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(54) Title: ADHESIVE COMPOSITION

(57) Abstract: The present disclosure provides a composition. In an embodiment, the composition is an adhesive composition. The adhesive composition includes an acrylic emulsion, a tackifier, and a rheology modifier. The present adhesive composition can be an adhesive layer disposed between a first substrate and a second substrate in a laminate structure, the first substrate and the second substrate selected from roof substrate and/or roofing membrane.



ADHESIVE COMPOSITION

BACKGROUND

[001] Roofing membrane is a sheet-like structure, usually single-ply, with moisture barrier properties and is composed of a polymeric material such as ethylene-propylene-diene terpolymer (EPDM), butyl rubber, neoprene, polyvinyl chloride (PVC), chlorinated polyethylene, thermoplastic polyolefin (TPO) and/or modified bitumen/asphalt. Roofing membrane is typically overlapped and/or spliced together with an adhesive to form a continuous, water-tight sheet for covering a roof area. One way to attach roofing membrane to other structural substrate(s) is by way of an adhesive composition. Adhesive composition finds favor as the adherent for roofing membrane (as opposed to rivets or fusion bonds, for example), because adhesive composition is easy to apply as a continuous layer, and adhesive composition provides even and uniform adhesion compared to rivets or fusion bonds which provide point bonding.

[002] The adhesive composition requires appropriate bond strength to adhere the roofing membrane to other industrial substrates such as steel, wood, concrete, roof boards, and insulation. As roofing membrane is exposed to stresses such as roof movement, heavy winds, freeze-thaw cycles and thermal cycles, so too must the adhesive composition be resilient and capable to withstand these same stresses. To meet these demands, conventional adhesive composition for roofing membrane is typically solvent-based and utilizes organic solvents such as toluene and xylene. Use of these solvents poses environmental, health and fire hazards, making solvent-based adhesive compositions undesirable.

[003] Thus, the art recognizes the need for an adhesive composition for roofing membrane, that reduces, or eliminates, the use of harmful organic solvents, yet maintains, or exceeds the bond strength of conventional solvent-based roofing adhesives.

SUMMARY

[004] The present disclosure provides a composition. In an embodiment, the composition is an adhesive composition. The adhesive composition includes an acrylic emulsion, a tackifier, and a rheology modifier.

[005] The present disclosure provides a laminate structure. In an embodiment, the laminate structure includes a first substrate and a second substrate. An adhesive composition is disposed between the first substrate and the second substrate. The adhesive composition is composed of an acrylic emulsion, a tackifier, and a rheology modifier.

[006] In an embodiment, the first substrate and the second substrate are selected from roof substrate and/or roofing membrane.

DEFINITIONS

[007] Any reference to the Periodic Table of Elements is that as published by CRC Press, Inc., 1990–1991. Reference to a group of elements in this table is by the new notation for numbering groups.

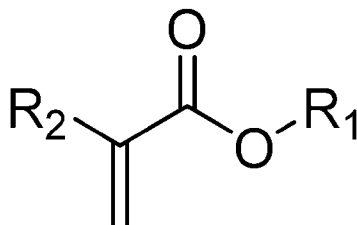
[008] For purposes of United States patent practice, the contents of any referenced patent, patent application or publication are incorporated by reference in their entirety (or its equivalent US version is so incorporated by reference) especially with respect to the disclosure of definitions (to the extent not inconsistent with any definitions specifically provided in this disclosure) and general knowledge in the art.

[009] The numerical ranges disclosed herein include all values from, and including, the lower and upper value. For ranges containing explicit values (e.g., 1 or 2, or 3 to 5, or 6, or 7), any subrange between any two explicit values is included (e.g., the range 1-7 above includes subranges of from 1 to 2; from 2 to 6; from 5 to 7; from 3 to 7; from 5 to 6; etc.).

[0010] Unless stated to the contrary, implicit from the context, or customary in the art, all parts and percents are based on weight and all test methods are current as of the filing date of this disclosure.

[0011] An "acrylic-based monomer," as used herein, is a monomer containing the Structure (A) below:

Structure (A)



wherein R_1 is H or a C_1 - C_{18} alkyl group, and R_2 is H or CH_3 . Acrylic-based monomers include acrylic acid, methacrylic acid, acrylates, and methacrylates.

