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(71) Applicant: **3M INNOVATIVE PROPERTIES COMPANY** [US/US]; 3M Center, Post Office Box 33427, Saint Paul, Minnesota 55133-3427 (US).

(72) Inventors: **THURBER, Ernest L.**; 3M Center, Post Office Box 33427, Saint Paul, Minnesota 55133-3427 (US). **SORENSEN, Gregory P.**; 3M Center, Post Office Box 33427, Saint Paul, Minnesota 55133-3427 (US). **GORODISHER, Ilya**; 3M Center, Post Office Box 33427, Saint Paul, Minnesota 55133-3427 (US). **NELSON, Thomas J.**; 3M Center, Post Office Box 33427, Saint Paul, Minnesota 55133-3427 (US). **LI, Junting**; 3M Center, Post Office Box 33427, Saint Paul, Minnesota 55133-3427 (US).

LENTZ, Daniel M.; 3M Center, Post Office Box 33427, Saint Paul, Minnesota 55133-3427 (US).

(74) Agent: **WRIGHT, Bradford B.** et al.; 3M Center, Office of Intellectual Property Counsel, Post Office Box 33427, Saint Paul, Minnesota 55133-3427 (US).

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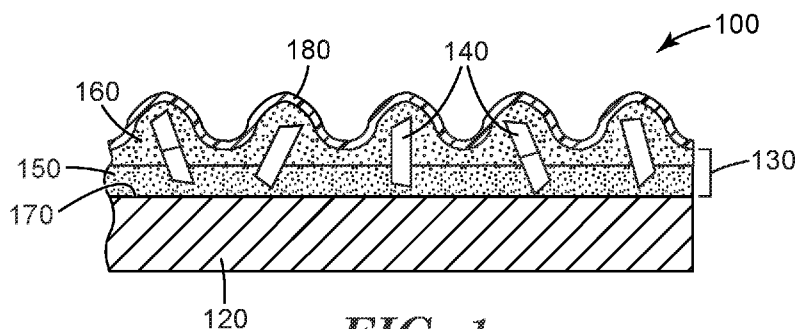


FIG. 1

(57) Abstract: A coated abrasive article comprises a backing having first and second opposed major surfaces, a make layer disposed on at least a portion of the first major surface and bonding abrasive particles to the backing, a size layer overlaid on at least a portion of the make layer and the abrasive particles, and an optional supersize layer. At least one of the size layer or the optional supersize layer comprises an at least partially cured resole phenolic resin and an organic polymeric rheology modifier, and wherein the amount of the at least partially cured resole phenolic resin comprises from 75 to 99.99 weight percent of the combined weight of the at least partially cured resole phenolic resin and the organic polymeric rheology modifier. A method of making the coated abrasive article is also disclosed.



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COATED ABRASIVE ARTICLE AND METHOD OF MAKING THE SAME

TECHNICAL FIELD

5 The present disclosure relates to abrasive articles including a phenolic binder material and abrasive particles, and methods of making the same.

BACKGROUND

10 Abrasive articles generally comprise abrasive particles (also known as "grains") retained within a binder. During manufacture of various types of abrasive articles, the abrasive particles are deposited on a binder material precursor in an oriented manner (e.g., by electrostatic coating or by some mechanical placement technique). Typically, the most desirable orientation of the abrasive particles is substantially perpendicular to the surface of the backing.

15 In the case of certain coated abrasive articles (e.g., grinding discs), the backing is a relatively dense planar substrate (e.g., vulcanized fiber or a woven or knit fabric, optionally treated with a saturant to increase durability). A make layer precursor (or make coat) containing a first binder material precursor is applied to the backing, and then the abrasive particles are partially embedded into the make layer precursor. Frequently, the abrasive particles are embedded in the make layer precursor with a degree of orientation; e.g., by electrostatic coating or by a mechanical placement technique. The make layer precursor is then at least partially cured in order to retain the abrasive particles when a size layer precursor (or size coat) containing a second binder material precursor is overlaid on the at least partially cured make layer precursor and abrasive particles. Next, the size layer precursor, and the make layer precursor if not sufficiently cured, are cured to form the coated abrasive article. In some instances, a supersize layer overlays the size layer.

20 For thermally cured size layer precursors, the coated abrasive product is often manufactured as a continuous web that is dried and cured in festoon ovens, where the web is draped over hanger bars that progress through the oven.

