thermoplastic resin, which is a thermoplastic resin other than the ethylene-based olefinic block copolymer. Also, the other optional layers of the thermoplastic membranes used in this invention that may not include ethylene-based olefinic block copolymer may include one or more non-ethylene-based olefinic block copolymers. In one or more embodiments, the non-ethylene-based olefinic block copolymers (i.e., distinct thermoplastic resins) may include thermoplastic polyolefins of the type conventionally employed in the manufacture of thermoplastic membranes. In these or other embodiments, the non-ethylene-based olefinic block copolymers may include low density polyethylene. In yet other embodiments, the non-ethylene-based olefinic block copolymers may include propylene-based elastomers.

THERMOPLASTIC POLYOLEFINS (TPOS)

[0032] In one or more embodiments, the thermoplastic olefinic polymer (TPO) employed in one or more embodiments may include an olefinic reactor copolymer, which may also be referred to as in-reactor copolymer. Reactor copolymers are generally known in the art and may include blends of olefinic polymers that result from the polymerization of ethylene and α -olefins (e.g., propylene) with sundry catalyst systems. In one or more embodiments, these blends are made by in-reactor sequential polymerization. Reactor copolymers useful in one or more embodiments include those disclosed in U.S. Patent No. 6,451,897. Reactor copolymers, which are also referred to as TPO resins, are commercially available under the tradenames HIFAX™ or Adflex™ (Lyondell-bassel); these materials are believed to include in-reactor blends of ethylene-propylene rubber and polypropylene or polypropylene copolymers. Other useful thermoplastic olefins include those available under the tradename T00G-00 (Ineos). In one or more embodiments, the in-

reactor copolymers may be physically blended with other polyolefins. For example, in reactor copolymers may be blended with linear low density polyethylene.

[0033] In other embodiments, the thermoplastic component may include a physical blend of chemically-distinct olefinic polymers. In one or more embodiments, blends of propylene-based thermoplastic polymer, elastomer, and/or low density polyethylene may be used. Useful blends include those described in International Application No. PCT/US06/033522. In other embodiments, the thermoplastic olefinic component is a blend of a linear low density polyethylene and a propylene-based plastic.

LOW-DENSITY POLYETHYLENE

[0034] In one or more embodiments, the low density polyethylene includes an ethylene- α -olefin copolymer. In one or more embodiments, the low density polyethylene includes linear low density polyethylene. The linear low density polyethylene employed in one or more embodiments of this invention may be similar to that described in U.S. Patent No. 5,266,392. This copolymer may include from about 2.5 to about 13 mole percent, and in other embodiments from about 3.5 to about 10 mole percent, *mer* units deriving from α -olefins, with the balance including *mer* units deriving from ethylene. The α -olefin included in the linear low density polyethylene may include butene-1, pentene-1, hexene-1, octene-1, or 4-methylpentene-1. In one or more embodiments, the linear low density polyethylene is devoid or substantially devoid of propylene *mer* units (*i.e.*, units deriving from propylene). Substantially devoid refers to that amount or less of propylene *mer* units that would otherwise have an appreciable impact on the copolymer or the compositions of this invention if present.

[0035] The linear low density polyethylene employed in one or more embodiments of this invention can be characterized by a density of from about 0.885 g/cc to about 0.930 g/cc, in other embodiments from about 0.900 g/cc to about 0.920 g/cc, and in other embodiments from about 0.900 g/cc to about 0.910 g/cc per ASTM D-792.

[0036] In one or more embodiments, the linear low density polyethylene may be characterized by a melt index of from about 0.2 to about 50 dg/min, in other embodiments from about 0.4 to about 20 dg/min, and in other embodiments from about 0.6 to about 10 dg/min per ASTM D1238 or ISO 1133 at 190°C and 2.16 kg load.

[0037] The linear low density polyethylene employed in one or more embodiments of this invention may be prepared by using a convention Ziegler Natta coordination catalyst system.

[0038] Useful linear low density polyethylene includes those that are commercially available. For example, linear low density polyethylene can be obtained under the tradename Dowlex™ 2038, 2045, and 2267G (Dow); under the tradename DFDA-1010 NT7 (Dow); or under the tradename GA502023 (Lyondell); or under the trade-

name LLDPE LL (ExxonMobil).

PROPYLENE-BASED ELASTOMERS

[0039] In one or more embodiments, useful propylene-based elastomers include propylene-based elastomers that have isotactic propylene sequences long enough to crystallize. In this regard, reference is made to U.S. Pat. No. 6,927,258, and U.S. Publ. Nos. 2004/0198912 and 2010/0197844. In one or more embodiments, the propylene-based elastomer is propylene/ α -olefin copolymer with semi-crystalline isotactic propylene segments. The α -olefin content (e.g. polymerized ethylene content) may range from about 5 to about 18%, or in other embodiments from about 10 to about 15%.

[0040] In one or more embodiments, the propylene-based elastomer is characterized by a melting point that is less than 110 °C and a heat of fusion of less than 75 J/g. In one embodiment, the propylene based elastomers of the present invention have a glass transition temperature (*T_g*) range of about -25 to -35 °C. The *T_g* as used herein is the temperature above which a polymer becomes soft and pliable, and below which it becomes hard and glassy. The propylene based elastomers and elastomers used in the present invention have a MFR range measured at 230 °C of between about 0.5 to about 25, and a melt temperature range of about 50 to 120 °C. In one embodiment, the propylene based elastomers of the present invention have a shore A hardness range of about 60 to about 90.

