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(54) Title: SULFUR ASPHALT IN ROOFING, DAMP-PROOFING AND WATER PROOFING

(57) Abstract: A method of waterproofing or damp proofing a protected member having a surface with a sulfur-extended plastomer asphalt binder composition uses a sulfur-extended plastomer asphalt binder composition that includes elemental sulfur, a plastomer and an asphalt binder. The method includes the steps of combining the plastomer with the asphalt binder maintained at a plastomer mixing temperature such that an intermediate asphalt binder mixture forms, and combining elemental sulfur with the intermediate asphalt binder maintained at a sulfur mixing temperature such that the sulfur-extended plastomer asphalt binder composition forms. The method also includes the step of applying the sulfur-extended plastomer asphalt binder composition to the surface of the protected member such that the sulfur-extended plastomer asphalt binder composition contacts, adheres to and forms a layer upon the surface of the protected member. The asphalt binder composition is applied at a temperature no greater than 150 °C.



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PCT PATENT APPLICATION

SULFUR ASPHALT IN ROOFING, DAMP-PROOFING AND WATER PROOFING

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BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The field of invention relates to asphalt compositions for roofing, damp-proofing and water proofing and their use. More specifically, the field relates to sulfur-extended plastomer asphalt binders.

2. Description of the Related Art

[0002] During the manufacturing and processing of materials containing asphalt such as asphalt-coated aggregates and hot asphalt mixes, working temperatures above 300 °F can cause problems for workers and their equipment. At temperatures greater than 300 °F, sulfur and sulfur compounds present in asphalt or bitumen mixes, including elemental sulfur and naturally present heteroatom organic compounds, begin to react with other constituents in the asphalt and with the oxygen in the air. One of the main products of these reactions is hydrogen sulfide gas, where free sulfur in hydrocarbon environments dehydrogenates hydrocarbons and forms hydrogen sulfide. Hydrogen sulfide in low quantities is an irritant but in high quantities it is toxic. Heated sulfur that oxidizes in the air forms sulfur dioxide. Sulfur dioxide has a noxious odor and is considered an air pollutant. Working in elevated conditions, including on top of metal roofing, or in confined conditions, including basements and pits, can concentrate and exacerbate the exposure to these unwanted byproducts. It is desirable to find an asphalt composition that is workable at temperatures below 300 °F for

worker comfort and safety in addition to not releasing noxious chemicals into the environment.

[0003] Sulfur, especially “free” or elemental sulfur, is an abundant and inexpensive material. Elemental sulfur is a byproduct of non-sweet natural gas and petroleum processing. Sources of free sulfur include petroleum refineries and gas sweetening plants. Because of the quantity of sulfur extracted annually from natural gas and petroleum processes, many sulfur producers consider elemental sulfur a “waste” product. Others have attempted to use waste sulfur as an expander or filler for asphalt and bitumen compositions but only have obtained limited success. Therefore, it is also desirable to find commercial uses for elemental sulfur. Incorporating sulfur into commercial products can transform what many consider a waste product into a product that has practical value as an expander of the hydrocarbon resource supply.

SUMMARY OF THE INVENTION

[0004] A sulfur-extended plastomer asphalt binder composition that is useful for water proofing, damp proofing and roofing applications includes elemental sulfur, a plastomer and an asphalt binder. The sulfur-extended plastomer asphalt binder composition includes elemental sulfur in a range of from about 10% to about 30%, the plastomer in a range of from about 3% to about 10% and the asphalt binder in a range of from about 60% to about 87%, each by total weight.

[0005] A method of waterproofing or damp proofing a protected member having a surface with a sulfur-extended plastomer asphalt binder composition includes a step of combining the plastomer with an asphalt binder maintained at a plastomer mixing temperature such that an intermediate asphalt binder mixture forms. The method also includes the step of combining elemental sulfur with the intermediate asphalt binder maintained at a sulfur mixing temperature such that the sulfur-extended plastomer asphalt binder composition forms. The sulfur-extended plastomer asphalt binder composition comprises elemental sulfur in a range of from about in a range of from about 10% to about 30%, the plastomer in a range of from about 3% to about 10% and the asphalt binder in a range of from about 60% to about 87%, each by total weight.. The method also includes the step of applying the sulfur-extended plastomer asphalt binder composition to the surface of the protected member such that the sulfur-extended plastomer asphalt binder composition contacts and forms a layer upon and adheres to the surface of the protected member. The asphalt binder composition is applied at

a temperature in a range of from about ambient temperature to no greater than 150 °C. The formed layer is operable to prevent water migration through the protected member. The formed layer has a first side in contact with and bonded to the surface of the protected member and a second side that does not contact the surface of the protected member.

