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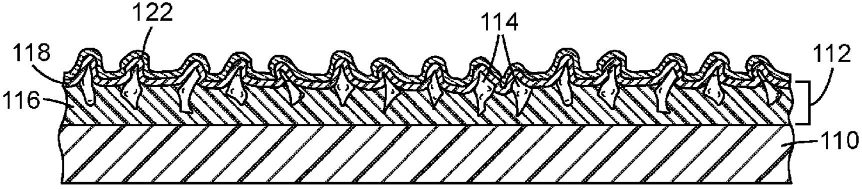

Fig. 1

(57) Abstract: Abrasive articles, along with related compositions and methods, are provided. The abrasive articles include a backing, abrasive layer, and supersize coat that includes calcium stearate and a sodium salt of a modified styrene acrylic polymer. The disclosed supersize compositions make possible a high level of abrasive cut rate and cut life relative to conventional supersize compositions. As a further advantage, the compositions enable supersize coats that provide a high degree of optical clarity, enabling graphic images to be printed on the abrasive side of the article.

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ABRASIVE ARTICLE

Field of the Invention

Provided are abrasive articles, along with related compositions and methods of use. The provided abrasive articles can be useful in, for example, abrading soft materials such as painted automotive surfaces.

Background

Abrasive articles are widely used by consumers, manufacturers, and service providers to perform sanding and finishing operations on almost any given substrate, or workpiece. Such workpieces are extraordinarily diverse in nature and can have surfaces made of plastic, wood, metal, or even ceramic materials.

Useful abrasive articles are generally made by affixing abrasive particles onto some sort of backing, which can be either rigid or flexible. In some cases, the abrasive particles are uniformly mixed with a polymeric binder to form a slurry, which is then coated onto the backing and cured to provide the final product. Alternatively, the abrasive particles can be directly adhered to the surface of the backing by at least partially embedding them in curable resins called “make” and “size” coats. An advantage of the latter approach is that the abrasive particles can be aligned in a preferred orientation on the working surface, enabling the substrate material to be removed efficiently.

Printed flexible abrasives are a particular kind of abrasive product in which a graphic image is permanently imparted (or “printed”) onto the abrasive sheet. Such articles offer unique benefits to both manufacturers and consumers. The ability to place graphics on an abrasive can enhance its appearance and provide branding or promotional information. The inclusion of printed information can also be effective in communicating technical details to the end user, such as its grit size, or safety information. Printing ornamental and functional images directly on the abrasive is generally preferred over placing them on product packaging because abrasive products frequently become separated from their packaging.

There is a demand for abrasive products that can have a printed image disposed not only on the backside but also the abrasive side. Abrasive articles that show graphic images visible from the abrasive-side of the article have been described, for example, in provisional U.S. Patent Application Serial No. 62/076,874 (Graham et al.). Placing an image prominently on the abrasive side is often technically challenging because the components of an abrasive article are often opaque or immiscible with each other. When immiscible components are mixed, the resulting mixture tends to have very limited translucency. Therefore, it is desirable to provide a supersize coat with a high degree of translucency (or clarity).

Summary

Abrasive performance tends to diminish as debris (or "swarf") is created from the sanding action and fills in the spaces between the abrasive grains. Swarf loading can prevent the abrasive from effectively contacting the work surface and degrade cut performance. This problem can be mitigated by applying a "supersize" coat of a soapy composition on top of the abrasive particles. The supersize coat generally includes an amphiphilic salt (or soap) compound, a polymeric binder, and optionally other ingredients such as a defoamer and biocide.

The use of oleic acid as an additive in abrasive products used in sanding and polishing is known. Oleic acid-containing compositions are described, for example, in U.S. Patent Nos. 2,403,821 (Morgan), 3,352,695 (Iacofano), 7,381,231 (Smith et al.), and 8,025,557 (Andrichik et al.). As a component in a supersize composition, oleic acid can improve clarity, but often at the expense of cut performance. Disclosed here are supersize compositions that, surprisingly, display improved translucency when oleic acid is removed from the composition. Moreover, the elimination of oleic acid was observed to yield significantly increased cut rate and cut life in abrasive articles based on these supersize compositions. A related advantage of improved translucency in the supersize coat is the possibility of increasing coating weight to further improve cut rate and cut life.

In a first aspect, a supersize composition for an abrasive article is provided. The supersize composition comprises: calcium stearate; and a sodium salt of a modified styrene acrylic copolymer.

In a second aspect, an abrasive article is provided. The abrasive article comprises a plurality of layers, in the following order: a backing; an abrasive layer; and a supersize coat comprising the aforementioned supersize composition.

In a third aspect, a method of making an abrasive article is provided, comprising: dispersing in water the following components to provide a dispersion: calcium stearate; a sodium salt of a modified styrene acrylic copolymer; coating the dispersion onto an abrasive layer; and removing the water from the dispersion to provide the abrasive article.

Brief Description of the Drawings

FIGS. 1-5 are side cross-sectional views of abrasive articles according to various exemplary embodiments.

Repeated use of reference characters in the specification and drawings is intended to represent the same or analogous features or elements of the disclosure. It should be understood that numerous other modifications and embodiments can be devised by those skilled in the art, which fall within the scope and spirit of the principles of the disclosure. Figures may not be drawn to scale.

DEFINITIONS

As used herein:

“aspect ratio” refers to the ratio between the longest and the shortest dimension of a given particle;

“diameter” refers to the longest dimension of a given object;

“surfactant” refers to a water-soluble organic molecule containing both a hydrophobic group and a hydrophilic group used to lower the surface tension of water.

Detailed Description

Described in more detail herein are abrasive articles, supersize compositions, and methods of making and using the same.

The words “preferred” and “preferably” refer to embodiments described herein that may afford certain benefits, under certain circumstances. However, other embodiments may also be preferred, under the same or other circumstances. Furthermore, the recitation of one or more preferred embodiments does not imply that other embodiments are not useful, and is not intended to exclude other embodiments from the scope of the invention.

As used herein and in the appended claims, the singular forms “a,” “an,” and “the” include plural referents unless the context clearly dictates otherwise. Thus, for example, reference to “a” or “the” component may include one or more of the components and equivalents thereof known to those skilled in the art. Further, the term “and/or” means one or all of the listed elements or a combination of any two or more of the listed elements.

Relative terms such as left, right, forward, rearward, top, bottom, side, upper, lower, horizontal, vertical, and the like may be used herein and, if so, are from the perspective observed in the particular figure. These terms are used only to simplify the description, however, and not to limit the scope of the invention in any way.

Reference throughout this specification to “one embodiment,” “certain embodiments,” “one or more embodiments” or “an 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 invention. 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 invention. Furthermore, the particular features, structures, materials, or characteristics may be combined in any suitable manner in one or more embodiments.

Further details on abrasive article constructions, backings, abrasive layers, supersize coats, and attachments layers are described in respective subsections below.

