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### Fabric-backed roofing membrane composite

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#### Abstract

A membrane composite comprising a membrane panel having opposed first and second planar surfaces and a fabric backing secured to a first planar surface through a UV-cured adhesive disposed on said planar surface of said membrane.

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## References Cited

### U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
3935353	12/1975	Doerfling et al.	N/A	N/A
4032491	12/1976	Schoenke	N/A	N/A
4404243	12/1982	Terpay	N/A	N/A
4585682	12/1985	Colarusso et al.	N/A	N/A
4657958	12/1986	Fieldhouse et al.	N/A	N/A
4732925	12/1987	Davis	N/A	N/A
4778852	12/1987	Futamura	N/A	N/A
4806400	12/1988	Sancaktar	N/A	N/A
4810565	12/1988	Sancaktar	N/A	N/A
4908229	12/1989	Kissel	N/A	N/A
4943461	12/1989	Karim	N/A	N/A
5073611	12/1990	Rehmer et al.	N/A	N/A
5086088	12/1991	Kitano et al.	N/A	N/A
5128386	12/1991	Rehmer et al.	N/A	N/A
5242727	12/1992	Briddell et al.	N/A	N/A
5253461	12/1992	Janoski et al.	N/A	N/A
5264533	12/1992	Rehmer et al.	N/A	N/A
5317035	12/1993	Jacoby et al.	N/A	N/A
5374477	12/1993	Lawless et al.	N/A	N/A
5389699	12/1994	Rehmer et al.	N/A	N/A
5389715	12/1994	Davis et al.	N/A	N/A
5456785	12/1994	Venable	N/A	N/A
5496615	12/1995	Bartlett et al.	N/A	N/A
5573092	12/1995	Gabilondo	N/A	N/A
5620554	12/1996	Venable	156/499	B65H 19/1852
5665822	12/1996	Bitler et al.	N/A	N/A
5686179	12/1996	Cotsakis	N/A	N/A

5849133	12/1997	Senderling et al.	N/A	N/A
5880241	12/1998	Brookhart et al.	N/A	N/A
5891563	12/1998	Letts	N/A	N/A
5895301	12/1998	Porter et al.	N/A	N/A
RE36674	12/1999	Gluck et al.	N/A	N/A
6044604	12/1999	Clayton et al.	N/A	N/A
6080818	12/1999	Thakker et al.	N/A	N/A
6117375	12/1999	Garrett et al.	N/A	N/A
6120869	12/1999	Cotsakis et al.	N/A	N/A
6184496	12/2000	Pearce	N/A	N/A
6218493	12/2000	Johnson et al.	N/A	N/A
6262144	12/2000	Zhao et al.	N/A	N/A
6284360	12/2000	Johnson	N/A	N/A
6297324	12/2000	Briddell et al.	N/A	N/A
6299936	12/2000	Reck et al.	N/A	N/A
6306460	12/2000	Reck et al.	N/A	N/A
6310163	12/2000	Brookhart et al.	N/A	N/A
6348530	12/2001	Reck et al.	N/A	N/A
6355701	12/2001	Soukup et al.	N/A	N/A
RE37683	12/2001	Briddell et al.	N/A	N/A
6502360	12/2002	Carr, III et al.	N/A	N/A
6569970	12/2002	Reck et al.	N/A	N/A
6586080	12/2002	Heifetz	N/A	N/A
6605662	12/2002	Zhao et al.	N/A	N/A
6641896	12/2002	Fensel et al.	N/A	N/A
6683126	12/2003	Keller et al.	N/A	N/A
6720399	12/2003	Husemann	N/A	N/A
6753079	12/2003	Husemann	N/A	N/A
6764733	12/2003	Clarke	N/A	N/A
6774071	12/2003	Horner, Jr. et al.	N/A	N/A
6776322	12/2003	Villela et al.	N/A	N/A
6790520	12/2003	Todd et al.	N/A	N/A
6794449	12/2003	Fisher	N/A	N/A
6813866	12/2003	Naipawer, III	N/A	N/A
6828020	12/2003	Fisher et al.	N/A	N/A
6831114	12/2003	Husemann	N/A	N/A
6841608	12/2004	Dreher et al.	N/A	N/A
6858315	12/2004	Khan et al.	N/A	N/A
6863944	12/2004	Naipawer, III et al.	N/A	N/A
6881442	12/2004	Husemann	N/A	N/A
6887917	12/2004	Yang et al.	N/A	N/A
6895724	12/2004	Naipawer, III	N/A	N/A
6901712	12/2004	Lionel	N/A	N/A
7066371	12/2005	Villela et al.	N/A	N/A
7101598	12/2005	Hubbard	N/A	N/A
7115313	12/2005	Zanchetta et al.	N/A	N/A
7132143	12/2005	Zanchetta et al.	N/A	N/A
7148160	12/2005	Porter	N/A	N/A
7175732	12/2006	Robison et al.	N/A	N/A
7238732	12/2006	Bamborough et al.	N/A	N/A