SUMMARY

30 Flow of the size layer precursor and/or supersize layer due to gravity can be a problem during curing in a festoon oven, especially if the abrasive particles are aligned such that flow is not impeded by the abrasive particles. However, the recent trend toward precise placement and/or orientation of the abrasive particles has increased the need for a solution to the gravity flow problem discussed above.

35 The present disclosure overcomes this problem by using a resole phenolic-based curable composition (typically thixotropic) suitable for use in manufacture of an abrasive article. The curable composition comprises a liquid phenolic resin and an organic polymeric rheology modifier comprising an alkali-swellable/soluble polymer. These organic polymeric rheology modifiers are presently discovered to provide better control of size layer precursor flow than the techniques previously used.

Organic polymeric rheology modifiers are known to give pseudoplastic flow characteristics. Particularly, Alkali-Swellable/soluble Emulsion (ASE) polymers, Hydrophobically-modified Alkali-Swellable/soluble Emulsion (HASE) polymers, and Hydrophobically-modified Ethoxylated Urethane (HEUR) polymers have been used in aqueous compositions for latex paints, personal care products, and drilling muds. As used herein, the term "Alkali-Swellable/soluble Emulsion (ASE) polymers" expressly excludes Hydrophobically-modified Alkali-Swellable/soluble Emulsion (HASE) polymers.

In a first aspect, the present disclosure provides a method of making a coated abrasive article comprising:

providing a backing having first and second opposed major surfaces, wherein a make layer is disposed on at least a portion of the first major surface and bonds abrasive particles to the backing;

coating a size layer precursor over at least a portion of the make layer and the abrasive particles, wherein the size layer precursor comprises a resole phenolic resin and an organic polymeric rheology modifier, wherein the organic polymeric rheology modifier comprises an alkali-swellable/soluble polymer, and, on a solids basis, and wherein the amount of the resole phenolic resin comprises from 75 to 99.99 weight percent of the combined weight of the resole phenolic resin and the organic polymeric rheology modifier; and

at least partially curing the size layer precursor to provide a size layer; and

optionally coating an optional supersize layer precursor over at least a portion of the size layer and at least partially curing the optional supersize layer precursor to provide an optional supersize layer,

wherein at least one of the size layer precursor or the optional supersize layer precursor comprises a resole phenolic resin and an organic polymeric rheology modifier, wherein the organic polymeric rheology modifier comprises an alkali-swellable/soluble polymer, and, on a solids basis, and wherein the amount of the resole phenolic resin comprises from 75 to 99.99 weight percent of the combined weight of the resole phenolic resin and the organic polymeric rheology modifier.

In a second aspect, the present disclosure provides a coated abrasive article comprising:

a backing having first and second opposed major surfaces,

a make layer disposed on at least a portion of the first major surface and bonding abrasive particles to the backing;

a size layer overlaid on at least a portion of the make layer and the abrasive particles; and

an optional supersize layer,

wherein at least one of the size layer or the optional supersize layer comprises an at least partially cured resole phenolic resin and an organic polymeric rheology modifier, and wherein the amount of the at least partially cured resole phenolic resin comprises from 75 to 99.99 weight percent of the combined weight of the at least partially cured resole phenolic resin and the organic polymeric rheology modifier.

As used herein:

"alkali-swellable" means at least partially swellable in an aqueous solution of a water-soluble base having a pH of greater than 7;

"alkali-swellable/soluble" means at least one of alkali-swellable or alkali-soluble (i.e., alkali-swellable and/or alkali-soluble); and

"polymer" refers to an organic polymer unless otherwise clearly indicated.

5 Features and advantages of the present disclosure will be further understood upon consideration of the detailed description as well as the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic cross-sectional side view of an exemplary coated abrasive article 100 according to the present disclosure.

10 FIG. 2 is a schematic perspective view of exemplary precisely-shaped abrasive particle 200.

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. The figures may not be drawn to scale.

15 DETAILED DESCRIPTION

An exemplary embodiment of a coated abrasive article according to the present disclosure is depicted in FIG. 1. Referring now to FIG. 1, coated abrasive article 100 has backing 120 and abrasive layer 130. Abrasive layer 130 includes abrasive particles 140 secured to major surface 170 of backing 120 by make layer 150 and size layer 160. Optional supersize layer 180 overlays size layer 160.

