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(54) Title: ROOFING REPAIR SYSTEM AND METHOD

(57) Abstract: A roofing repair system including a multi-part primer and a water-activated overcoat composition. The multi-part primer includes a first part including a hydroxyl-functional (meth)acrylic (co)polymer, and a second part including a mixture of a hydrophilic polyfunctional aliphatic polyisocyanate and a hydrophobic polyfunctional aliphatic polyisocyanate, wherein a molar ratio of hydroxyl functionality in the first part to isocyanate functionality in the second part is less than 1. The water-activated overcoat composition includes at least one compound selected from polyketimines having amino groups attached to secondary carbon atoms, polyenamines, and oxazolidines. In some exemplary embodiments, the volume ratio of the multi-part primer to the water-activated composition is from 5:1 to 7:1. In certain exemplary embodiments, the multi-part primer is substantially free of organic solvents. A method of using the roofing repair system to repair the weathered surface of an elastomeric roofing membrane is also described.

ROOFING REPAIR SYSTEM AND METHOD

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Patent Application No. 61/349,235, filed May 28, 2010, which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

The present disclosure relates to a roofing repair system, and more particularly, to a method for treating weathered elastomeric roofing membranes to improve their weather resistance.

BACKGROUND

A fundamental requirement for any successful roofing system, particularly roofing systems for commercial, institutional, and industrial buildings with flat or low-slope roofs installed, is the ability of the roofing system to maintain its integrity and prevent the entry of water upon weathering by exposure to sunlight and the elements such as rain and snow. In the past, a variety of roofing systems have been used in connection with such no- or low-slope roofs, including, for example, metal panel roofing. Such roofing usually consists of metal panels overlapped at their ends and secured to the roofing decks of building structures with nails, screws, clips or other fasteners. However, while metal panels are relatively durable, the panels are subject to significant thermally induced contractions and expansions due to ambient temperature variations, a characteristic that often leads to the cracking of such roofing, especially along the roof seams and fastener locations, with leakage occurring as a result thereof.

In order to overcome the foregoing and other problems associated with weather-proofing low-slope and flat roofs, single ply roofing membranes formed from ethylene-propylene (non-conjugated) diene monomer (EPDM) elastomers, or chlorosulfonated ethylene (e.g. HYPALON®) elastomers, have been exploited as roofing system components. In particular, elastomeric single ply roofing membranes have proven to be well suited components of roofing systems for no- or low-slope metal panel roofs, since such elastomeric roofing membranes typically are relatively easy to apply, have a long life, have substantial flexibility, retain their resiliency at very low temperatures, withstand the high temperatures frequently encountered in roofing environments without unduly stretching or softening, and possess good resistance to ultraviolet light.

Typically, a membrane adhesive, generally a 20-40 percent by weight solution of elastomeric rubber in a suitable volatile organic solvent, is applied to the interface between the roof deck surface and the elastomeric roofing membrane in order to improve the final adhesion of the membrane to the roof deck. Fasteners may also be used to attach the elastomeric roofing membrane to the roof deck.

SUMMARY

Although elastomeric roofing membranes have been advantageously used in no- and low-slope roofing applications, such membranes have a number of disadvantages. For example, elastomeric roofing membranes tend to be black or dark colored and do not exhibit a high degree of solar reflectivity, leading to increased energy consumption and air conditioning costs during the summer months. In addition, over time, weathering due to exposure of the roofing membrane to solar radiation and the elements, combined with thermally induced contractions and expansions of the roofing membrane due to normal seasonal ambient temperature variations, may cause weathering of the elastomeric membrane.

In fact, known single-ply membranes all eventually succumb to the effects of extended exposure to the elements (i.e. weathering). These effects typically manifest themselves through degradation of the surface as it begins to oxidize, check, crack and/or craze. Seams, whether heat-welded or glued, also eventually begin to come apart, allowing water intrusion beneath the membrane. Cracking of the weathered roofing membrane and the resulting water leakage may be so severe as to require the expense of removing the weathered roofing system down to the roof deck, and replacement with a new roofing system.

Removal, disposal and replacement of an old single ply roofing system is a costly process involving disposal of waste roofing materials in a landfill. Alternatively, the weathered roofing membrane may be repaired by patching in place. However, attempts to patch or otherwise repair leaks in weathered elastomeric roofing membranes may result in even more water leakage, since merely walking on the weathered roofing membrane to effect repairs may cause additional cracking. Furthermore, known compositions for repairing weathered elastomeric roofing membranes involve a tradeoff of attributes between the desired performance results, the potential toxicity and environmental friendliness of the materials, satisfactory shelf-life, and ease of use by relatively unskilled users. Ideally, a simpler and more cost effective solution has been sought.

One such solution involves the application of a liquid roofing repair system to the entire roof to renew or repair and thereby extend the life of the existing elastomeric roofing membrane. Thus, in one aspect, the present disclosure describes a roofing repair system comprising a multi-part primer and a water-activated overcoat composition. The multi-part primer comprises a first part including a hydroxyl-functional (meth)acrylic (co)polymer, and a second part including a mixture of a hydrophilic polyfunctional aliphatic polyisocyanate and a hydrophobic polyfunctional aliphatic polyisocyanate, wherein a molar ratio of hydroxyl functionality in the first part to isocyanate functionality in the second part is less than 1. The water-activated overcoat composition comprises at least one compound selected from polyketimines having amino groups attached to secondary carbon atoms, polyenamines, and oxazolidines.

In some exemplary embodiments of the foregoing roofing repair system, the volume ratio of the multi-part primer to the water-activated overcoat composition is from 5:1 to 7:1. In certain exemplary embodiments, the multi-part primer is substantially free of organic solvents. In further exemplary embodiments, the first part of the multi-part primer further comprises water.

In additional exemplary embodiments according to any of the foregoing roofing repair systems, the multi-part primer further comprises a catalyst, a biocide, a surfactant, a dispersant, a rheology modifier, a defoamer, a plasticizer, a particulate filler, a fibrous material, or a combination thereof. In some exemplary embodiments, the hydroxyl-functional (meth)acrylic (co)polymer comprises dispersed particles. In certain exemplary embodiments, the hydroxyl-functional (meth)acrylic (co)polymer comprises from 30 to 50% by weight of the first part of the multi-part primer.

In additional exemplary embodiments of any of the foregoing roofing repair systems, the weight ratio of hydrophilic polyfunctional aliphatic polyisocyanate to hydrophobic polyfunctional aliphatic polyisocyanate in the second part of the multi-part primer is at least 1:1. In some exemplary embodiments, the combined weight of hydrophilic polyfunctional aliphatic polyisocyanate and hydrophobic aliphatic polyisocyanate comprises at least 80% by weight of the second part.

In other exemplary embodiments of any of the foregoing roofing repair systems, the water-activated overcoat composition further comprises a film-forming thermoplastic polymer. In some exemplary embodiments, the film-forming thermoplastic polymer comprises a polyurethane segment. In certain exemplary embodiments, the water-activated overcoat composition further comprises a urethane prepolymer comprising an isocyanate which has been blocked with a phenol or an oxime.

In additional exemplary embodiments, the roofing repair systems of any of the foregoing embodiments further comprise a reinforcing layer. In some exemplary embodiments, the reinforcing layer comprises a fiberglass mesh, a polyester fiber mesh, an ethylene-propylene dimer elastomer membrane, a chlorinated polyethylene elastomer membrane, a chlorosulfonated polyethylene elastomer membrane, an acrylonitrile-rubber membrane, a poly(isobutylene) elastomer membrane, a thermoplastic polyolefin elastomer membrane, a poly(vinyl) chloride elastomer membrane, or a combination thereof. In certain exemplary embodiments, the roofing repair systems according to any of the preceding embodiments further comprise an applicator selected from a brush, a pad, a squeegee, a roller, a sprayer, or a combination thereof.

In another aspect, the disclosure describes a method of using the roofing repair system according to any one of the preceding embodiments, the method comprising the steps of: (a) mixing together the first part and the second part of the multi-part primer to obtain an activated primer mixture, (b) applying the activated primer mixture to a weathered surface of an elastomeric roofing membrane, and (c) applying the water-activated overcoat composition to the primer mixture on the weathered surface of the elastomeric membrane.

