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62/303,597 4 March 2016 (04.03.2016) US(71) Applicant: **PENN COLOR, INC.** [US/US]; 400 Old Dublin Pike, Doylestown, PA 18901 (US).(72) Inventors: **MILES, William, C.**; 4016 Sarah Court, Collegeville, PA 19426 (US). **MEESE, James**; 2152 Claymont Drive, Quakertown, PA 18951 (US).(74) Agents: **ROSSI, Joseph, D.** et al.; Stradley Ronon Stevens & Young, LLP, 30 Valley Stream Parkway, Great Valley Corporate Center, Malvern, PA 19355 (US).

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(54) Title: COATINGS FOR REDUCING HEAT ABSORPTION

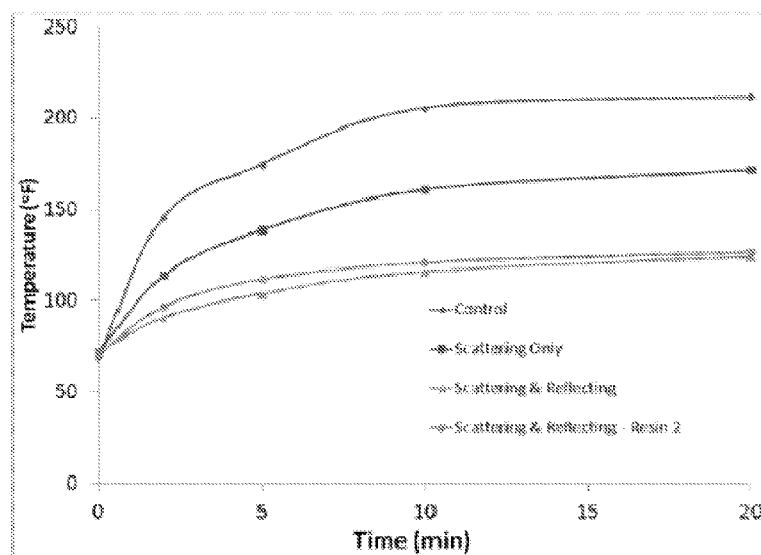


FIG. 1

(57) **Abstract:** A method for reducing heat build-up on a substrate, the method comprising the steps of: applying a coating composition to a surface of a substrate or article to be coated, wherein the coating composition comprises: an IR reflective compound; a light-scattering compound; a binder resin; and a solvent; coalescing the coating composition to form a substantially continuous film; and curing the substantially continuous film. The coating composition when formed into a film and cured reduces heat buildup on a substrate such as, for example, an artificial turf field.



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## COATINGS FOR REDUCING HEAT ABSORPTION

### TECHNICAL FIELD

The present invention relates generally to coatings which reduce heat absorption of a coated substrate, and particularly to coatings which include an infrared(IR)-reflecting compound and an light-scattering compound.

### BACKGROUND

Various publications, including patents, published applications, technical articles and scholarly articles are cited throughout the specification. Each of these cited publications is incorporated by reference herein, in its entirety and for all purposes.

It is commonly known in the art to fill areas with a particulate matter for various purposes. For example, synthetic turf fields include a carpet-like pile fabric with rows of synthetic ribbons extending upwardly from the fabric to simulate real grass. Such synthetic turf fields are most often used as playing surfaces for sports which are normally played on grass (e.g., soccer, football, etc.), but are also used as a replacement for natural grass in other residential or commercial settings. A granular material (also referred to herein as “fill” material) is placed over the fabric to support the ribbons in a vertical position and to simulate soil. Commonly used fill materials include granulated rubber particles, polymer beads, sand, etc., as well as mixtures thereof. However, one primary disadvantage of such synthetic fields is the propensity of the fill material to absorb and retain heat. Particularly in direct sunlight, the fill material can be heated to levels that render the field unusable due to unsafe temperatures. Further, heating rubber fill materials may result in the outgassing of hazardous chemicals. Accordingly, it is desirable to prevent the fill material from overheating. Similar fill materials may be used in other applications, such as artificial gardens, rooftops, etc.

Methods of preventing heat buildup in synthetic fields include regularly watering the field. Evaporation of the applied water removes heat from the field, similar to the way sweating is used to cool a human. Hydrophilic materials have been added to the fill material to increase the amount of water the fill material can absorb and use to regulate heat. Other attempted solutions include coating the fill material with an IR-reflecting pigment. However, such systems can cool the field

for only limited periods of time and can have only marginal effects on temperature, especially under extreme conditions.

It is also commonly known in the art that outdoor building materials, particularly those constructed of polymeric materials, are susceptible to weathering and/or warpage due to exposure to excess heat. For example, plastic exteriors for homes used for decoration and weatherproofing, such as vinyl siding, have regional limitations due to outside temperatures and sun exposure. Other outdoor materials, such as synthetic and wood decking, also exhibit issues when exposed to direct sunlight. This can range from the comfort of the user when bare skin comes into contact with the surface to expansion and contraction of the decking that allows water infiltration and premature aging.

Methods of preventing heat buildup in exterior materials include incorporation of IR reflecting pigments into polymeric materials and applying topical coatings of IR reflecting pigments onto surfaces to reduce heat build. Glass spheres have also been used as resonators in conjunction with a layer of silver to induce radiative cooling. None of these solutions provide cooling much more than 10-15 percent at relevant temperatures. Thus there remains a need for an improved system for reducing temperature build on outdoor building materials.

## SUMMARY OF THE INVENTION

In one aspect, the present invention provides a composition comprising: an IR reflective compound; a light-scattering compound; a binder resin; and a solvent.

In another aspect, the present invention provides a composition comprising: an IR reflective compound; a light-scattering compound; a binder resin; and a solvent.

In another aspect, the present invention provides a composition comprising: from about 5 % wt. to about 30 % wt. of an IR reflective compound; from about 5 % wt. to about 30 % wt. of a light-scattering compound; from about 10 % wt. to about 40 % wt. of a binder resin; and remainder is a solvent.