ABRASIVE ARTICLE CONSTRUCTION

An exemplary abrasive article, shown in FIG. 1, is illustrated according to one embodiment and herein referred to by the numeral 100. As shown, the abrasive article 100 includes a plurality of layers. From the bottom to the top, with the abrasive surface facing upwards, these layers include: a backing 110, an abrasive layer 112, and a supersize coat 122. Here, the abrasive layer 112 is itself multilayered and includes a make coat 116, abrasive particles 114, and a size coat 118.

FIG. 2, like FIG. 1, shows an abrasive article 200 having a backing 210, abrasive layer 212, and supersize coat 222. The abrasive article 200 additionally has a continuous attachment layer 230 that extends across and directly contacts a major surface of the backing 210 facing away from the abrasive layer 212. In the exemplary embodiment depicted here, the attachment layer 230 is a removable pressure-sensitive adhesive.

FIG. 3, like FIGS. 1 and 2, shows an abrasive article 300 having a backing 310, abrasive layer 312, and supersize coat 322. Like the abrasive article 200 in FIG. 2, the abrasive article 300 has an attachment layer 330. In this case, the attachment layer 330 is one part of a hook-and-loop attachment mechanism. A polymeric compressible foam 340 is interposed between the backing 310 and the attachment layer 330. Optionally but not shown, one or more additional layers could be disposed between any of the above layers to help adhere layers to each other, provide a printed image, act as a barrier layer, or serve any other purpose known in the art. By providing compressibility to the abrasive article 300, the compressible foam 340 can enable a more uniform contact with the workpiece to the abraded, and particularly so where the workpiece has non-planar contours. As a further option, the backing 310 and compressible foam 340 could be consolidated into a single layer that serves both functions.

FIG. 4, like FIGS. 1-3, shows an abrasive article 400 having a backing 410, abrasive layer 412, and supersize coat 422. The abrasive article 400 further includes an adhesive layer 450 bonding the backing 410 to an underlying reinforcing layer 452, which is in turn adhered to a gripping layer 454. The gripping layer 454 includes integral protrusions 456 that extend outwardly from the backing and assist the operator in handling the abrasive article 400. To provide improved handling of the abrasive article 400, it is beneficial for the gripping layer 454 to be made from an elastomeric polymer, and preferably elastomeric polymers having a Shore A hardness ranging from 5 to 90. Further information concerning useful materials and geometries for the gripping layer 454 are described in U.S. Patent No. 6,372,323 (Kobe et al.) and co-pending International Patent Application No. PCT/US15/61762 (Graham et al.).

FIG. 5, like FIGS. 1-4, shows an abrasive article 500 having a backing 510, abrasive layer 512, and supersize coat 522. The abrasive article 500 differs from the others in that the abrasive layer 512 is comprised of discontinuous, or discrete, islands of a hardened abrasive composite. Such a composite can be made by uniformly mixing abrasive particles with a binder to form a viscous slurry. This slurry can then be cast and appropriately hardened (for example, using a thermal or radiation curing process) onto a backing 510 to obtain the abrasive layer 512, as shown in FIG. 5.

Advantageously, the abrasive slurry can be cast between the underlying film and a mold having tiny geometric cavities prior to hardening. After hardening, the resulting abrasive coating is molded into a plurality of tiny, precisely shaped abrasive composite structures affixed to the underlying film. The hardening of the binder can be achieved by a curing reaction triggered by heat or exposure to actinic radiation. Examples of actinic radiation include, for example, an electron beam, ultraviolet light, or visible light.

The layer configurations described above are not intended to be exhaustive, and it is to be understood that one or ordinary skill may add or remove layers with respect to any of the embodiments depicted in FIGS. 1-5 for reasons already known in the art.

BACKING

The aforementioned abrasive articles generally include a backing, such as any of backings 110, 210, 310 410, 510 above. The backing may be constructed from any of a number of materials known in the art for making coated abrasive articles. Although not necessarily so limited, the backing can have a thickness of at least 0.02 millimeters, at least 0.03 millimeters, 0.05 millimeters, 0.07 millimeters, or 0.1 millimeters. The backing could have a thickness of up to 5 millimeters, up to 4 millimeters, up to 2.5 millimeters, up to 1.5 millimeters, or up to 0.4 millimeters.

The backing is preferably flexible and may be either solid (as shown in FIG. 1) or porous. Flexible backing materials include polymeric film (including primed films) such as polyolefin film (e.g., polypropylene including biaxially oriented polypropylene, polyester film, polyamide film, cellulose ester film), polyurethane rubber, metal foil, mesh, foam (e.g., natural sponge material or polyurethane foam), cloth (e.g., cloth made from fibers or yarns comprising polyester, nylon, silk, cotton, and/or rayon), scrim, paper, coated paper, vulcanized paper, vulcanized fiber, nonwoven materials, combinations thereof, and treated versions thereof. The backing may also be a laminate of two materials (e.g., paper/film, cloth/paper, film/cloth). Cloth backings may be woven or stitch bonded. In some embodiments, the backing is a thin and conformable polymeric film capable of expanding and contracting in transverse (i.e. in-plane) directions during use.

Preferably, a strip of such a backing material that is 5.1 centimeters (2 inches) wide, 30.5 centimeters (12 inches) long, and 0.102 millimeters (4 mils) thick and subjected to a 22.2 Newton (5 Pounds-Force) dead load longitudinally stretches at least 0.1%, at least 0.5%, at least 1.0%, at least 1.5%, at least 2.0%, at least 2.5%, at least 3.0%, or at least 5.0%, relative to the original length of the strip. Preferably, the backing strip longitudinally stretches up to 20%, up to 18%, up to 16%, up to 14%, up to 13%, up to 12%, up to 11%, or up to 10%, relative to the original length of the strip. The stretching of the backing material can be elastomeric (with complete spring back), inelastic (with zero spring back), or some mixture of both. This property helps promote contact between the abrasive particles 114 and the underlying workpiece, and can be especially beneficial when the workpiece includes raised and/or recessed areas.

Useful backing materials can be highly conformable. Highly conformable polymers that may be used in the backing include certain polyolefin copolymers, polyurethanes, and polyvinyl chloride. One particularly preferred polyolefin copolymer is an ethylene-acrylic acid resin (available under the trade designation "PRIMACOR 3440" from Dow Chemical Company, Midland, MI). Optionally, ethylene-acrylic acid resin is one layer of a bilayer film in which the other layer is a polyethylene terephthalate ("PET") carrier film. In this embodiment, the PET film is not part of the backing itself and is stripped off prior to using the abrasive article 100. While it is possible to strip the PET from the ethylene-acrylic acid resin surface, the ethylene-acrylic acid resin and the PET can also be bonded such that these two layers stay together during use of the abrasive article.

In some embodiments, the backing has a modulus of at least 10, at least 12, or at least 15 kilogram-force per square centimeter (kgf/cm^2). In some embodiments, the backing has a modulus of up to 200, up to 100, or up to 30 kgf/cm^2. The backing can have a tensile strength at 100% elongation (double its original length) of at least 200 kgf/cm^2, at least 300 kgf/cm^2, or at least 350 kgf/cm^2. The tensile strength of the backing can be up to 900 kgf/cm^2, up to 700 kgf/cm^2, or up to 550 kgf/cm^2. Backings with these properties can provide various options and advantages, some of which are described in U.S. Patent No. 6,183,677 (Usui et al.).