In some exemplary embodiments of the foregoing method, the activated primer mixture comprises water in an amount sufficient to obtain a non-volatile solids content of from 30% to 50% by volume of the activated primer mixture. In certain exemplary embodiments, step (b) is completed within two hours after beginning step (a). In further exemplary embodiments, step (c) is begun at least two hours after step (b) is completed, and step (c) is completed no more than 168 hours after beginning step (a). In additional exemplary embodiments, the elastomeric roofing membrane comprises ethylene-propylene dimer elastomer, chlorinated polyethylene elastomer, chlorosulfonated polyethylene elastomer, acrylonitrile-rubber, poly(isobutylene) elastomer, thermoplastic polyolefin elastomer, polyvinyl chloride elastomer, or a combination thereof.

In some exemplary embodiments, the roofing repair system and method of the present disclosure provides a number of unexpected results and advantages. In exemplary embodiments, the roofing repair system and method uses a water-based multi-part primer that has low toxicity, is environmentally benign, has excellent shelf stability, is easy to apply, and, when activated, has a sufficiently low viscosity to permit penetration and good adhesion of the primer layer to a weathered surface of an elastomeric roofing membrane.

In further exemplary embodiments, the roofing repair system includes a water-activated overcoat composition that reacts with (i.e. covalently bonds to) the at least partially cured activated primer layer on the weathered surface of the elastomeric roofing membrane, thereby promoting good interlayer adhesion between the overcoat layer and the primer layer, as well as good adhesion of the roofing repair system to the weathered surface of the elastomeric roofing membrane. Moreover, the roofing repair system may be formulated to contain little or no volatile organic solvents, is typically easy to apply by relatively unskilled works using a variety of application methods (e.g. brushing, spraying, and the like), and generally exhibits excellent extended shelf stability. The roofing repair system thus offers an effective and relatively low cost solution to the problem of renewing, refurbishing, or repairing weathered single ply roofing surfaces which employ elastomeric roofing membranes, particularly EPDM or HYPALON® elastomeric roofing membranes.

Various aspects and advantages of exemplary embodiments of the present disclosure have been summarized. The above Summary is not intended to describe each illustrated embodiment or every implementation of the exemplary embodiments of the present disclosure. The Detailed Description that follows more particularly exemplifies certain presently preferred embodiments using the principles disclosed herein.

DETAILED DESCRIPTION

Glossary

As used throughout this application:

the term "continuous" refers to covering the surface of the substrate with virtually no discontinuities or gaps in the areas where the covering is applied.;

the term "hydrophilic" refers to a material, component or region which is water soluble, water miscible or water dispersible;

the term "hydrophobic" refers to a material, component or region which is not appreciably soluble in water and which does not substantially disperse when added to water in the absence of other additives or components;

the term "surfactant" describes a molecule having both hydrophilic (e.g. polar) and hydrophobic (e.g. non-polar) regions on the same molecule and which is capable of reducing the surface tension of an aqueous mixture;

the term "dispersant" describes a molecule, which may be a surfactant, used to prepare a liquid/liquid or solid/liquid dispersion by imparting phase stability for a period of time sufficient for the dispersion to be used for its intended purpose;

the term "(co)polymer" means a homopolymer or copolymer;

the term "(meth)acrylic (co)polymer" means a (co)polymer obtained by polymerizing one or more alkyl ester monomers formed by reaction of an alkyl alcohol with acrylic acid or methacrylic acid.

the term "polyfunctional aliphatic polyisocyanate" refers to a (co)polymer comprising two or more isocyanate groups, which may be blocked isocyanate groups, and based on hexamethylene diisocyanate.

the term "polyurethane" includes any polymeric material that has at least one polyurethane segment;

the term "polyurethane segment" refers to at least two urethane and/or urea groups that are connected by an organic group;

the term "single ply roofing" refers to a single layer elastomeric roofing membrane which may be ballasted, fully-adhered, and/or mechanically attached installations;

the term "elastomeric roofing membrane" means a pre-manufactured flexible or semi-flexible sheet formed with non-vulcanized and/or vulcanized elastomers, such as ethylene-propylene diene monomer (EPDM) elastomers, poly(vinyl) chloride (PVC) elastomers, chlorinated polyethylene (CPE) elastomers, chlorosulfonated polyethylene (CSPE) elastomers, acrylonitrile-rubber (NBR) elastomers, poly(isobutylene) (PIB) elastomers, thermoplastic polyolefin (TPO) elastomers, and the like.

In general, this disclosure describes a roofing repair system including a multi-part primer suitable for promoting the adhesion of a water-activated overcoat composition to weathered roofing membranes such as, for example, single ply roofing membranes formed from ethylene-propylene diene monomer (EPDM) or chlorosulphonated ethylene (e.g. HYPALON® ex DuPont).

Adhesion of roofing repair materials to weathered elastomeric roofing membranes, which tend to have a friable surface particularly after exposure to ponding water conditions, has been problematic. None of the known roofing repair systems for use on weathered elastomeric roofing membranes are believed to include a water-based primer have the capability of binding to both the weathered elastomeric membrane material and the subsequently applied overcoat composition by anything other than physical means.

Thus, in exemplary embodiments, the present disclosure provides a roofing repair system comprising a multi-part primer and a water-activated overcoat composition which is covalently bonded to the primer after application to the weathered surface of an elastomeric roofing membrane. In other exemplary embodiments, the present disclosure provides a method of applying the roofing repair system to a weathered surface of an elastomeric roofing membrane.

Roofing Repair System

In one aspect, the present disclosure describes a roofing repair system including a multi-part reactive primer which can be activated prior to application to a weathered elastomeric roofing membrane, thereby producing *in situ* an isocyanate-functional (meth)acrylate-urethane (co)polymer having excess unreacted isocyanate groups. The activated primer is sufficiently fluid to penetrate into the weathered surface of an elastomeric roofing membrane, thereby promoting good adhesion between the primer and the elastomeric roofing membrane.

After drying of the coated primer, a water-activated overcoat composition is applied over and in contact with the at least partially cured primer. Upon activation by exposure to water (e.g. moisture in the air), the water-activated overcoat composition reacts with water to provide a pre-polymer having amine and/or hydroxyl functional groups, which undergo chemical reaction with the excess unreacted isocyanate groups in the primer to form urea or urethane chemical bonds to the primer, thereby promoting good interlayer adhesion between the activated overcoat layer and the at least partially cured primer layer.

Multi-part Primer

The multi-part primer comprises a first part including a hydroxyl-functional (meth)acrylic (co)polymer, and a second part including a mixture of a hydrophilic polyfunctional aliphatic polyisocyanate and a hydrophobic polyfunctional aliphatic polyisocyanate, wherein the molar ratio of hydroxyl functionality in the first part to isocyanate functionality in the second part is less than 1. In certain presently preferred embodiments, the molar ratio of hydroxyl functionality in the first part to isocyanate functionality in the second part is less than 0.9, more preferably less than 0.75, even more preferably less than 0.5, 0.4, 0.3, 0.2 or 0.1. In some of these embodiments, the molar ratio of hydroxyl functionality in the first part to isocyanate functionality in the second part is at least 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, or even 0.8.

In further exemplary embodiments, the volume ratio of the multi-part primer to the water-activated overcoat composition is from 1:1 to 12:1, more preferably from 2:1 to 10:1, even more preferably from 2:1 to 10:1, 3:1 to 9:1, 4:1 to 8:1, 5:1 to 7:1, or most preferably 6:1. In some exemplary embodiments, the roofing repair system provides the multi-part primer and the water-activated overcoat composition in pre-determined amounts at a volume ratio of from 2:1 to 10:1, more preferably 3:1 to 9:1, 4:1 to 8:1, 5:1 to 7:1, or most preferably 6:1.

In certain exemplary embodiments, the multi-part primer is substantially free of organic solvents. In such embodiments, the multi-part primer preferably includes no more than 10%, 9%, 8%, 7%, 6%, 5%, 4%, 3%, 2%, 1%, or 0% by weight of an organic solvent based on the total weight of the multi-part primer.

In some particular exemplary embodiments, at least the first part of the multi-part primer is substantially free of organic solvents. In such embodiments, the roofing repair system components preferably include no more than 10%, 9%, 8%, 7%, 6%, 5%, 4%, 3%, 2%, 1%, or 0% by weight of an organic solvent based on the weight of the first part of the multi-part primer.