[0041] In one or more embodiments, the propylene-based elastomer is blended with a propylene-based thermoplastic resin, which may include a crystalline resin. In particular embodiments, the propylene-based thermoplastic resin is characterized by a melting point that is greater than 110 °C, in other embodiments greater than 120 °C, and in other embodiments greater than 130 °C, and a heat of fusion greater than 75 J/g, in other embodiments greater than 80 J/g, and in other embodiments greater than 85 J/g. In one or more embodiments, the propylene-based thermoplastic resin is stereoregular polypropylene. In one or more embodiments, the ratio of the propylene-based elastomer to the propylene-based thermoplastic resin within the blend composition may vary in the range of 1:99 to 95:5 by weight and, in particular, in the range 2:98 to 70:30 by weight.

[0042] In one embodiment, the propylene-based elastomers may have a flexural modulus range of about 500 to about 6000 psi, preferably about 1500-5000 psi.

FUNCTIONALIZED THERMOPLASTIC RESIN

[0043] As suggested above, one or more layers of the membranes used in the present invention may include a functionalized thermoplastic resin. In one or more embodiments, the functionalized polymer is a thermoplastic polymer that includes at least one functional group. The functional group, which may also be referred to as a func-

tional substituent or functional moiety, includes a hetero atom. In one or more embodiments, the functional group includes a polar group. Examples of polar groups include hydroxy, carbonyl, ether, ester halide, amine, imine, nitrile, oxirane (e.g., epoxy ring) or isocyanate groups. Exemplary groups containing a carbonyl moiety include carboxylic acid, anhydride, ketone, acid halide, ester, amide, or imide groups, and derivatives thereof. In one embodiment, the functional group includes a succinic anhydride group, or the corresponding acid, which may derive from a reaction (e.g., polymerization or grafting reaction) with maleic anhydride, or a β -alkyl substituted propanoic acid group or derivative thereof. In one or more embodiments, the functional group is pendant to the backbone of the hydrocarbon polymer. In these or other embodiments, the functional group may include an ester group. In specific embodiments, the ester group is a glycidyl group, which is an ester of glycidol and a carboxylic acid. A specific example is a glycidyl methacrylate group.

[0044] In one or more embodiments, the functionalized thermoplastic polymer may be prepared by grafting a graft monomer to a thermoplastic polymer. The process of grafting may include combining, contacting, or reacting a thermoplastic polymer with a graft monomer. These functionalized thermoplastic polymers include those described in U.S. Patent Nos. 4,957,968, 5624,999, and 6,503,984.

[0045] The thermoplastic polymer that can be grafted with the graft monomer may include solid, generally high molecular weight plastic materials. These plastics include crystalline and semi-crystalline polymers. In one or more embodiments, these thermoplastic polymers may be characterized by a crystallinity of at least 20%, in other embodiments at least 25%, and in other embodiments at least 30%. Crystallinity may be determined by dividing the heat of fusion of a sample by the heat of fusion of a 100% crystalline polymer, which is assumed to be 209 joules/gram for polypropylene or 350 joules/gram for polyethylene. Heat of fusion can be determined by differential scanning calorimetry. In these or other embodiments, the thermoplastic polymers to be functionalized may be characterized by having a heat of fusion of at least 40 J/g, in other embodiments in excess of 50 J/g, in other embodiments in excess of 75 J/g, in other embodiments in excess of 95 J/g, and in other embodiments in excess of 100 J/g.

[0046] In one or more embodiments, the thermoplastic polymers, prior to grafting, may be characterized by a weight average molecular weight (M_w) of from about 100 kg/mole to about 2,000 kg/mole, and in other embodiments from about 300 kg/mole to about 600 kg/mole. They may also be characterized by a number-average molecular weight (M_n) of about 80 kg/mole to about 800 kg/mole, and in other embodiments about 90 kg/mole to about 200 kg/mole. Molecular weight may be determined by size exclusion chromatography (SEC) by using a Waters 150 gel permeation chromatograph equipped with the differential refractive index detector and calibrated

using polystyrene standards.

[0047] In one or more embodiments, these thermoplastic polymer, prior to grafting, may be characterized by a melt flow of from about 0.3 to about 2,000 dg/min, in other embodiments from about 0.5 to about 1,000 dg/min, and in other embodiments from about 1 to about 1,000 dg/min, per ASTM D-1238 at 230°C and 2.16 kg load.

[0048] In one or more embodiments, these thermoplastic resins, prior to grafting, may have a melt temperature (T_m) that is from about 110°C to about 250°C, in other embodiments from about 120 to about 170°C, and in other embodiments from about 130°C to about 165°C. In one or more embodiments, they may have a crystallization temperature (T_c) of these optionally at least about 75°C, in other embodiments at least about 95°C, in other embodiments at least about 100°C, and in other embodiments at least 105°C, with one embodiment ranging from 105° to 115°C.

[0049] Exemplary thermoplastic polymers that may be grafted include polyolefins, polyolefin copolymers, and non-olefin thermoplastic polymers. Polyolefins may include those thermoplastic polymers that are formed by polymerizing ethylene or α -olefins such as propylene, 1-butene, 1-hexene, 1-octene, 2-methyl-1-propene, 3-methyl-1-pentene, 4-methyl-1-pentene, 5-methyl-1-hexene, and mixtures thereof. Copolymers of ethylene and propylene and ethylene and/or propylene with another α -olefin such as 1-butene, 1-hexene, 1-octene, 2-methyl-1-propene, 3-methyl-1-pentene, 4-methyl-1-pentene, 5-methyl-1-hexene or mixtures thereof is also contemplated. Other polyolefin copolymers may include copolymers of olefins with styrene such as styrene-ethylene copolymer or polymers of olefins with α,β -unsaturated acids, α,β -unsaturated esters such as polyethylene-acrylate copolymers. Non-olefin thermoplastic polymers may include polymers and copolymers of styrene, α,β -unsaturated acids, α,β -unsaturated esters, and mixtures thereof. For example, polystyrene, polyacrylate, and polymethacrylate may be functionalized.