[0006] Forming sulfur-extended plastomer asphalt binders consumes a significant amount of “waste” sulfur in a low-temperature asphalt binder application. The sulfur-extended plastomer asphalt binder includes elemental sulfur in a range of from about 10% to about 30% of the total weight of the composition. In traditional plastomer/asphalt mixes, this substituted 10% to 30% of material is usually mostly asphalt. The use of the sulfur therefore extends the supply of asphalt with a cheaper and more available material that, surprisingly, imparts desirable viscosity properties. In addition, the compositions comply with ASTM requirements for certain types of rooming, damp proofing, and waterproofing applications.

[0007] Maintaining the application temperature of the sulfur-extended plastomer asphalt binder in a range of from about ambient condition to no greater than 150 °C prevents the formation of hydrogen sulfide and sulfur oxides around workers and equipment, especially in isolated and confined environments such as roof tops, basements and generally human-inaccessible locations. The lower temperature of manufacturing and use along with the lower viscosity of the sulfur-extended plastomer asphalt binders results in significant energy savings for users.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] No figures.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0009] The Specification, which includes the Summary of Invention, Brief Description of the Drawings and the Detailed Description of the Preferred Embodiments, and the appended Claims refer to particular features (including process or method steps) of the invention. Those of skill in the art understand that the invention includes all possible combinations and uses of particular features described in the Specification. Those of skill in the art understand that the invention is not limited to or by the description of embodiments given in the Specification. The inventive subject matter is not restricted except only in the spirit of the Specification and appended Claims.

[0010] Those of skill in the art also understand that the terminology used for describing particular embodiments does not limit the scope or breadth of the invention. In interpreting

the Specification and appended Claims, all terms should be interpreted in the broadest possible manner consistent with the context of each term. All technical and scientific terms used in the Specification and appended Claims have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs unless defined otherwise.

[0011] As used in the Specification and appended Claims, the singular forms “a”, “an”, and “the” include plural references unless the context clearly indicates otherwise.

[0012] As used, the words “comprise,” “has,” “includes”, and all other grammatical variations are each intended to have an open, non-limiting meaning that does not exclude additional elements, components or steps. Embodiments of the present invention may suitably “comprise”, “consist” or “consist essentially of” the limiting features disclosed, and may be practiced in the absence of a limiting feature not disclosed. For example, it can be recognized by those skilled in the art that certain steps can be combined into a single step. In the context of the present invention, “consist essentially of” means consist of the specified materials or steps but not any other material that is of a nature to or in an amount to materially affect the basic functioning or novel characteristics of the steps or materials identified. It is understood, for example, that trace elements may exist that do not materially modify functionality.

[0013] Where a range of values is provided in the Specification or in the appended Claims, it is understood that the interval encompasses each intervening value between the upper limit and the lower limit as well as the upper limit and the lower limit. The invention encompasses and bounds smaller ranges of the interval subject to any specific exclusion provided.

[0014] Where reference is made in the Specification and appended Claims to a method comprising two or more defined steps, the defined steps can be carried out in any order or simultaneously except where the context excludes that possibility.

[0015] When a patent or a publication is referenced in this disclosure, the reference is incorporated by reference and in its entirety to the extent that it does not contradict statements made in this disclosure.

Sulfur-extended plastomer asphalt binder

[0016] The sulfur-extended plastomer asphalt binder is made by combining the asphalt binder, elemental sulfur and the plastomer. The sulfur-extended plastomer asphalt binder is a combination of elemental sulfur in a range of from about in a range of from about 10% to

about 30%, the plastomer in a range of from about 3% to about 10% and the asphalt binder in a range of from about 60% to about 87%, each by total weight of the sulfur-extended plastomer asphalt binder composition.

[0017] An embodiment of the sulfur-extended plastomer asphalt binder composition consists essentially of elemental sulfur, plastomer and asphalt binder. An embodiment of the composition consists essentially of about 20% elemental sulfur, about 5% the plastomer and about 75% the asphalt binder, each by total weight of the sulfur-extended plastomer asphalt binder composition. An embodiment of the composition consists essentially of about 30% elemental sulfur, about 5% the plastomer and about 65% the asphalt binder, each by total weight of the sulfur-extended plastomer asphalt binder composition.