Optionally, the backing may have at least one of a saturant, presize layer, or backsize layer. These materials can be used to seal the backing or to protect yarn or fibers present in the backing. If the backing is a cloth material, at least one of these materials is typically used. Advantageously, the addition of the presize layer or backsize layer can provide a smoother surface on either the front and/or the back side of the backing. Other optional layers known in the art may also be used, as described in U.S. Patent No. 5,700,302 (Stoetzel et al.).

ABRASIVE LAYER

The abrasive layer is a layer containing a hard mineral that serves to abrade the workpiece. In FIGS. 1-4, the abrasive layer is a coated abrasive film that includes a plurality of abrasive particles 114 secured to a plurality of hardened resin layers. The abrasive particles 114 are adhesively coupled to the backing by implementing a sequence of coating operations involving a hardenable make coat 116 and size coat 118. It is common for the make coat 116 to include a curable polymeric resin in which the abrasive particles 114 are at least partially embedded and the size coat 118 to include the same or optionally a different curable polymeric resin disposed on the make coat 116.

In the configuration shown in FIGS. 1-4, the abrasive particles 114 are partially or fully embedded in respective make and size coats 116, 118 in close proximity to the surface of the abrasive article 100. This allows the abrasive particles 114 to easily come into frictional contact with the workpiece when the abrasive article 100 is rubbed against the workpiece.

The abrasive particles 114 are not limited and may be composed of any of a variety of hard minerals known in the art. Examples of suitable abrasive particles include, for example, fused aluminum oxide, heat treated aluminum oxide, white fused aluminum oxide, black silicon carbide, green silicon carbide, titanium diboride, boron carbide, silicon nitride, tungsten carbide, titanium carbide, diamond, cubic boron nitride, hexagonal boron nitride, garnet, fused alumina zirconia, alumina-based sol gel derived abrasive particles, silica, iron oxide, chromia, ceria, zirconia, titania, tin oxide, gamma alumina, and mixtures thereof. The alumina abrasive particles may contain a metal oxide modifier. The diamond and cubic boron nitride abrasive particles may be monocrystalline or polycrystalline.

There is almost always some range or distribution of abrasive particle sizes. Such a distribution can be characterized by its median particle size. For instance, the median particle size of the abrasive particles may be at least 0.001 micrometers, at least 0.005 micrometers, at least 0.01 micrometers, at least 0.015 micrometers, or at least 0.02 micrometers. In some instances, the median particle size of the abrasive particles may be up to 300 micrometers, up to 275 micrometers, up to 250 micrometers, up to 150 micrometers, or up to 100 micrometers.

FIG. 5 shows an alternative kind of abrasive layer. In this embodiment, the abrasive layer 512 is comprised of discrete islands of an abrasive composite. Such a composite can be made by uniformly mixing abrasive particles with a binder to form a viscous slurry. This slurry can then be cast and appropriately hardened (for example, using a thermal or radiation curing process) onto a backing 510 to afford the abrasive layer 512, as shown in the figure. The cast slurry can be cast onto the backing in a continuous layer or a patterned, discontinuous layer, as shown in FIG. 5.

Optionally, the abrasive slurry is molded onto a suitable backing to form a structured abrasive. Structured abrasives can be made by mixing abrasive particles and a hardenable precursor resin in a suitable binder resin (or binder precursor) to form a slurry, casting the slurry between the underlying film and a mold having tiny geometric cavities, and then hardening the binder. After hardening, the resulting abrasive coating is molded into a plurality of tiny, precisely shaped abrasive composite structures affixed to the underlying film. The hardening of the binder can be achieved by a curing reaction triggered by heat or exposure to actinic radiation. Examples of actinic radiation include, for example, an electron beam, ultraviolet light, or visible light.

SUPERSIZE COAT

In general, the supersize coat is the outermost coating of the abrasive article and directly contacts the workpiece during an abrading operation. The supersize coat has a composition that acts to reduce the loading of swarf around the abrasive particles and improve the overall cut performance of the abrasive article.

A first major component of the provided supersize coats is a metal salt of a long-chain fatty acid. In preferred embodiments, the metal salt of a long-chain fatty acid is a stearate (i.e., a salt of stearic acid). The conjugate base of stearic acid is $C_{17}H_{35}COO^-$, also known as the stearate anion. Useful stearates include calcium stearate, zinc stearate, and combinations thereof.

Of the metal salts above, calcium stearate is especially preferred. Calcium stearate is a white waxy powder that, unlike other stearates, is insoluble in water. When used in combination with certain polymeric binders, as will be discussed further below, calcium stearate can be used to prepare translucent supersize compositions that perform well in the absence of oleic acid.

As indicated previously, the provided supersize compositions display a high degree of clarity without the need for added surfactants. In some embodiments, the supersize composition displays a transmittance of at least 5 percent, at least 20 percent, at least 40 percent, at least 50 percent, or at least 60 percent, according to the Transmittance Test (as described in the forthcoming Examples).

In some embodiments, the supersize composition has an oleic acid content of up to 10 percent by weight, up to 6 percent by weight, up to 2 percent by weight, up to 1 percent by weight, or up to 0.5 percent by weight, based on the overall weight of the supersize composition. Preferably, wherein the supersize composition is essentially free of oleic acid (i.e., 0 percent oleic acid by weight).

The metal salt of a long-chain fatty acid can be present in an amount of at least 10 percent, at least 50 percent, at least 70 percent, at least 80 percent, or at least 90 percent by weight based on the normalized weight of the supersize coat (i.e., the average weight for a unit surface area of the abrasive article). The metal salt of a long-chain fatty acid can be present in an amount of up to 100 percent, up to 99 percent, up to 98 percent, up to 97 percent, up to 95 percent, up to 90 percent, up to 80 percent, or up to 60 percent by weight based on the normalized weight of the supersize coat.

A second major component of the supersize composition is the polymeric binder, which enables the composition to form a smooth and continuous film over the abrasive layer. In a preferred embodiment, the polymeric binder is a sodium salt of a modified styrene-acrylic polymer. The ammonium salt of a styrene-acrylic polymer can have, for example, a weight average molecular weight (M_w) of at least 100,000 g/mol, at least 150,000 g/mol, at least 200,000 g/mol, or at least 250,000 g/mol.

The minimum film-forming temperature, also referred to as MFFT, is the lowest temperature at which a polymer self-coalesces in a semi-dry state to form a continuous polymer film. In the context of the present disclosure, this polymer film can then function as a binder for the remaining solids present in the supersize coat. Preferably, the ammonium salt of a styrene-acrylic polymer has an MFFT that is up to 90 degrees Celsius, up to 80 degrees Celsius, up to 70 degrees Celsius, up to 65 degrees Celsius, or up to 60 degrees Celsius.