In certain presently preferred embodiments, the activated multi-part primer is waterborne, that is, comprising at least 50%, more preferably at least 60%, even more preferably at least 70% or even 80% water, based on the weight of the activated multi-part primer. In further embodiments, the activated multi-part primer comprises no more than 90%, more preferably no more than 85%, even more preferably about 75% or even 55-65% by weight of water based on the weight of the activated multi-part primer.

First Part - Hydroxyl-Functional (Meth)Acrylic (Co)Polymer

The first part of the primer comprises at least one hydroxyl-functional (meth)acrylic (co)polymer. In some exemplary embodiments, the hydroxyl-functional (meth)acrylic (co)polymer comprises a solution polymer, for example, those described in U.S. Patent Nos. 6,001,931 and 6,103,849, each of which is incorporated herein by reference in its entirety. In certain presently preferred exemplary embodiments, the hydroxyl-functional (meth)acrylic (co)polymer comprises dispersed particles, for example, those described in U.S. Patent Application Publication Nos. 2008/0214766 and 2009/0105409, each of which is incorporated herein by reference in its entirety. In some exemplary embodiments, a combination of a hydroxyl-functional (meth)acrylic solution (co)polymer and hydroxyl-functional (meth)acrylic dispersed particles may be advantageously employed. In such embodiments, the weight ratio of hydroxyl-functional (meth)acrylic (co)polymer in the solution to hydroxyl-functional (meth)acrylic (co)polymer particles in the dispersion may be advantageously varied over a wide range, for example, from 1:9, 1:5; 1:4; 1:3: 1:2, 1:1, 2:1, 3:1, 4:1, 5:1, or even 9:1.

In further presently preferred embodiments, the dispersed particles comprise the hydroxyl-functional (meth)acrylic (co)polymer, and the dispersion medium comprises water. (i.e. the first part of the multi-part primer comprises a waterborne dispersion). Presently preferred waterborne hydroxyl-functional (meth)acrylic (co)polymers in dispersed form are sold under the trade name BAYHYDROL (available from Bayer Material Science LLC, Pittsburgh, PA). A presently preferred waterborne hydroxyl-functional (meth)acrylic (co)polymer in dispersed is BAYHYDROL A 145 (available from Bayer Material Science LLC, Pittsburgh, PA), a dispersion of a hydroxyl-functional acrylic polymer (43-47% w/w) in water.

In certain exemplary embodiments, the hydroxyl-functional (meth)acrylic (co)polymer comprises at least 20%, more preferably at least 30%, even more preferably at least 40%, or even 50% by weight of the first part of the multi-part primer. In further exemplary embodiments, the hydroxyl-functional (meth)acrylic (co)polymer comprises from 20% to 70%, more preferably from 25% to 60%, even more preferably from 30% to 50% by weight of the first part of the multi-part primer.

In further exemplary embodiments of the foregoing roofing repair systems, the first part of the multi-part primer further comprises water. Preferably, at least the first part of the multi-part primer is waterborne, more preferably a waterborne dispersion as noted above. In some presently preferred embodiments, the first part of the multi-part primer comprises water, and is substantially free of organic solvents. In such embodiments, the first part of the multi-part primer preferably includes no more than 10%, 9%, 8%, 7%, 6%, 5%, 4%, 3%, 2%, 1%, or 0% by weight of an organic solvent.

Second Part - Polyfunctional Aliphatic Polyisocyanates

The second part of the multi-part primer comprises a mixture of a hydrophilic polyfunctional aliphatic polyisocyanate and a hydrophobic polyfunctional aliphatic polyisocyanate. Exemplary aliphatic polyisocyanates are described in U.S. Patent No. 4,619,999, which is incorporated herein by reference in its entirety. Aliphatic polyisocyanates based on hexamethylene diisocyanate (HMDI) are presently preferred in order to obtain the benefits of improved light stability for the applied roofing repair system, in contrast to aromatic polyisocyanates based on aromatic isocyanates, such as m-tetramethylenexylene diisocyanate (TMXDI) and isophorone isocyanate (IPI). However, small amounts, for example, less than 15%, less than 10%, less than 5%, or even less than 1% by weight of the second part of the multi-part primer may comprise an aromatic polyisocyanate, although this is not presently preferred.

Preferably, the polyisocyanate compound employed contains two isocyanate groups, however, polyisocyanate compounds containing greater than two isocyanate groups may also be used, for example, polyisocyanates based on ethylene diisocyanate, 3-isocyanatomethyl-3,5,5,-trimethylcyclohexylisocyanate (IPDI), and bis(4-isocyanateocyclohexyl)methane. A mixture or a blend of more than one polyisocyanate compound may also be employed, for example, an aromatic polyisocyanate, preferably in combination with at least one aliphatic isocyanate based on hexamethylene diisocyanate (HMDI) as a major component of the second part of the multi-part primer.

In some exemplary embodiments, unblocked aliphatic polyisocyanates containing from about 6 to 100 carbon atoms may be used. Blocked aliphatic isocyanates may be advantageously used in some exemplary embodiments. Exemplary blocked isocyanates are described in, for example, U.S. Patent Nos. 5,246,557; 5,352,755; and 6,843,933, the disclosures of which are incorporated herein by reference in their entireties. If used in the multi-part primer, the blocked isocyanate preferably exhibits a low de-blocking temperature, preferably less than 110°C, more preferably less than 100°C, even more preferably less than 90°C.

Hydrophilic Polyfunctional Aliphatic Isocyanate

Suitable hydrophilic polyisocyanates include water miscible or water dispersible aliphatic polyisocyanates sold under the trade names BAYHYDUR® 304, BAYHYDUR® 305, BAYHYDUR® 3100, BAYHYDUR® XP 2451, BAYHYDUR® XP 2487/1, BAYHYDUR® XP2547, BAYHYDUR® XP 2655, and BAYHYDUR® XP 2700 (available from Bayer Material Science LLC, Pittsburgh, PA). BAYHYDUR® XP 2487/1, a hydrophilic, water dispersible poly-functional aliphatic polyisocyanate based on hexamethylene diisocyanate, is presently preferred.

In some exemplary embodiments, the hydrophilic polyisocyanate may be advantageously selected to be a waterborne aliphatic polyisocyanate, such as sold under the trade name Easaqua XD 401, Easaqua XD 501, Easaqua XD 502, Easaqua XD 803, Easaqua WT 2102, Easaqua WAT, Easaqua WAT-1, Easaqua X WAT-3, and Easaqua X WAT-4 (all available from Perstop, Inc., Freeport, TX).

Hydrophobic Polyfunctional Aliphatic Isocyanate

Suitable hydrophobic aliphatic polyisocyanates include blocked aliphatic polyisocyanates based on hexamethylene diisocyanate, for example, those sold under the trade names DESMODUR BL 3175A, DESMODUR 3272 MPA, DESMODUR BL 3370 MPA, DESMODUR 3475 BA/BN, DESMODUR 3575 MPA/SN, DESMODUR BL 5375, DESMODUR DA/l, DESMODUR DN, and DESMODUR N 3600. DESMODUR N 3600, a hydrophobic, solvent-free blocked isocyanate based on hexamethylene diisocyanate, is presently preferred.

In additional exemplary embodiments of any of the foregoing roofing repair systems, the weight ratio of hydrophilic polyfunctional aliphatic polyisocyanate to hydrophobic polyfunctional aliphatic polyisocyanate in the second part of the multi-part primer is at least 1:1, 2:1, or even 3:1. In some of these embodiments, the weight ratio of hydrophilic polyfunctional aliphatic polyisocyanate to hydrophobic polyfunctional aliphatic polyisocyanate in the second part of the multi-part primer is at most 4:1, 3:1, 2:1 or even 1:1.

In certain exemplary embodiments, the combined weight of hydrophilic polyfunctional aliphatic polyisocyanate and hydrophobic polyfunctional aliphatic polyisocyanate comprises at least 50%, 60%, 70% or even 80% by weight of the second part. In some of these embodiments, the combined weight of hydrophilic polyfunctional aliphatic polyisocyanate and hydrophobic polyfunctional aliphatic polyisocyanate comprises at most 90%, 85%, 75%, 65% or even 55% by weight of the second part.

Water-Activated Overcoat Composition

The water-activated overcoat composition comprises at least one compound selected from polyketimines having amino groups attached to secondary carbon atoms, polyenamines, and oxazolidines. Suitable compounds are described in U.S. Patent Nos. 4,118,376 and 6,103,849, the disclosures of which are each incorporated herein by reference in their entirety.