[0012] The terms "blend" or "polymer blend," as used herein, is a blend of two or more polymers. Such a blend may or may not be miscible (not phase separated at molecular level). Such a blend may or may not be phase separated. Such a blend may or may not contain one or more domain configurations, as determined from transmission electron spectroscopy, light scattering, x-ray scattering, and other methods known in the art.

[0013] The term "composition" refers to a mixture of materials which comprise the composition, as well as reaction products and decomposition products formed from the materials of the composition.

[0014] The terms "comprising," "including," "having" and their derivatives, are not intended to exclude the presence of any additional component, step or procedure, whether or not the same is specifically disclosed. In order to avoid any doubt, all compositions claimed through use of the term "comprising" may include any additional additive, adjuvant, or compound, whether polymeric or otherwise, unless stated to the contrary. In contrast, the term "consisting essentially of" excludes from the scope of any succeeding recitation any other component, step, or procedure, excepting those that are not essential to operability. The term "consisting of" excludes any component, step, or procedure not specifically delineated or listed. The term "or," unless stated otherwise, refers to the listed members individually as well as in any combination. Use of the singular includes use of the plural and vice versa.

[0015] An "olefin-based polymer" or "polyolefin" is a polymer that contains more than 50 weight percent polymerized olefin monomer (based on total amount of polymerizable monomers), and optionally, may contain at least one comonomer. A nonlimiting example of an olefin-based polymer is ethylene-based polymer.

[0016] A "polymer" is a compound prepared by polymerizing monomers, whether of the same or a different type, that in polymerized form provide the multiple and/or repeating "units" or "mer units" that make up a polymer. The generic term polymer thus embraces the term homopolymer, usually employed to refer to polymers prepared from only one type of

monomer, and the term copolymer, usually employed to refer to polymers prepared from at least two types of monomers. It also embraces all forms of copolymer, e.g., random, block, etc. The terms "ethylene/ α -olefin polymer" and "propylene/ α -olefin polymer" are indicative of copolymer as described above prepared from polymerizing ethylene or propylene respectively and one or more additional, polymerizable α -olefin monomer. It is noted that although a polymer is often referred to as being "made of" one or more specified monomers, "based on" a specified monomer or monomer type, "containing" a specified monomer content, or the like, in this context the term "monomer" is understood to be referring to the polymerized remnant of the specified monomer and not to the unpolymerized species. In general, polymers herein are referred to as being based on "units" that are the polymerized form of a corresponding monomer.

TEST METHODS

[0017] 90° peel test. 90° peel test was conducted with an Instron Peel Text Fixture (INSTRON 5566). Test speed is 2 in/min.

[0018] Emulsion or dispersion viscosity. Emulsion or dispersion viscosity was measured using a Brookfield Viscometer Model, and a Brookfield RV-DV-II-Pro viscometer spindle #27, at 25°C. The sample was poured into a cup and enough volume was poured in, such that when the viscometer apparatus was lowered, the spindle was completely submerged into the dispersion. The viscometer was turned on and set to operate at a shear rate from 1 to 10 rounds per minute (rpm) to ensure torque is within 100%. Readings were monitored for 15 minutes, or until the values stabilized, at which point, a final reading was recorded.

DETAILED DESCRIPTION

[0019] The present disclosure provides an adhesive composition. In an embodiment, the adhesive composition includes an acrylic emulsion, a tackifier, and a rheology modifier.

1. Acrylic emulsion

[0020] The present adhesive composition includes the acrylic emulsion. The acrylic emulsion is

a water-based acrylic dispersion (interchangeably referred to as “acrylic emulsion”). The term “water-based acrylic dispersion” is a composition wherein water is the continuous phase, *i.e.*, a composition having an aqueous medium. The acrylic dispersion (acrylic emulsion) is formed by the polymerization of one or more acrylic-based monomers and optionally other unsaturated monomers. Nonlimiting examples of suitable polymerization procedures include emulsion polymerization, mini emulsion polymerization, micro-emulsion polymerization, or suspension polymerization processes where the solvent is water.

[0021] The water-based acrylic emulsion (interchangeably referred to as “acrylic dispersion”) includes one or more acrylic-based monomers (and optionally one or more other unsaturated monomers), a surfactant, an initiator, a neutralizer, and water, optionally to the exclusion of an ethylene-based polymer. As used herein, the use of the term “(meth)” followed by another term such as acrylate refers to both acrylates and methacrylates. For example, the term “(meth)acrylate” refers to either acrylate or methacrylate; the term “(meth)acrylic” refers to either acrylic or methacrylic; the term “(meth)acrylic acid” refers to either acrylic acid or methacrylic acid; and the term “(meth)acrylamide” refers to either acrylamide or methacrylamide.