In yet another aspect, the present invention provides a method for reducing heat build-up on a substrate, the method comprising the steps of: applying a coating composition to a surface of a

substrate or article to be coated, wherein the coating composition comprises: an IR reflective compound; a light-scattering compound; a binder resin; and a solvent; coalescing the coating composition to form a substantially continuous film; and curing the substantially continuous film.

### BRIEF DESCRIPTION OF DRAWINGS

The invention is best understood from the following detailed description when read in conjunction with the accompanying drawing. It is emphasized that, according to common practice, the various features of the drawing are not to scale. On the contrary, the various features are arbitrarily expanded or reduced for clarity. Included in the drawing are the following figures:

FIG. 1 is a graph depicting the temperature of various substrates coated with combinations of light scattering and IR-reflecting compounds over time;

FIG. 2 is another graph depicting the temperature of various substrates coated with combinations of light-scattering and IR-reflecting compounds over time; and

FIG. 3 is a graph depicting the reflectance of various substrates coated with combinations of light-scattering and IR-reflecting compounds over a range of light wavelengths.

### DETAILED DESCRIPTION

For purposes of the following detailed description, it is to be understood that the invention may assume various alternative variations and step sequences, except where expressly specified to the contrary. Moreover, other than in any operating examples, or where otherwise indicated, all numbers expressing, for example, quantities of ingredients used in the specification and claims are to be understood as being modified in all instances by the term “about.” Accordingly, unless indicated to the contrary, the numerical parameters set forth in the following specification and attached claims are approximations that may vary depending upon the desired properties to be obtained by the present invention. At the very least, and not as an attempt to limit the application of the doctrine of equivalents to the scope of the claims, each numerical parameter should at least be construed in light of the number of reported significant digits and by applying ordinary rounding techniques.

Notwithstanding that the numerical ranges and parameters setting forth the broad scope of the invention are approximations, the numerical values set forth in the specific examples are reported as precisely as possible. Any numerical value, however, inherently contains certain errors necessarily resulting from the standard variation found in their respective testing measurements.

Also, it should be understood that any numerical range recited herein is intended to include all sub-ranges subsumed therein. For example, a range of "1 to 10" is intended to include all sub-ranges between (and including) the recited minimum value of 1 and the recited maximum value of 10, that is, having a minimum value equal to or greater than 1 and a maximum value of equal to or less than 10.

In this application, the use of the singular includes the plural and plural encompasses singular, unless specifically stated otherwise. In addition, in this application, the use of "or" means "and/or" unless specifically stated otherwise, even though "and/or" may be explicitly used in certain instances.

Embodiments of the present invention include coatings for substrates which reduce the amount of infrared (IR) radiation absorbed by the substrate, thereby making the substrate more resistant to heating due to IR absorption. IR radiation could come from any of a number of sources, such as the sun, lamps, etc. The coating includes both an light-scattering compound and an IR-reflecting compound which are mixed and applied to the substrate in a single layer. As used herein, reflection refers the change of direction of a wave of light at a surface from a single incoming direction to a single outgoing direction. Scattering refers to the deviation of a wave of light into many outgoing directions due to an anomaly in the wave's path. Light refers to not only electromagnetic radiation in the visible light spectrum (i.e., wavelengths of about 390 nm to about 700 nm), but also to IR radiation and ultraviolet (UV) radiation. IR radiation refers to any radiation with a wavelength greater than the wavelengths of visible light (i.e. greater than about 700 nm) but less than the wavelength of microwaves (i.e., less than about 1 mm).

Certain embodiments of the present invention are directed to compositions that are transparent and colorless. As used herein, a composition is "transparent" if it has a luminous transmission in the visible region (400 to 800 nanometers) of at least 80 percent, such as at least 85

percent, or, in some cases, at least 90 percent of the incident light and is preferably free of haze to the human eye. As used herein, a composition is “colorless” if the human eye observes the composition as “true white” rather than a colored tone. In other embodiments, the compositions of the present invention have a color in the visible spectrum and, therefore, are not colorless.

Compositions according to the present development comprise an IR reflective compound; a light-scattering compound; a binder resin; and a solvent. Each component and its function will be described in detail.

#### IR Reflective Compound

The IR-reflecting compound is any suitable compound which reflects IR radiation.

Inorganic pigments are preferred as IR-reflecting compounds and may be white or color pigments made to maximize refractive index, minimize light absorption and optimize particle size such that the reflectivity in the IR wavelength region is maximized. For example,  $\text{TiO}_2$  is an excellent IR reflective pigment because of its high refractive index and low radiation absorption. However, reducing the particle size of  $\text{TiO}_2$  from 1 micron to 200 nm average particle size significantly reduces its reflectivity in the IR region. Typically these characteristics are found in inorganic complexes, which reflect the wavelengths in the infrared region as well as selectively reflect visible light. The reflectivity and absorptivity are dependent of the pigment. Therefore, an infrared-reflective pigment may be white or in any color and it can be synthesized by the calcination of a mixture of oxides, nitrates, acetates and even metal oxide at temperatures above 1000 °C. Suitable IR-reflecting compounds include, but are not limited to, metal oxides, cobalt compounds, and chromium compounds. In an preferred embodiment, the IR-reflecting compound includes rutile titanium dioxide such as, for example, Altiris® 800 from Huntsman International LLC.

The IR-reflecting compound may be present in the compositions of the present development in an amount of from about 1.0 % wt. to about 60 % wt., preferably from about 5 % wt. to about 30 % wt., and more preferably from about 7.5 % wt. to about 15 % wt.

#### Light-Scattering Compound

The light-scattering compound is any suitable compound which has a high refractive index and therefore scatters light. The light-scattering compound preferably scatters IR radiation, but may also scatter visible light or UV light instead of, or in addition to, IR radiation. Suitable light-scattering compounds include, but are not limited to, hollow latex spheres, such as Sunspheres™ available from Dow Chemical and Celacor™ opaque polymers from Arkema.