Exemplary presently preferred water-activated overcoat compositions comprising oxazolidines are available under the trade names SCOTCHKOTE™ Advanced CSM Liquid Roof Membrane, SCOTCHKOTE™ Premier EC Liquid Roof Membrane, SCOTCHKOTE™ Premier UV Liquid Roof Membrane, SCOTCHKOTE™ Premier Plus EC Liquid Roof

Membrane, and SCOTCHKOTE™ Premier Plus UV Liquid Roof Membrane (all available from 3M Company, St. Paul, MN).

Other optional components may additionally be included in the water-activated overcoat composition. Particularly preferred additional optional components include one or more thermoplastic polymers, and radiation reflective particles, as described further below.

Optional Film-forming Thermoplastic Polymer

In some exemplary embodiments of any of the foregoing roofing repair systems, the water-activated overcoat composition further comprises a film-forming thermoplastic polymer. Preferred film-forming thermoplastic polymers are substantially water insoluble, but are more preferably water miscible or water dispersible. In some exemplary embodiments, the film-forming thermoplastic polymer comprises a polyurethane segment. For example, one or more of any of the foregoing disclosed hydrophilic polyisocyanates and/or hydrophobic polyisocyanates may be added to the water-activated overcoat composition to form a film-forming thermoplastic polymer comprising a polyurethane segment.

In certain exemplary embodiments, the water-activated overcoat composition further comprises a urethane prepolymer comprising an isocyanate which has been blocked with a phenol or an oxime. Exemplary urethane prepolymers comprising an isocyanate which has been blocked with a phenol or an oxime are described, for example, in U.S. Patent No. 6,103,849, which was previously incorporated by reference in its entirety.

In some particularly preferred embodiments, an optional additional top or outer layer of the roofing repair system may be applied over (preferably applied directly to) the at least partially cured water-activated overcoat composition in order to provide additional protection from exposure to solar radiation, for example, ultraviolet (UV). Exemplary presently preferred top or outer layer compositions suitable to impart UV radiation protection are available under the trade names SCOTCHKOTE™ Premier UV Liquid Roof Membrane, and SCOTCHKOTE™ Premier Plus UV Liquid Roof Membrane (available from 3M Company, St. Paul, MN). Preferably, the optional additional top or outer layer of the roofing repair system comprises radiation reflective particles that provide a solar reflective surface, as described further below.

Radiation Reflective Particles

In some exemplary embodiments, the multi-part primer and/or water-activated overcoat composition and/or an optional top or outer layer of the roofing repair system comprise radiation reflective particles, so that the roofing repair system provides a solar reflective surface when applied to a weathered elastomeric roofing membrane and dried to form a film. In certain exemplary embodiments, the solar reflective surface may exhibit a direct solar reflectance of at least 20%, more preferably at least 30%, even more preferably at least 40%, 50%, 60% or still more preferably at least 70% or even 80% or higher.

By direct solar reflectance is meant that fraction reflected of the incident solar radiation received on a surface perpendicular to the axis of the radiation within the wavelength range of 300 to 2500 nm as computed according to the following modification of the ordinate procedure defined in ASTM Method G159. A spreadsheet (available upon request from Lawrence Berkeley Laboratory, Berkeley, CA), combining the direct and hemispherical Solar Irradiance Air Mass 1.5 data from ASTM method G159 may be used to compute interpolated irradiance data at 5 nm intervals in the region of interest. The 5 nm interval data may be used to create weighting factors by dividing the individual irradiances by the total summed irradiance from 300 to 2500 nm. The weighting factors may then be multiplied by the experimental reflectance data taken at 5 nm intervals to obtain the direct solar reflectance at those wavelengths.

In certain exemplary embodiments, the radiation reflective particles may be selected to include light reflective particles reflective to visible light, that is, actinic radiation having a wavelength from about 400 nm to about 700 nm. In one presently preferred embodiment, the light reflective particles comprise aluminum metal, more preferably aluminum metal particulates, even more preferably dispersed aluminum flake pigments. Suitable dispersed aluminum flake pigments are available under the trade name SPARKLE SILVER (available from Silberline Manufacturing Company, Tamaqua, PA). These dispersed aluminum flake pigments are available at different average particle sizes and in varying concentrations dispersed in a carrier solvent.

In other exemplary embodiments, the multi-part primer and/or water-activated overcoat composition and/or an optional top or outer layer of the roofing repair system may additionally or alternatively comprise radiation reflective particles reflective to infrared (IR) radiation, thereby forming a solar reflective surface. Thus, in some exemplary embodiments, the solar reflective surface exhibits a direct solar reflectance of at least about 20%, more preferably at least 25%, even more preferably at least 30%, 40%, 50% or still more preferably at least 60% or even 75% or higher at substantially all points in the wavelength range between 770 and 2500 nm as computed according to the foregoing modification of the ordinate procedure defined in ASTM Method G159, except that the total summed irradiance is determined from 770 to 2500 nm instead of from 300 to 2500 nm.

In one presently preferred embodiment, the radiation reflective particles may be white pigments, such as titanium dioxide, which may be surface treated using methods known to those skilled in the art to improve resistance to "yellowing" when used with polymeric binder systems subject to photocatalytic degradation.

In some exemplary embodiments, colored pigments that exhibit enhanced reflectivity in the near infrared (NIR) portion of the solar spectrum as compared to previous colorants, may be advantageously used. The NIR portion comprises approximately 50-60% of the sun's incident energy. Improved reflectivity in the NIR portion of the solar spectrum leads to significant gains in energy efficiency and such pigments are useful in some embodiments of the present invention.

Thus, in certain exemplary presently preferred embodiments, the radiation reflective particles may be colored pigments that have enhanced NIR reflectivity, and are thus both colored and NIR reflective. Such pigments include, for example, 10415 Golden Yellow, 10411 Golden Yellow, 10364 Brown, 10201 Eclipse Black, V-780 IR BRN Black, 10241 Forest Green, V-9248 Blue, V-9250 Bright Blue, F-5686 Turquoise, 10202 Eclipse Black, V-13810 Red, V-12600 IR Cobalt Green, V-12650 Hi IR Green, V-778 IR Brown-Black, V-799 Black, and 10203 Eclipse Blue Black (all available from Ferro Corp., Cleveland, OH); and Yellow 193, Brown 156, Brown 8, Brown 157, Green 187B, Green 223, Blue 424, Black 411, Black 10C909 (all available from Shepherd Color Co., Cincinnati, OH). Additional colored pigments of interest, some displaying enhanced infrared light reflectivity, are discussed in Sliwinski et al., U.S. Patent Nos. 6,174,360 and 6,454,848, both of which are incorporated herein by reference in their entirety.

In some presently preferred embodiments, the resulting direct solar reflectance or radiation reflectivity of the solar reflective surface obtained using the roofing repair system of the present disclosure may exceed 20% at the wavelengths of interest. The phrase solar reflectivity and direct solar reflectance are used interchangeably in the present application. Solar reflectivity values of at least 25% meet the present solar reflectivity standard set forth by the U.S. Environmental Protection Agency (EPA) under the program entitled "Energy Star". The EPA permits manufacturers to use the designation "Energy Star" for those roofing products that meet certain energy specifications. This "Energy Star" designation is a desirable designation to place on roofing products.

In general, the amount of radiation reflective particles added to the water-activated overcoat composition and/or optional top or outer layer of the roofing repair system may vary with the particular material. In some exemplary embodiments, the concentration is preferably no more than about 30% w/w, more preferably no more than 25% by weight, more preferably no more than 20% by weight, and even more preferably no more than 15% by weight of the total weight of the water-activated overcoat composition and/or an optional top or outer layer of the roofing repair system. In certain exemplary embodiments, the radiation reflective particles comprise 1-30%, more preferably 2.5-25%, even more preferably 5-20% by weight of the water-activated overcoat composition and/or optional top or outer layer of the roofing repair system.

Optional Additives

In additional exemplary embodiments, the multi-part primer and/or water-activated overcoat composition and/or optional top or outer layer of the roofing repair system may further comprise an additive selected from a catalyst, a biocide, a surfactant, a dispersant, a rheology modifier, a defoamer, a plasticizer, a particulate filler, a fibrous material, or a combination thereof. In some presently preferred embodiments, the additive is added to the first part of the multi-part primer.