[0022] Nonlimiting examples of suitable acrylic-based monomers include C₁-C₁₉-alkyl (meth)acrylates, for example, methyl (meth)acrylate, ethyl (meth)acrylate, n-butyl (meth)acrylate, 2-ethylhexyl (meth)acrylate, cyclohexyl (meth)acrylate, n-octyl (meth)acrylate, n-decyl (meth)acrylate, n-dodecyl (meth)acrylate (*i.e.*, lauryl (meth)acrylate), tetradecyl (meth)acrylate, oleyl (meth)acrylate, palmityl (meth)acrylate, stearyl (meth)acrylate, isobornyl (meth)acrylate, benzyl (meth)acrylate, (meth)acrylic acid, butyl acrylate (BA), ethylhexyl acrylate (2-EHA), ethyl acrylate (EA), methyl acrylate (MA), butyl methacrylate (BMA), uridomethacrylate (UMA), octyl acrylate, isooctyl acrylate, decyl acrylate, isodecyl acrylate, lauryl acrylate, cyclohexyl acrylate, methyl methacrylate (MMA), isobutyl methacrylate, octyl methacrylate, isooctyl methacrylate, decyl methacrylate, isodecyl methacrylate, lauryl methacrylate, pentadecyl methacrylate, stearyl methacrylate, n-butyl methacrylate, C₁₂ to C₁₈ alkyl methacrylates, cyclohexyl methacrylate, acrylic acid, methacrylic acid, and combinations thereof.

[0023] One or more other unsaturated monomers may be polymerized with the acrylic-based monomer(s). Nonlimiting examples of suitable “other unsaturated monomers” include 2-hydroxyethyl acrylate (2-HEA), 2-hydroxyethyl methacrylate (2-HEMA), styrene (STY), acrylonitrile (AN), vinyl ester, vinyl acetate, unsaturated carboxylic acid, monomethacryloylethyl phosphate (PEM), allyl phthalate, and combinations thereof. Nonlimiting examples of suitable unsaturated carboxylic acid include itaconic acid, fumaric acid, citraconic acid, sorbic acid, cinnamic acid, glutaconic acid and maleic acid; monoethylenically unsaturated carboxylic anhydride, such as itaconic acid anhydride, fumaric acid anhydride, citraconic acid anhydride, sorbic acid anhydride, cinnamic acid anhydride, glutaconic acid anhydride and maleic acid anhydride; monoethylenically unsaturated amides, such as N-alkylolamides, such as (meth)acrylamide, methylol (meth)acrylamide, 2-hydroxyethyl (meth)acrylamide; and hydroxyalkyl esters of monoethylenically unsaturated carboxylic acids, such as hydroxyethyl (meth)acrylate and hydroxypropyl (meth)acrylate and combinations thereof.

[0024] The acrylic dispersion includes a surfactant. Nonlimiting examples of suitable surfactant include cationic surfactants, anionic surfactants, zwitterionic surfactants, non-ionic surfactants, and combinations thereof. The surfactant can be an anionic surfactant and/or a nonionic surfactant such as, for example, alkali metal or ammonium salts of alkyl, aryl, or alkylaryl sulfates, sulfonates or phosphates; alkyl sulfonic acids; fatty acids; ethylenically unsaturated surfactant monomers; ethoxylated alcohols or phenols, and sodium vinyl sulfonate. In an embodiment, the surfactant is sodium lauryl sulfate (SLS).

[0025] The acrylic dispersion includes a neutralizer. The neutralizer serves two purposes. It improves colloidal stability by ionic repulsive interactions of deprotonated (meth)acrylic acid moieties. It also provides a way to improve the solubility of the post-additive ethoxylated phosphate ester surfactants. Nonlimiting examples of suitable neutralizer include NaOH, KOH, NH₄OH, Borax, NaHCO₃, KHCO₃, Na₂CO₃, K₂CO₃, Na₂HPO₄, K₂HPO₄, Na₂B₄O₇, and organoamines (alkylamines, alkanolamines) such as methylamine, ethylamine, isopropylamine, n-butylamine, n-hexylamine, n-octylamine, 2-ethylhexylamine, diethylamine, di-n-butylamine, diisopropylamine, triethylamine, tri-n-butylamine, benzylamine, 2-phenyl-

ethylamine, 2-amino-2-methyl-1-propanol, monoethanolamine, diethanolamine, triethanolamine, isopropanolamine, N-methylethanolamine, N-methyldiethanolamine, N,N-dimethylethanolamine, and combinations thereof.