7304119	12/2006	Balzer	N/A	N/A
7323242	12/2007	Gerst et al.	N/A	N/A
7358319	12/2007	Balzer et al.	N/A	N/A
7368155	12/2007	Larson et al.	N/A	N/A
7387753	12/2007	Tackett et al.	N/A	N/A
7473734	12/2008	Beckley et al.	N/A	N/A
7517934	12/2008	Deeter et al.	N/A	N/A
7575653	12/2008	Johnson et al.	N/A	N/A
7589145	12/2008	Brant et al.	N/A	N/A
7612120	12/2008	Letts	N/A	N/A
7614194	12/2008	Shah	N/A	N/A
7645829	12/2009	Tse et al.	N/A	N/A
7744998	12/2009	Nakamuta	N/A	N/A
7771807	12/2009	Hubbard	N/A	N/A
7776417	12/2009	Mohseen et al.	N/A	N/A
7838568	12/2009	Letts et al.	N/A	N/A
7914868	12/2010	Naipawer, III et al.	N/A	N/A
8063141	12/2010	Fisher	N/A	N/A
8153220	12/2011	Nebesnak et al.	N/A	N/A
8202596	12/2011	Yang et al.	N/A	N/A
8206817	12/2011	Donovan et al.	N/A	N/A
8241446	12/2011	Naipawer, III et al.	N/A	N/A
8262833	12/2011	Dyal et al.	N/A	N/A
8327594	12/2011	Merryman et al.	N/A	N/A
8329800	12/2011	Terrenoire et al.	N/A	N/A
8381450	12/2012	Cummings et al.	N/A	N/A
8389103	12/2012	Kiik et al.	N/A	N/A
8399571	12/2012	Becker et al.	N/A	N/A
8492472	12/2012	Elizalde et al.	N/A	N/A
8530582	12/2012	Becker et al.	N/A	N/A
10132082	12/2017	Tang et al.	N/A	N/A
10370854	12/2018	Tang et al.	N/A	N/A
10519663	12/2018	Tang et al.	N/A	N/A
2001/0023264	12/2000	Yamamoto	N/A	N/A
2002/0013379	12/2001	Singh	N/A	N/A
2003/0032351	12/2002	Horner, Jr.	N/A	N/A
2003/0032691	12/2002	Bolte	N/A	N/A
2003/0082365	12/2002	Geary	N/A	N/A
2003/0153656	12/2002	Sjerps	N/A	N/A
2003/0215594	12/2002	Hamdar	N/A	N/A
2004/0103608	12/2003	Borenstein	N/A	N/A
2004/0109983	12/2003	Rotter	N/A	N/A
2004/0191508	12/2003	Hubbard	N/A	N/A
2004/0242763	12/2003	Tielemans	N/A	N/A
2005/0097857	12/2004	Mehta	52/782.1	E04D 12/002
2005/0214496	12/2004	Borenstein	N/A	N/A
2006/0017974	12/2005	Shapovalov et al.	N/A	N/A
2006/0100408	12/2005	Powell	N/A	N/A
2006/0127627	12/2005	Larson et al.	N/A	N/A
2006/0216523	12/2005	Takaki	N/A	N/A

2007/0054088	12/2006	Matijasic et al.	N/A	N/A
2007/0207284	12/2006	McClintic	N/A	N/A
2007/0281119	12/2006	Di Stefano	N/A	N/A
2008/0088056	12/2007	Vavra	N/A	N/A
2010/0075092	12/2009	Kendra et al.	N/A	N/A
2010/0086712	12/2009	Moller	N/A	N/A
2010/0200148	12/2009	Douglas	N/A	N/A
2010/0279049	12/2009	Hubbard	N/A	N/A
2010/0292403	12/2009	Ansems	N/A	N/A
2011/0048513	12/2010	Booth	N/A	N/A
2011/0017391	12/2010	Franklin et al.	N/A	N/A
2012/0240996	12/2011	Keiser	N/A	N/A
2013/0122287	12/2012	Moeller	N/A	N/A
2013/0184393	12/2012	Satrijo	N/A	N/A
2013/0225020	12/2012	Flood	N/A	N/A
2014/0215937	12/2013	Zhou et al.	N/A	N/A
2015/0231863	12/2014	Knebel	428/355R	B32B 5/022
2016/0230392	12/2015	Tang et al.	N/A	N/A
2017/0015083	12/2016	Tang et al.	N/A	N/A
2017/0044406	12/2016	Hubbard et al.	N/A	N/A
2017/0067257	12/2016	Zhou et al.	N/A	N/A
2017/0096588	12/2016	Demoulin et al.	N/A	N/A
2017/0114543	12/2016	Tang et al.	N/A	N/A
2019/0316359	12/2018	Tang et al.	N/A	N/A

#### FOREIGN PATENT DOCUMENTS

Patent No.	Application Date	Country	CPC
2809955	12/2012	CA	N/A
19945732	12/2000	DE	N/A
0342811	12/1994	EP	N/A
1548080	12/2004	EP	N/A
2439062	12/2011	EP	N/A
2305667	12/1996	GB	N/A
2004002577	12/2003	JP	N/A
2004003225	12/2003	JP	N/A
199856866	12/1997	WO	N/A
199924290	12/1998	WO	N/A
2006084134	12/2005	WO	N/A
2006108509	12/2005	WO	N/A
2013142562	12/2012	WO	N/A
WO-2015042258	12/2014	WO	B32B 25/04
2015134889	12/2014	WO	N/A
2017049280	12/2016	WO	N/A
2017165868	12/2016	WO	N/A
2017165870	12/2016	WO	N/A
2017165871	12/2016	WO	N/A

#### OTHER PUBLICATIONS

Translation of WO 2006108509 A1. cited by applicant  
Translation of JP 2004003225. cited by applicant

Translation of JP 2004002577. cited by applicant  
Translation of EP 1548080 B1. cited by applicant  
Translation of EP 2439062 A1. cited by applicant  
European Standard EN 13956:2012. cited by applicant  
Technical Datasheet of RoofSea/OneStep tape. cited by applicant  
Technical Datasheet of Sika Sarnafil G410 SA Flashing Membrane. cited by applicant

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## **Background/Summary**

(1) This application is a continuation of U.S. application Ser. No. 16/088,175 filed on Sep. 25, 2018, which is a national-stage application of PCT/US2017/024190 filed on Mar. 25, 2017, which claims the benefit of U.S. provisional application No. 62/313,225 filed on Mar. 25, 2016, which are incorporated herein by reference.