Asphalt binder

[0018] Bitumen and asphalt that are useful as the asphalt binder can originate from petroleum distillation (for example, vacuum tails); coal, tar sands or oil shale processing; or from naturally occurring sources (for example, Trinidad Lakes). The base asphalt material can be a singular material or a blend of several base asphalts.

[0019] Asphalt and bitumen is a colloidal dispersion of asphaltenes in a maltenes phase. Asphaltenes include clusters of large polycyclic aromatic molecules. The structure of asphaltenes may include, in no particular order or regularity, cyclo-alkanes, cyclo-alkenes, and alkane and alkene chains extending from polycyclic molecules for up to 30 carbons (C₃₀) in length. Asphaltenes can also have functional moieties that are capable of reacting with other materials. Functional moieties include alcohols, carboxylic acids, ketones, phenols, amines, amides, sulfides, sulfoxides, sulfones, sulfonic acids, and porphyrin rings chelated with vanadium, nickel, and iron. Asphaltenes also have heterorganic aromatic rings part of their overall polycyclic structure, including benzothiophene, pyrrole and pyridine rings.

[0020] The maltenes phase, which is more mobile than the asphaltene phase, includes asphaltene resins, polar and non-polar aromatics, cyclic saturated hydrocarbons (for example, naphthenes), and both straight and long-chain saturated hydrocarbons. Although not intending to be bound by theory, it is believed that polar aromatics in the maltene phase tend to be the dispersing agent for the asphaltenes, interacting with polar functional groups that can exist on asphaltenes. Maltenes can be partially extracted from the dispersion using an n-alkane-based solvent; asphaltenes cannot.

[0021] All asphalt and bitumen are suitable as the asphalt binder. Asphaltene concentration varies in amount and functionality depending on the source of the bitumen. The asphaltene content of the asphalt is typically in the range of from about 0.01% by weight to about 30% by weight of the material. An embodiment of the sulfur-extended plastomer asphalt binder composition includes a “Performance Graded” binder based upon the properties listed in the Performance Grade table (“Table 1”) of the AASHTO Performance Graded Asphalt Binder Specification M 320 as the asphalt binder. An embodiment of the asphalt binder composition includes where the asphalt binder comprises a PG 64-10 asphalt binder. An embodiment of the asphalt binder composition includes where the asphalt binder consists essentially of a neat PG 64-10 asphalt binder.

Elemental Sulfur

[0022] The elemental or “free” sulfur includes not only singular sulfur atoms but also sulfur in complexes and covalently bonded to other sulfur atoms, including α -sulfur (orthorhombic sulfur), β -sulfur (monoclinic sulfur) and “catena” sulfur. Chains or rings of sulfur atoms can range from a few sulfur atoms to hundreds of covalently linked sulfur atoms. All allotropes of elemental sulfur are suitable for use in the sulfur-extended composition. Sulfur covalently bonded with non-sulfur atoms, such as carbon, hydrogen or other atomic species, including heterorganic compounds, is not considered “free” or elemental sulfur. Because of the wide variety of allotropes, elemental sulfur is found in many different solid and liquid forms and can change between forms based upon modifications to its environment, including heating and pressure. Typically, however, it is handled in either a pellet or powdered solid form or a molten liquid form.

[0023] The source of elemental sulfur can be naturally occurring (for example, mined) or a resultant from natural gas or petroleum treatment processes. For example, a well-known and understood natural gas sweetening process converts hydrogen sulfide into elemental sulfur in a Claus unit.

Plastomer

[0024] Plastomers occupy a position between traditional polyolefins and elastomers. Plastomers are a class of polymers that when a load is applied it will yield and stretch (not brittle fracture like a traditional polyolefin such as atactic polypropylene) and will remain in its elongated position when the load is released (unlike an elastomer). Plastomers typically also add the property of high-temperature stiffness similar to a traditional polyolefin, whereas

elastomers will begin to flow at lower temperatures. Plastomers can mitigate the potential of permanent deformation and loss of integrity through long-term high temperature exposure, such as what a composition may encounter on roof tops and near appliances that radiate heat. Plastomers are thermoplastic in nature, and therefore will deform in a plastic or viscous manner at melt temperatures of the plastomer and becomes hard and stiff at temperatures below melt.