[0026] The surfactant acts as an emulsifier and enables droplets of the acrylic-based monomer (and optional other unsaturated monomer), which is hydrophobic, to form throughout the aqueous medium. An initiator is then introduced into the emulsified mixture. The initiator reacts with the acrylic-based monomer(s) (and optional other unsaturated monomer) dispersed throughout the aqueous medium until all, or substantially all, of the acrylic-based monomer(s) (and optional other unsaturated monomer) is/are polymerized. The end result is an acrylic dispersion composed of a dispersion of acrylic-based polymer particles in the aqueous medium, the acrylic-based polymer particles composed of one or more acrylic-based monomer subunits (and optional other unsaturated monomer) to the exclusion of ethylene-based polymer. A neutralizer is added to adjust the pH of the resulting acrylic-based polymer particles to the desired pH range. The neutralizer also serves to solubilize any post-additive surfactant.

[0027] The acrylic dispersion may optionally include a defoamer, a wetting agent, a rheology modifier, and any combination thereof.

[0028] In an embodiment, the acrylic dispersion includes a crosslinking monomer. Nonlimiting examples suitable crosslinking monomer include allyl acrylate, allyl methacrylate, di-allyl phthalate, N-methylol acrylamide, and any combination thereof.

[0029] In an embodiment, the adhesive acrylic dispersion optionally includes one or more additives. Nonlimiting examples of suitable additives include defoamers, rheology modifiers, solvents, coalescing agents, biocides, preservatives, and combinations thereof. Commercially available defoamers include, but are not limited to, Tego Antifoam 2291, Foamaster MO S090, Tego Antifoam KS 53, Tego Antifoam 2450, Tego Antifoam D 2315, BYK 011, and Fluxair A-97.

[0030] In an embodiment, the acrylic dispersion includes

an acrylic-based polymer composed of one or more acrylic-based monomers selected from butyl acrylate (BA), ethylhexyl acrylate (2-EHA), ethyl acrylate (EA), methyl acrylate (MA), butyl methacrylate (BMA), and combinations thereof,

an unsaturated monomer selected from 2-hydroxyethyl acrylate (2-HEA), 2-hydroxyethyl methacrylate (2-HEMA), styrene (STY), acrylonitrile (AN), vinyl ester, vinyl acetate, methacrylic acid, acrylic acid, itaconic acid, allyl acrylate, allyl phthalate, and combinations thereof, and

a surfactant that is sodium vinyl sulfonate.

[0031] In an embodiment, the acrylic dispersion includes an acrylic-based polymer composed of

- (a) from 80 wt% to 95 wt% of 2-ethylhexyl acrylate monomer,
- (b) from 20 wt% to 2 wt% ethylene vinyl acetate comonomer, and
- (c) from 1% to 3% of acrylic acid and itaconic acid, and
- (d) a surfactant that is sodium vinyl sulfonate, wherein (a), (b), (c), and (d) amount to 100 dry wt% of the acrylic-based polymer and weight percent is based on total dry weight of the acrylic-based polymer.

2. Tackifier

[0032] The present adhesive composition includes the tackifier. The tackifier can be an aliphatic hydrocarbon resin made from the polymerization of monomers including ethylenically unsaturated C₄ -C₈ molecules; a rosin ester and/or a rosin acid; mixed aliphatic/aromatic tackifying resins; a polyterpene; and a hydrogenated tackifying resin. The hydrogenated resins also include resins formed from the polymerization and subsequent hydrogenation of a feedstock based on dicyclopentadiene; resins produced from the polymerization and subsequent hydrogenation of pure aromatic feedstocks such as styrene, alpha-methylstyrene, vinyl toluene; resins formed from the polymerization and subsequent hydrogenation of C₇ -C₁₂ aromatics; and resins produced from the polymerization and subsequent hydrogenation of aliphatic petroleum derivatives of C₄ -C₁₀ dienes and mono-olefins, such as piperylene, isoprene and 2-methyl-2-butene.