### **FIELD OF THE INVENTION**

(1) Embodiments of the present invention are directed toward fabric-backed (also known as fleece-backed) roofing membranes wherein the fabric backing is adhesively secured to the membrane through a cross-linked adhesive that is applied to the membrane as a hot-melt.

### **BACKGROUND OF THE INVENTION**

(2) Flat or low-sloped roofs can be covered with polymeric membranes such as EPDM membranes. The membranes can be secured to the roof using several attachment mechanisms including ballasting, mechanical attachment, and adhesive attachment. Attachment of the membrane to the roof is important because the membranes can be subjected to severe wind uplift forces.

(3) Adhesive attachment is typically employed to form adhered roofing systems. The membrane may be adhered to the roof substrate substantially across the entire planar surface of the membrane to form fully-adhered systems. Fully-adhered roofing systems are advantageously installed where maximum wind uplift prevention is desired. Also, fully-adhered systems are desirable in re-roofing situations, especially where the new membrane is placed over an existing membrane (a technique that is commonly referred to as re-skinning).

(4) Several techniques are employed to prepare fully-adhered roofing systems. One technique includes the use of a fleece-backed EPDM membrane that is secured to the substrate by using a low-rise polyurethane foam adhesive that is sprayed over the substrate. Once the adhesive polyurethane foam is applied, the fleece-backed membrane is applied to the adhesive layer, which attaches itself to the fleece backing. Alternatively, nitrile-based bonding adhesive can be applied to the substrate and the fleece-backed EPDM membrane can be secured thereto.

(5) While fleece-backed membranes typically offer superior wind-uplift resistance, which superiority stems from the strong adhesive bond formed between the fleece and the adhesive applied to the roof surface, a potential point of failure is the adhesion between the fleece and the membrane. In the case of thermoplastic membranes, the fleece is often attached to the membrane by heating or partially melting the membrane and mating the fleece to the membrane while in its molten or partially molten state. In a case of thermoset membranes, such as EPDM membranes, the fleece is often attached by employing a hot-melt adhesive. For example, it is common to employ ethylene vinyl acetate as an adhesive to secure the fleece to the membrane. In either event, extreme

temperatures can negatively impact the adhesion between the fleece and the membrane. For example, in the case of ethylene vinyl acetate, as the membrane temperature nears the softening point of the ethylene vinyl acetate, the adhesive forces could be compromised.

## SUMMARY OF THE INVENTION

(6) One or more embodiments of the present invention provide a membrane composite comprising a membrane panel having opposed first and second planar surfaces and a fabric backing secured to a planar surface through a UV-cured adhesive disposed on said planar surface of said membrane.

(7) Other embodiments of the present invention provide a method for preparing a membrane composite, said method comprising (i) providing a polymeric membrane having opposed planar surfaces, (ii) applying a curable adhesive onto a planar surface of the membrane to form a curable layer, (iii) curing the curable layer to form a cured layer, (iv) applying a fabric to the cured layer.

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## Description

### BRIEF DESCRIPTION OF THE DRAWINGS

(1) FIG. 1 is a cross-sectional side view of a fabric-backed roofing membrane composite according to aspects of the invention.

(2) FIG. 2 is a cross-sectional side view of a roofing composite employed in alternate embodiments of the present invention.

(3) FIG. 3 is a cross-sectional side view of a roofing composite employed in alternate embodiments of the present invention.

(4) FIG. 4 is a cross-sectional side view of a roof system according to embodiments of the present invention.

(5) FIG. 5 is a flow chart describing a process for making membrane composite according to embodiments of the present invention.

(6) FIG. 6 is a schematic of a continuous process for making membrane composite according to the present invention.

### DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

(7) Embodiments of the invention are based, at least in part, on the discovery of a roofing membrane composite including a fabric backing adhered to a polymeric membrane through a cross-linked adhesive that is applied to the membrane as a hot-melt. While the prior art employs hot-melt adhesives to secure fabric backing to membranes, use of the adhesive proposed by the present invention provides superior bond strength at elevated temperatures without compromising other attributes of the composite system.

#### (8) Membrane Composite

(9) A membrane composite according to embodiments of the present invention can be described with reference to FIG. 1, which shows membrane composite **11** including polymeric planar body **21**, adhesive layer **31**, and fabric backing **41**. Planar body **21** includes top planar surface **23**, bottom planar surface **25**, first lateral edge **27**, and second lateral edge **29**. Adhesive layer **31**, which is a pressure-sensitive adhesive as described herein, is disposed on bottom planar surface **25** along at least a portion of the width of planar body **21**. Fabric backing **41** is adhesively mated to planar body **21** through adhesive **31**. As suggested in FIG. 1, the area of bottom surface **25** of planar body **21** carrying fabric backing **41** can be secured to a roof substrate through fabric backing **41**, and therefore this area may be referred to as roof-surface contacting portion **61**. That area of bottom surface **25** of planar body **21** that may be exposed (i.e. does not include adhesive **31** nor fabric backing **41**) may be referred to as lap area **51**.

(10) An alternate embodiment of the membrane composites of the present invention may be described with reference to FIG. 2, which shows composite **12** including polymeric planar body **21**, adhesive layer **31**, which is a pressure-sensitive adhesive as described herein, fabric backing **41**,

and release member 71. Planar body 21 includes top planar surface 23, bottom planar surface 25, first lateral edge 27, and second lateral edge 29. Adhesive layer 31, which is a pressure-sensitive adhesive as described herein, is disposed on bottom planar surface 25 and extends the entire width of planar body 21 from first lateral edge 27 to second lateral edge 29. As with the embodiments in FIG. 1, fabric backing 41 partially extends across the width of planar body 21 thereby leaving exposed, at surface 33, a portion of adhesive layer 31. In lieu of fabric backing 41, a release member 71 may be removably affixed to adhesive layer 31 at surface 33. As a skilled person will appreciate, composite 12 can be secured to a roof substrate through fabric backing 41, and therefore this area of composite 12 may be referred to as roof-surface contacting portion 61. That portion of adhesive layer 31 represented by surface 33, and which may be covered with release member 71, can be employed to form a lap seal between overlapping, adjacent membranes.