20 Coated abrasive articles according to the present disclosure may include additional layers such as, for example, a backing antistatic treatment layer and/or an attachment layer may also be included, if desired.

Useful backings include, for example, those known in the art for making coated abrasive articles. Typically, the backing has two opposed major surfaces, although this is not a requirement. The thickness of the backing generally ranges from about 0.02 to about 5 millimeters, desirably from about 0.05 to about 2.5 millimeters, and more desirably from about 0.1 to about 1.0 millimeter, although thicknesses outside of these ranges may also be useful. Generally, the strength of the backing should be sufficient to resist tearing or other damage during abrading processes. The thickness and smoothness of the backing should also be suitable to provide the desired thickness and smoothness of the coated abrasive article; for example, depending on the intended application or use of the coated abrasive article.

Exemplary backings include dense nonwoven fabrics (e.g., needletacked, meltspun, spunbonded, hydroentangled, or meltblown nonwoven fabrics), knitted fabrics, stitchbonded and/or woven fabrics; scrim; polymer films; treated versions thereof; and combinations of two or more of these materials.

35 Fabric backings can be made from any known fibers, whether natural, synthetic or a blend of natural and synthetic fibers. Examples of useful fiber materials include fibers or yarns comprising polyester (e.g., polyethylene terephthalate), polyamide (e.g., hexamethylene adipamide, polycaprolactam), polypropylene, acrylic, cellulose acetate, polyvinylidene chloride-vinyl chloride copolymers, vinyl

chloride-acrylonitrile copolymers, graphite, polyimide, silk, cotton, linen, jute, hemp, or rayon. Useful fibers may be of virgin materials or of recycled or waste materials reclaimed from garment cuttings, carpet manufacturing, fiber manufacturing, or textile processing, for example. Useful fibers may be homogenous or a composite such as a bicomponent fiber (for example, a co-spun sheath-core fiber). The fibers may be tensilized and crimped, but may also be continuous filaments such as those formed by an extrusion process.

The backing may have any suitable basis weight; typically, in a range of from 100 to 1250 grams per square meter (gsm), more typically 450 to 600 gsm, and even more typically 450 to 575 gsm. In many embodiments (e.g., abrasive belts and sheets), the backing typically has good flexibility; however, this is not a requirement (e.g., vulcanized fiber discs). To promote adhesion of binder resins to the backing, one or more surfaces of the backing may be modified by known methods including corona discharge, ultraviolet light exposure, electron beam exposure, flame discharge, and/or scuffing.

The make layer is formed by at least partially curing a make layer precursor comprising a thermosetting/curable composition. Examples of suitable thermosetting/curable resins that may be useful for the make layer precursor include, for example, free-radically polymerizable monomers and/or oligomers, epoxy resins, acrylic resins, urethane resins, phenolic resins, urea-formaldehyde resins, melamine-formaldehyde resins, aminoplast resins, cyanate resins, and combinations thereof. Useful binder precursors include thermally curable resins and radiation curable resins, which may be cured, for example, thermally and/or by exposure to radiation. Additional details concerning make layer precursors may be found in U.S. Pat. No. 4,588,419 (Caul et al.), U.S. Pat. No. 4,751,138 (Turney et al.), and U.S. Pat. No. 5,436,063 (Follett et al.).

The make layer precursor and the make layer may be modified by various additives (e.g., fibers, lubricants, wetting agents, surfactants, pigments, dyes, antistatic agents (e.g., carbon black, vanadium oxide, and/or graphite.), coupling agents (e.g., silanes, titanates, zircoaluminates, etc.), plasticizers, suspending agents). In some embodiments, the make layer precursor comprises a resole phenolic resin and an organic polymeric rheology modifier of a type suitable for use in a size layer and/or supersize layer precursor, and which may aid in preserving the initial placement and orientation of the abrasive particles during manufacture.

At least one of the size layer precursor and/or the optional supersize layer precursor comprises a resole phenolic resin and an organic polymeric rheology modifier.

The organic polymeric rheology modifier comprises an alkali-swellable/soluble polymer. On a solids basis, the amount of the resole phenolic resin comprises from 75 to 99.99 weight percent of the combined weight of the resole phenolic resin and the organic polymeric rheology modifier.