[0033] In an embodiment, the tackifier is a rosin resin formed from (i) a rosin acid and/or a rosin ester obtained by esterifying the rosin acid/ester with an alcohol, an epoxy compound, a non-hydrogenated aliphatic C₅ resin, a hydrogenated aliphatic C₅ resin, an aromatic modified

C₅ resin, a terpene resin, a hydrogenated C₉ resin, a (meth)acrylic resin, and combinations thereof. Nonlimiting examples of suitable tackifier include SNOWTACK 100X, SNOWTACK 100G, and combinations thereof.

3. Rheology modifier

[0034] The present adhesive composition includes the rheology modifier. The rheology modifier can be a non-ionic polyurethane; a hydrophobically modified alkali swellable emulsion (HASE) that is a polyacrylate based polymer such as polyacrylate polymer based on a majority by monomer number percentage of acrylic acid, acrylic acid esters, vinyl acetate, methacrylic acid, acrylonitrile and mixtures thereof; a hydrophobically modified ethylene oxide urethane rheology modifier (HEUR), a hydroxyl ethyl cellulose such as hydrophobically modified hydroxyl ethyl cellulose; xanthan gum; hydrogenated castor oil (HCO) and mixtures thereof.

[0035] In an embodiment, the rheology modifier is selected from a hydrophobically modified, alkali swellable emulsions (HASE) rheology modifier, a hydrophobically-modified ethylene oxide urethane (HEUR) rheology modifier, and combinations thereof.

4. Optional Additives

[0036] One or more optional additives may be present in the adhesive composition. When the additive is present, nonlimiting examples of suitable additives include defoamer, wetting agent, mechanical stabilizer, pigment, filler, freeze-thaw agent, neutralizing agent, plasticizer, adhesion promoter, and combinations thereof.

[0037] In an embodiment, the adhesive composition includes a defoamer. Nonlimiting examples of defoamer include mineral oil based defoamer, such as Airase 4500 and TEGO Antifoam 2263, FoamStar ST2410, or organo modified siloxanes, such as TEGO Antifoam D2315, TEGO Antifoam 4-88, TEGO Antifoam 1488, DOWSIL AFE-7610, XIAMETER AFE-2210, DOWSIL 112F additive, DOWSIL 62 additive.

[0038] In an embodiment, the adhesive composition comprises, or consists of

(1) from 65 wt% to 94 wt%, or from 65 wt% to 80 wt% of the acrylic emulsion,

(2) from 5 wt% to 35 wt%, or from 15 wt% to 30 wt% of the tackifier,

(3) from 0.2 wt% to 3 wt% or from 0.5 wt% to 2 wt% of the rheology modifier,

(4) from 0 wt%, or from 0.1 wt% to 0.5 wt% of a defoamer,

components (1), (2), (3), and (4) amount to 100 wt% of the adhesive composition, and weight percent is based on total wet formulation weight, and the adhesive composition has one, some, or all of the following properties:

a pH from 7.5 to 9.5, and/or

a viscosity from 15,000 cP to 200,000 cP, or from 30,000 cP to 150,000 cP.

5. Laminate structure

[0039] The present disclosure provides a laminate structure. The laminate structure includes a first substrate and a second substrate. The present adhesive composition is disposed between, or is otherwise located between, the first substrate and the second substrate and forms an adhesive layer. The adhesive composition is the present adhesive composition formed from the acrylic emulsion, the polyurethane dispersion, the rheology modifier, and the tackifier as previously disclosed herein.

[0040] The adhesive layer (composed of the present adhesive composition) may be a continuous layer or may be a discontinuous layer disposed between the first substrate and the second substrate. In an embodiment, the adhesive layer is in direct contact with the first substrate and is in direct contact with the second substrate. The term “direct contact,” as used herein, is a configuration whereby two components, or two structures, are in physical contact with each other with no intervening layer(s) and/or no intervening material(s) and/or no intervening structure(s) located between a portion of the two contacting components. The thickness of the adhesive layer is from 50 microns to 1500 microns, or from 100 microns to 800 microns.

[0041] The laminate structure includes the first substrate and the second substrate. The first substrate and/or the second substrate can be a roof substrate or a roofing membrane. A “roof substrate,” as used herein is a plywood roof substrate, a glass roof substrate, a cellulosic roof substrate, a roofing shingle, a glass mat, a fiberglass mat, an underlayment, a roof deck, a

photovoltaic (PV) panel, a modified bitumen (MODBIT) substrate, a roll good, a chimney, a polyisocyanurate (ISO) foam board, a fiberglass roof board an insulation board and a cover board wherein the insulation board and/or cover board 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, OSB and plywood, as well as gypsum or any combination thereof. The roof substrate may also include the roof deck, which may include steel, concrete, and/or wood.