Catalysts

In some exemplary embodiments, an optional catalyst may be added to the multi-part primer, preferably to catalyze reaction of the hydroxyl-functional (meth)acrylic (co)polymer with the hydrophilic polyfunctional aliphatic polyisocyanate and the hydrophobic polyfunctional aliphatic polyisocyanate, for example, by forming a urethane linkage.

Useful catalysts include metallic complex catalysts include Group I metal salts, i.e., alkali salts, of carboxylic acids such as stearates, octoates and phenoxides, as well as Lewis Acids such as tin salts, zinc chloride, ferric chloride, tin octoate, and alkali salts of phenoxides, for example, potassium p-nonylphenoxide. Presently preferred catalysts include metal soaps, particular soaps of tin, such as dibutyl tin dilaurate (DBTDL).

Generally, the catalyst should be employed in a catalytically effective amount, such as an amount from about 1% to about 10% by weight, more preferably from about 2.5% to about 7.5% by weight, even more preferably from about 4% by weight to about 6% by weight, based on the total weight of the activated multi-part primer.

Biocides

In some exemplary embodiments, one or more components of the roofing repair system includes a biocide. Preferably, the biocide is an organic biocide, more preferably an organic algaecide. In some exemplary presently preferred embodiments, the organic algaecide is selected from the class consisting of hexahydro-1,3,5-tris(2-hydroxyethyl)-s-triazine, hexahydro-1,3,5-triethyl-s-triazine, 2-(tert-butylamino)-4-chloro-6-(ethylamino)-S-triazine, tetrahydro-3,5-dimethyl-2H-1,3,5-thiadiazine-2-thione, 3-iodo-2-propyl butyl carbamate, sodium dimethyldithiocarbamate, disodium ethylene bisdithiocarbamate, disodium cyanodithioimidocarbamate, potassium N-methyldithiocarbamate, potassium dimethyldithiocarbamate, 2,2-dibromo-3-nitrilopropionamide, 2,2-dibromo-2-nitroethanol, 2-bromo-2-nitro-1,3-propanediol, 4,5-dichloro-2-n-octyl-4-isothiazolin-3-one, 2-methyl-2,3-dihydroisothiazol-3-one, 5-chloro-2-methyl-4-isothiazolin-3-one, 2-n-octyl-4-isothiazolin-3-

one, chloroallyl-3,5,7-azoniaadamantane chloride, tetrakishydroxymethyl phosphonium sulfate, poly[oxyethylene(dimethyliminio)ethylene-(dimethyliminio)ethylene dichloride], didecyl dimethyl ammonium chloride, and dodecylguanidine hydrochloride.

Typically, the biocide may be added in an amount of at least 0.01 % to at most 5.0 % by weight, more preferably at least 0.02% to at most 3% by weight, even more preferably at least 0.05% and at most 2.5% by weight, based on the total weight of the multi-part primer.

Surfactants and Dispersants

In some exemplary embodiments, an optional surface active agent (i.e. surfactant) or dispersant may be added to the multi-part primer. Suitable surfactants include anionic surfactants, cationic surfactants, zwitterionic surfactants, nonionic surfactants, and mixtures thereof. Exemplary anionic surfactants include, for example, long chain carboxylic and sulphonic acids. Exemplary cationic surfactants include, for example, the hydrochlorides of fatty diamines, imidazolines, ethoxylated amines, amido-amines and quaternary ammonium compounds. Exemplary non-ionic surfactants include, for example, ethoxylated alkyl phenols, ethoxylated alcohols and ethoxylated sorbitan esters. Fluorochemical surfactants may also be used advantageously. A presently preferred surfactant is sold under the trade name Surfynol® 104E (available from Air Products and Chemicals, Inc., Allentown, PA).

Typically, the surfactant may be added in an amount of at least 0.01 % to at most 5.0% by weight, more preferably at least 0.02% to at most 3% by weight, even more preferably at least 0.05% and at most 2.5% by weight, based on the total weight of the multi-part primer.

Rheology Modifiers

In some exemplary embodiments, the viscoelastic properties of the multi-part primer may be further improved using an optional rheology modifier. Plasticizers (described further below) may, in some embodiments, be used to modify the rheological properties of the multi-part primer to obtain a desired consistency when activated.

In some exemplary embodiments, the multi-part primer may further comprise a thixotrope. Such thixotropes are well known to those skilled in the art and include alumina, limestone, talc, kaolin clay, zinc oxides, sulfur oxides, calcium carbonate, Perlite®, slate flour, cyclodextrin and the like. The thixotrope may be added to the adhesive of composition in a sufficient amount to give the desired rheological properties.

Preferably the thixotrope, if used, is present in an amount of about 0.1 part by weight or greater, more preferably about 0.5 part by weight or greater, even more preferably about 1.0 part by weight or greater based on the weight of the first part of the multi-part primer. Preferably the optional thixotrope is present in an amount of about 10 parts by weight or less, more preferably about 5 parts by weight or less, even more preferably about 2.5 parts by weight or less based on the weight of the first part of the multi-part primer.

In other exemplary embodiments, an optional gelling agent may be added to the multi-part primer. The gelling agent may, in some embodiments, function both as a filler and a viscosity control agent, by forming a three-dimensional network upon mixing with the bituminous material. Suitable gelling agents include clays such as, for example, attapulgite, bentonite or sepiolite clays, although other similar functioning materials are probably acceptable and are intended to come within the scope of this disclosure. In certain exemplary embodiments, especially for high performance construction materials, the multi-part primer may contain an optional polymer or ground up rubber or some other "plastic" like material which can be dispersed or dissolved in the asphalt to swell and/or gel and thereby form a matrix. When such gelling agents are added, conventional techniques may be used to blend the gelling agent with the base asphalt.

In some exemplary embodiments, the multi-part primer preferably comprises at least 0.01 to at most 5.0 wt. % of the rheology modifier, more preferably at least 0.02% to at most 2.5%, even more preferably at least 0.05% and at most 1% based on the total weight of the multi-part primer.

Defoamers

In some exemplary embodiments, a defoamer or an anti-foaming agent that reduces and/or hinders the formation of foam may be included in one or more component of the roofing repair system. Suitable defoamers are known in the art, and include, for example, silicone (co)polymers and/or poly(ethylene oxide)-poly(propylene oxide) copolymers. One particularly useful defoamer is available under the trade name Surfynol® DF-178 (available from Air Products and Chemicals, Inc., Allentown, PA).

Plasticizers

The multi-part primer may further comprise a plasticizer. Suitable plasticizers are common plasticizers useful in polyurethane adhesive applications and well known to those skilled in the art. Suitable plasticizers are well known in the art and presently preferred plasticizers include alkyl phthalates such as dioctylphthalate or dibutylphthalate, partially hydrogenated terpene commercially available as "HB-40", trioctyl phosphate, epoxy plasticizers, toluene-sulfamide, chloroparaffins, adipic acid esters, castor oil, toluene and alkyl naphthalenes.

If used, the plasticizer is preferably present in an amount sufficient to plasticize one or more of the hydrophilic polyfunctional aliphatic polyisocyanate, the hydrophobic polyfunctional aliphatic, or the weathered surface of the elastomeric roofing membrane to which the primer is applied. The plasticizer can be added to the first part or the second part of the multi-part primer, although preferably the plasticizer is added to the second part of the multi-part primer. Preferably the plasticizer is present in the second part of the multi-part primer in an amount of about 0.5 percent by weight of the second part or greater, more preferably about 1 percent by weight of the second part or greater, and most preferably about 2 percent by weight of the second part or greater. Preferably the plasticizer is present in the second part of the multi-part primer in an amount of no more than about 5 percent by weight of the second part or less, more preferably no more than about 3 percent by weight of the second part or less, and most preferably no more than about 2.5 percent by weight of the second part or less.

Particulate Fillers

The multi-part primer may, in some exemplary embodiments, include, or have added to it, at least one optional filler. The filler may, in some embodiments, comprise a flame retardant or a pigment. Mixtures of different fillers may also be used. Fillers in particulate form are presently preferred. Filler particles generally have an average particle size range between about 0.5 and about 500 micrometers. In some embodiments, the filler particle is between about 5 and about 20 micrometers.