[0025] Examples of useful plastomers include long-chain branched polyolefins, including low-density polyethylenes (LDPE); highly-branched polyolefins, including linear low-density polyethylenes (LLDPE), ethylene/ α -olefin(s) copolymers/terpolymers/tetrapolymers, and propylene/ α -olefin copolymers/terpolymers/tetrapolymers, where the α -olefin(s) include one or more C3 to C20 olefins, including propylene, butene, hexene, and octane, and the ethylene/propylene comprises at least 50% by weight of the copolymers/terpolymers/tetrapolymers; ethylene butyl acrylates (EBA); and ethylene vinyl acetate (EVA). An embodiment of the sulfur-extended plastomer asphalt binder composition includes where the plastomer is an ethylene vinyl acetate (EVA) polymer. An embodiment of the sulfur-extended plastomer asphalt binder composition includes where the plastomer consists essentially of an ethylene vinyl acetate (EVA) polymer.

[0026] Examples of useful EVA plastomers for the sulfur-extended plastomer asphalt binder include the EVA polymers and the homogeneous sulfur-modified polymers (HSMP) as described in PCT Published Application No. 2010/120482 (Hussein, et al.), titled "Sulfur Extended Polymer of use in Asphalt Binder and Road Maintenance". An embodiment of the sulfur-extended plastomer asphalt binder composition includes where the plastomer is a homogeneous sulfur-modified polymer (HSMP). An embodiment of the sulfur-extended plastomer asphalt binder composition includes where the plastomer consists essentially of a homogeneous sulfur-modified polymer.

Forming the sulfur-extended plastomer asphalt binder

[0027] Addition and blending of components of the sulfur-extended plastomer asphalt binder can occur in any order. A non-limiting example includes adding components individually to a pre-heated and stirred asphalt binder material. Addition of the other components to form the sulfur-extended plastomer asphalt binder can occur sequentially or simultaneously.

[0028] Blending occurs in a vessel or apparatus appropriate to combine all of the sulfur-extended plastomer asphalt binder components together. Suitable vessels and apparatuses

include metal cans with hand blenders, reactors, buckets, mixing bowls, tanks and low- or high-shear mixing processors. The blending apparatus is operable to both maintain the base asphalt, the intermediate composition and the formed sulfur-extended plastomer asphalt binder at a steady temperature greater than ambient conditions as well as mix the components until obtaining uniformity. Maintaining an elevated and steady temperature ensures that upon addition of sulfur to the composition or formation of the sulfur-extended plastomer asphalt binder limits the likelihood of hydrogen sulfide and sulfur dioxide gas formation, which can be harmful to those individuals performing the blending operation. The blending apparatus is operable to induce circulation in the molten asphalt binder and maintains any intermediate blends in a molten form to ensure the thorough incorporation of asphalt binder components.

[0029] A process of forming an embodiment of the sulfur-extended plastomer asphalt binder composition includes introducing into the suitable blending apparatus the asphalt binder used as the base material and then heating the asphalt binder to a plastomer mixing temperature. The plastomer mixing temperature is greater than 150 °C and is usually maintained where the base asphalt becomes molten and fluidic, but not much greater than that. In some cases, the base asphalt is heated to a plastomer mixing temperature of about 180 °C. The plastomer is introduced to the asphalt binder and mixed at the plastomer mixing temperature until thoroughly incorporated, forming an intermediate asphalt binder mixture. The plastomer mixing temperature is relatively low compared to typical hot mix asphalt applications. Heat is applied for as long as necessary to blend the plastomer and the asphalt binder together. The risk of forming hydrogen sulfide and sulfur dioxide is low since the base asphalt does not have significant quantities of free sulfur.

[0030] Upon thorough incorporation of the plastomer, the temperature of the intermediate asphalt binder mixture cools to a sulfur mixing temperature. The sulfur mixing temperature is in a range of from about the melting point of elemental sulfur to no greater than higher of the flash point of the sulfur-extended plastomer asphalt binder or about 150 °C, depending on the content of elemental sulfur. Depending on the molecular configuration of the free sulfur, the melting point of sulfur varies between about 120 °C and about 140 °C. Upon reaching the sulfur mixing temperature, elemental sulfur is introduced and blended for an adequate period into the intermediate asphalt binder mixture until thoroughly incorporated. The sulfur-extended plastomer asphalt binder forms upon incorporation of the sulfur.