In embodiments, wherein the optional supersize layer precursor is present and comprises resole phenolic resin and an organic polymeric rheology modifier according to the present disclosure, the size layer precursor may comprise a different thermosetting/curable composition. Examples of suitable thermosetting/curable resins that may be useful for the size layer precursor include, for example, free-radically polymerizable monomers and/or oligomers, epoxy resins, acrylic resins, urethane resins, phenolic

resins, urea-formaldehyde resins, melamine-formaldehyde resins, aminoplast resins, cyanate resins, and combinations thereof. Useful binder precursors include thermally curable resins and radiation curable resins, which may be cured, for example, thermally and/or by exposure to radiation. Additional details concerning size layer precursors may be found in U.S. Pat. No. 4,588,419 (Caul et al.), U.S. Pat. No. 4,751,138 (Tumey et al.), and U.S. Pat. No. 5,436,063 (Follett et al.). The size layer precursor may also be modified by various additives such as, for example, fibers, lubricants, wetting agents, surfactants, pigments, dyes, antistatic agents (e.g., carbon black, vanadium oxide, and/or graphite), coupling agents (e.g., silanes, titanates, zircoaluminates, etc.), plasticizers, and/or suspending agents.

In embodiments, wherein the supersize layer precursor comprises resole phenolic resin and an organic polymeric rheology modifier, and a supersize layer is present, it may comprise components as described for the size layer precursor, or components known in the art for use as a supersize layer, for example. Examples of useful supersize layer precursor compositions include metal salts of fatty acids, urea-formaldehyde, novolac phenolic resins, epoxy resins, waxes, mineral oils, and combinations thereof.

If present, the supersize layer typically has a basis weight of 5 to 1100 grams per square meter (gsm), preferably 50 to 700 gsm, and more preferably 250 to 600 gsm, although this is not a requirement. The basis weight of the make layer, size layer, and optional supersize layer typically depend at least in part on the abrasive particle size grade and the particular type of abrasive article.

Phenolic resins are generally formed by condensation of phenol and formaldehyde, and are usually categorized as resole or novolac phenolic resins. Novolac phenolic resins are acid-catalyzed and have a molar ratio of formaldehyde to phenol of less than 1:1. Resole (also resol) phenolic resins can be catalyzed by alkaline catalysts, and the molar ratio of formaldehyde to phenol is greater than or equal to one, typically between 1.0 and 3.0, thus presenting pendant methylol groups. Alkaline catalysts suitable for catalyzing the reaction between aldehyde and phenolic components of resole phenolic resins include sodium hydroxide, barium hydroxide, potassium hydroxide, calcium hydroxide, organic amines, and sodium carbonate, all as solutions of the catalyst dissolved in water.

Resole phenolic resins are typically coated as a solution with water and/or organic solvent (e.g., alcohol). Typically, the solution includes about 70 percent to about 85 percent solids by weight, although other concentrations may be used. If the solids content is very low, then more energy is required to remove the water and/or solvent. If the solids content is very high, then the viscosity of the resulting phenolic resin is too high which typically leads to processing problems.

Phenolic resins are well-known and readily available from commercial sources. Examples of commercially available resole phenolic resins useful in practice of the present disclosure include those marketed by Durez Corporation under the trade designation VARCUM (e.g., 29217, 29306, 29318, 29338, 29353); those marketed by Ashland Chemical Co. of Bartow, Florida under the trade designation AEROFENE (e.g., AEROFENE 295); and those marketed by Kangnam Chemical Company Ltd. of Seoul, South Korea under the trade designation PHENOLITE (e.g., PHENOLITE TD-2207).

A general discussion of phenolic resins and their manufacture is given in Kirk-Othmer,

Encyclopedia of Chemical Technology, 4th Ed., John Wiley & Sons, 1996, New York, Vol. 18, pp. 603-644.