[0050] These homopolymers and copolymers may be synthesized by using an appropriate polymerization technique known in the art. These techniques may include conventional Ziegler-Natta, type polymerizations, catalysis employing single-site organometallic catalysts including, but not limited to, metallocene catalysts, and high-pressure free radical polymerizations.

[0051] The degree of functionalization of the functionalized thermoplastic polymer may be recited in terms of the weight percent of the pendant functional moiety based on the total weight of the functionalized polymer. In one or more embodiments, the functionalized thermoplastic polymer may include at least 0.2% by weight, in other embodiments at least 0.4% by weight, in other embodiments at least 0.6% by weight, and in other embodiments at least 1.0 weight percent functionalization, in these or other embodiments, the functionalized thermoplastic polymers may include less than 10% by weight,

in other embodiments less than 5% by weight, in other embodiments less than 3% by weight, and in other embodiments less than 2% by weight functionalization.

[0052] In one or more embodiments, where the functionalized thermoplastic polymer is a functionalized propylene-based polymer, it can be characterized by a melt flow rate of from about 20 to about 2,000 dg/min, in other embodiments from about 100 to about 1,500 dg/min, and in other embodiments from about 150 to about 750 dg/min, per ASTM D-1238 at 230°C and 2.16 kg load. In one or more embodiments, where the functionalized thermoplastic polymer is a functionalized ethylene-based polymer, it can be characterized by a melt flow index of from about 0.2 to about 2,000 dg/min, in other embodiments from about 1 to about 1,000 dg/min, and in other embodiments from about 5 to about 100 dg/min, per ASTM D-1238 at 190°C and 2.16 kg load.

[0053] Functionalized thermoplastic polymers are commercially available. For example, maleated propylene-based polymers may be obtained under the trade-name FUSABOND™ (DuPont), POLYBOND™ (Crompton), and EXXELOR™ (ExxonMobil). Another example includes polymers or oligomers including one or more glycidyl methacrylate groups such as Lotader™ AX8950 (Arkema).

MINERAL FILLER

[0054] In one or more embodiments, the fillers, which may also be referred to as mineral fillers, include inorganic materials that may aid in reinforcement, heat aging resistance, green strength performance, and/or flame resistance. In other embodiments, these materials are generally inert with respect to the composition therefore simply act as diluent to the polymeric constituents. In one or more embodiments, mineral fillers include clays, silicates, titanium dioxide, talc (magnesium silicate), mica (mixtures of sodium and potassium aluminum silicate), alumina trihydrate, antimony trioxide, calcium carbonate, titanium dioxide, silica, magnesium hydroxide, calcium borate ore, and mixtures thereof. In one or more embodiments, the fillers are not surface modified or surface functionalized.

[0055] Suitable clays may include airfloated clays, water-washed clays, calcined clays, surface-treated clays, chemically-modified clays, and mixtures thereof.

[0056] Suitable silicates may include synthetic amorphous calcium silicates, precipitated, amorphous sodium aluminosilicates, and mixtures thereof.

[0057] Suitable silica (silicon dioxide) may include wet-processed, hydrated silicas, crystalline silicas, and amorphous silicas (noncrystalline).

[0058] In one or more embodiments, the mineral fillers are characterized by an average particle size of at least 1 μm, in other embodiments at least 2 μm, in other embodiments at least 3 μm, in other embodiments at least 4 μm, and in other embodiments at least 5 μm. In these or other embodiments, the mineral fillers are character-

ized by an average particle size of less than 15 μm, in other embodiments less than 12 μm, in other embodiments less than 10 μm, and in other embodiments less than 8 μm. In these or other embodiments, the mineral filler has an average particle size of between 1 and 15 μm, in other embodiments between 3 and 12 μm, and in other embodiments between 6 and 10 μm.

OTHER INGREDIENTS

[0059] The thermoplastic membranes used in the present invention (e.g., one or more layers of the membranes) may also include other ingredients such as those that are convention in thermoplastic membranes. For example, other useful additives or constituents may include flame retardants, stabilizers, pigments, and fillers.

[0060] In one or more embodiments, useful flame retardants include and compound that will increase the burn resistivity, particularly flame spread such as tested by UL 94 and/or UL 790, of the laminates of the present invention. Useful flame retardants include those that operate by forming a char-layer across the surface of a specimen when exposed to a flame. Other flame retardants include those that operate by releasing water upon thermal decomposition of the flame retardant compound. Useful flame retardants may also be categorized as halogenated flame retardants or non-halogenated flame retardants.

[0061] Exemplary non-halogenated flame retardants include magnesium hydroxide, aluminum trihydrate, zinc borate, ammonium polyphosphate, melamine polyphosphate, and antimony oxide (Sb₂O₃). Magnesium hydroxide (Mg(OH)₂) is commercially available under the trade-name Vertex™ 60, ammonium polyphosphate is commercially available under the tradename Exolite™ AP 760 (Clarian), which is sold together as a polyol masterbatch, melamine polyphosphate is available under the tradename Budit™ 3141 (Budenheim), and antimony oxide (Sb₂O₃) is commercially available under the trade-name Fireshield™. Those flame retardants from the foregoing list that are believed to operate by forming a char layer include ammonium polyphosphate and melamine polyphosphate.