[0031] The sulfur-extended plastomer asphalt binder is compositionally stable. The sulfur-extended plastomer asphalt binder can be maintained at a temperature greater than ambient but no greater than 150 °C for extended periods for both exterior and interior applications.

Use of the sulfur-extended plastomer asphalt binder

[0032] In the method of waterproofing or damp proofing, an embodiment of the sulfur-extended plastomer asphalt binder composition is applied to a surface of a protected member to form a water proof or damp proof layer. The formed layer has a first side in contact with and adhered to the surface of the protected member and a second side that is not in contact with the surface of the protected member. The layer adheres to the surface of the protected member and prevents water migration through the protected member. The surface is preferably clean; however, this is not necessary. The sulfur-extended plastomer asphalt binder is particularly suited for applying to roof tops and roofing materials already in place.

[0033] Sulfur-extended plastomer asphalt binder is useful as a primer for other coatings; roofing; damp-proofing and waterproofing, including adhering roofing sheets to roofs or waterproofing coverings for roofing fabrics; and spray coating for pipes and other industrial protection schemes, including steel and iron. In an embodiment of the method, a second material is introduced to the second side of the layer such that the layer adheres to the second material. The temperature of the layer is in a range of from about ambient temperature to no greater than 140 °C. The sulfur-extended plastomer asphalt binder is applied to walls, roofs and other surfaces using asphalt binder spreading and spraying equipment known to one of ordinary skill in the art.

[0034] The bonding adhesion of the sulfur-extended plastomer asphalt binder to surfaces, especially metal surfaces, over traditional neat asphalt allows it not only to adhere to surfaces but also to materials applied to it while the composition is at a higher-than-ambient temperature, including roofing tiles, crushed stone and aggregate, tar and waxed papers, fabrics and other materials that support waterproofing, damp proofing and roofing construction activities.

Example

[0035] Examples of specific embodiments facilitate a better understanding of using the sulfur-extended plastomer asphalt binder composition. In no way should the Examples limit or define the scope of the invention.

[0036] The asphalt binder for all of the example compositions is a neat Performance Grade asphalt PG 64-10. The plastomer used for all of the example compositions where it is included is HSMP150 made using the procedures as described in PCT Published Application No. WO 2010/120482 (Hussein, et al.) and has the properties as given in, at least, Tables 3 and 4 and paragraphs [0057-0066] of the specification of Published Application. "HSMP150" is the product of combining as described in the Published Application of 50 wt.% elemental sulfur and 50 wt.% EVA28-150. The EVA copolymer has 28 wt.% vinyl acetate content of the copolymer and a melt flow index of 150 g/10 minutes before forming HSMP150.

[0037] The asphalt binder is heated to the mixing temperature of greater than 150 °C. When sulfur and a plastomer are both part of the same experimental composition, neat asphalt is mixed with the plastomer at 140 °C with a blender having a high shear blade and a blending speed of 2500 RPM, forming an intermediate composition. The elemental sulfur is introduced to the intermediate composition and blended until obtaining a uniform composition. In compositions where plastomer is not part of the composition, the asphalt binder is heated to a temperature of about 160 °C. For all experimental compositions, a blender with a high shear mixing blade combines each component for about 5 minutes to achieve uniformity. Each of the formed experimental compositions (neat asphalt, plastomer-extended asphalt, and sulfur-extended plastomer asphalt binders) are maintained at a temperature in a range of from about 135 °C to about 145 °C for application and experimentation.

[0038] Each of the compositions as listed in Table 1 are by total composition weight. For example, "+10 % Plastomer" represents a composition that is 10 % plastomer and 90 % plain or neat asphalt binder, each by total weight of the composition.

[0039] Prepared experimental compositions are evaluated for viscosity using ASTM D449 and ASTM D312 physical requirements for asphalt useful for damp proofing, waterproofing and roofing. In addition, the experimental compositions are also analyzed for conformance to ASTM D4402. For penetration, ASTM D5 is followed. For ductility, ASTM D113 is followed. For the softening point temperature, ASTM D36 is followed. For the flash point, ASTM D92 is followed.

[0040] The test results are presented in Table 1.