The light-scattering compound may be present in the compositions of the present development in an amount of from about 1.0 % wt. to about 60 % wt., preferably from about 5.0 % wt. to about 30 % wt., and more preferably from about 7.5 % wt. to about 15.0 % wt.

#### Binder Resin

The compositions of the present invention comprise a binder. As used herein, the term “binder” refers to a continuous material in which light scattering and IR-reflective particles described herein are dispersed. In certain embodiments, the binder is a resinous binder such as those comprising, for example, thermoplastic compositions, thermosetting compositions, and radiation curable compositions. The compositions of the present invention may be water-based or solvent-based liquid compositions, or, alternatively, in solid particulate form, i.e., a powder compositions.

In certain embodiments, the binder resin included within the compositions of the present invention comprises a thermosetting resin. As used herein, the term “thermosetting” refers to resins that “set” irreversibly upon curing or crosslinking, wherein the polymer chains of the polymeric components are joined together by covalent bonds. This property is usually associated with a cross-linking reaction of the composition constituents often induced, for example, by heat or radiation. Curing or crosslinking reactions also may be carried out under ambient conditions. Once cured or cross-linked, a thermosetting resin will not melt upon the application of heat and is insoluble in solvents.

Thermosetting resins suitable for use in the compositions, such as coating compositions, of the present invention include, for example, those formed from the reaction of a polymer having at least one type of reactive group and a curing agent having reactive groups reactive with the reactive group(s) of the polymer. As used herein, the term “polymer” is meant to encompass oligomers, and



includes, without limitation, both homopolymers and copolymers. The polymers can be, for example, acrylic, saturated or unsaturated polyester, polyurethane or polyether, polyvinyl, cellulosic, acrylate, silicon-based polymers, co-polymers thereof, and mixtures thereof, and can contain reactive groups such as epoxy, carboxylic acid, hydroxyl, isocyanate, amide, carbamate and carboxylate groups, among others, including mixtures thereof.

Suitable acrylic polymers include, for example, those described in United States Patent Application Publication 2003/0158316 A1 at [0030]-[0039], the cited portion of which being incorporated herein by reference. Suitable polyester polymers include, for example, those described in United States Patent Application Publication 2003/0158316 A1 at [0040]-[0046], the cited portion of which being incorporated herein by reference. Suitable polyurethane polymers include, for example, those described in United States Patent Application Publication 2003/0158316 A1 at [0047]-[0052], the cited portion of which being incorporated herein by reference. Suitable silicon-based polymers are defined in U.S. Pat. No. 6,623,791 at col. 9, lines 5-10, the cited portion of which being incorporated herein by reference.

In other embodiments, the film-forming resin included within the coating compositions of the present invention comprises a thermoplastic resin. As used herein, the term “thermoplastic” refers to resins that comprise polymeric components that are not joined by covalent bonds and thereby can undergo liquid flow upon heating and are soluble in solvents.

Suitable thermoplastic resins include, without limitation, those usable for coating compositions and for injection molding of articles such as container preforms and the like. Examples of such resins include, but are not limited to, polyesters, polycarbonates, polyamides, polyolefins, polystyrenes, vinyl polymers, acrylic polymers and copolymers and blends thereof. In certain embodiments, the thermoplastic resin comprises a polyester, polypropylene and/or oriented polypropylene which may suitably be used to produce containers. In certain embodiments, the binder comprises a thermoplastic polyester as used to make liquid containers, such as beverage bottles, such as poly(ethylene terephthalate) or a copolymer thereof. In such embodiments, the compositions of the present invention can be used in producing preforms such as container preforms before the preforms are heated or inserted into a stretch-blow molding machine. Suitable

polyethylene terephthalate resins include, for example, those described in United States Patent Application Publication No. 2007/0203279 at [0063], the cited portion of which being incorporated herein by reference.

Injection molding of polyethylene terephthalate and other polyester molding compositions is often carried out using an injection molding machine and a maximum barrel temperature in the range of from 260 °C to 285 °C or more, for example, up to about 310 °C. The dwell time at this maximum temperature is often in the range of from 15 seconds to 5 minutes or more, such as 30 seconds to 2 minutes.

In certain embodiments, the binder comprises a radiation curable composition. As used herein, the term “radiation-curable composition” refers to a composition that comprises a radiation curable polymer and/or monomer. As used herein, the term “radiation curable polymer and/or monomer” refers to monomers and/or polymers having reactive components that are polymerizable by exposure to an energy source, such as an electron beam (EB), ultraviolet light, or visible light.

In certain embodiments, the radiation curable composition comprises a multi-functional (meth)acrylate. As used herein, the term “multi-functional (meth)acrylate” refers to monomers and/or oligomers having an acrylate functionality of greater than 1. In the certain of the compositions of the present invention, upon exposure to radiation, a radical induced polymerization of the multi-functional (meth)acrylate occurs. As used herein, the term “(meth)acrylate” and terms derived therefrom are intended to include both acrylates and methacrylates.

Suitable radiation curable oligomers and polymers include (meth)acrylated urethanes (i.e., urethane (meth)acrylates), (meth)acrylated epoxies (i.e., epoxy (meth)acrylates), (meth)acrylated polyesters (i.e., polyester (meth)acrylates), (meth)acrylated melamine (i.e., melamine (meth)acrylates), (meth)acrylated (meth)acrylics, (meth)acrylated silicones, (meth)acrylated polyethers (i.e., polyether (meth)acrylates), vinyl (meth)acrylates, and (meth)acrylated oils.

Suitable (meth)acrylated aliphatic urethanes include di(meth)acrylate esters of hydroxy terminated isocyanate extended aliphatic polyesters or aliphatic polyethers. (Meth)acrylated polyesters include the reaction products of (meth) acrylic acid with an aliphatic dibasic acid/aliphatic diol-based polyester.