[0062] In one or more embodiments, treated or functionalized magnesium hydroxide may be employed. For example, magnesium oxide treated with or reacted with a carboxylic acid or anhydride may be employed. In one embodiment, the magnesium hydroxide may be treated or reacted with stearic acid. In other embodiments, the magnesium hydroxide may be treated with or reacted with certain silicon-containing compounds. The silicon-containing compounds may include silanes, polysiloxanes including silane reactive groups. In other embodiments, the magnesium hydroxide may be treated with maleic anhydride. Treated magnesium hydroxide is commercially available. For example, Zerogen™ 50.

[0063] Examples of halogenated flame retardants may include halogenated organic species or hydrocarbons

such as hexabromocyclododecane or N,N'-ethylene-bis-(tetrabromophthalimide). Hexabromocyclododecane is commercially available under the tradename CD-75P™ (ChemTura). N,N'-ethylene-bis-(tetrabromophthalimide) is commercially available under the tradename Saytex™ BT-93 (Albemarle).

[0064] In one or more embodiments, the use of char-forming flame retardants (e.g. ammonium polyphosphate and melamine polyphosphate) has unexpectedly shown advantageous results when used in conjunction with nanoclay within the cap layer of the laminates of the present invention. It is believed that there may be a synergistic effect when these compounds are present in the cap layer. As a result, the cap layer of the laminates used in the certain embodiments of the present invention are devoid of or substantially devoid of halogenated flame retardants and/or flame retardants that release water upon thermal decomposition. Substantially devoid referring to that amount or less that does not have an appreciable impact on the laminates, the cap layer, and/or the burn resistivity of the laminates.

[0065] In one or more embodiments, the membranes used in the invention may include a stabilizers. Stabilizers may include one or more of a UV stabilizer, an antioxidant, and an antiozonant. UV stabilizers include Tinuvin™ 622. Antioxidants include Irganox™ 1010.

[0066] In one or more embodiments, one or more layers of the membranes used in the present invention may include expandable graphite, which may also be referred to as expandable flake graphite, intumescent flake graphite, or expandable flake. Generally, expandable graphite includes intercalated graphite in which an intercallant material is included between the graphite layers of graphite crystal or particle. Examples of intercallant materials include halogens, alkali metals, sulfates, nitrates, various organic acids, aluminum chlorides, ferric chlorides, other metal halides, arsenic sulfides, and thallium sulfides. In certain embodiments of the present invention, the expandable graphite includes non-halogenated intercallant materials. In certain embodiments, the expandable graphite includes sulfate intercallants, also referred to as graphite bisulfate. As is known in the art, bisulfate intercalation is achieved by treating highly crystalline natural flake graphite with a mixture of sulfuric acid and other oxidizing agents which act to catalyze the sulfate intercalation. Expandable graphite useful in the applications of the present invention are generally known as described in International Publ. No. WO/2014/078760.

[0067] Commercially available examples of expandable graphite include HPMS Expandable Graphite (HP Materials Solutions, Inc., Woodland Hills, CA) and Expandable Graphite Grades 1721 (Asbury Carbons, Asbury, NJ). Other commercial grades contemplated as useful in the present invention include 1722, 3393, 3577, 3626, and 1722HT (Asbury Carbons, Asbury, NJ).

[0068] In one or more embodiments, the expandable graphite may be characterized as having a mean or average size in the range from about 30 μm to about 1.5

mm, in other embodiments from about 50 μm to about 1.0 mm, and in other embodiments from about 180 to about 850 μm . In certain embodiments, the expandable graphite may be characterized as having a mean or average size of at least 30 μm , in other embodiments at least 44 μm , in other embodiments at least 180 μm , and in other embodiments at least 300 μm . In one or more embodiments, expandable graphite may be characterized as having a mean or average size of at most 1.5 mm, in other embodiments at most 1.0 mm, in other embodiments at most 850 μm , in other embodiments at most 600 μm , in yet other embodiments at most 500 μm , and in still other embodiments at most 400 μm . Useful expandable graphite includes Graphite Grade #1721 (Asbury Carbons), which has a nominal size of greater than 300 μm .

[0069] In one or more embodiments, the expandable graphite may be characterized as having a nominal particle size of 20x50 (US sieve). US sieve 20 has an opening equivalent to 0.841 mm and US sieve 50 has an opening equivalent to 0.297 mm. Therefore, a nominal particle size of 20x50 indicates the graphite particles are at least 0.297 mm and at most 0.841 mm.

[0070] In one or more embodiments, the expandable graphite may be characterized by an onset temperature ranging from about 100 °C to about 250 °C; in other embodiments from about 160 °C to about 225 °C; and in other embodiments from about 180 °C to about 200 °C. In one or more embodiments, the expandable graphite may be characterized by an onset temperature of at least 100 °C, in other embodiments at least 130 °C, in other embodiments at least 160 °C, and in other embodiments at least 180 °C. In one or more embodiments, the expandable graphite may be characterized by an onset temperature of at most 250 °C, in other embodiments at most 225 °C, and in other embodiments at most 200 °C. Onset temperature may also be interchangeably referred to as expansion temperature; and may also be referred to as the temperature at which expansion of the graphite starts.

[0071] In one or more embodiments, one or more layers of the membranes used in the present invention include a nanoclay. Nanoclays include the smectite clays, which may also be referred to as layered silicate minerals. Useful clays are generally known as described in U.S. Pat. No. 6,414,070 and U.S. Pat. Publ. No. 2009/0269565. In one or more embodiments, these clays include exchangeable cations that can be treated with organic swelling agents such as organic ammonium ions, to intercalate the organic molecules between adjacent planar silicate layers, thereby substantially increasing the interlayer spacing. The expansion of the interlayer distance of the layered silicate can facilitate the intercalation of the clay with other materials. The interlayer spacing of the silicates can be further increased by formation of the polymerized monomer chains between the silicate layers. The intercalated silicate platelets act as a nanoscale (sub-micron size) filler for the polymer.