[0042] A “roofing membrane,” as used herein, is a sheet of a flexible material having a thickness from 20 mil (0.508 mm) to 140 mil (3.556 mm), or from 30 mil (0.762 mm) to 120 mil (3.048 mm), or from 40 mil (1.016 mm) to 100 mil (2.54 mm). Roofing membrane, when properly installed, prevents water and/or moisture from leaking into a building, a home, or other structure or dwelling. Nonlimiting examples of roofing membrane include polyvinyl chloride (PVC) roofing membrane, a thermoplastic polyolefin (TPO) roofing membrane, an ethylene propylene diene monomer (EPDM) roofing membrane, chlorosulfonated polyethylene roofing membrane, asphalt-based roofing membrane such as modified asphalt membranes and/or built roof systems.

[0043] In an embodiment, the first substrate is a roof substrate, and the second substrate is a roof substrate. The second substrate can be the same roof substrate as the first substrate, or the second substrate is a roof substrate that is different than the roof substrate for the first substrate.

[0044] In an embodiment, the first substrate is a roof substrate, and the second substrate is a roofing membrane.

[0045] In an embodiment, the first substrate is a roofing membrane, and the second substrate is a roofing membrane. The second substrate can be the same roofing membrane as the first substrate, or the second roofing membrane is a roofing membrane that is different than the roofing membrane for the first substrate.

[0046] The adhesive composition can be applied to the first substrate (*substrate1*) and/or to the second substrate (*substrate2*) by way of dip and roll techniques, roller, brush, spray, and any combination thereof to prepare an adhesive-coated substrate. The first substrate and/or the second substrate may or may not be subjected to a surface treatment prior to application

of the present adhesion composition thereto. Nonlimiting examples of suitable surface treatments include a primer coating, and a corona discharge treatment prior to application of the adhesive composition as a layer onto the substrate surface(s). The other substrate is then placed, or otherwise positioned, on the adhesive-exposed surface of the adhesive-coated substrate. A roller, or a similar device, can then be applied to ensure firm contact between the adhesive composition and the other substrate, thereby forming the laminate structure with configuration: *substrate1 (substrate2)/present adhesive composition/substrate2 (substrate1)*, with alternate layer configuration shown in parentheses. The laminate structure is then dried and/or cured.

[0047] The adhesive layer for the laminate structure is the present adhesive composition formed from the acrylic emulsion, the polyurethane dispersion, the rheology modifier, and the tackifier as previously disclosed herein. When fully dried, or otherwise fully cured, the laminate structure includes the first substrate, the second substrate, and the adhesive layer disposed between the first substrate and the second substrate, and the adhesive layer comprises, or consists of

- (1) from 65 wt% to 94 wt%, or from 65 wt% to 80 wt% of an acrylic-based polymer,
 - (2) from 5 wt% to 35 wt%, or from 15 wt% to 30 wt% of the tackifier,
 - (3) from 0.2 wt% to 3 wt%, or from 0.2 wt% to 2 wt% of the rheology modifier, and
 - (4) from 0 wt%, or from 0.1 wt% to 0.5 wt% of a defoamer, and
- components (1), (2), (3), and (4), amount 100 wt% of the adhesive composition (in wet).

[0048] The present adhesive composition does not require the use of organic solvents—that is, the present adhesive composition is solvent-free. Applicant surprisingly discovered that the present adhesive composition that is waterborne, is fast-curing and develops bond strength immediately after application to a substrate. The present adhesive composition is formulated to form a bond between a roof substrate and a roofing membrane, and combinations thereof.

[0049] By way of example, and not limitation, some embodiments of the present disclosure will now be described in detail in the following Examples.

EXAMPLES

[0050] The materials used in the inventive examples (“IE”) and comparative samples (“CS”) are provided in Table 1 below.

[0051] Table 1

Material/Description	Properties	Source
<i>Acrylic emulsion1</i>	waterborne vinyl-acrylic emulsion with solid content 63%, pH 4.6, viscosity 250mPa.s, particle size 200-1200nm, composed of 2-ethylhexyl acrylate monomer, ethylene vinyl acetate, styrene, acrylic acid, itaconic acid, sodium vinyl sulfonate, and water	Dow Chemical
<i>Acrylic emulsion2</i>	waterborne acrylic emulsion composed of butyl acrylate monomer, methyl methacrylate monomer, methacrylic acid, acrylic acid, and water	Dow Chemical
ACRYSOL TT615	a solvent-free rheology modifier composed of a polyacrylic acid	Dow Chemical
SNOWTACK 110X	waterborne rosin ester tackifier, composed of modified rosin resin in water dispersion	Lawte

[0052] The materials used in the PVC based membrane are provided in Table 1B below.