Non-limiting examples of suitable fillers include: carbon black, fly ash, slate dust, limestone, dolomite, siliceous fillers (e.g. mica and other sheet silicates). metal carbonates (such as calcium carbonate (e.g., chalk, calcite, marl, travertine, marble and limestone), calcium magnesium carbonate, sodium carbonate, magnesium carbonate), silica (e.g., quartz, glass beads, glass bubbles and glass fibers) silicates (e.g., sodium silicate, calcium silicate, calcium metasilicate, sodium aluminosilicate), metal sulfates (such as calcium sulfate, barium sulfate, sodium sulfate, aluminum sodium sulfate, aluminum sulfate), certain metal oxides (e.g., calcium oxide (lime), alumina, tin oxide (stannic oxide), titanium dioxide), metal sulfites (e.g., calcium sulfite), talc, clays (e.g., montmorillonite, bentonite), feldspar, gypsum, vermiculite, wood flour, Perlite®, aluminum trihydrate, and the like.

The filler may also be a metal filler. Examples of metal fillers include copper, tin, zinc, bismuth, cobalt, antimony, cadmium, iron, and titanium. Other miscellaneous fillers include sulfur, organic sulfur compounds, graphite, boron nitride, and metallic sulfides.

Flame retardant fillers, for example, sodium bicarbonate and aluminum hydrate, could comprise all or a portion of the filler. The multi-part primer may also be colored by adding colored fillers, for example pigments, thereto. The multi-part primer may also include an anticorrosion pigment. Exemplary suitable organic coloring pigments include carbon black and phthalocyanine blue; exemplary suitable inorganic coloring pigments include titanium oxide, ferric oxide, lead chromate, and zinc oxide; exemplary suitable anticorrosion pigments include lead oxide, calcium plumbate, zinc chromate, basic lead chromate, zinc molybdate and condensed zinc phosphate. The above mentioned examples of fillers are meant to be a representative showing of some useful fillers, and are not meant to encompass all useful fillers.

The fillers may be provided with a surface treatment. Preferably, the surface treatment makes the surface of the filler particles more oleophilic, more hydrophobic, or less hydrophilic. Examples of suitable surface treatments include silanes, siloxanes, and surfactants, particularly surfactants exhibiting a hydrophile-lipophile balance (HLB) of ten or less.

The amount of filler is typically more than 5% by weight, suitably less than 50% by weight, more preferably at least 10% to at most 40% by weight, more preferably at least 20% to at most 30% by weight, even more preferably about 25-28% by weight based on the total weight of the first part of the multi-part primer.

Fibrous Materials

If desired, the multi-part primer may further comprise a fibrous material (e.g. fibers such as, for example, glass fibers, rock fibers, cellulose fibers, and/or polymeric fibers). In certain presently preferred embodiments, the fibrous material comprises polymeric fibers. The polymeric fibers preferably comprise a polyolefin, for example, polyethylene, polypropylene, polybutylene, combinations thereof, and the like. In general, the amount of fibrous material added to the multi-part primer may vary, although, in some exemplary embodiments, the concentration is preferably at least 1% and no more than about 25% w/w, more preferably at least 2.5% and no more than 20% w/w, more preferably at least 5% and no more than 15% w/w, and even more preferably from 5-10% w/w of the multi-part primer.

Optional Reinforcing Layer

In additional exemplary embodiments, the roofing repair system of any of the foregoing embodiments further comprises a reinforcing layer. The reinforcing layer is preferably applied over the at least partially cured activated multi-part primer, between the at least partially cured activated multi-part primer and the water-activated overcoat composition.

In some exemplary embodiments, the reinforcing layer comprises a fiberglass mesh, a polyester mesh, a ethylene-propylene dimer elastomer membrane, a chlorosulfonated elastomer membrane, a poly(vinyl) chloride elastomer membrane, or a combination thereof. Suitable fiberglass mesh reinforcing layers are sold under the trade names SCOTCHKOTE™ Advanced CSM Reinforcing Mat, SCOTCHKOTE™ Premier EC/UV Reinforcing Mat, and SCOTCHKOTE™ Premier Plus Reinforcing Mat (available from 3M Company, St. Paul, MN).

Optional Applicator

In certain exemplary embodiments, the roofing repair systems according to any of the preceding embodiments further comprise an applicator selected from a brush, a pad, a squeegee, a roller, a sprayer, or a combination thereof. Suitable applicators are described, for example, in U.S. Patent No. 6,679,018 B2, which is incorporated herein by reference in its entirety.

Method of Using the Roofing Repair System

In another aspect, the disclosure describes a method of using the roofing repair system according to any one of the preceding embodiments, the method comprising the steps of: (a) mixing together the first part and the second part of the multi-part primer to obtain an activated primer mixture, (b) applying the activated primer mixture to a weathered surface of an elastomeric roofing membrane, and (c) applying the water-activated overcoat composition to the primer mixture on the weathered surface of the elastomeric membrane.

In certain exemplary embodiments, step (b) is completed within two hours after beginning step (a). In further exemplary embodiments, step (c) is begun at least two hours after step (b) is completed, and step (c) is completed no more than 168 hours after beginning step (a).

The roofing repair system of the present disclosure is used to overcoat a weathered surface of an elastomeric roofing membrane. In some exemplary embodiments, the elastomeric roofing membrane comprises ethylene-propylene dimer elastomer, chlorinated polyethylene elastomer, chlorosulfonated polyethylene elastomer, acrylonitrile rubber, poly(isobutylene) elastomer, thermoplastic polyolefin elastomer, polyvinyl chloride elastomer, or a combination thereof.

In some presently preferred embodiments, the surface to which the activated multi-part primer is applied is prepared or cleaned by washing with a detergent and lightly abrading the surface prior to application of the activated multi-part primer. Other surface preparation methods are described, for example, in U.S. Patent Nos. 3,707,521; 3,779,794; and 4,525,511; each of which is incorporated herein by reference in its entirety.

In some exemplary embodiments of the foregoing method, the activated multi-part primer mixture comprises water in an amount sufficient to obtain a non-volatile solids content of from 30% to 50% by volume of the activated primer mixture.

The parts of the multi-part primer may be activated by mixing the first part and the second part using mixing means well-known in the art. Generally the components are blended in a suitable mixer, for example, a propeller mixer inserted into a tank, drum, or pail containing the components to be mixed. It may be advantageous to add any plasticizers to the mixture so that such mixture may be easily mixed and handled.

In use, the activated multi-part primer is generally applied to the weathered surface of the elastomeric roofing membrane, and allowed to dry or at least partially cure at ambient temperature for at least one hour, more preferably at least two hours, even more preferably at least eight hours, and still more preferably at least 16-24 hours. Curing can be accelerated by by pre-heating the activated multi-part or the components of the multi-part primer prior to mixing and application to the weathered surface of the elastomeric roofing membrane, and/or by applying heat to the applied activated multi-part primer using external heating means such as a heat gun, flame gun or torch, and/or exposure to solar radiation, and the like.

An optional reinforcing layer is then, in some exemplary embodiments, preferably applied over the at least partially cured activated multi-part primer, between the at least partially cured activated multi-part primer and the water-activated overcoat composition.

The water-activated overcoat composition is then applied over the at least partially cured activated multi-part primer in the presence of atmospheric moisture. Exposure to atmospheric moisture is generally sufficient to result in curing of the water-activated overcoat composition. Curing can be accelerated by the addition of additional water, by pre-heating the water-activated overcoat composition prior to application, and/or by applying heat to the applied water-activated overcoat composition using external heating means such as a heat gun, flame gun or torch, and/or exposure to solar radiation, and the like.

Preferably the multi-part primer is formulated to provide a working time of at least one hour, more preferably at least two hours, even more preferably at least five hours, eight hours, 12 hours, or even 24 hours after activation before fully curing. In such embodiments, the activated multi-part primer preferably fully cures in 48 hours or less, more preferably 24 hours or less, even more preferably 12 hours or less, and most preferably in eight hours or less.

Preferably the water-activated overcoat composition is formulated to provide a working time of at least one hour, more preferably at least two hours, even more preferably at least five hours, eight hours, 12 hours, or even 24 hours after activation before fully curing. In such embodiments, the activated water-activated overcoat composition preferably fully cures in 48 hours or less, more preferably 24 hours or less, even more preferably 12 hours or less, and most preferably in eight hours or less.