[0072] Intercalation of the silicate layers in the clay can take place either by cation exchange or by absorption. For intercalation by absorption, dipolar functional organic molecules such as nitrile, carboxylic acid, hydroxy, and pyrrolidone groups are desirably present on the clay surface. Intercalation by absorption can take place when either acid or non-acid clays are used as the starting material. Cation exchange can take place if an ionic clay containing ions such as, for example, Na⁺, K⁺, Ca⁺⁺, Ba⁺⁺, and Li⁺ is used. Ionic clays can also absorb dipolar organic molecules.

[0073] Smectite clays include, for example, montmorillonite, saponite, beidellite, hectorite, and stevensite. In one or more embodiments, the space between silicate layers may be from about 15 to about 40 Å, and in other embodiments from about 17 to about 36 Å, as measured by small angle X-ray scattering. Typically, a clay with exchangeable cations such as sodium, calcium and lithium ions may be used. Montmorillonite in the sodium exchanged form is employed in one or more embodiments

[0074] Organic swelling agents that can be used to treat the clay include quaternary ammonium compound, excluding pyridinium ion, such as, for example, poly(propylene glycol)bis(2-aminopropyl ether), poly(vinylpyrrolidone), dodecylamine hydrochloride, octadecylamine hydrochloride, and dodecylpyrrolidone. These treated clays are commercially available. One or more of these swelling agents can be used.

AMOUNTS

[0075] In one or more embodiments, the ethylene-based olefinic block copolymer may form the entire thermoplastic component of the given layer in which the ethylene-based olefinic block copolymer is present. As suggested above, in other embodiments, the ethylene-based olefinic block copolymer is present in conjunction with a distinct and/or complementary thermoplastic polymer within the given layer in which the ethylene-based olefinic block copolymer is present.

[0076] The layer in which the ethylene-based olefinic block copolymer is present includes at least 60% by weight ethylene-based olefinic block copolymer based upon the total weight of the ethylene-based olefinic block copolymer and any complementary thermoplastic material. In these or other embodiments, the layer in which the ethylene-based olefinic block copolymer is present includes at most 100, in other embodiments at most 80% by weight ethylene-based olefinic block copolymer based upon the total weight of the ethylene-based olefinic block copolymer and any complementary thermoplastic material.

[0077] In one or more embodiments, one or more layers of the membranes used in the present invention may include at least 5 weight %, in other embodiments at least 20 weight %, and in other embodiments at least 30 weight % of the filler (e.g. mineral filler) based on the entire weight of the given layer of the membrane that includes

the filler. In one or more embodiments, one or more layers of the membranes used in the present invention may include at most 70 weight %, in other embodiments at most 50 weight %, and in other embodiments at most 30 weight % of a filler based on the entire weight of the given layer of the membrane that includes the filler. In one or more embodiments, the one or more layers of the membranes of the present invention may include from about 1 to about 70, in other embodiments from about 5 to about 50, and in other embodiments from about 10 to about 30 weight % of the filler based upon the entire weight of the given layer of the membrane that includes the filler.

[0078] The one or more layers including the ethylene-based olefinic block copolymer includes a first EBOC (e.g. low melt index) and a second EBOC (e.g. high melt index) and these one or more layers may include at least 40, in other embodiments at least 50, and in other embodiments at least 60 weight % of the first EBOC based upon the total weight of the first EBOC and the second EBOC combined. In these or other embodiments, these layers may include at most 99, in other embodiments at most 90, and in other embodiments at most 80 weight % of the first EBOC based upon the total weight of the first EBOC and the second EBOC combined. In one or more embodiments, these layers may include from about 30 to about 99, in other embodiments from about 50 to about 90, and in other embodiments from about 60 to about 80 weight % of the first EBOC based upon the total weight of the first EBOC and the second EBOC combined.

METHOD OF MAKING

[0079] In one or more embodiments, the compositions and membranes used in the present invention may be prepared by employing conventional techniques. The polymeric composition that may be extruded to form the polymeric sheet may include the ingredients or constituents described herein. For example, the polymeric composition may include thermoplastic polyolefin, filler, and ethylene-based olefin block copolymers defined herein. The ingredients may be mixed together by employing conventional polymer mixing equipment and techniques. In one or more embodiments, an extruder may be employed to mix the ingredients. For example, single-screw or twin-screw extruders may be employed. For example, the various ingredients can be separately fed into a reaction extruder and pelletized or directly extruded into membrane or laminate sheet. In other embodiments, the various ingredients can be combined and mixed within a mixing apparatus such as an internal mixer and then subsequently fabricated into membrane sheets or laminates.

[0080] In one or more embodiments, the membranes used in the present invention may be prepared by extruding a polymeric composition into a sheet. Multiple sheets may be extruded and joined to form a laminate. A membrane including a reinforcing layer may be prepared by extruding at least one sheet on and/or below a reinforcement (e.g., a scrim). In other embodiments, the

polymeric layer may be prepared as separate sheets, and the sheets may then be calandered with the scrim sandwiched there between to form a laminate. In one or more embodiments, one or more layers of the membranes used in the present invention are prepared by employing coextrusion technology. Useful techniques include those described in co-pending U.S. Serial Nos. 11/708,898 and 11/708,903.