[0053] Table 1B

Trade Name	Supplier	Description
Formolon® 680	Formosa Plastics	Suspension PVC homopolymer, K = 70
Jayflex™ DIDP	ExxonMobil	Diisodecyl Phthalate (DIDP), Liquid Plasticizer
ELVALOY™ HP661	Dow	KEE Polymeric Plasticizer
Mark® 9586	Galata Chemicals	Ba/Zn Heat Stabilizer
Drapex® 6.8	Galata Chemicals	Epoxidized Soybean Oil (ESO); Co-stabilizer
Ti-Pure™ R-105	Chemours	Titanium Dioxide (TiO ₂)
Stearic Acid	Sigma-Aldrich	Lubricant/Process Aid
Irganox® 1076	BASF	Antioxidant
Tinuvin® XT835	BASF	UV Additive Package

A. Preparation of adhesive composition

[0054] An amount (as shown in Table 5) of the waterborne acrylic emulsion was loaded into a plastic container connected with a overhead mixer. The mixing from the overhead mixer forms a vortex area directly under the overhead mixer in the plastic container. An amount (as shown in Table 5) of the waterborne rosin ester tackifier (SNOWTACK 100x) was slowly added to the vortex area under the overhead mixer to form a two-component blend. The pH of the two-component blend was adjusted to 6.5 by adding an amount of ammonia. A given amount (Table 5) of the solvent-free rheology modifier (ACRYSOL TT615) was slowly added in the vortex area and mixed at 50-100 rpm to form a pre-mixture. The pre-mixture pH was 6.5 and was increased to pH 8.5 by adding an amount of ammonia. Adhesive composition formulations for inventive example ("IE") 1 and IE2 and comparative samples ("CS") CS-1, CS-2, and CS-3 are provided in Table 5 below.

B. Preparation of PVC based membrane

[0055] Dry blends consisting of the PVC powder, DIDP liquid plasticizer, and additives were first prepared using a 4L Eberbach high powered, single speed blender (Model E8010) equipped with an insulation jacket and thermocouple. The operating speed of the blender was 10,800 rpm. The temperature during blending was monitored, and the components were

added according to the sequence outlined below in Table 3. After blending, the samples were transferred to Ziplock bags.

[0056] Table 3

Sequence	Materials	Temperature (°C)
1	PVC resin	Before starting blender
2	Stabilizers	52
3	Lubricants	57
4	Plasticizers	66
5	Filler/Pigment	75
6	End	82

[0057] A Haake PolyLab Rheocord 300p Drive Unit equipped with the large Rheomix 300p bowl cart and cam rotors was used to melt mix the PVC dry blends. The Haake mixer was set to a temperature of 170°C, and the rotor speed set to 20 rpm. The PVC dry blend was added to the mixing bowl. For the formulation containing Elvaloy KEE plasticizer, the temperature was first allowed to increase back to 170°C after the addition of the PVC dry blend. Elvaloy KEE plasticizer was then added at a rate of 10 grams per every 2 – 3 minutes. After the additional of all the Elvaloy, the rotor speed was increased to 50 rpm and mixed for 10 minutes. After mixing, the polymer was removed from the Haake bowl and pressed into a flat patty. The samples were allowed to cool, and then transferred to a Ziplock bag. The formulation in part per hundred (PHR) of PVC based membrane is shown in Table 4.

[0058] Table 4

Material	PVC based membrane containing KEE (PHR)
PVC	100
DIDP	40
ELVALOY™ HP661	25
Ba/Zn Stabilizer	3
ESO	5
TiO ₂	15
Stearic Acid	0.3
Irganox® 1076	0.3
Tinuvin® XT835	0.5

C. Preparation of Laminate

[0059] 4.3g of adhesive composition formulation was applied by brush to coat a surface of a wood substrate (4.5 inch by 6 inch). A PVC-based flexible membrane (3 inch by 10 inch) was placed in direct contact with the adhesive composition formulation coated onto the wood substrate. A 5 lb roller was used to press the PVC-based flexible membrane upon the adhesive/wood substrate, ensuring full contact between the flexible membrane and the wood substrate (roll the entire laminate five times) and forming laminate structures with the configuration flexible membrane/adhesive composition formulation/wood substrate. The laminate structure was cured for seven days at room temperature before testing. The 90° peel test was then conducted with results shown in Table 5 below.