In some exemplary embodiments, the roofing repair system and method of the present disclosure provides a number of unexpected results and advantages. In exemplary embodiments, the roofing repair system and method uses a water-based multi-part primer that has low toxicity, is environmentally benign, has excellent shelf stability, is easy to apply, and, when activated, has a sufficiently low viscosity to permit penetration and good adhesion of the primer layer to a weathered surface of an elastomeric roofing membrane.

In further exemplary embodiments, the roofing repair system includes a water-activated overcoat composition that reacts with (i.e. covalently bonds to) the at least partially cured activated primer layer on the weathered surface of the elastomeric roofing membrane, thereby promoting good interlayer adhesion between the overcoat layer and the primer layer, as well as good adhesion of the roofing repair system to the weathered surface of the elastomeric roofing membrane. Moreover, the roofing repair system may be formulated to contain little or no volatile organic solvents, is typically easy to apply by relatively unskilled works using a variety of application methods (e.g. brushing, rolling, spraying, and the like), and generally exhibits excellent extended shelf stability. The roofing repair system thus offers an effective and relatively low cost solution to the problem of renewing, refurbishing, or repairing weathered single ply roofing surfaces which employ elastomeric roofing membranes, particularly EPDM or HYPALON® elastomeric roofing membranes.

Exemplary embodiments of roofing repair systems and methods are further illustrated by the following non-limiting example, but the particular materials and amounts thereof recited in the example, as well as other conditions and details, should not be construed to unduly limit this disclosure.

EXAMPLE

An exemplary embodiment of the disclosure will now be described. Embodiments of the present disclosure may take on various modifications and alterations without departing from the spirit and scope of the disclosure. Accordingly, it is to be understood that the embodiments of the present disclosure are not to be limited to the following described exemplary embodiment, but is to be controlled by the limitations set forth in the claims and any equivalents thereof. Unless otherwise expressly noted, all parts, percentages, ratios, etc. in the Example and the rest of the specification are by weight. In addition, the following abbreviations and materials are used in the Example below:

Materials:

Hydroxyl-Functional (Meth)acrylic Polymer

BAYHYDROL A 145 is a dispersion of a hydroxyl-functional acrylic polymer (43-47% w/w) in water (available from Bayer Material Science LLC, Pittsburgh, PA).

Hydrophilic Polyfunctional Aliphatic Isocyanate

BAYHYDUR® XP 2487/1 is a hydrophilic, water dispersible poly-functional aliphatic polyisocyanate based on hexamethylene diisocyanate (available from Bayer Material Science LLC, Pittsburgh, PA).

Hydrophobic Polyfunctional Aliphatic Isocyanate

DESMODUR N 3600 is a hydrophobic, solvent-free

Optional Catalyst

Dibutyl tin dilaurate (available from Sigma-Aldrich Chemical Co., St. Louis, MO).

Optional Biocides

PROMEX™ Na2OS, a glycolic solution (20% w/w) of 1,2-Benzisothiazolin-3-one (available from Prom Chem, Ltd., Caterham, United Kingdom).

ACTICIDE® MKW1, a water-based solution (32-38% w/w) of 3-(3,4-dichlorophenyl)-1,1-dimethylurea; 3-iodopropargyl-N-butylcarbamate; and protected 2-n-octyl-4-isothiazolin-3-one (available from Thor Specialties, Ltd., Northwich, Cheshire, England).

Optional Surfactant

Surfynol® 104E, a solution (50% w/w) of 2,4,7,9-tetramethyl-5-decyne-4,7-diol in 2-ethylhexanol (available from Air Products and Chemicals, Inc., Allentown, PA).

Optional Dispersant

DISPERBYK 190, a 40% w/w aqueous solution of a high molecular weight block copolymer with pigment affinic groups (available from BYK-Chemie GmbH, Wesel, Germany).

AMP-95, a solution (95% w/w) of 2-amino-2-methyl-1-propanol in water (available from Angus Chemie GmbH, Ibbenbüren, Germany).

Optional Particulate Filler

Tiona® 595, an alumina/zirconia/organic surface treated titanium dioxide (available from Millenium Chemicals, Hunt Valley, MD).

MICRO-TALC AT 1, talc powder available from Suter-Kunststoffe AG, Jegenstorf, Switzerland).

Optional Rheology Modifer

ACRYSOL™ RM-825, a non-ionic polyurethane rheology modifier (25% w/w) in water/butyl carbitol (75/25 % w/w) (available from Rohm and Haas Co., Philadelphia, PA).

Laponite RDS, an aqueous dispersion (10% w/w) of synthetic layered silicate incorporating an inorganic polyphosphate peptiser (available from Rockwood Additives, Ltd., Cheshire, United Kingdom).

Optional Solvent

Proglyde DMM, a mixture of isomeric dipropylene glycol dimethyl ethers (available from Dow Chemical Co., Midland, MI).

Water-Activated Overcoat Composition

3M SCOTCHKOTE™ Polyurethane Base Coat EC/UV, a water-activated overcoat composition comprising at least one compound selected from polyketimines having amino groups attached to secondary carbon atoms, polyenamines, and oxazolidines (available from 3M Co., St. Paul, MN).

Substrates

Ethylene-propylene diene monomer (EPDM) elastomeric roofing membrane (obtained from Goodyear Rubber Co., Akron, OH), was weathered by exposure to solar radiation and the elements.

Chlorosulfonated ethylene (HYPALON®, obtained from E.I. DuPont de Nemours Corp., Wilmington, DE), was weathered by exposure to solar radiation and the elements.

All substrates were washed with a detergent and lightly abraded with a 3M abrasive pad (available from 3M Company, St. Paul, MN) prior to application of any primer or roofing repair system.

Preparative Example 1 - Multi-part Primer

This example illustrates the preparation of a multi-part primer comprising a first part including a hydroxyl-functional (meth)acrylic (co)polymer, and a second part including a mixture of a hydrophilic polyfunctional aliphatic polyisocyanate and a hydrophobic polyfunctional aliphatic polyisocyanate, wherein a molar ratio of hydroxyl functionality in the first part to isocyanate functionality in the second part is less than 1.

First Part (including a hydroxyl-functional (meth)acrylic (co)polymer)

The following ingredients were combined in the order given at the indicated weight percentages and mixed by stirring for 30 minutes to obtain a fluid mixture:

Water:	15.60%
Laponite RDS:	6.10%
AMP-95:	0.04%
Surfynol® 104E:	0.76%
Tiona® 595:	3.82%
DISPERBYK 190	1.95%
MICRO-TALC AT 1:	22.89%
BAYHYDROL A 145:	48.15%
PROMEX™ Na2OS:	0.08%
ACTICIDE® MKW1:	0.23%
ACRYSOL™ RM-825:	0.38%

The specific gravity of the mixture was measured as 1.26.

Second Part (including a mixture of a hydrophilic polyfunctional aliphatic polyisocyanate and a hydrophobic polyfunctional aliphatic polyisocyanate)

The following ingredients were combined in the order given at the indicated weight percentages and mixed by stirring for 30 minutes to obtain a fluid mixture:

BAYHYDUR® XP 2487/1:	40.00%
DESMODUR N 3600:	40.00%
Proglyde DMM:	20.00%

The specific gravity of the mixture was measured as 1.10.

Example 1 - Roofing Repair System

This example illustrates the preparation of a roofing repair system comprising the multi-part primer of Preparative Example 1 and a water-activated overcoat composition comprising at least one compound selected from polyketimines having amino groups attached to secondary carbon atoms, polyenamines, and oxazolidines. The First Part of the primer of Preparative Example 1 was combined with the Second Part of the primer of Preparative Example 1 at a 6:1 ratio (volume/volume) based on the measured specific gravities of the First Part and the Second Part. The mixture was mixed for 15 minutes to activate the primer.

The resulting activated primer was applied to a weathered EPDM substrate as described above. After allowing the activated primer coating on the weathered EPDM substrate to dry for approximately eight hours, the primer layer was overlaid with a strip of woven polyester mesh fabric (to facilitate manual pull adhesion testing) and then coated with a layer of water-activated overcoat composition, 3M SCOTCHKOTE™ Polyurethane Base Coat EC/UV. The sample was allowed to dry before testing according to the following test methods.