Examples of commercially available (meth)acrylated urethanes and polyesters include those commercially available from Henkel Corp., Hoboken, N.J., under the trade designation “Photomer”; those commercially available from UCB Radcure Inc., Smyrna, Ga., under the trade designation “Ebecryl” series 284, 810, 4830, 8402, 1290, 1657, 1810, 30 2001, 2047, 230, 244, 264, 265, 270, 4833, 4835, 4842, 4866, 4883, 657, 770, 80, 81, 811, 812, 83, 830, 8301, 835, 870, 8800, 8803, 8804; and commercially available from Morton International, Chicago, Ill. under the trade designation “Uvithane.”

Suitable acrylated acrylics include, for example, acrylic oligomers or polymers that have reactive pendant or terminal (meth)acrylic acid groups capable of forming free radicals for subsequent reaction. Examples of commercially available (meth)acrylated acrylics include those commercially available from UCB Radcure Inc. under the trade designation “Ebecryl” series 745, 754, 767, 1701, and 1755.

Another suitable radiation curable oligomer is a polyester polyurethane oligomer that is the reaction product of an aliphatic polyisocyanate comprising two or more isocyanate groups; and a radiation curable alcohol comprising one or more radiation curable moieties, one or more hydroxyl moieties, and one or more polycaprolactone ester moieties. The polyisocyanate often comprises 2,2,4-trimethylhexamethylene diisocyanate; 2,4,4-trimethylhexamethylene diisocyanate, and mixtures thereof employed in combination with at least one of isophorone diisocyanate and/or an isocyanate functional isocyanurate.

Multi-functional (meth)acrylate monomers are also suitable for use in the compositions of the present invention and include, without limitation, difunctional, trifunctional, tetrafunctional, pentafunctional, hexafunctional (meth)acrylates and mixtures thereof.

Representative examples of suitable difunctional and trifunctional (meth)acrylate monomers include, without limitation, ethylene glycol di(meth)acrylate, 1,3-butylene glycol di(meth)acrylate, 1,4-butanediol diacrylate, 2,3-dimethylpropane 1,3-diacrylate, 1,6-hexanediol di(meth)acrylate, dipropylene glycol diacrylate, ethoxylated hexanediol di(meth)acrylate, propoxylated hexanediol di(meth)acrylate, neopentyl glycol di(meth)acrylate, alkoxylated neopentyl glycol di(meth)acrylate, hexylene glycol di(meth)acrylate, diethylene glycol di(meth)acrylate, tripropylene glycol

di(meth)acrylate, thiodiethylene glycol diacrylate, trimethylene glycol dimethacrylate, pentaerythritol tri(meth)acrylate, trimethylolpropane tri(meth)acrylate, glycerolpropoxy tri(meth)acrylate, ethoxylated trimethylolpropane tri(meth)acrylate, and tetraethylene glycol di(meth)acrylate and mixtures thereof.

Representative examples of suitable tetra functional (meth)acrylate monomers include, but are not limited to, di-trimethylolpropane tetraacrylate, ethoxylated 4-pentaerythritol tetraacrylate, pentaerythritol ethoxylate tetraacrylate, pentaerythritol propoxylate tetraacrylate, including mixtures thereof.

Representative examples of suitable penta functional and hexa functional (meth)acrylate monomers include, but are not limited to, dipentaerythritol pentaacrylate, dipentaerythritol ethoxylate pentaacrylate, and dipentaerythritol propoxylate pentaacrylate, dipentaerythritol hexaacrylate, and mixtures of any of the foregoing.

Appropriate mixtures of the various binder resin materials described herein may also be used in the preparation of the compositions of the present invention.

Preferable binder resins include sulfonated polyester, for example 48 Ultra Polymer from Eastman AQ™, carboxylated nitrile, such as NIPOL® 1422X5 from Zeon Chemicals, and vinyl chloride/vinyl acetate copolymers, such as VINNOL® H 11/59 from Wacker Chemie AG.

The binder resin may be present in the compositions of the present development in an amount of from about 1.0 % wt. to about 80 % wt., preferably from about 10 % wt. to about 40 % wt., and more preferably from about 15 % wt. to about 25 % wt.

#### Solvent

The compositions of the present invention comprise a solvent, which functions in various ways such as, for example, to dissolve one or more solid components of the composition, and as a carrier of the components. In particular, it is preferred that the solvent is suitable for solubilization of the binder resin system.

In some embodiments, the solvent may be non-polar (i.e. toluene, cyclohexane), polar aprotic (THF, ethyl acetate), or polar protic solvents (water, ethanol, isopropanol). Preferred

solvents are water, ketones, acetates, aldehydes, and glycol ethers. In preferred embodiments, methyl ethyl ketone is the solvent.

In yet other embodiments, the solvent is a mixture of water and a water-miscible organic solvent. As used herein, the term “water-miscible organic solvent” refers to an organic solvent that, when mixed with water, does not phase separate. Examples of water-miscible organic solvents that can be used are ethylene glycol, propylene glycol, 1,4-butanediol, tripropylene glycol methyl ether, propylene glycol propyl ether, diethylene glycol n-butyl ether (e.g. commercially available under the trade designation Dowanol DB), hexyloxypropylamine, poly(oxyethylene)diamine, dimethylsulfoxide, tetrahydrofurfuryl alcohol, glycerol, alcohols, sulfoxides, or mixtures thereof. Preferred solvents are alcohols, diols, or mixtures thereof. Most preferred solvents are diols such as, for example, propylene glycol.

It is believed that, for most applications, the solvent will comprise, for example, from about 0 % to about 90 % by wt. of water. Other preferred embodiments of the present invention could comprise from about 5% to about 80% by wt. of solvent. Still other preferred embodiments of the present invention could include solvent in an amount to achieve the desired weight percent of the other ingredients.

The composition may also include any number of additional typical coating components, such as surfactants to improve the wetting properties of the coating, adhesion promoters, viscosity modifiers, and plasticizers to improve the pliability of the coating. The mixture is then deposited onto the substrate as a film and dried to form the coating.