(11) An alternate embodiment of the membrane composites of the present invention may be described with reference to FIG. 3, which shows composite 13 including polymeric planar body 21, adhesive layer 31, which is a pressure-sensitive adhesive as described herein, fabric layer 41, external adhesive layer 55, and release member 57. Planar body 21 includes top planar surface 23, bottom planar surface 25, first lateral edge 27, and second lateral edge 29. Adhesive layer 31, which is a pressure-sensitive adhesive as described herein, is disposed on bottom planar surface 25 and extends the entire width of planar body 21 from first lateral edge 27 to second lateral edge 29. Fabric layer 41 is mated to adhesive layer 31 and can extend the entire width of planar body 21 from first lateral edge 27 to second lateral edge 29. External adhesive layer 55, which is a pressure-sensitive adhesive as described herein, is disposed on fabric layer 41 and extends the entire width of fabric layer 41 across the entire width of planar body 21 from first lateral edge 27 to second lateral edge 29. External adhesive layer 55 includes an outer surface, which is opposite fabric layer 41, to which release member 59 may be removably mated. According to one or more embodiments of the present invention, external adhesive layer 55 can be used to secure membrane composite 13 to a roof surface or adjoining membrane. Fabric layer 41 advantageously serves to provide impact strength and/or resistance to the composite, which will facilitate certain applications of the membrane composite, such as re-skinning procedures.

(12) Uv-Curable Hot-Melt Pressure-Sensitive Adhesive

(13) In one or more embodiments, the pressure-sensitive adhesive layer (e.g. layer 31 in FIG. 1 and FIG. 2) is a cured pressure-sensitive adhesive. In sub-embodiments thereof, this cured pressure-sensitive adhesive layer is formed from a curable hot-melt adhesive. In other words, and as will be described in greater detail below, an uncured adhesive composition is applied to the membrane as a hot-melt composition (i.e. the composition is heated and applied as a flowable composition in the absence or appreciable absence of solvent), and then the composition is subsequently crosslinked (i.e. cured) to form the cured pressure-sensitive layer.

(14) In one or more embodiments, the cured pressure-sensitive adhesive layer may be an acrylic-based hot-melt adhesive. In one or more embodiments, the adhesive is a polyacrylate such as a polyacrylate elastomer. In one or more embodiments, useful polyacrylates include one or more units defined by the formula:

(15) ##STR00001##

where each R.sup.1 is individually hydrogen or a hydrocarbyl group and each R.sup.2 is individually a hydrocarbyl group. In the case of a homopolymer, each R.sup.1 and R.sup.2, respectively, throughout the polymer are same in each unit. In the case of a copolymer, at least two different R.sup.1 and/or two different R.sup.2 are present in the polymer chain.

(16) In one or more embodiments, hydrocarbyl groups include, for example, alkyl, cycloalkyl, substituted cycloalkyl, alkenyl, cycloalkenyl, substituted cycloalkenyl, aryl, substituted aryl, aralkyl, alkaryl, allyl, and alkynyl groups, with each group containing in the range of from 1 carbon atom, or the appropriate minimum number of carbon atoms to form the group, up to about 20 carbon atoms. These hydrocarbyl groups may contain heteroatoms including, but not limited to,



nitrogen, oxygen, boron, silicon, sulfur, and phosphorus atoms. In particular embodiments, each R.sup.2 is an alkyl group having at least 4 carbon atoms. In particular embodiments, R.sup.1 is hydrogen and R.sup.2 is selected from the group consisting of butyl, 2-ethylhexyl, and mixtures thereof.

(17) In one or more embodiments, the polyacrylate elastomers that are useful as adhesives in the practice of this invention may be characterized by a glass transition temperature (T<sub>g</sub>) of less than 0° C., in other embodiments less than -20° C., in other embodiments less than -30° C. In these or other embodiments, useful polyacrylates may be characterized by a T<sub>g</sub> of from about -70 to about 0° C., in other embodiments from about -50 to about -10° C., and in other embodiments from about -40 to about -20° C.

(18) In one or more embodiments, the polyacrylate elastomers that are useful as adhesives in the practice of this invention may be characterized by a number average molecular weight of from about 90 to about 800 kg/mole, in other embodiments from about 100 to about 350 kg/mole, in other embodiments from about 100 to about 700 kg/mole, in other embodiments from about 150 to about 270 kg/mole, in other embodiments from about 120 to about 600 kg/mole, and in other embodiments from about 180 to about 250 kg/mole.

(19) In one or more embodiments, the polyacrylate elastomers that are useful as adhesives in the practice of this invention may be characterized by a Brookfield viscosity at 150° C. of from about 10,000 to about 200,000 cps, in other embodiments from about 30,000 to about 60,000 cps, in other embodiments from about 30,000 to about 170,000 cps, in other embodiments from about 25,000 to about 150,000 cps, in other embodiments from about 30,000 to about 60,000 cps, and in other embodiments from about 40,000 to about 50,000 cps.