It is preferred that the binder be dried at relatively low temperatures (e.g., at 70 degrees Celsius or less). It is preferred that drying temperatures are below the melting temperature of metal salt component. As mentioned previously, use of excessively high temperatures to dry the supersize coat is undesirable because it can induce brittleness and cracking in the backing, complicate web handling, and increase manufacturing costs. By virtue of its low MFFT, a binder comprised of a sodium salt of a styrene-acrylic polymer allows the supersize coat to achieve better film formation at lower binder levels and at lower temperatures without need for added surfactants.

The polymeric binder can be present in an amount of at least 0.1 percent, at least 1 percent, or at least 3 percent by weight, based on the normalized weight of the supersize coat. The polymeric binder can be present in an amount of up to 20 percent, up to 12 percent, up to 10 percent, or up to 8 percent by weight, based on the normalized weight of the supersize coat. Advantageously, when a sodium salt of a modified styrene acrylic copolymer was used as a binder, the haziness normally associated with the stearate coating was reduced. This enables oleic acid to be removed from the composition while continuing to provide acceptable clarity for printed abrasive articles.

The supersize coats of the present disclosure optionally contain clay particles dispersed in the supersize coat. The clay particles are preferably uniformly mixed with the metal salt of a long chain fatty acid, polymeric binder, and other components of the supersize composition. The clay bestows unique advantageous properties to the abrasive article, such as improved optical clarity and improved cut performance. It was also discovered that the inclusion of clay particles can enable cut performance to be sustained for longer periods of time relative to supersize coats in which the clay additive is absent.

In some embodiments, the clay particles can reduce the CIELAB ΔE^* color difference relative to an uncoated abrasive layer by at least 5 percent, at least 7 percent, at least 10 percent, at least 15 percent, or at least 25 percent, compared with the CIELAB ΔE^* color difference obtained when the clay particles are absent.

The clay particles can be present in an amount of at least 0.01 percent, at least 0.05 percent, at least 0.1 percent, at least 0.15 percent, or at least 0.2 percent by weight based on the normalized weight of the supersize coat. Further, the clay particles can be present in an amount of up to 99 percent, up to 50 percent, up to 25 percent, up to 10 percent, or up to 5 percent by weight based on the normalized weight of the supersize coat.

Useful clay particles can have particle sizes that vary over a very wide range. For example, the median particle size can be at least 0.01 micrometers, at least 0.02 micrometers, or at least 0.1 micrometers. The individual clay particles can have a median particle size of up to 100 micrometers, up to 10 micrometers, or up to 1 micrometer.

The unique physical properties of many useful clay materials relate to their layered platelet-like structures. Such particles can have a median aspect ratio of at least 10, at least 15, at least 20, at least 50, at least 75, or at least 100. Further, the median aspect ratio can be up to 10,000, up to 8000, up to 6000, up to 4000, up to 2000, or up to 1000.

The clay particles may include particles of any known clay material. Such clay materials include those in the geological classes of the smectites, kaolins, illites, chlorites, serpentines, attapulgites, palygorskites, vermiculites, glauconites, sepiolites, and mixed layer clays. Smectites in particular include montmorillonite (e.g., a sodium montmorillonite or calcium montmorillonite), bentonite, pyrophyllite, hectorite, saponite, sauconite, nontronite, talc, beidellite, and volchonskoite. Specific kaolins include kaolinite, dickite, nacrite, antigorite, anauxite, halloysite, indellite and chrysotile. Illites include bravaisite, muscovite, paragonite, phlogopite and biotite. Chlorites can include, for example, corrensite, penninite, donbassite, sudoite, pennine and clinochlore. Mixed layer clays can include allevardite and vermiculitebiotite. Variants and isomorphic substitutions of these layered clays may also be used.

Layered clay materials may be either naturally occurring or synthetic. Exemplary clay materials include natural and synthetic hectorites, montmorillonites and bentonites. Examples of montmorillonite and bentonite clays include those clays available from Altana AG, Wesel, Germany, under the trade designations “CLOISITE”, “MINERAL COLLOID”, “NANOFIL”, “GELWHITE”, and “OPTIGEL” (e.g., “MINERAL COLLOID BP”, “CLOISITE NA+”, “NANOFIL 116”, and “OPTIGEL CK”), as well as those clays available from R.T. Vanderbilt, Murray, KY, under the trade designation “VEEGUM” (e.g., “VEEGUM PRO” and “VEEGUM F”), and clay available from Nanocor, Inc., Hoffman Estates, IL, under the trade designation “NANOMER.” Examples of hectorite clays include the commercially available clays available from Altana AG under the trade designation “LAPONITE”.

Other clay particles may be composed of vermiculite clays, such as those commercially available from Specialty Vermiculite Corp., Enoree, SC, under the trade designations “VERMICULITE”, “MICROLITE”, “VERXITE”, and “ZONOLITE.”

Natural clay minerals often exist as layered silicate minerals. A layered silicate mineral has SiO_4 tetrahedral sheets arranged into a two-dimensional network structure. A 2:1 type layered silicate mineral has a laminated structure of several to several tens of silicate sheets having a three layered structure in which a magnesium octahedral sheet or an aluminum octahedral sheet is interposed between a pair of silica tetrahedral sheets.

Particular silicates include hydrous silicate, layered hydrous aluminum silicate, fluorosilicate, mica-montmorillonite, hydrotalcite, lithium magnesium silicate and lithium magnesium fluorosilicate. Substituted variants of lithium magnesium silicate are also possible, where the hydroxyl group is partially substituted with fluorine, for example. Lithium and magnesium may also be partially substituted by aluminum. More broadly, the lithium magnesium silicate may be isomorphically substituted by any member selected from the group consisting of magnesium, aluminum, lithium, iron, chromium, zinc and mixtures thereof.

Synthetic hectorite is commercially available from Altana AG under the trade designation “LAPONITE.” There are many grades or variants and isomorphous substitutions of LAPONITE, including those synthetic hectorites available under the trade designations “LAPONITE B”, “LAPONITE S”, “LAPONITE XLS”, “LAPONITE RD”, “LAPONITE XLG”, “LAPONITE S482”, and “LAPONITE RDS.”

The clay materials can provide particular frictional and static charge accumulation properties that affect both swarf loading and abrasives performance. In regards to friction, the clay particles in the supersize coat can alleviate localized frictional heating known to increase swarf coalescence during an abrading operation. In the latter case, the clay particles can disrupt the electrostatic attraction that normally occurs between the abrasive article 100 and swarf particles.

As an optional additive, abrasive performance may be further enhanced by nanoparticles (i.e., nanoscale particles) interdispersed with the clay particles of the supersize coat. Useful nanoparticles include, for example, nanoparticles of metal oxides, such as zirconia, titania, silica, ceria, alumina, iron oxide, vanadia, zinc oxide, antimony oxide, tin oxide, and alumina-silica. The nanoparticles can have a median particle size of at least 1 nanometer, at least 1.5 nanometers, or at least 2 nanometers. The median particle size can be up to 200 nanometers, up to 150 nanometers, up to 100 nanometers, up to 50 nanometers, or up to 30 nanometers.