The IR-reflecting compound and the light-scattering compound may be formed into a coating by first blending both compounds together with a base resin and then letting the mixture down into water or any other appropriate solvent, such as methyl ethyl ketone. The IR-reflecting compound, the light-scattering compound, and the base resin are combined in a suitable ratio, for example 50 wt. % base resin, 25 wt. % IR-reflecting compound, and 25 wt. % light-scattering compound. The resulting mixture may have any solids concentration suitable for deposition, for example 30 wt. % solids.

The coating compositions of the present invention can be applied to such substrates by any of a variety of methods including dipping or immersion, spraying, intermittent spraying, dipping followed by spraying, spraying followed by dipping, brushing, or roll-coating, among other methods. In certain embodiments, however, the coating compositions of the present invention are applied by spraying and, accordingly, such compositions often have a viscosity that is suitable for application by spraying at ambient conditions.

After application of the coating composition of the present invention to the substrate, the composition is typically allowed to coalesce to form a substantially continuous film on the substrate. Typically, the film thickness will be 0.01 to 20 mils (about 0.25 to 508 microns), such as 0.01 to 5 mils (0.25 to 127 microns), or, in some cases, 0.1 to 2 mils (2.54 to 50.8 microns) in thickness. A method of forming a coating film according to the present invention, therefore, comprises applying a coating composition of the present invention to the surface of a substrate or article to be coated, coalescing the coating composition to form a substantially continuous film and then curing the thus-obtained coating.

In certain embodiments, the present invention provides methods of drying or curing coatings using IR energy. In certain embodiments, drying or curing steps comprise exposing the coating of the present invention to IR energy. The IR energy can be applied in any manner. In some embodiments, the IR energy is applied using an IR heat source, such as an IR lamp. IR lamps are commonly used and available to one of skill in the art. Ambient IR energy is suitable. The IR energy can also be applied by simply exposing the coating to some other light source. The other light source can be the light emitted by standard fluorescent lights or even sun light. Thus, the IR energy can be supplied in any manner, as long as the IR energy is sufficient to at least partially affect the curing or drying.

The coating compositions of the present invention are suitable for application to any of a variety of substrates, including human and/or animal substrates, such as keratin, fur, skin, teeth, nails, and the like, as well as plants, trees, seeds, agricultural lands, such as grazing lands, crop lands and the like; turf-covered land areas, e.g., lawns, golf courses, athletic fields, etc., and other land areas, such as forests and the like.

In a preferred embodiment, the substrate may be a fill material used in conjunction with a synthetic turf field, such as granulated rubber particles, polymer beads, sand, etc., as well as mixtures thereof. However, the invention is not limited to such embodiments, and the coating may be suitable on any substrate where reduced IR absorption is desirable. For example, the coating may be applied to a rubber roofing material, such as a shingle or membrane, to prevent the roof from heating up in sunlight. Other uses include, but are not limited to, interior and exterior architectural coatings, automobile coatings, plastic playground or athletic equipment, synthetic and wood decking, vinyl and other exterior, and commercial-grade coatings for equipment and infrastructure (bridges, road signs, etc.). The coating may be particularly useful with rubber substrates, especially those that are dark in color, which tend to absorb large amounts of IR radiation and therefore can become extremely hot. Where the substrate is a particle, the coating may completely surround or only partially surround the particle. Where the substrate is a layer, the coating may be applied only to the side of the substrate which faces the direction of the IR radiation.

The coating may be applied to the substrate in a thin layer. Further, thicker coatings unexpectedly result in greater heat buildup than thinner coatings. For example, less than 50 mg of the coating may be applied per square inch of substrate. In other embodiments, less than 45 mg of the coating may be applied per square inch of substrate. In other embodiments, less than 40 mg of the coating may be applied per square inch of substrate. In other embodiments, less than 35 mg of the coating may be applied per square inch of substrate. In other embodiments, less than 30 mg of the coating may be applied per square inch of substrate. In other embodiments, less than 25 mg of the coating may be applied per square inch of substrate. In other embodiments, less than 20 mg of the coating may be applied per square inch of substrate. In other embodiments, less than 15 mg of the coating may be applied per square inch of substrate. In other embodiments, less than 10 mg of the coating may be applied per square inch of substrate. In other embodiments, less than 5 mg of the coating may be applied per square inch of substrate. It will be understood that these coating thicknesses refer to the weight of the coating after it is dried to remove the solvent. The mass of the coating applied to the substrate before drying the substrate will be greater.

The combination of the IR-reflecting compound and the light-scattering compound unexpectedly prevented IR absorption to a greater degree than the IR-reflecting compound alone, despite not causing a substantial increase in IR reflectance. The light-scattering compound reduces the overall intensity of any IR radiation that isn't reflected away from the substrate by the IR-reflecting compound, resulting in significantly lower temperature build and a significantly lower equilibrium temperature on the surface of the coating when compared to a coating of only the IR-reflecting compound. The light-scattering compound accomplishes this in at least two ways. First, because the light is scattered in all directions, at least some of the scattered light will not reach the surface of the substrate. Second, because the incident radiation intensity is lessened, any IR radiation that does reach the surface of the substrate is less intense than it would be if not scattered.

The features and advantages are more fully shown by the illustrative examples discussed below.

### EXAMPLES

#### Example 1

In Example 1, four substrates consisting of 2" by 2" squares of black polybutadiene rubber were tested for heat buildup over time. Four substrates were tested with various coatings as indicated in Table 1. As used in the Examples "Resin A" is water-based 48 Ultra Polymer from Eastman AQ™, "Resin B" is a solvent-based mixture of NIPOL® 1422X5 from Zeon Chemicals and VINNOL® H 11/59 from Wacker Chemie AG. The solvent used with Resin B was methyl ethyl ketone. Each mixture included 30 wt. % total solids.