Binder Type	Flash Point (°C)	Softening Point (°C)	Ductility (cm)	Penetration @ 25 °C under 100 g load for 5 seconds (tenths of mm)	Viscosity (cp) at 135 °C (20 rpm)
Plain Asphalt	338	52.3	150+	67.6	571.0
+5 % Plastomer	200	54.1	73.0	70.0	750.0
+10% Plastomer	200	56.7	34.5	73.9	912.5
+20% Sulfur, +5% Plastomer	140	53.5	51.5	85.5	362.5
+30% Sulfur, +5% Plastomer	150	52.9	44.8	85.2	350.0

Table 1: Various properties of neat asphalt binder, plastomer-extended asphalt binder with 5-10 wt.% plastomer, and several sulfur/plastomer extended asphalt binders with varying amounts of plastomer and sulfur.

[0041] As Table 1 shows, the 5/20/75 plastomer/sulfur/asphalt composition shows a 51.7% reduction in viscosity versus the 5/95 plastomer/asphalt composition and a 36.5% reduction in viscosity versus the neat asphalt. The 5/30/65 plastomer/sulfur/asphalt composition shows a 53.3% reduction in viscosity versus the 5/95 plastomer/asphalt composition and a 38.7% reduction in viscosity versus the neat asphalt. The viscosity improvement over both traditional plastomer/asphalt combinations and the neat asphalt binder allows the plastomer/sulfur/asphalt compositions to be worked with a relative lower energy demand, reduces mixing time, and improves ease of application through traditional asphalt spreading equipment.

[0042] Table 1 shows that the 5/20/75 and the 5/30/65 plastomer/sulfur/asphalt compositions have similar penetration values and softening points as the plastomer/asphalt and neat asphalt compositions. The 5/20/75 and the 5/30/65 plastomer/sulfur/asphalt compositions have similar improvement in ductility values over the neat asphalt as the plastomer/asphalt compositions. Having similar penetration values, softening points, and ductility to the

plastomer/asphalt compositions permits the plastomer/sulfur/asphalt compositions to be treated similarly in application and maintenance.

CLAIMS

What is claimed is:

1. A method of waterproofing or damp proofing a protected member having a surface with a sulfur-extended plastomer asphalt binder composition, the method comprising the steps of:

combining a plastomer with an asphalt binder maintained at a plastomer mixing temperature such that an intermediate asphalt binder mixture forms;

combining elemental sulfur with the intermediate asphalt binder maintained at a sulfur mixing temperature such that the sulfur-extended plastomer asphalt binder composition forms; and

applying the sulfur-extended plastomer asphalt binder composition at a temperature in a range of from ambient temperature to no greater than 150 °C to the surface of the protected member such that the sulfur-extended plastomer asphalt binder composition contacts, adheres to and forms a layer upon the surface of the protected member that is operable to prevent water migration through the protected member;

where the sulfur-extended plastomer asphalt binder composition comprises elemental sulfur in a range of from 10% to 30%, the plastomer in a range of from 3% to 10% and the asphalt binder in a range of from 60% to 87%, each by total weight of the sulfur-extended plastomer asphalt binder composition, and

where the formed layer has a first side in contact with and adhered to the surface of the protected member and a second side that does not contact the surface of the protected member.

2. The method of claim 1, where the sulfur-extended plastomer asphalt binder composition consists essentially of 20% elemental sulfur, 5% plastomer and 75% asphalt binder, each by total weight of the sulfur-extended plastomer asphalt binder composition.

3. The method of claim 1, where the sulfur-extended plastomer asphalt binder composition consists essentially of 30% elemental sulfur, 5% plastomer and 65% asphalt binder, each by total weight of the sulfur-extended plastomer asphalt binder composition.

4. The method of any one of claims 1 to 3, further comprising the step of introducing a second material to the second side of the layer such that the layer adheres with the second material, where the temperature of the layer during introduction is in a range of from greater than ambient temperature to no greater than 140 °C.
5. The method of any one of claims 1 to 4, where the second material is selected from the group consisting of roofing tiles, crushed stones, stone aggregates, tar papers, waxed papers, non-flammable fabrics and combinations thereof.
6. A sulfur-extended plastomer asphalt binder composition useful for water proofing, damp proofing and roofing applications, the sulfur-extended plastomer asphalt binder composition comprises elemental sulfur in a range of from 10% to 30%, the plastomer in a range of from 3% to 10% and the asphalt binder in a range of from 60% to 87%, each by total weight of the sulfur-extended plastomer asphalt binder composition.
7. The composition of claim 6, where the sulfur-extended plastomer asphalt binder composition consists essentially of 20% elemental sulfur, 5% plastomer and 75% asphalt binder, each by total weight of the sulfur-extended plastomer asphalt binder composition.
8. The composition of claim 6, where the sulfur-extended plastomer asphalt binder composition consists essentially of 30% elemental sulfur, 5% plastomer and 65% asphalt binder, each by total weight of the sulfur-extended plastomer asphalt binder composition.
9. The composition of any one of claims 6 to 8, where the asphalt binder is a Performance Grade asphalt per the AASHTO Performance Graded Asphalt Binder Specification M 320, Table 1.
10. The composition of any one of claims 6 to 9, where the asphalt binder consists essentially of a PG 64-10 asphalt.
11. The composition of any one of claims 6 to 10, where the plastomer comprises an ethylene-vinyl acetate (EVA) copolymer.
12. The composition of any one of claims 6 to 11, where the EVA copolymer has a 28 wt.% vinyl acetate content and a melt flow index of 150 g/10 minutes.