(20) Specific examples of polyacrylate elastomers that are useful as adhesives in the practice of the present invention include poly(butylacrylate), and poly(2-ethylhexylacrylate). These polyacrylate elastomers may be formulated with photoinitiators, solvents, plasticizers, and resins such as natural and hydrocarbon resins. The skilled person can readily formulate a desirable adhesive composition. Useful adhesive compositions are disclosed, for example, in U.S. Pat. Nos. 6,720,399, 6,753,079, 6,831,114, 6,881,442, and 6,887,917, which are incorporated herein by reference.

(21) In other embodiments, the polyacrylate elastomers may include polymerized units that serve as photoinitiators. These units may derive from copolymerizable photoinitiators including acetophenone or benzophenone derivatives. These polyacrylate elastomers and the adhesive compositions formed therefrom are known as disclosed in U.S. Pat. Nos. 7,304,119 and 7,358,319, which are incorporated herein by reference.

(22) Useful adhesive compositions are commercially available in the art. For example, useful adhesives include those available under the tradename acResin (BASF), those available under the tradename AroCure (Ashland Chemical), and NovaMeltRC (NovaMelt). In one or more embodiments, these hot-melt adhesives may be cured (i.e., crosslinked) by UV light.

(23) In one or more embodiments, the hot-melt adhesive is at least partially cured after being applied to the membrane, as will be discussed in greater detail below. In one or more embodiments, the adhesive is cured to an extent that it is not thermally processable in the form it was prior to cure. In these or other embodiments, the cured adhesive is characterized by a cross-linked infinite polymer network. While at least partially cured, the adhesive layer of one or more embodiments is essentially free of curative residue such as sulfur or sulfur crosslinks and/or phenolic compounds or phenolic-residue crosslinks.

(24) As indicated above, the pressure-sensitive adhesive, in its cured state, provides sufficient tack to allow the membrane composites of this invention to be used in roofing systems that meet industry standards for wind uplift resistance. In one or more embodiments, this tack may be quantified based upon the peel strength when adhered to another membrane in accordance with ASTM D-1876-08. In one or more embodiments, the cured pressure-sensitive adhesive of the present invention is characterized by a peel strength, according to ASTM D-1876-08, of at least 1.8

lbf/in, in other embodiments at least 3.6 lbf/in, in other embodiments at least 8.0 lbf/in, in other embodiments at least 15 lbf/in, and in other embodiments at least 20 lbf/in.

(25) Similarly, the tack of the pressure-sensitive adhesive, in its cured state, may be quantified based upon the peel strength when adhered to a construction board (e.g. insulation board) having a kraft paper facer in accordance with ASTM D-903-98 (2010). In one or more embodiments, the cured pressure-sensitive adhesive of the present invention is characterized by a peel strength, according to ASTM D-903-98 (2010) using an insulation board with kraft paper facer, of at least 1.5 lbf/in, in other embodiments at least 2.0 lbf/in, in other embodiments at least 2.5 lbf/in, in other embodiments at least 3.0 lbf/in, and in other embodiments at least 3.5 lbf/in.

(26) Release Member

(27) In one or more embodiments, the release member (e.g. release member **71** and **57**), which may also be referred to as a release member or release paper, may include a polymeric film or extrudate, or in other embodiments it may include a cellulosic substrate. In one or more embodiments, the polymeric film and/or cellulosic substrate can carry a coating or layer that allows the polymeric film and/or cellulosic substrate to be readily removed from the adhesive layer after attachment. This polymeric film or extrudate may include a single polymeric layer or may include two or more polymeric layers laminated or coextruded to one another.

(28) Suitable materials for forming a release member that is a polymeric film or extrudate include polypropylene, polyester, high-density polyethylene, medium-density polyethylene, low-density polyethylene, polystyrene or high-impact polystyrene. The coating or layer applied to the film and/or cellulosic substrate may include a silicon-containing or fluorine-containing coating. For example, a silicone oil or polysiloxane may be applied as a coating. In other embodiments, hydrocarbon waxes may be applied as a coating. As the skilled person will appreciate, the coating, which may be referred to as a release coating, can be applied to both planar surfaces of the film and/or cellulosic substrate. In other embodiments, the release coating need only be applied to the planar surface of the film and/or cellulosic substrate that is ultimately removably mated with the adhesive layer.

(29) In one or more embodiments, the release member is characterized by a thickness of from about 15 to about 80  $\mu\text{m}$ , in other embodiments from about 18 to about 75  $\mu\text{m}$ , and in other embodiments from about 20 to about 50  $\mu\text{m}$ .

(30) Thickness of Adhesive Layer

(31) In one or more embodiments, the thickness of the pressure-sensitive adhesive layer (e.g. layer **31**) may be at least 15  $\mu\text{m}$ , in other embodiments at least 30  $\mu\text{m}$ , in other embodiments at least 45  $\mu\text{m}$ , and in other embodiments at least 60  $\mu\text{m}$ . In these or other embodiments, the thickness of the pressure-sensitive adhesive layer may be at most 1000  $\mu\text{m}$ , in other embodiments at most 600  $\mu\text{m}$ , in other embodiments at most 300  $\mu\text{m}$ , in other embodiments at most 150  $\mu\text{m}$ , and in other embodiments at most 75  $\mu\text{m}$ . In one or more embodiments, the thickness of the pressure-sensitive adhesive layer may be from about 15  $\mu\text{m}$  to about 600  $\mu\text{m}$ , in other embodiments from about 15  $\mu\text{m}$  to about 1000  $\mu\text{m}$ , in other embodiments from about 30  $\mu\text{m}$  to about 300  $\mu\text{m}$ , and in other embodiments from about 45  $\mu\text{m}$  to about 150  $\mu\text{m}$ .