[0060] Table 5 Adhesive composition formulations, laminate structures, and performance

Ingredient	Formulation (wt%)				
	IE1	IE2	CS-1	CS-2	CS-3
<i>Acrylic Emulsion 1</i>	69	80		99	70
<i>Acrylic Emulsion 2</i>			68.5		
SNOWTACK 100X	30	19	30		30
ACRYSOL TT615	1	1	1.5	1	
Laminate structure	Wood/IE1/ PVC Membrane	Wood/IE2/ PVC Membrane	Wood/CS-1/ PVC Membrane	Wood/CS-2/ PVC Membrane	Wood/CS-3/ PVC membrane
90° Peel (lbf/inch)	4.2	3.4	3.1	1.5	0.6

[0061] IE1 and IE2 demonstrated improved adhesion performance on wood/KEE membrane laminate structure compared to the comparative samples CS-1, CS-2, and CS-3.

[0062] It is specifically intended that the present disclosure not be limited to the embodiments and illustrations contained herein, but include modified forms of those embodiments including

portions of the embodiments and combinations of elements of different embodiments as come within the scope of the following claims.

CLAIMS

1. An adhesive composition comprising:
an acrylic emulsion;
a tackifier; and
a rheology modifier.
2. The adhesive composition of claim 1 wherein the acrylic emulsion comprises an acrylic-based polymer comprising one or more acrylic-based monomers selected from the group consisting of butyl acrylate (BA), ethylhexyl acrylate (2-EHA), ethyl acrylate (EA), methyl acrylate (MA), butyl methacrylate (BMA), 2-hydroxyethyl methacrylate (2-HEMA), allyl acrylate, methacrylic acid, acrylic acid, and combinations thereof.
3. The adhesive composition of claim 2 wherein the acrylic-based polymer comprises 2-ethylhexyl acrylate monomer, ethylene vinyl acetate comonomer, styrene, acrylic acid, itaconic acid, and sodium vinyl sulfonate monomer.
4. The adhesive composition of any of claims 1-3 wherein the tackifier is a rosin resin.
5. The adhesive composition of any of claims 1-4 wherein the rheology modifier is selected from the group consisting of a hydrophobically modified, alkali swellable emulsion (HASE) rheology modifier, a hydrophobically-modified ethylene oxide urethane (HEUR) rheology modifier, and combinations thereof.
6. The adhesive composition of any of claims 1-5 wherein the adhesive composition comprises
 - (1) from 65 wt% to 94 wt% of the acrylic emulsion,
 - (2) from 5 wt% to 35 wt% of the tackifier,
 - (3) from 0.2 wt% to 3 wt% of the rheology modifier,

(4) from 0 wt% to 0.5 wt% of a defoamer.

7. The adhesive composition of any of claims 1-6 wherein the adhesive composition has a pH from 7.5 to 9.5.

8. The adhesive composition of any of claims 1-7 wherein the adhesive composition has a viscosity from 15,000 cP to 200,000 cP.

9. A laminate structure comprising:
a first substrate;
a second substrate; and
an adhesive composition disposed between the first substrate the second substrate,
the adhesive composition comprising
an acrylic-based polymer;
a tackifier; and
a rheology modifier.

INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER INV. C09J133/06 B32B21/08 B32B27/30 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) C09J Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2022/132611 A1 (ASHLAND LICENSING & IP LLC [US]) 23 June 2022 (2022-06-23) claim 1 example 3; table 2 -----	1,2,4-6, 8,9
X	US 2018/265754 A1 (QIE LILI [US] ET AL) 20 September 2018 (2018-09-20) claims 1,14 paragraph [0188]; example 7 paragraph [0176]; example 1 paragraph [0194] -----	1,2,6-9
X	US 2015/291858 A1 (NISHIMURA IZUMI [JP] ET AL) 15 October 2015 (2015-10-15) paragraph [0181] paragraph [0151] table 2 paragraph [0090] ----- - / - -	1,2,4,8, 9
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 10 July 2024		Date of mailing of the international search report 06/08/2024
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Flores de Paco, M

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