Table 1

| Substrate                         | Base Resin  | Light-scattering Compound | IR-Reflecting Compound |
|-----------------------------------|-------------|---------------------------|------------------------|
| Control                           | 0%          | 0%                        | 0%                     |
| Scattering Only                   | 50% Resin A | 50%                       | 0%                     |
| Scattering & Reflecting (Resin 1) | 50% Resin A | 25%                       | 25%                    |
| Scattering &                      | 50% Resin B | 25%                       | 25%                    |



|                      |  |  |  |
|----------------------|--|--|--|
| Reflecting (Resin 2) |  |  |  |
|----------------------|--|--|--|

For each experiment, the substrate was placed under a heat lamp at the same distance. The temperature was measured at the center of the rubber substrate using a digital infrared thermometer. In Example 1, the heat lamp was positioned 10 inches above the substrate and surface temperature was measured for 20 minutes, after which the substrates reached an equilibrium temperature. The equilibrium temperature can be controlled by changing the distance between the heat lamp and the substrate. The results of Example 1 are depicted below in FIG. 1. As shown by FIG. 1, the coating containing both the light-scattering and the IR-reflecting compounds in a single coating is able to reduce heat buildup over time by approximately 40% compared to the untreated substrate. Example 1 further shows that the effect is not specific to the base resin use and is effective in both water-based and solvent-based resin systems.

#### Example 2

In Example 2, additional substrates consisting of 2" by 2" squares of polybutadiene rubber were tested for heat buildup over time. Four substrates were tested with various coatings as indicated in Table 2. The "Dual Layer" substrate was first treated with a layer of an IR-reflecting-only coating followed by a layer of an IR-scattering-only coating.

Table 2

| Substrate               | Base Resin  | Light-scattering Compound | IR-Reflecting Compound |
|-------------------------|-------------|---------------------------|------------------------|
| Control                 | 0%          | 0%                        | 0%                     |
| Reflecting Only         | 50% Resin A |                           | 50%                    |
| Scattering & Reflecting | 50% Resin A | 25%                       | 25%                    |
| Dual Layer              | 50% Resin A | 0%                        | 50%                    |
|                         | 50% Resin A | 50%                       | 0%                     |

Table 2

Each substrate was placed under a heat lamp at a distance of 17 inches below the heat lamp for 160 minutes while the surface temperature of the substrate was measured over time. The results are depicted below in FIG. 2. As shown by FIG. 2, the dual layer substrate resulted in substantially more heat buildup over time compared to the IR-reflecting-only coating and the coating including both IR-reflecting compound and light-scattering compound and performed similarly to the uncoated substrate. This result indicates that the reduction in heat buildup only occurs when the IR-reflecting compound and the light-scattering compound are mixed in a single-layer coating.

### Example 3

In Example 3, the same control substrate and 3 coated substrates from Example 1 were tested for reflectance using UV-Vis-NIR spectroscopy. As indicated in FIG. 3, the coating with both the IR-reflecting compound and the light-scattering compound does not demonstrate substantially increased reflectance of IR wavelengths. Because IR radiation is responsible for most heat transfer, a significant decrease in heat buildup would be unexpected because only small amounts of additional IR radiation are being reflected. However, as shown in Examples 1 and 2 above, the combination of the IR-reflecting compound and the light-scattering compound results in less heat buildup than would be expected based on IR reflection alone. This suggests that the overall heat buildup is reduced by reducing the intensity of the IR radiation, as hypothesized above.

The foregoing description of exemplary embodiments of the invention should be taken as illustrating, rather than as limiting, the present invention as defined by the claims. As will be readily appreciated, numerous variations and combinations of the features set forth above can be utilized without departing from the present invention as set forth in the claims. Such variations are not regarded as a departure from the spirit and scope of the invention, and all such variations are intended to be included within the scope of the claims.

## WE CLAIM:

1. A composition comprising:  
an IR reflective compound;  
a light-scattering compound;  
a binder resin; and  
a solvent.
2. The composition of claim 1 wherein the IR reflective compound is selected from the group consisting of metal oxides, cobalt compounds, and chromium compounds.
3. The composition of claim 2 wherein the IR reflective compound is a metal oxide.
4. The composition of claim 3 wherein the IR reflective compound is titanium dioxide
5. The composition of claim 1 wherein the IR reflective compound is present in an amount of from 1 % wt. to about 60 % wt.
6. The composition of claim 1 wherein the light scattering compound comprises hollow latex spheres.
7. The composition of claim 1 wherein the light scattering compound is present in an amount of from 1 % wt. to about 60 % wt.

8. The composition of claim 1 wherein the binder resin is selected from the group consisting of thermoplastic compositions, thermosetting compositions, and radiation curable compositions.
9. The composition of claim 8 wherein the binder resin is a thermosetting composition.
10. The composition of claim 9 wherein the thermosetting composition comprises a polymer having at least one type of reactive group and a curing agent having reactive groups reactive with the reactive group(s) of the polymer.
11. The composition of claim 10, wherein the thermoplastic composition comprises poly(ethylene terephthalate) or a copolymer thereof.
12. The composition of claim 8, wherein the binder resin is a radiation curable composition comprising a multi-functional (meth)acrylate.
13. The composition of claim 1 wherein the binder resin is present in an amount of from 1 % wt. to about 80 % wt.
14. The composition of claim 1 wherein the solvent is water.
15. The composition of claim 1 wherein the solvent is an organic solvent selected from the group consisting of ketones, acetates, aldehydes, and glycol ethers.
16. A composition comprising:

from about 5 % wt. to about 30 % wt. of an IR reflective compound;  
from about 5 % wt. to about 30 % wt. of a light-scattering compound;  
from about 10 % wt. to about 40 % wt. of a binder resin; and  
remainder is a solvent.

17. The composition of claim 16 wherein the IR reflective compound is selected from the group consisting of metal oxides, cobalt compounds, and chromium compounds.
18. The composition of claim 17 wherein the IR reflective compound is a metal oxide.
19. The composition of claim 18 wherein the IR reflective compound is titanium dioxide
20. The composition of claim 16 wherein the IR reflective compound is present in an amount of from 7.5 % wt. to about 15 % wt.
21. The composition of claim 16 wherein the light scattering compound comprises hollow latex spheres.
22. The composition of claim 16 wherein the light scattering compound is present in an amount of from 7.5 % wt. to about 15 % wt.
23. The composition of claim 16 wherein the binder resin is selected from the group consisting of thermoplastic compositions, thermosetting compositions, and radiation curable compositions.