(32) Membrane Panel

(33) In one or more embodiments, the membrane, which may be referred to as a panel (e.g. panel **21**) may be a thermoset material. In other embodiments the membrane may be a thermoformable material. In one or more embodiments, the membrane may be EPDM based. In other embodiments, the membrane may be TPO based. In these or other embodiments, the membrane may be flexible and capable of being rolled up for shipment. In these or other embodiments, the membrane may include fiber reinforcement, such as a scrim. In one or more embodiments, the membrane includes EPDM membranes including those that meet the specifications of the ASTM D-4637. In other embodiments, the membrane includes thermoplastic membranes including those that meet the specifications of ASTM D-6878-03. Still other membranes may include PVC, TPV, CSPE, and

asphalt-based membranes.

(34) In one or more embodiments, the roofing membrane panels are characterized by conventional dimensions. For example, in one or more embodiments, the membrane panels may have a thickness of from about 500  $\mu\text{m}$  to about 3 mm, in other embodiments from about 1,000  $\mu\text{m}$  to about 2.5 mm, and in other embodiments from about 1,500  $\mu\text{m}$  to about 2 mm. In these or other embodiments, the membrane panels of the present invention are characterized by a width of about 1 m to about 20 m, in other embodiments from about 2 m to about 18 m, and in other embodiments from about 3 m to about 15 m.

(35) Fabric Backing

(36) In one or more embodiments, the fabric backing (e.g. fabric backing **41**) may include a synthetic fabric including glass or polymeric fibers or filaments. In particular embodiments, the fabric backing is a fleece, such as a napped fleece. Fleece backings of the type that are useful as fabric backings for roofing membranes are generally known in the art as described in U.S. Pat. Nos. 4,996,812, 5,422,179, 5,981,030, and 6,502,360 which are incorporated herein by reference. In particular embodiments, the fabric backing is fleece prepared from polyester filaments such as those prepared from polyethylene terephthalate. In one or more embodiments, the fabric backing is a continuous filament polyester, needle punched, nonwoven fabric. In other embodiments, the fabric backing is a scrim reinforced nonwoven polyester mat. In yet other embodiments, the fabric backing is a glass fiber mat.

(37) In one or more embodiments, where the fabric backing is a glass fiber mat, the fabric may be characterized by a basis weight of at least 50, in other embodiments at least 60, and in other embodiments at least 70 g/m.<sup>sup.2</sup>. In these or other embodiments, the glass fiber mat may be characterized by a basis weight of at most 150, in other embodiments at most 130, and in other embodiments at most 100 g/m.<sup>sup.2</sup>. In one or more embodiments, the glass fiber mat may be characterized by a basis weight of from about 50 to about 150 g/m.<sup>sup.2</sup>, in other embodiments from about 60 to about 130 g/m.<sup>sup.2</sup>, and in other embodiments from about 70 to about 110 g/m.<sup>sup.2</sup>.

(38) In one or more embodiments, where the fabric backing is a glass fiber mat, the glass mat may be characterized by a thickness of at least 0.5 mm, in other embodiments at least 0.7 mm, and in other embodiments at least 1.0 mm. In these or other embodiments, the glass mat may be characterized by a thickness of at most 2.0 mm, in other embodiments at most 1.5 mm, and in other embodiments at most 1.2 mm. In one or more embodiments, the glass mat may be characterized by a thickness of from about 0.5 to about 2.0 mm, in other embodiments from about 0.7 to about 1.5 mm, and in other embodiments from about 1.0 to about 1.2 mm.

(39) In one or more embodiments, where the fabric backing is a polyester fleece, the fabric may be characterized by a basis weight of at least 70, in other embodiments at least 85, and in other embodiments at least 100 g/m.<sup>sup.2</sup>. In these or other embodiments, the polyester fleece may be characterized by a basis weight of at most 400, in other embodiments at most 300, and in other embodiments at most 280 g/m.<sup>sup.2</sup>. In one or more embodiments, the polyester fleece may be characterized by a basis weight of from about 70 to about 400 g/m.<sup>sup.2</sup>, in other embodiments from about 85 to about 300 g/m.<sup>sup.2</sup>, and in other embodiments from about 100 to about 280 g/m.<sup>sup.2</sup>.

(40) In one or more embodiments, where the fabric backing is a polyester fleece, the glass mat may be characterized by a thickness of at least 0.5 mm, in other embodiments at least 0.7 mm, and in other embodiments at least 1.0 mm. In these or other embodiments, the polyester fleece may be characterized by a thickness of at most 4.0 mm, in other embodiments at most 2.0 mm, and in other embodiments at most 1.5 mm. In one or more embodiments, the polyester fleece may be characterized by a thickness of from about 0.5 to about 4.0 mm, in other embodiments from about 0.7 to about 2.0 mm, and in other embodiments from about 1.0 to about 1.5 mm.

(41) Preparation of Membrane Composite

(42) The membrane panels employed in the membrane composites of the present invention may be prepared by conventional techniques. For example, thermoplastic membrane panels may be formed by the extrusion of thermoplastic compositions into one or more layers that can be laminated into a membrane panel. Thermoset membranes can be formed using known calendering and curing techniques. Alternatively, thermoset membranes can be made by continuous process such as those disclosed in WO 2013/142562, which is incorporated herein by reference.

(43) Once the membrane is formed, the curable hot-melt adhesive can be extruded onto the membrane by using known apparatus such as adhesive coaters. The adhesive can then subsequently be cured by using, for example, UV radiation. Once the adhesive has been sufficiently cured (e.g. by exposure to UV curing), a fabric backing can be applied to the cured coating, and then the composite can be wound into a roll for storage and shipment. Advantageously, where the membrane panel is made by using continuous techniques, the process can be supplemented with continuous techniques for applying and curing the adhesive coatings according to embodiments of the present invention to thereby prepare usable membrane composites within a single continuous process.