The nanoparticles can have any of a number of different particle size distributions. In some embodiments, the nanoparticles have a D_{90}/D_{50} particle size ratio of at least 1.1, at least 1.2, at least 1.3, or at least 1.4. In some embodiments, the nanoparticles have a D_{90}/D_{50} particle size ratio of up to 5, up to 4, up to 3, up to 2, or up to 1.8.

In some embodiments, the nanoparticles are sintered to form nanoparticle agglomerates. For example, the nanoparticles may be comprised of fumed silica in which primary silica particles are sintered to provide silica particles aggregated into chains.

Other optional components of the supersize composition include curing agents, surfactants, antifoaming agents, biocides, and other particulate additives known in the art for use in supersize compositions.

The supersize coat can be formed, in some embodiments, by providing a supersize composition in which the components are dissolved or otherwise dispersed in a common solvent. Preferably, the solvent is water. After being suitably mixed, the supersize dispersion can be coated onto the underlying layers of the abrasive article and dried to provide the finished supersize coat. If a curing agent is present, the supersize composition can be cured (i.e., hardened) either thermally or by exposure to actinic radiation at suitable wavelengths to activate the curing agent.

The coating of the above dispersion onto the supersize coat can be carried out using any known process. In exemplary embodiments, the dispersion is applied by spray coating at a constant pressure to achieve a pre-determined coating weight. Alternatively, a knife coating method where the coating thickness is controlled by the gap height of the knife coater could be used.

ATTACHMENT LAYERS

An attachment layer can be affixed to the backing to help secure the abrasive article to a sanding block, power tool, or even the hand of an operator. In FIG. 2, the attachment layer 230 is comprised of a pressure-sensitive adhesive. The attachment layer can also use a mechanical retention mechanism. In FIG. 3, the attachment layer 330 is comprised of a fibrous material, such as a scrim or non-woven material forming half of a hook and loop attachment system. The other half can be provided, for example, on a sanding block or the movable chuck of a power tool. Such attachment systems are advantageous because they allow the abrasive article to be easily replaced when worn out.

Additional options and advantages of these abrasive articles are described in U.S. Patent Nos. 4,988,554 (Peterson, et al.), 6,682,574 (Carter, et al.), 6,773,474 (Koehnle et al.), and 7,329,175 (Woo et al.).

While not intended to be exhaustive, further non-limiting embodiments of the abrasive articles and methods described herein are as follows:

1. A supersize composition for an abrasive article comprising: calcium stearate; and a sodium salt of a modified styrene acrylic copolymer.

2. The supersize composition of embodiment 1, wherein the sodium salt of a modified styrene acrylic copolymer is a non-film forming polymer.

3. The supersize composition of embodiment 1 or 2, wherein the supersize composition has an oleic acid content of up to 10 percent by weight based on the overall weight of the supersize composition.

4. The supersize composition of embodiment 3, wherein the supersize composition has an oleic acid content of up to 2 percent by weight based on the overall weight of the supersize composition.

5. The supersize composition of embodiment 4, wherein the supersize composition is essentially free of oleic acid.

6. The supersize composition of any one of embodiments 1-5, wherein the supersize composition further comprises clay particles present in an amount of from 0.01

percent to 99 percent by weight based on the overall weight of the supersize composition.

7. The supersize composition of embodiment 6, wherein the clay particles are present in an amount of from 0.1 percent to 25 percent by weight based on the overall weight of the supersize composition.

8. The supersize composition of embodiment 7, wherein the clay particles are present in an amount of from 0.2 percent to 5 percent by weight based on the overall weight of the supersize composition.

9. The supersize composition of any one of embodiments 6-8, wherein the clay particles comprise a layered silicate.

10. The supersize composition of embodiment 9, wherein the layered silicate comprises a montmorillonite.

11. The supersize composition of embodiment 10, wherein the montmorillonite comprises a sodium montmorillonite, calcium montmorillonite, or combination thereof.

12. The supersize composition of any one of embodiments 6-11, wherein the clay particles have a median particle size of from 0.01 micrometers to 100 micrometers.

13. The supersize composition of embodiment 12, wherein the clay particles have a median particle size of from 0.02 micrometers to 10 micrometers.

14. The supersize composition of embodiment 13, wherein the clay particles have a median particle size of from 0.1 micrometers to 1 micrometer.

15. The supersize composition of any one of embodiments 1-14, wherein the calcium stearate is present in an amount of from 50 percent to 99 percent by weight based on the overall weight of the supersize composition.

16. The supersize composition of embodiment 15, wherein the calcium stearate is present in an amount of from 60 percent to 98 percent by weight based on the overall weight of the supersize composition.

17. The supersize composition of embodiment 16, wherein the calcium stearate is present in an amount of from 80 percent to 97 percent by weight based on the overall weight of the supersize composition.

18. The supersize composition of any one of embodiments 1-17, wherein the sodium salt of a modified styrene acrylic copolymer is present in an amount of from 0.1 percent to 20 percent by weight based on the overall weight of the supersize composition.

19. The supersize composition of embodiment 18, wherein the sodium salt of a modified styrene acrylic copolymer is present in an amount of from 1 percent to 12 percent by weight based on the overall weight of the supersize composition.

20. The supersize composition of embodiment 19, wherein the sodium salt of a modified styrene acrylic copolymer is present in an amount of from 1 percent to 8 percent by weight based on the normalized weight of the supersize composition.

21. The supersize composition of any one of embodiments 1-20, wherein the supersize composition displays a transmittance of at least 5 percent according to the Transmittance Test.

22. The supersize composition of embodiment 21, wherein the supersize composition displays a transmittance of at least 40 percent according to the Transmittance Test.

23. The supersize composition of embodiment 22, wherein the supersize composition displays a transmittance of at least 60 percent according to the Transmittance Test.

24. An abrasive article comprising a plurality of layers, in the following order: a backing; an abrasive layer; and a supersize coat comprising the supersize composition of any one of embodiments 1-23.

25. The abrasive article of embodiment 24, wherein the abrasive layer comprises: a make coat comprising a first polymeric resin and a plurality of abrasive particles at least partially embedded in the first polymeric resin; and a size coat disposed on the make coat and comprising a second polymeric resin.

26. The abrasive article of embodiment 24, wherein the abrasive layer comprises a plurality of abrasive composites that are precisely shaped.

27. The abrasive article of embodiment 26, wherein the abrasive composites are molded from an abrasive slurry.

28. The abrasive article of any one of embodiments 24-27, wherein the backing comprises paper, polymeric film, polymeric foam, or a combination thereof.

29. The abrasive article of any one of embodiments 24-28, further comprising an attachment layer coupled to a major surface of the backing opposite the abrasive layer.