24. The composition of claim 23 wherein the binder resin is a thermosetting composition.
25. The composition of claim 24 wherein the thermosetting composition comprises a polymer having at least one type of reactive group and a curing agent having reactive groups reactive with the reactive group(s) of the polymer.
26. The composition of claim 25, wherein the thermoplastic composition comprises poly(ethylene terephthalate) or a copolymer thereof.
27. The composition of claim 23, wherein the binder resin is a radiation curable composition comprising a multi-functional (meth)acrylate.
28. The composition of claim 16 wherein the binder resin is present in an amount of from 15 % wt. to about 25 % wt.
29. The composition of claim 16 wherein the solvent is water.
30. The composition of claim 16 wherein the solvent is an organic solvent selected from the group consisting of ketones, acetates, aldehydes, and glycol ethers.
31. A substrate coated with the composition of claim 1.
32. The substrate of claim 31, wherein the substrate is a fill material used in conjunction with a synthetic turf field.

33. A method for reducing heat build-up on a substrate, the method comprising the steps of:
- applying a coating composition to a surface of a substrate or article to be coated, wherein the coating composition comprises:
- an IR reflective compound;
  - a light-scattering compound;
  - a binder resin; and
  - a solvent;
- coalescing the coating composition to form a substantially continuous film; and
- curing the substantially continuous film.
34. The method of claim 33 wherein the IR reflective compound is selected from the group consisting of metal oxides, cobalt compounds, and chromium compounds.
35. The method of claim 34 wherein the IR reflective compound is a metal oxide.
36. The method of claim 35 wherein the IR reflective compound is titanium dioxide
37. The method of claim 33 wherein the IR reflective compound is present in an amount of from 1 % wt. to about 60 % wt.
38. The method of claim 33 wherein the light scattering compound comprises hollow latex spheres.

39. The method of claim 33 wherein the light scattering compound is present in an amount of from 1 % wt. to about 60 % wt.
40. The method of claim 33 wherein the binder resin is selected from the group consisting of thermoplastic compositions, thermosetting compositions, and radiation curable compositions.
41. The method of claim 40 wherein the binder resin is a thermosetting composition.
42. The method of claim 41 wherein the thermosetting composition comprises a polymer having at least one type of reactive group and a curing agent having reactive groups reactive with the reactive group(s) of the polymer.
43. The method of claim 42, wherein the thermoplastic composition comprises poly(ethylene terephthalate) or a copolymer thereof.
44. The method of claim 40, wherein the binder resin is a radiation curable composition comprising a multi-functional (meth)acrylate.
45. The method of claim 33 wherein the binder resin is present in an amount of from 1 % wt. to about 80 % wt.
46. The method of claim 33 wherein the solvent is water.



47. The method of claim 33 wherein the solvent is an organic solvent selected from the group consisting of ketones, acetates, aldehydes, and glycol ethers.