[0081] Following extrusion, and after optionally joining one or more polymeric layers, or optionally joining one or more polymeric layer together with a reinforcement, the membrane may be fabricated to a desired thickness. This may be accomplished by passing the membrane through a set of squeeze rolls positioned at a desired thickness. The membrane may then be allowed to cool and/or rolled for shipment and/or storage.

FULLY-ADHERED ROOFING SYSTEM

[0082] The fully-adhered roof(ing) systems of the present invention can be described with reference to Fig. 4. Roofing system 40 includes a roof deck 51, optional insulation layer 53, optional protection layer 55, optional existing membrane 57, adhesive layer 60, and membrane 71, where membrane 71 is as defined in claim 1 and described above. For purposes of this specification, the material to which the adhesive secures the membrane, which is the uppermost layer, can be referred to as the substrate. For example, where the membrane is adhesively secured to an insulation board or layer, the insulation board or layer may be referred to as a substrate.

[0083] Practice of this invention is not limited by the selection of any particular roof deck. Accordingly, the roofing systems herein can include a variety of roof decks. Exemplary roof decks include concrete pads, steel decks, wood beams, and foamed concrete decks.

[0084] In one or more embodiments, the existing membranes may include cured rubber systems such as EPDM membranes, thermoplastic polymers systems such as TPO membranes, or asphalt-based systems such as modified asphalt membranes and/or built roof systems.

[0085] Practice of this invention is likewise not limited by the selection of any particular insulation board. Moreover, the insulation boards are optional. Several insulation materials can be employed including polyurethane or polyisocyanurate cellular materials. These boards are known as described in U.S. Patent Nos. 6,117,375, 6,044,604, 5,891,563, 5,573,092, U.S. Publication Nos. 2004/01099832003/0082365, 2003/0153656, 2003/0032351, and 2002/0013379, as well as U.S. Serial Nos. 10/640,895, 10/925,654, and 10/632,343. As those skilled in the art appreciate, insulation boards and cover boards may carry a variety of facer materials including, but not limited to, paper facers, fiberglass-reinforced paper facers, fiberglass facers, coated fiberglass facers, metal facers such as aluminum facers, and solid facers such as wood.

[0086] In one or more embodiments, cover boards may include high density polyurethane or polyisocyanurate board as disclosed in U.S. Publ. Nos. 2006/0127664, 2013/0164524, 2014/0011008, 2013/0036694, and 2012/0167510,25. In other embodiments, the cover boards may include construction boards such as DensDeck.

[0087] In other embodiments, these membranes may be employed to cover flat or low-slope roofs following a re-roofing event. In one or more embodiments, the membranes may be employed for re-roofing as described in U.S. Publication No. 2006/0179749.

[0088] Practice of the present invention is also not necessarily limited by the adhesive employed to bond the membrane to the substrate. For example, the adhesive may include an adhesive that forms a bond through curing action such as is the case with a liquid bond adhesive (e.g. a butyl rubber adhesive) or a polyurethane adhesive. In other embodiments, the adhesive may be a pressure-sensitive adhesive, which may be applied to the membrane at the location where the membrane is manufactured (e.g. a factory-applied pressure-sensitive adhesive).

[0089] As used within the specification, the term "fully-adhered roofing system" refers to a roofing system wherein the primary mode of attachment of the membrane to the underlying substrate is through the use of an adhesive. At least 50%, in other embodiments at least 70%, in other embodiments at least 90%, and in other embodiments at least 98% of the underlying surface of the membrane (i.e., the substrate-contacting planar surface of the membrane) is adhered to the substrate through an adhesive.

Claims

1. A roof system comprising:
a substrate and a thermoplastic membrane adhered to the substrate, where the thermoplastic membrane includes one or more layers that include at least 60% by weight of an ethylene-based olefinic block copolymer based upon the ethylene-based olefinic block copolymer and a complementary thermoplastic material that may be present, where the one or more layers including the ethylene-based olefinic block copolymer includes a first ethylene-based olefinic block copolymer having a melt index of less than 5 g/10 min and a second ethylene-based olefinic block copolymer having a melt index of greater than 5 g/10 min, where the membrane is characterized, prior to being adhered to the substrate, by a storage modulus of less than 450 MPa at 0 °C determined by dynamic mechanical analysis (DMA) in the machine direction, where at least 50% of the at least one planar surface of the membrane is adhered to the substrate.

2. The roof system of claim 1, where the substrate is selected from the group consisting of a roof deck, an insulation board, a cover board, and an existing membrane.
3. The roof system of any of the preceding claims, where the thermoplastic membrane includes first and second opposed planar surface with one of the opposed planar surfaces being adhered to the substrate.
4. The roof system of any of the preceding claims, where the membrane is adhered to the substrate through a polyurethane adhesive.
5. The roof system of any of the preceding claims, where the membrane is adhered to the substrate through a pressure-sensitive adhesive.
6. The roof system of any of the preceding claims, where the membrane is a bilaminate membrane including upper and lower layers.
7. The roof system of any of the preceding claims, where the layer including the ethylene-based olefinic block copolymer also includes a thermoplastic resin distinct from the ethylene-based olefinic block copolymer, wherein the thermoplastic resin distinct from the ethylene-based olefinic block copolymer is linear low-density polyethylene.
8. The roof system of any of the preceding claims, where the layer including the ethylene-based olefinic block copolymer also includes mineral filler.
9. The roof system of any of the preceding claims, where the layer including the ethylene-based olefinic block copolymer includes at least 20 wt % magnesium hydroxide.
10. The roof system of any of the preceding claims, where the sheet is **characterized by** a storage modulus of less than 400 MPa at 0 °C determined by dynamic mechanical analysis (DMA) in the machine direction.