30. The abrasive article of embodiment 29, wherein the attachment layer comprises a pressure-sensitive adhesive.

31. The abrasive article of embodiment 29, wherein the attachment layer comprises part of a hook and loop attachment mechanism.

32. The abrasive article of embodiment 29, wherein the attachment layer comprises a plurality of protrusions extending outwardly from the backing, the protrusions comprising a polymer having a Shore A hardness ranging from 5 to 90.

33. A method of making an abrasive article comprising: dispersing in water the following components to provide a dispersion: calcium stearate; and a sodium salt of a modified styrene acrylic copolymer; coating the dispersion onto an abrasive layer; and removing the water from the modified styrene acrylic copolymer to provide the abrasive article.

34. The method of embodiment 33, wherein the abrasive layer is disposed on a backing.

EXAMPLES

Objects and advantages of this disclosure are further illustrated by the following non-limiting examples, but the particular materials and amounts thereof recited in these examples, as well as other conditions and details, should not be construed to unduly limit this disclosure.

The following abbreviations are used to describe the examples:

°C:	degrees Centigrade
cm:	centimeter
cm/s:	centimeters per second
ctg. wt.:	coating weight
g/m^2:	grams per square meter
in/s:	inches per second
Kg:	kilogram
lb:	pound
MFFT:	minimum film forming temperature
min:	minute
mL:	milliliter
µm:	micrometer

nm:	nanometer
rpm:	revolutions per minute
T_g:	glass transition temperature
wt.%:	weight percent

Unless stated otherwise, all reagents were obtained or are available from chemical vendors such as Sigma-Aldrich Company, St. Louis, Missouri, or may be synthesized by known methods. Unless otherwise reported, all ratios are by dry weight.

Abbreviations for materials and reagents used in the examples are as follows:

DPnP:	Dipropylene glycol n-butyl ether, obtained under the trade designation "DOWANOL DPnP" from Dow Chemical Company, Midland, Michigan.
HL27:	An antifoaming agent, obtained under the trade designation "HL27" from Harcross, Inc., St. Paul, Minnesota.
J-89:	A 48.0 wt.% aqueous, non-film forming, styrene acrylic emulsion, having an MFFT of greater than 80°C and a T_g of 98°C, obtained under the trade designation "JONCRYL J89" from BASF Company, Ludwigshafen, Germany.
J-1655:	A 48.0 wt.% aqueous, non-film forming, sodium neutralized, acrylic emulsion, having an MFFT of greater than 80°C and a T_g of 108°C, obtained under the trade designation "JONCRYL 1655" from BASF Company.
LS-233-3:	A 52 wt.% aqueous calcium stearate dispersion containing 3% by weight oleic acid, obtained under the trade designation "LOXANOL MI S233" from Geo Specialty Chemicals, Inc., Ambler, Pennsylvania.
LS-233-2:	A "LOXANOL MI S233" calcium stearate dispersion, wherein the oleic acid was reduced from 3% to 2% by weight.
LS-233-0:	A "LOXANOL MI S233" calcium stearate dispersion, wherein the oleic acid was omitted.

210U: A urea-urea-formaldehyde coated abrasive having a grade P320 alumina mineral, obtained under the trade designation “3M HOOKIT PAPER DISC 210U P320” from 3M Company, St. Paul, Minnesota.

Comparative A

A stearate/styrene acrylic supersize composition was prepared as follows. 69.55 grams calcium stearate dispersion LS233-3, 1.64 grams surfactant DPnP, 0.29 grams anti-foaming agent HL27 and 16.35 grams of deionized water were homogeneously dispersed by means of a propeller blade mixer at 500 rpm for 5 minutes at 21°C. Approximately 1 mL of this supersize composition was evenly coated onto the corona treated surface of a 15 by 20 cm by 5 mil (127.0 μm) sheet of clear polyester film using a #8 Meyer rod bar coater and dried for 2 hours at 21°C. % Transmittance of the dried coating was then measured according to ASTM D1003 standard using a spectrophotometer, model “HAZE-GARD PLUS”, from BYK Instruments, Columbia, Maryland (i.e., according to the “Transmittance Test”).

Examples 1-20

Stearate/styrene acrylic supersize compositions were prepared and coated onto the clear polyester film according to the procedure generally described in Comparative A, according to the quantities listed in Table 1.

TABLE 1

Supersize Composition	Composition (grams)								Transmittance (%)
	LS-233-0	LS-233-2	LS-233-3	J-89	J-1655	DPnP	HL27	Water	
Example 1	82.0	0	0	0	0	0	0	18.0	69.95
Example 2	79.0	0	0	3.0	0	0	0	18.0	71.80
Example 3	76.0	0	0	6.0	0	0	0	18.0	74.70
Example 4	73.0	0	0	9.0	0	0	0	18.0	75.95
Example 5	70.0	0	0	12.0	0	0	0	18.0	76.00
Example 6	0	82.0	0	0	0	0	0	18.0	73.10
Example 7	0	79.0	0	3.0	0	0	0	18.0	73.20

Supersize Composition	Composition (grams)								Transmittance (%)
	LS-233-0	LS-233-2	LS-233-3	J-89	J-1655	DPnP	HL27	Water	
Example 8	0	76.0	0	6.0	0	0	0	18.0	73.40
Example 9	0	73.0	0	9.0	0	0	0	18.0	75.80
Example 10	0	70.0	0	12.0	0	0	0	18.0	78.20
Example 11	82.0	0	0	0	0	0	0	18.0	69.95
Example 12	79.0	0	0	0	3.0	0	0	18.0	76.50
Example 13	76.0	0	0	0	6.0	0	0	18.0	79.00
Example 14	73.0	0	0	0	9.0	0	0	18.0	82.65
Example 15	70.0	0	0	0	12.0	0	0	18.0	83.20
Example 16	0	82.0	0	0	0	0	0	18.0	73.10
Example 17	0	79.0	0	0	3.0	0	0	18.0	77.00
Example 18	0	76.0	0	0	6.0	0	0	18.0	81.00
Example 19	0	73.0	0	0	9.0	0	0	18.0	84.10
Example 20	0	70.0	0	0	12.0	0	0	18.0	85.05
Comparative A	0	0	69.55	12.17	0	1.64	0.29	16.35	78.20

Examples 21-44 and Comparatives B-D

A spray gun, model "ACCUSPRAY HG14", obtained from 3M Company, mounted on a robotic arm at a distance of 12 inches (30.48cm) from abrasive sheet 210U, was used to uniformly apply supersize compositions over the abrasive surface at an inline pressure of 20 psi (137.9 kPa), at coating weights of 8, 11 and 14 g/m^2. Samples were then dried for 120 minutes at 21°C. Loop attachment material was then laminated to the backside of the coated abrasive material by means of transfer tape and converted into 6-inch (15.24 cm) diameter discs.