Test Methods:

The sample of Example 1 was first assessed for dry adhesion of the roofing repair system to the prepared EPDM substrate, after which adhesion was measured after exposing the coated substrate to 100% humidity. Adhesion was tested by making a cut across the surface of the coating with a sharp blade, and pulling on the exposed embedded polyester mesh fabric by hand to determine whether the mesh fabric could be removed from the weathered EPDM substrate.

Adhesion was retested after applying the following environmental exposure conditions on the coated weathered EPDM substrate:

1. Cold water immersion for 10 weeks;
2. Exposure to ultraviolet (UV) light 1000 hours (according to ASTM Test Method G53, using a QUV tester equipped with B-313 tubes, programmed for four hours of UV exposure @ 60^0C alternating with 4 hours of exposure to a high humidity condensing environment @ 40^0C); and
3. Humidity Cabinet Exposure for 800 hours (according to ASTM Test Method BS3900; Part F2)

Adhesion after all three environmental exposure conditions was visually observed to be excellent, with no visible failures of the bond at the interface with the weathered EPDM surface, or at the interface between the activated primer layer and the water-activated overcoat composition. The mode of failure was observed to be entirely cohesive within the weathered EPDM elastomeric roofing membrane.

The formulations of Preparative Example 1 (multi-part primer) and Example 1 (roofing repair system) were also applied to a weathered HYPALON® the procedures and methods of Preparatory Example 1 and Working Example 1, except that weathered HYPALON® was used as the substrate instead of weathered EPDM. Adhesion after all three environmental exposure conditions was visually observed to be excellent, with no visible failures of the bond at the interface with the weathered HYPALON® surface, or at the interface between the activated primer layer and the water-activated overcoat composition. The mode of failure was observed to be entirely cohesive within the weathered HYPALON® elastomeric roofing membrane.

Reference throughout this specification to “one embodiment,” “certain embodiments,” “one or more embodiments” or "an embodiment," whether or not including the term “exemplary” preceding the term “embodiment,” means that a particular feature, structure, material, or characteristic described in connection with the embodiment is included in at least one embodiment of the exemplary embodiments of the present disclosure. Thus, the appearances of the phrases such as “in one or more embodiments,” “in certain embodiments,” “in one embodiment” or “in an embodiment” in various places throughout this specification are not necessarily referring to the same embodiment of the exemplary embodiments of the present disclosure. Furthermore, the particular features, structures, materials, or characteristics may be combined in any suitable manner in one or more embodiments.

While the specification has described in detail certain exemplary embodiments, it will be appreciated that those skilled in the art, upon attaining an understanding of the foregoing, may readily conceive of alterations to, variations of, and equivalents to these embodiments. Accordingly, it should be understood that this disclosure is not to be unduly limited to the illustrative embodiments set forth hereinabove. In particular, as used herein, the recitation of numerical ranges by endpoints is intended to include all numbers subsumed within that range (e.g. 1 to 5 includes 1, 1.5, 2, 2.75, 3, 3.80, 4, and 5). In addition, all numbers used herein are assumed to be modified by the term 'about'. Furthermore, all publications, published patent applications and issued patents referenced herein are incorporated by reference in their entirety to the same extent as if each individual publication or patent was specifically and individually indicated to be incorporated by reference. Various exemplary embodiments have been described. These and other embodiments are within the scope of the following claims.

What is claimed is:

1. A roofing repair system comprising:

(a) a multi-part primer comprising a first part including a hydroxyl-functional (meth)acrylic polymer, and a second part including a mixture of a hydrophilic polyfunctional aliphatic polyisocyanate and a hydrophobic polyfunctional aliphatic polyisocyanate, wherein a molar ratio of hydroxyl functionality in the first part to isocyanate functionality in the second part is less than 1; and

(b) a water-activated overcoat composition comprising at least one compound selected from polyketimines having amino groups attached to secondary carbon atoms, polyenamines, and oxazolidines.

2. The roofing repair system of claim 1, wherein a volume ratio of the multi-part primer to the water-activated overcoat composition is from 5:1 to 7:1.

3. The roofing repair system of claim 1 or 2, wherein the multi-part primer is substantially free of organic solvents.

4. The roofing repair system of any one of the preceding claims, wherein the first part of the multi-part primer further comprises water.

5. The roofing repair system of any one of the preceding claims, wherein the multi-part primer further comprises a catalyst, a biocide, a surfactant, a dispersant, a rheology modifier, a particulate filler, a fibrous material, a defoamer, a plasticizer, or a combination thereof.

6. The roofing repair system of any one of the preceding claims, wherein the hydroxyl-functional (meth)acrylic (co)polymer comprises dispersed particles.

7. The roofing repair system of any one of the preceding claims, wherein the hydroxyl-functional (meth)acrylic (co)polymer comprises from 30 to 50% by weight of the first part of the multi-part primer.

8. The roofing repair system of any one of the preceding claims, wherein a weight ratio of hydrophilic polyfunctional aliphatic polyisocyanate to hydrophobic polyfunctional aliphatic polyisocyanate in the second part of the multi-part primer is at least 1:1.

9. The roofing repair system of claim 8, wherein the combined weight of hydrophilic polyfunctional aliphatic polyisocyanate and hydrophobic polyfunctional aliphatic polyisocyanate comprises at least 80% by weight of the second part.

10. The roofing repair system of any one of the preceding claims, wherein the water-activated overcoat composition further comprises a film-forming thermoplastic polymer.

11. The roofing repair system of any one of the preceding claims, wherein the film-forming thermoplastic polymer comprises a polyurethane segment.

12. The roofing repair system of any one of the preceding claims, wherein the water-activated overcoat composition further comprises a urethane prepolymer comprising an isocyanate which has been blocked with a phenol or an oxime.

13. The roofing repair system of any one of the preceding claims, further comprising a reinforcing layer.

14. The roofing repair system of claim 13, wherein the reinforcing layer comprises a fiberglass mesh, a polyester fiber mesh, an ethylene-propylene dimer elastomer, a chlorinated polyethylene elastomer, a chlorosulfonated polyethylene elastomer, an acrylonitrile rubber, a poly(isobutylene) elastomer, a thermoplastic polyolefin elastomer, a polyvinyl chloride elastomer, or a combination thereof.

15. The roofing repair system of any one of the preceding claims, further comprising an applicator selected from a brush, a pad, a squeegee, a roller, a sprayer, or a combination thereof.

16. A method of using the roofing repair system according to any one of the preceding claims, comprising the steps of:

(a) mixing together the first part and the second part of the multi-part primer to obtain an activated primer mixture;

(b) applying the activated primer mixture to a weathered surface of an elastomeric roofing membrane; and

(c) applying the water-activated overcoat composition to the primer mixture on the weathered surface of the elastomeric membrane.

17. The method of claim 16, wherein the activated primer mixture comprises water in an amount sufficient to obtain a non-volatile solids content of from 30% to 50% by volume of the activated primer mixture.

18. The method of claim 16 or 17, wherein step (b) is completed within two hours after beginning step (a).

19. The method of claim 18, wherein step (c) is begun at least two hours after step (b) is completed, and step (c) is completed no more than 168 hours after beginning step (a).

20. The method of any one of claims 16-19, wherein the elastomeric roofing membrane comprises ethylene-propylene dimer elastomer, chlorinated polyethylene elastomer, chlorosulfonated polyethylene elastomer, acrylonitrile rubber, poly(isobutylene) elastomer, thermoplastic polyolefin elastomer, polyvinyl chloride elastomer, or a combination thereof.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2011/036970

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - C08J 3/07 (2011.01)
USPC - 525/131
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)
IPC(8) - C08J 3/00, 3/02, 3/03, 3/07 (2011.01)
USPC - 524/523; 525/127, 131

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)
MicroPatent

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,567,761 A (SONG) 22 October 1996 (22.10.1996) entire document	1-3
A	US 2009/0042033 A1 (ESWARAKRISHNAN et al) 12 February 2009 (12.02.2009) entire document	1-3
A	US 2009/0047443 A1 (BOWMAN et al) 19 February 2009 (19.02.2009) entire document	1-3
A	US 2010/0093914 A1 (YUKAWA et al) 15 April 2010 (15.04.2010) entire document	1-3

☐ Further documents are listed in the continuation of Box C. ☐

* 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
05 August 2011

Date of mailing of the international search report
18 AUG 2011

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2011/036970

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

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

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 4-20
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

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

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

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.