Patentansprüche

1. Dachsystem, umfassend:
ein Substrat und eine thermoplastische Membran, die an dem Substrat anhaftet, wobei die thermoplastische Membran umfasst: eine oder mehr Schichten, welche umfassen: mindestens 60 Gew.-% eines olefinischen Blockcopolymers auf Ethylenbasis, bezogen auf das olefinische Blockcopolymer auf Ethylenbasis und ein komplementäres thermoplastisches Material, das vorhanden sein kann, wobei die eine

oder mehr Schichten, enthaltend das olefinische Blockcopolymer auf Ethylenbasis, enthalten: ein erstes olefinisches Blockcopolymer auf Ethylenbasis mit einem Schmelzindex von weniger als 5 g/10 min und ein zweites olefinisches Blockcopolymer auf Ethylenbasis mit einem Schmelzindex von mehr als 5 g/10 min, wobei die Membran, bevor sie an das Substrat angeheftet wird, **gekennzeichnet ist durch** ein Speichermodul von weniger als 450 MPa bei 0°C, bestimmt durch dynamische mechanische Analyse (DMA) in der Maschinenrichtung, wobei mindestens 50% von der mindestens einen planaren Oberfläche der Membran angeheftet sind an das Substrat.

2. Dachsystem nach Anspruch 1, wobei das Substrat ausgewählt ist aus der Gruppe, bestehend aus einem Oberdeck, einer Isolationsplatte, einer Bedeckungsplatte und einer existierenden Membran.
3. Dachsystem nach einem der voranstehenden Ansprüche, wobei die thermoplastische Membran einschließt: erste und zweite gegenüberliegende planare Oberfläche, wobei eine der gegenüberliegenden planaren Oberflächen an das Substrat angeheftet ist.
4. Dachsystem nach einem der voranstehenden Ansprüche, wobei die Membran an das Substrat angeheftet ist durch ein Polyurethanklebeittel.
5. Dachsystem nach einem der voranstehenden Ansprüche, wobei die Membran an das Substrat angeheftet ist durch einen Haftklebstoff.
6. Dachsystem nach einem der voranstehenden Ansprüche, wobei die Membran eine Bilaminatmembran ist, die obere und untere Schichten enthält.
7. Dachsystem nach einem der voranstehenden Ansprüche, wobei die Schicht, die das olefinische Blockcopolymer auf Ethylenbasis enthält, auch enthält: ein thermoplastisches Harz, das von dem olefinischen Blockcopolymer auf Ethylenbasis verschieden ist, wobei das von dem olefinischen Blockcopolymer auf Ethylenbasis verschiedene thermoplastische Harz lineares Polyethylen niedriger Dichte ist.

8. Dachsystem nach einem der voranstehenden Ansprüche, wobei die Schicht, die das olefinische Blockcopolymer auf Ethylenbasis enthält, auch einen mineralischen Füllstoff enthält.
9. Dachsystem nach einem der voranstehenden Ansprüche, wobei die Schicht, die das olefinische Blockcopolymer auf Ethylenbasis enthält, mindestens 20 Gew.-% Magnesiumhydroxid enthält.

10. Dachsystem nach einem der voranstehenden Ansprüche, wobei das Flächegebilde **gekennzeichnet ist durch** ein Speichermodul von weniger als 400 MPa bei 0°C, bestimmt durch dynamische mechanische Analyse (DMA) in der Maschinenrichtung.

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Revendications

1. Système de toiture comprenant :
un substrat et une membrane thermoplastique collée au substrat, la membrane thermoplastique comportant une ou plusieurs couches qui comportent au moins 60 % en poids d'un copolymère séquencé oléfinique à base d'éthylène basé sur le copolymère séquencé oléfinique à base d'éthylène et un matériau thermoplastique complémentaire qui peut être présent, la ou les couches comportant le copolymère séquencé oléfinique à base d'éthylène comportent un premier copolymère séquencé oléfinique à base d'éthylène ayant un indice de fluidité inférieur à 5 g/10 min et un second copolymère séquencé oléfinique à base d'éthylène ayant un indice de fluidité supérieur à 5 g/10 min, la membrane étant **caractérisée**, avant d'être collée au substrat, par un module de conservation inférieur à 450 MPa à 0 °C déterminé par analyse mécanique dynamique (AMD) dans le sens machine, au moins 50 % de l'au moins une surface plane de la membrane étant collée au substrat.
2. Système de toiture selon la revendication 1, le substrat étant choisi dans le groupe constitué d'un plateau de toiture, d'un panneau isolant, d'un panneau de revêtement et d'une membrane existante.
3. Système de toiture selon l'une quelconque des revendications précédentes, la membrane thermoplastique comportant des première et seconde surfaces planes opposées, l'une des surfaces planes opposées étant collée au substrat.
4. Système de toiture selon l'une quelconque des revendications précédentes, la membrane étant collée au substrat par l'intermédiaire d'un adhésif polyuréthane.
5. Système de toiture selon l'une quelconque des revendications précédentes, la membrane étant collée au substrat par l'intermédiaire d'un adhésif sensible à la pression.
6. Système de toiture selon l'une quelconque des revendications précédentes, la membrane étant une membrane bistratifiée comportant des couches supérieure et inférieure.
7. Système de toiture selon l'une quelconque des re-

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vendications précédentes, la couche comportant le copolymère séquencé oléfinique à base d'éthylène comportant également une résine thermoplastique distincte du copolymère séquencé oléfinique à base d'éthylène, la résine thermoplastique distincte du copolymère séquencé oléfinique à base d'éthylène étant du polyéthylène linéaire basse densité.