Abrasive performance testing was performed on an 18 inches by 24 inches (45.7 cm by 61 cm) black painted cold roll steel test panels having "NEXA OEM" type clearcoat, obtained from ACT Laboratories, Inc., Hillsdale, Michigan. Sanding was performed using a random orbit sander, model "ELITE RANDOM ORBITAL SANDER", from 3M Company, operating at a line pressure of 90 psi (620.5 KPa) and 5/16-inch (7.94 mm) stroke. For testing purposes, the abrasive discs were attached to a 6-inch (15.2 cm) backup pad, commercially available under the trade designation "HOOKIT BACKUP PAD, PART NO. 05865", from 3M Company. Each abrasive disc was tested for 2 minutes, in 1-minute intervals. The test panel was weighed before and after sanding, and where the difference in mass is the measured cut, reported as grams per interval. Two abrasive discs were tested per each Comparative and Example. Results are listed in Table 2.

TABLE 2

Coated Abrasive Sample	Supersize Composition	Supersize Ctg. Wt. (g/m^2)	Total Cut (grams)
Example 21	Example 3	8.0	8.8
Example 22	Example 3	11.0	8.4
Example 23	Example 3	14.0	8.8
Example 24	Example 5	8.0	7.5
Example 25	Example 5	11.0	8.4
Example 26	Example 5	14.0	8.5
Example 27	Example 8	8.0	7.0
Example 28	Example 8	11.0	7.2
Example 29	Example 8	14.0	7.6
Example 30	Example 10	8.0	7.4
Example 31	Example 10	11.0	8.5
Example 32	Example 10	14.0	7.1
Example 33	Example 13	8.0	9.5
Example 34	Example 13	11.0	8.0
Example 35	Example 13	14.0	9.4
Example 36	Example 15	8.0	8.4
Example 37	Example 15	11.0	9.3
Example 38	Example 15	14.0	8.6
Example 39	Example 18	8.0	8.2
Example 40	Example 18	11.0	8.4
Example 41	Example 18	14.0	7.6
Example 42	Example 20	8.0	7.6
Example 43	Example 20	11.0	7.5
Example 44	Example 20	14.0	7.7

Coated Abrasive Sample	Supersize Composition	Supersize Ctg. Wt. (g/m^2)	Total Cut (grams)
Comparative B	Comparative A	8.0	7.6
Comparative C	Comparative A	11.0	7.7
Comparative D	Comparative A	14.0	8.3

All cited references, patents, and patent applications in the above application for letters patent are herein incorporated by reference in their entirety in a consistent manner. In the event of inconsistencies or contradictions between portions of the incorporated references and this application, the information in the preceding description shall control. The preceding description, given in order to enable one of ordinary skill in the art to practice the claimed disclosure, is not to be construed as limiting the scope of the disclosure, which is defined by the claims and all equivalents thereto.

CLAIMS:

What is claimed is:

1. A supersize composition for an abrasive article comprising:
    calcium stearate; and
    a sodium salt of a modified styrene acrylic copolymer.

2. The supersize composition of claim 1, wherein the sodium salt of a modified styrene acrylic copolymer is a non-film forming polymer.

3. The supersize composition of claim 1 or 2, wherein the supersize composition is essentially free of oleic acid.

4. The supersize composition of any one of claims 1-3, wherein the supersize composition further comprises clay particles present in an amount of from 0.2 percent to 5 percent by weight based on the overall weight of the supersize composition.

5. The supersize composition of claim 4, wherein the clay particles comprise a layered silicate.

6. The supersize composition of claim 5, wherein the layered silicate comprises a montmorillonite.

7. The supersize composition of claim 6, wherein the montmorillonite comprises a sodium montmorillonite, calcium montmorillonite, or combination thereof.

8. The supersize composition of any one of claims 4-7, wherein the clay particles have a median particle size of from 0.1 micrometers to 1 micrometer.

9. The supersize composition of any one of claims 1-8, wherein the calcium stearate is present in an amount of from 80 percent to 97 percent by weight based on the overall weight of the supersize composition.

10. The supersize composition of any one of claims 1-9, wherein the sodium salt of a modified styrene acrylic copolymer is present in an amount of from 0.1 percent to 20 percent by weight based on the overall weight of the supersize composition.

11. The supersize composition of claim 10, wherein the sodium salt of a modified styrene acrylic copolymer is present in an amount of from 1 percent to 12 percent by weight based on the overall weight of the supersize composition.

12. The supersize composition of claim 11, wherein the sodium salt of a modified styrene acrylic copolymer is present in an amount of from 1 percent to 8 percent by weight based on the normalized weight of the supersize composition.

13. The supersize composition of any one of claims 1-12, wherein the supersize composition displays a transmittance of at least 60 percent according to the Transmittance Test.

14. An abrasive article comprising a plurality of layers, in the following order:
 a backing;
 an abrasive layer; and
 a supersize coat comprising the supersize composition of any one of claims 1-13.

15. A method of making an abrasive article comprising:
 dispersing in water the following components to provide a dispersion:
  calcium stearate; and
  a sodium salt of a modified styrene acrylic copolymer;
 coating the dispersion onto an abrasive layer; and

removing the water from the modified styrene acrylic copolymer to provide the abrasive article.