(44) As generally shown in FIG. 5, process **230** for preparing a composite membrane according to the present invention generally begins with a step of heating **232**, wherein a pressure-sensitive adhesive is heated to a sufficient temperature to allow the adhesive to be applied as a coating within a coating step **234**. Within coating step **234**, the adhesive is applied to the membrane to form a coating layer. Following formation of the coating, the coating is subjected to a UV-curing step **236** where sufficient UV energy is applied to the coating to thereby effect a desirable curing or crosslinking of the adhesive. Once the adhesive has been sufficiently cured by exposure to UV curing step **236**, a fabric backing can be applied to the cured coating in an application step **238**. Following application of the fabric, the composite can be wound into a roll at winding step **240**.

(45) In one or more embodiments, heating step **232** heats the adhesive to a temperature of from about 120 to about 160° C., in other embodiments from about 125 to about 155° C., and in other embodiments from about 130 to about 150° C.

(46) In one or more embodiments, adhesive step **234** applies an adhesive to the surface of a membrane to form an adhesive layer of adhesive that has a thickness of at least 51  $\mu\text{m}$  (2 mil), in other embodiments at least 102  $\mu\text{m}$  (4 mil), in other embodiments at least 127  $\mu\text{m}$  (5 mil), and in other embodiments at least 152  $\mu\text{m}$  (6 mil). In one or more embodiments, adhesive step **234** applies an adhesive to the surface of a membrane to form an adhesive layer of adhesive that has a thickness of from about 51 to about 381  $\mu\text{m}$  (about 2 to about 15 mil), in other embodiments from about 102 to about 305  $\mu\text{m}$  (about 4 to about 12 mil), and in other embodiments from about 127 to about 254  $\mu\text{m}$  (about 5 to about 10 mil). In one or more embodiments, the adhesive has a uniform thickness such that the thickness of the adhesive at any given point on the surface of the membrane does not vary by more than 51  $\mu\text{m}$  (2 mil), in other embodiments by more than 38  $\mu\text{m}$  (1.5 mil), and in other embodiments by more than 25  $\mu\text{m}$  (1 mil).

(47) In one or more embodiments, UV curing step **236** subjects the adhesive to a UV dosage of from about 30 to about 380 millijoule/cm.<sup>2</sup>, in other embodiments from about 35 to about 300 millijoule/cm.<sup>2</sup>, in other embodiments from about 40 to about 280 millijoule/cm.<sup>2</sup>, in other embodiments from about 45 to about 240 millijoule/cm.<sup>2</sup>, and in other embodiments from about 48 to about 235 millijoule/cm.<sup>2</sup>. It has advantageously been discovered that the required dosage of energy can be exceeded without having a deleterious impact on the adhesives of the present invention. For example, up to ten times, in other embodiments up to five times, and in other embodiments up to three times the required dosage can be applied to the adhesive composition without having a deleterious impact on the adhesive composition and/or its use in the present invention.

(48) In one or more embodiments, UV curing step **236** subjects the adhesive to a UV intensity, which may also be referred to as UV irradiance, of at least 150 milliWatts/cm.<sup>2</sup>, in other

embodiments at least 200, and in other embodiments at least 250 milliWatts/cm.sup.2. In these or other embodiments, UV curing step **236** subjects the adhesive to a UV intensity of from about 150 to about 500 milliWatts/cm.sup.2, in other embodiments from about 200 to about 400 milliWatts/cm.sup.2, and in other embodiments from about 250 to about 350 milliWatts/cm.sup.2. It has advantageously been discovered that the ability to appropriately cure the adhesive compositions of the present invention, and thereby provide a useful pressure-sensitive adhesive for the roofing applications disclosed herein, critically relies on the UV intensity applied to the adhesive. It is believed that the thickness of the adhesives (and therefore the thickness of the pressure-sensitive adhesive layer) employed in the present invention necessitates the application of greater UV intensity.

(49) In one or more embodiments, the energy supplied to the adhesive layer within UV radiation step **236** is in the form of UV-C electromagnetic radiation, which can be characterized by a wave length of from about 250 to about 260 nm. In one or more embodiments, the UV dosage applied during UV curing step **236** is regulated based upon a UV measuring and control system that operates in conjunction with UV curing step **236**. According to this system, UV measurements are taken proximate to the surface of the adhesive layer using known equipment such as a UV radiometer. The data from these measurements can be automatically inputted into a central processing system that can process the information relative to desired dosage and/or cure states and automatically send signal to various variable-control systems that can manipulate one or more process parameters. For example, the power supplied to the UV lamps and/or the height at which the UV lamps are positioned above the adhesive layer can be manipulated automatically based upon electronic signal from the central processing unit. In other words, the UV intensity, and therefore the UV dosage, can be adjusted in real time during the manufacturing process.

(50) In one or more embodiments, an exemplary process for preparing the membrane composites of the present invention can be described with reference to FIG. **6**. Continuous process **250** includes a heating step **252** where UV-curable hot-melt adhesive **251** is heated to a desired temperature within a heated tank **253**. Adhesive **251** is fed into an extrusion device, such as a coater **255**, which may include a pump, such as a gear pump **257**, and a slot die **259**. Within coating step **254**, coater **255** extrudes adhesive **251**, which is in its molten, liquid or flowable state, and deposits a coating layer **261** of adhesive **251** onto a planar surface **263** of membrane **265**.