8. Système de toiture selon l'une quelconque des revendications précédentes, la couche comportant le copolymère séquencé oléfinique à base d'éthylène comportant également une charge minérale.

9. Système de toiture selon l'une quelconque des revendications précédentes, la couche comportant le copolymère séquencé oléfinique à base d'éthylène comportant au moins 20 % en poids d'hydroxyde de magnésium.

10. Système de toiture selon l'une quelconque des revendications précédentes, la feuille étant **caractérisée par** un module de conservation inférieur à 400 MPa à 0 °C déterminé par analyse mécanique dynamique (AMD) dans le sens machine.

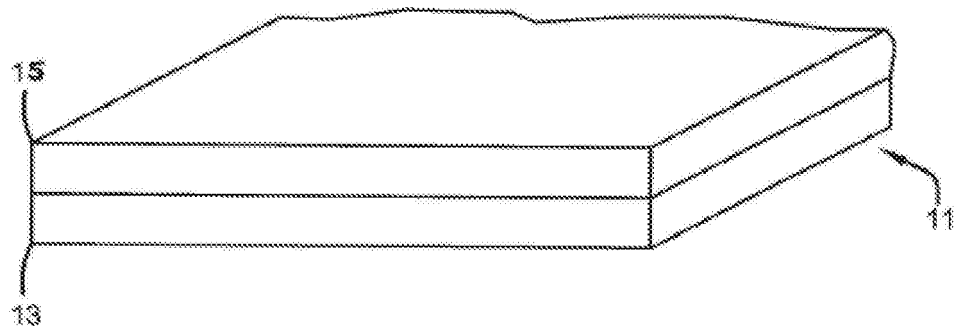


FIG. 1

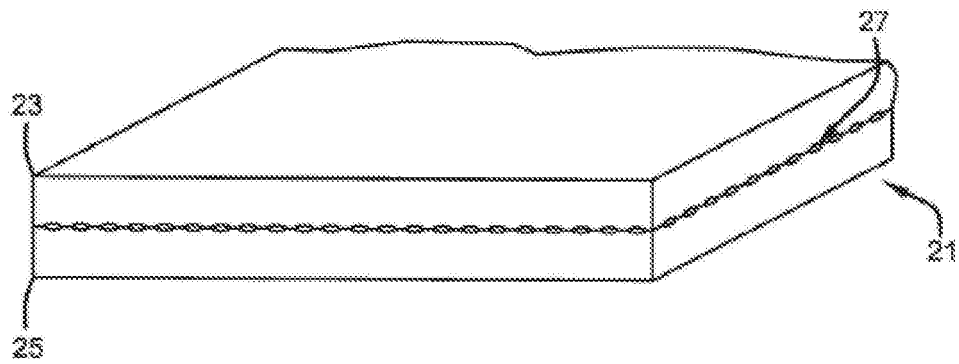


FIG. 2

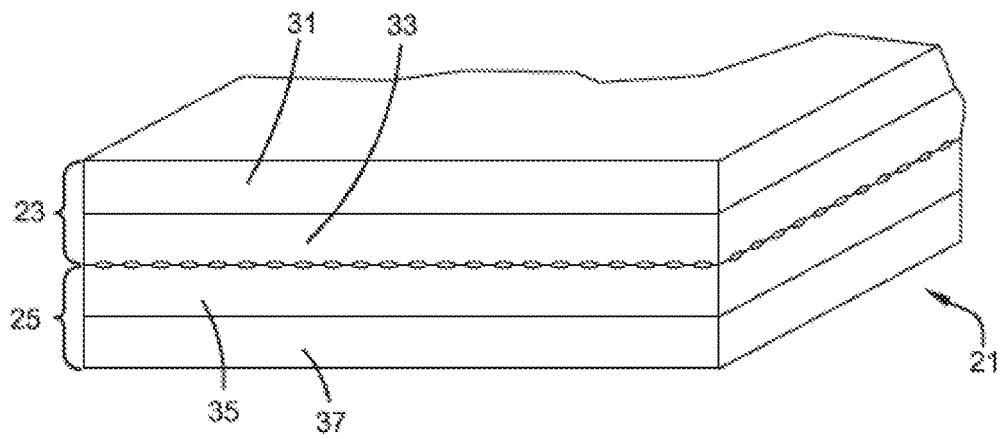


FIG. 3

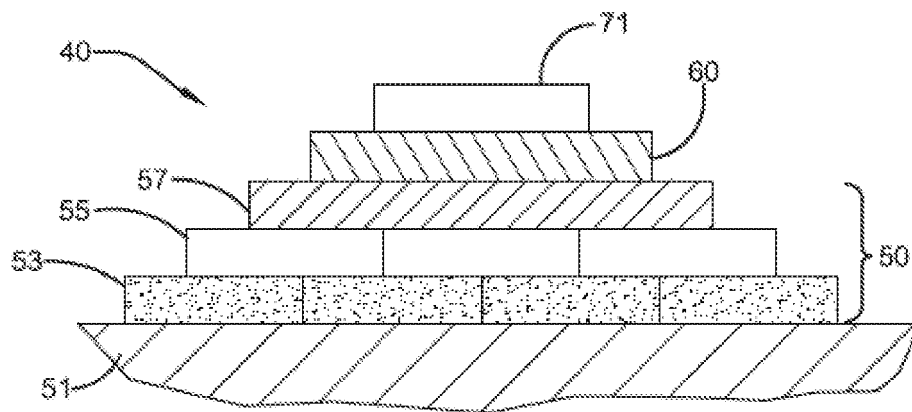


FIG. 4

REFERENCES CITED IN THE DESCRIPTION

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