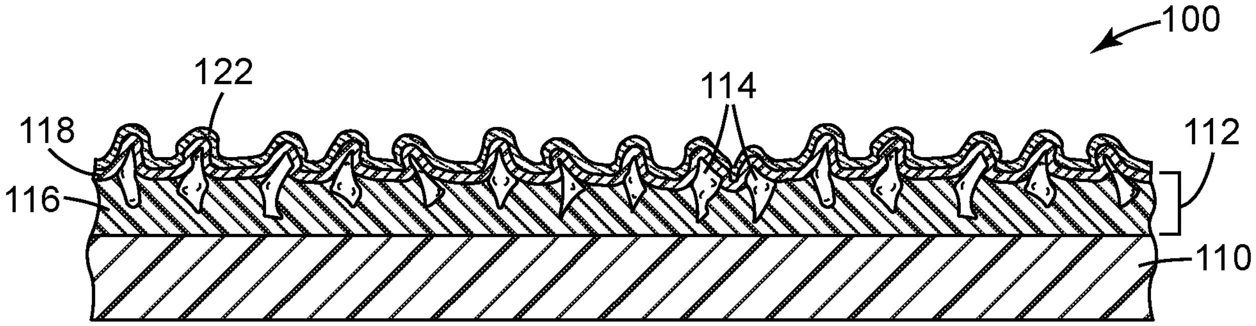

Fig. 1

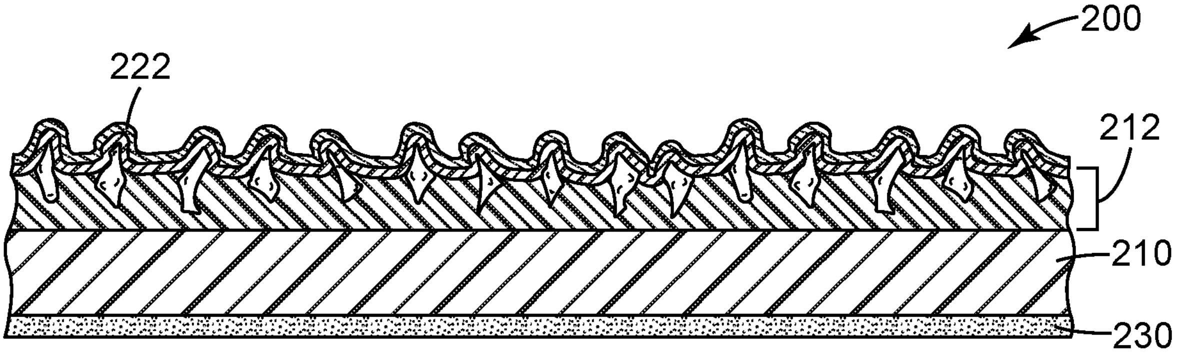

Fig. 2

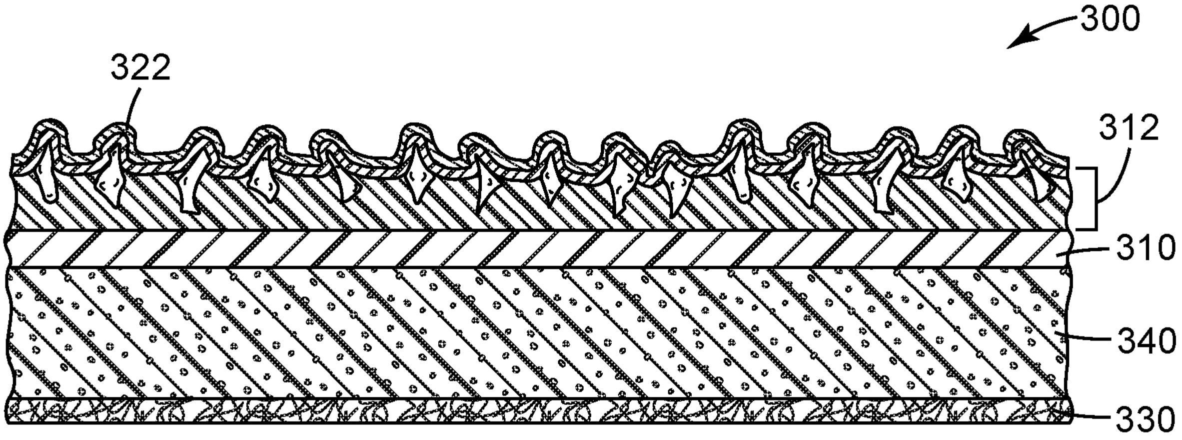

Fig. 3

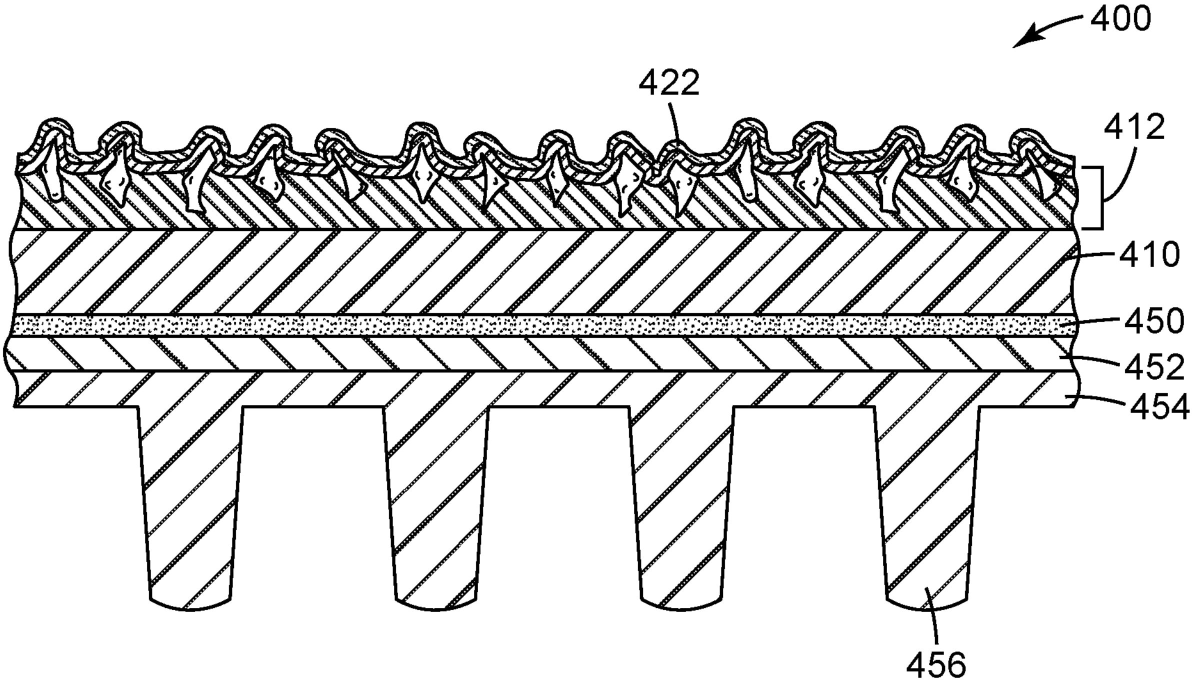

Fig. 4

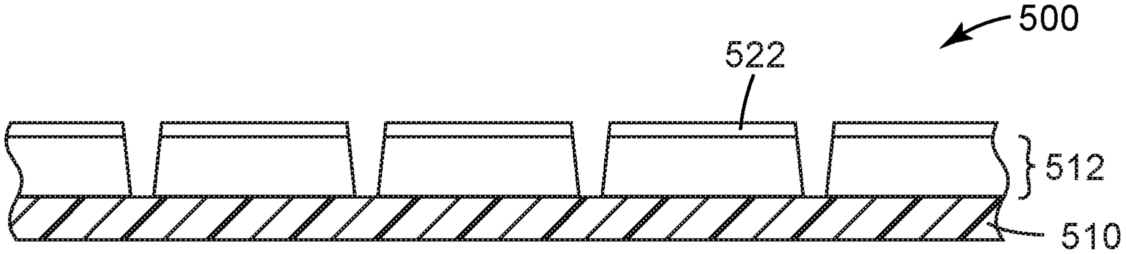

Fig. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/026591

A. CLASSIFICATION OF SUBJECT MATTER
INV. C09K3/14 B24D3/34
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)
C09K B24D

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

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y A	WO 99/15315 A1 (MINNESOTA MINING & MFG [US]) 1 April 1999 (1999-04-01) "optional additives"; page 31 - page 32	4-8 1-3,9-15
Y A	US 5 704 952 A (LAW KAM W [US] ET AL) 6 January 1998 (1998-01-06) column 21	4-8 1-3,9-15
A	WO 2008/109211 A1 (3M INNOVATIVE PROPERTIES CO [US]) 12 September 2008 (2008-09-12) page 2, line 5 - page 3, line 13	1-15

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

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search 17 July 2017	Date of mailing of the international search report 26/07/2017
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 Poole, Robert

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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