(51) As shown in FIG. **6**, coating step **254** can include a roll-coating operation, where adhesive **251** is applied to membrane **265** while membrane **265** is at least partially wound around a coating mandrel **267**. Membrane **265** carrying coating layer **261** is fed to a crosslinking step **256**, where coating layer **261** of adhesive **251** is subjected to a desired dosage of UV radiation **269**, which may be supplied by one or more UV lamps **271**. UV lamps **271** may include, for example, mercury-type UV lamps or LED UV lamps. As the skilled person appreciates, the desired dosage of UV energy can be supplied to coating **261** by adjusting the UV intensity and exposure time. The intensity can be manipulated by the power supplied to the respective lamps and the height (H) that the lamps are placed above the surface of coating **261** of adhesive **251**. Exposure time can be manipulated based upon the line speed (i.e., the speed at which membrane **265** carrying coating layer **261** is passed through UV curing step **256**).

(52) Following UV curing step **256**, fabric **273** may be applied to upper surface **275** of coating layer **261** within fabric application step **258**. As shown in FIG. **6**, fabric **273** may be supplied from a mandrel **277** and mated to upper surface **275** through pressure supplied by nip rolls **279**. After application of fabric **273**, the composite product may be wound within winding step **260** to provide wound rolls **281** of composite products **283**.

(53) Installation of Membrane Composite

(54) In one or more embodiments, the membrane composites of the present invention can be adhesively secured to a roof system (i.e. secured to an underlying roof substrate) by employing techniques well known in the art of securing fabric-backed roofing membranes. For example, a

liquid-based adhesive can be applied to the roof surface and then the membrane composite can be unrolled onto the adhesive to contact the fabric backing to the adhesive. Various liquid-based adhesives can be employed including polyurethane, one-part and two-part adhesives (which are often foaming adhesives), as well as those bonding adhesives based upon polychloroprenes and neoprenes. Other adhesive systems include solvent-free bonding adhesive such as those polymeric systems that rely upon silicon functionalities for crosslinking. Exemplary solvent-free bonding systems include those described in U.S. Publ. No. 2016/0340905, which is incorporated herein by reference. Using conventional techniques, adjacent membranes are typically overlapped, and a lap seam is formed between overlapping membranes. In the case of thermoplastic membranes, the lap seam can be formed by heat welding. Alternatively, especially in the case of EPDM membranes, a lap seam can be formed by using a solid tape or liquid adhesive (e.g. butyl-based adhesive). In yet other embodiments, as suggested with respect to FIG. 2, the adhesives employed in the present invention for securing the fabric backing to the membrane can also be used in securing a seam between adjacent, overlapping membranes. In other embodiments, such as those described with reference to FIG. 3, the outer adhesive layer can be used, after exposing the layer by removal of the release liner, to secure the membrane composite to the roof deck and/or to adjacent membranes by employing standard peel-and-stick techniques.

(55) Roof System

(56) A roof system according to embodiments of the present invention can be described with reference to FIG. 4, which shows roof system **101** including membrane composite **111**, which includes planar body **113** and fabric backing **115** secured to planar body **113** through pressure-sensitive adhesive layer **117**.

(57) Various modifications and alterations that do not depart from the scope and spirit of this invention will become apparent to those skilled in the art. This invention is not to be duly limited to the illustrative embodiments set forth herein.

## Claims

1. A method for preparing a membrane composite, the method comprising: (i) providing an EPDM roofing membrane panel having opposed first and second planar surfaces; (ii) providing a UV-curable polyacrylate composition, wherein the UV-curable polyacrylate includes monomeric units defined by the formula:  $##STR00002##$  where each R<sup>sup.1</sup> is individually hydrogen or a hydrocarbyl group and each R<sup>sup.2</sup> is individually a hydrocarbyl group, where R<sup>sup.2</sup> is an alkyl group having at least 4 carbon atoms; (iii) providing a fabric; (iv) applying the UV-curable polyacrylate composition to the first planar surface of the EPDM membrane to thereby form a laminate that includes a layer of UV-curable polyacrylate and a layer of EPDM roofing membrane panel; (v) subjecting the layer of UV-curable polyacrylate to UV radiation to thereby form a cured laminate that includes a layer of cured polyacrylate and a layer of EPDM roofing membrane panel, where the layer of cured polyacrylate is a pressure-sensitive adhesive; and (vi) mating the layer of fabric to the layer of cured polyacrylate to thereby form the membrane composite.
2. The method of claim 1, where the UV-curable polyacrylate consists essentially of monomeric units defined by the formula:  $##STR00003##$  where each R<sup>sup.1</sup> is individually hydrogen or a hydrocarbyl group and each R<sup>sup.2</sup> is individually a hydrocarbyl group, where R<sup>sup.2</sup> is an alkyl group having at least 4 carbon atoms.
3. The method of claim 1, where the UV-curable polyacrylate consists of monomeric units defined by the formula:  $##STR00004##$  where each R<sup>sup.1</sup> is individually hydrogen or a hydrocarbyl group and each R<sup>sup.2</sup> is individually a hydrocarbyl group, where R<sup>sup.2</sup> is an alkyl group having at least 4 carbon atoms.
4. The method of claim 1, where the fabric is a polyester fleece.
5. The method of claim 4, where the EPDM membrane panel meets the specifications of ASTM D-

6. The method of claim 5, where the polyester fleece has a thickness of from about 0.5 to about 4.0 mm and a basis weight of at least 70 g/m.<sup>2</sup>.
  7. The method of claim 1, where said step of applying includes applying the UV-curable polyacrylate composition across the entire width of the first planar surface of the membrane panel.
  8. The method of claim 2, where R.<sup>1</sup> is hydrogen and R.<sup>2</sup> is selected from the group consisting of butyl, 2-ethylhexyl, and mixtures thereof.
  9. The method of claim 8, where the polyacrylate is a copolymer including monomeric units of the formula where R.<sup>2</sup> is butyl and monomeric units of the formula where R.<sup>2</sup> is 2-ethylhexyl.
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