13. The composition of any one of claims 6 to 12, where the plastomer is a homogeneous sulfur-modified polymer (HSMP).
14. The composition of any one of claims 6 to 13, where the HSMP is HSMP150.
15. The composition of any one of claims 6 to 14, where the composition has a viscosity that is no greater than 400 cP per ASTM D449.

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2014/063598

A. CLASSIFICATION OF SUBJECT MATTER INV. C08L95/00 C08K3/06 B32B11/04 C09D195/00 C09J195/00 C08L23/08 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) C08K C08L B32B C09D 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, WPI Data														
C. DOCUMENTS CONSIDERED TO BE RELEVANT <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 10%;">Category*</th> <th style="width: 70%;">Citation of document, with indication, where appropriate, of the relevant passages</th> <th style="width: 20%;">Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td style="text-align: center; vertical-align: top;">X</td> <td>US 4 412 019 A (KRAUS GERARD [US]) 25 October 1983 (1983-10-25) column 1, line 4 - column 3, line 35; claims; examples III, Run 9 -----</td> <td style="text-align: center; vertical-align: top;">1-10, 13-15</td> </tr> <tr> <td style="text-align: center; vertical-align: top;">X</td> <td>WO 2013/063343 A1 (SAUDI ARABIAN OIL CO [SA]; ARAMCO SERVICES CO [US]) 2 May 2013 (2013-05-02) paragraphs [0001], [0005] - [0013], [0043] - [0055], [0064] - [0079]; claims 33-56 -----</td> <td style="text-align: center; vertical-align: top;">1-15</td> </tr> <tr> <td style="text-align: center; vertical-align: top;">X</td> <td>WO 2012/061577 A1 (SAUDI ARABIAN OIL CO [SA]; VAIDYA MILIND M [SA]; KHAWAJAH ANWAR H [SA]) 10 May 2012 (2012-05-10) paragraphs [0001], [0002], [0011] - [0020], [0032] - [0047], [0062] - [0066]; claims ----- -/-</td> <td style="text-align: center; vertical-align: top;">1-3,5-15</td> </tr> </tbody> </table>			Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	X	US 4 412 019 A (KRAUS GERARD [US]) 25 October 1983 (1983-10-25) column 1, line 4 - column 3, line 35; claims; examples III, Run 9 -----	1-10, 13-15	X	WO 2013/063343 A1 (SAUDI ARABIAN OIL CO [SA]; ARAMCO SERVICES CO [US]) 2 May 2013 (2013-05-02) paragraphs [0001], [0005] - [0013], [0043] - [0055], [0064] - [0079]; claims 33-56 -----	1-15	X	WO 2012/061577 A1 (SAUDI ARABIAN OIL CO [SA]; VAIDYA MILIND M [SA]; KHAWAJAH ANWAR H [SA]) 10 May 2012 (2012-05-10) paragraphs [0001], [0002], [0011] - [0020], [0032] - [0047], [0062] - [0066]; claims ----- -/-	1-3,5-15
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☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.														
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Date of the actual completion of the international search 6 February 2015		Date of mailing of the international search report 17/02/2015												
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 Otegui Rebollo, Juan												

INTERNATIONAL SEARCH REPORT

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PCT/US2014/063598

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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X	WO 2013/119789 A1 (SAUDI ARABIAN OIL CO [SA]; ARAMCO SERVICES CO [US]; KING FAHD UNIVERSI) 15 August 2013 (2013-08-15) paragraphs [0001], [0005] - [0027] -----	6-15
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2014/063598

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