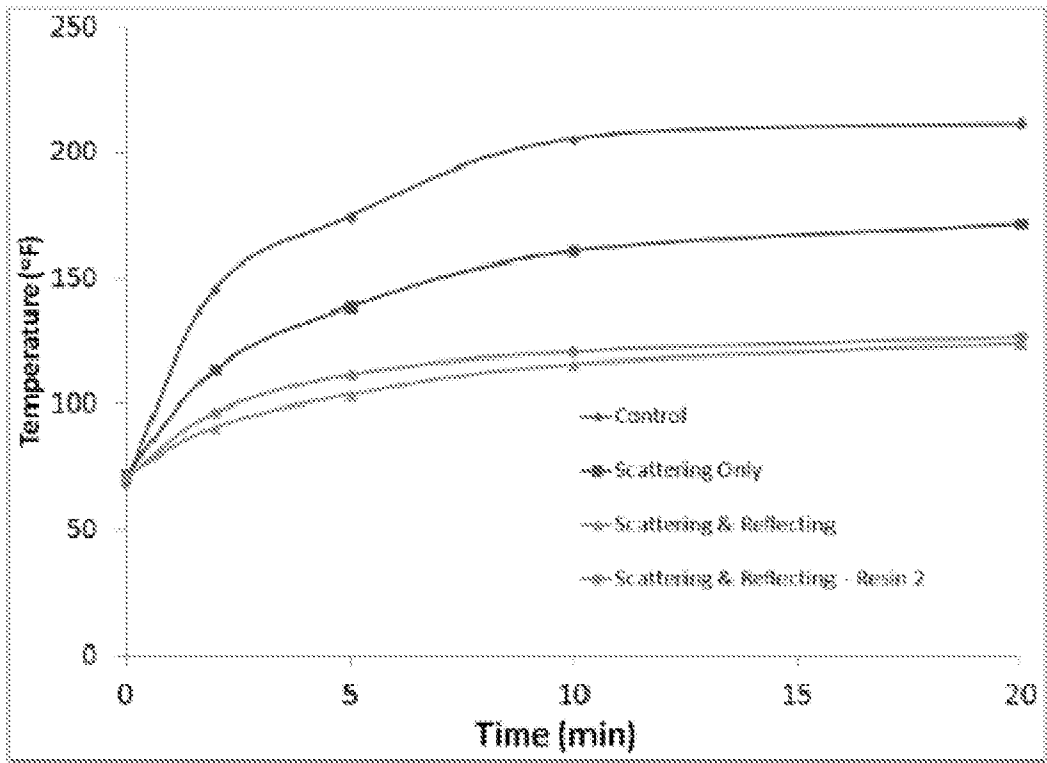


FIG. 1

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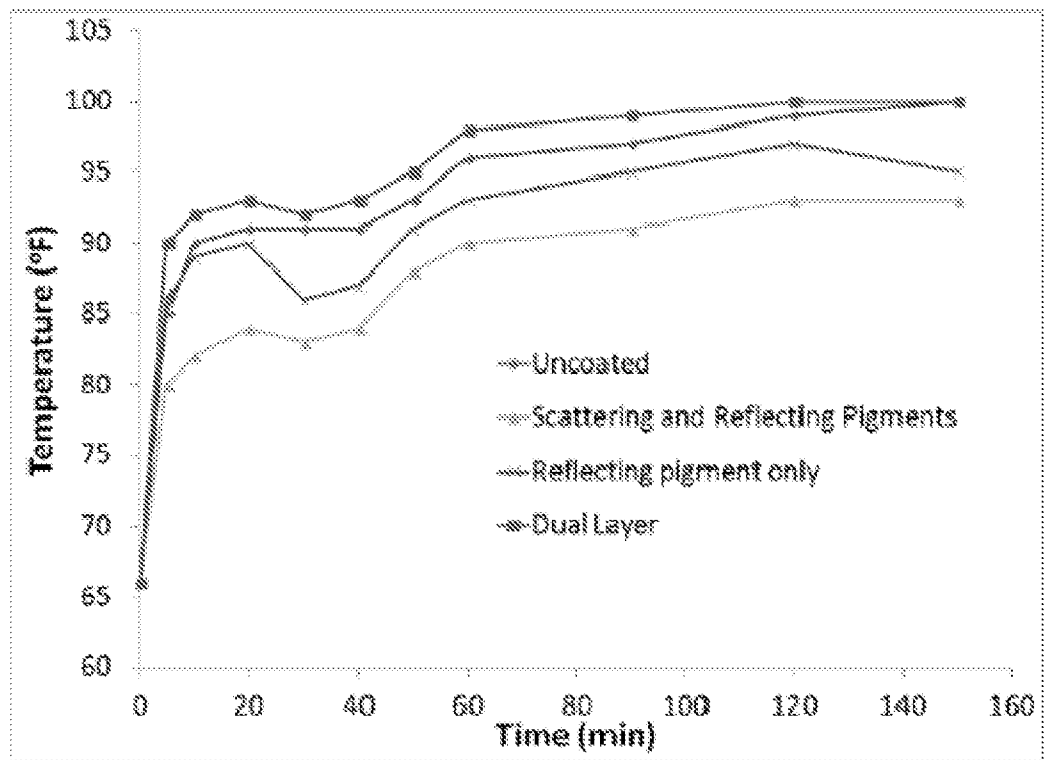
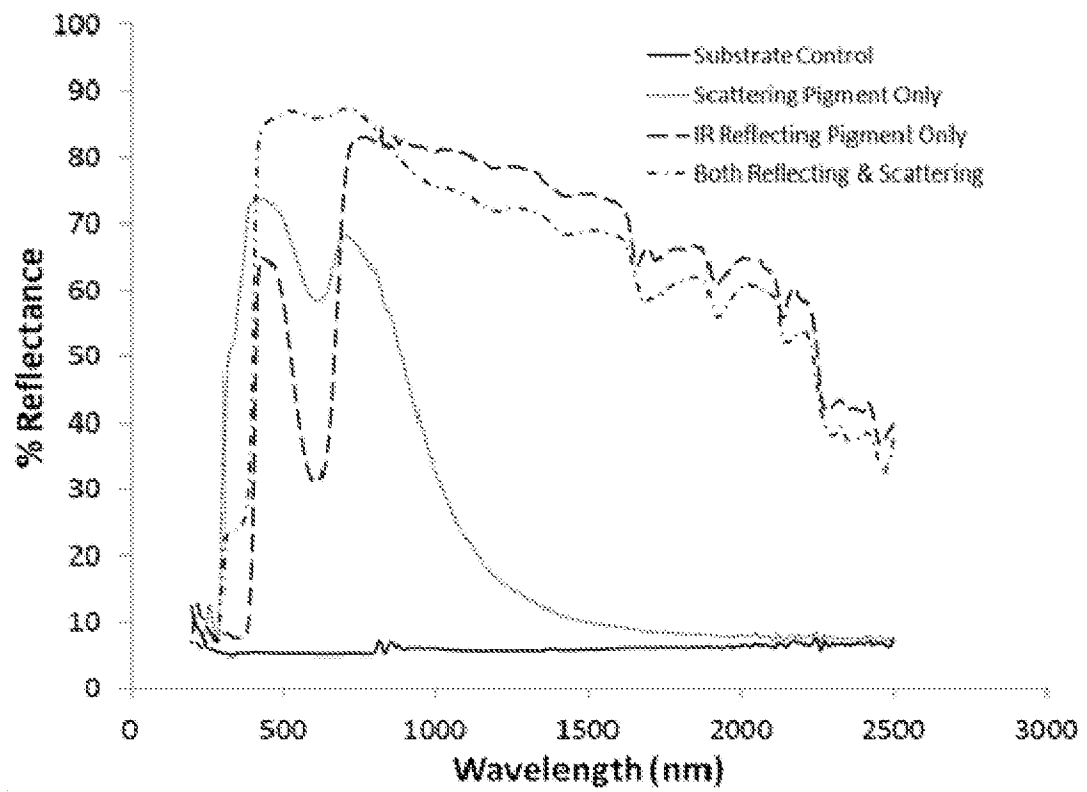


FIG. 2

**3 / 3****FIG. 3**

# INTERNATIONAL SEARCH REPORT

International application No  
PCT/US2017/020835

A. CLASSIFICATION OF SUBJECT MATTER  
INV. C09D7/12  
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)  
C09D

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)

EP0-Internal

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

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| X         | DE 10 2005 061684 A1 (ECKART GMBH & CO KG [DE]) 28 June 2007 (2007-06-28)<br>paragraph [0013] - paragraph [0017]<br>abstract; claims 1-6, 8, 17; figures 1, 2; example 1; table 3<br>-----                     | 1-47                  |
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Further documents are listed in the continuation of Box C.



See patent family annex.

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"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

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Date of the actual completion of the international search

4 May 2017

Date of mailing of the international search report

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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

Glomm, Bernhard

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2017/020835

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