In addition to the resole phenolic resin, the curable composition contains an organic polymeric rheology modifier that comprises an alkali-swellable/soluble polymer. The curable composition comprises a resole phenolic resin (typically diluted with water) and an organic polymeric rheology modifier that comprises an alkali-swellable/soluble polymer. On a solids basis, wherein the amount of the resole phenolic resin comprises from 75 to 99.99 weight percent (preferably 82 to 99.99 weight percent, and even more preferably 88 to 99.99 weight percent) of the combined weight of the resole phenolic resin and the organic polymeric rheology modifier. Accordingly, the curable composition contains from 0.01 to 25 weight percent, preferably 0.01 to 18 weight percent, and more preferably 0.01 to 12 weight percent of the organic polymeric rheology modifier, based on the combined weight of the resole phenolic resin and the organic polymeric rheology modifier. Combinations of more than one resole phenolic resin and/or more than one organic polymeric rheology modifier may be used if desired.

Alkali-swellable/soluble polymers suitable for use as the organic polymeric rheology modifier include, for example, Alkali-Swellable/soluble Emulsion (ASE) organic polymers, Hydrophobically-modified Alkali-Swellable/soluble Emulsion polymers (HASE), and Hydrophobically modified Ethoxylated URethane polymers (HEUR).

The organic polymeric rheology modifier may be chosen from alkali-swellable/soluble acrylic emulsion polymers (ASE), Hydrophobically-modified alkali-swellable/soluble acrylic emulsion polymers (HASE), and Hydrophobically-modified Ethoxylated URethane (HEUR) organic polymers, for example.

Alkali-Swellable/soluble Emulsion (ASE) rheology modifiers are dispersions of insoluble acrylic polymers in water have a high percentage of acid groups distributed throughout their polymer chains. When these acid groups are neutralized, the salt that is formed is hydrated. Depending on the concentration of acid groups, the molecular weight and degree of crosslinking, the salt either swells in aqueous solutions or becomes completely water-soluble.

As the concentration of neutralized polymer in an aqueous formulation increases, the polymer chains swell, thereby causing the viscosity to increase.

ASE polymers can be synthesized from acid and acrylate co-monomers, and are generally made through emulsion polymerization. Exemplary commercially available ASE polymers include ACUSOL 810A, ACUSOL 830, ACUSOL 835, and ACUSOL 842 polymers.

Hydrophobically-modified Alkali-Swellable/soluble Emulsion (HASE) polymers are commonly employed to modify the rheological properties of aqueous emulsion systems. Under the influence of a base, organic or inorganic, the HASE particles gradually swell and expand to form a three-dimensional network by intermolecular hydrophobic aggregation between HASE polymer chains and/or with components of the emulsion. This network, combined with the hydrodynamic exclusion volume created by the expanded HASE chains, produces the desired thickening effect. This network is sensitive to applied stress, breaks down under shear and recovers when the stress is relieved.

HASE rheology modifiers can be prepared from the following monomers: (a) an ethylenically unsaturated carboxylic acid, (b) a nonionic ethylenically unsaturated monomer, and (c) an ethylenically unsaturated hydrophobic monomer. Representative HASE polymer systems include those shown in EP 226097 B1 (van Phung et al.), EP 705852 B1 (Doolan et al.), U.S. Pat. No. 4,384,096 (Sonnabend) and U.S. Pat. No. 5,874,495 (Robinson).

Exemplary commercially available HASE polymers include those marketed by Dow Chemical under the trade designations ACUSOL 801S, ACUSOL 805S, ACUSOL 820, and ACUSOL 823.

ASE and HASE rheology modifiers are pH-triggered thickeners. Whether the emulsion polymer in each is water-swellaible or water-soluble typically depends on its molecular weight. Both forms are acceptable. Further details concerning synthesis of ASE and HASE polymers can be found, for example, in U.S. Pat. No. 9,631,165 (Droege et al.).

Hydrophobically-modified Ethoxylated URethane (HEUR) polymers are generally synthesized from an alcohol, a diisocyanate and one or more polyalkylene glycols. HEURs are water-soluble polymers containing hydrophobic groups, and are classified as associative thickeners because the hydrophobic groups associate with one another in water. Unlike HASEs, HEURs are nonionic substances and are not dependent on alkali for activation of the thickening mechanism. They develop intra- or intermolecular links as their hydrophobic groups associate with other hydrophobic ingredients in a given formulation. As a general rule, the strength of the association depends on the number, size, and frequency of the hydrophobic capping or blocking units. HEURs develop micelles as would a normal surfactant. The micelles then link between the other ingredients by associating with their surfaces. This builds a three-dimensional network.

Exemplary commercially available HEUR polymers include those marketed by Dow Chemical under the trade designations ACUSOL 880, ACUSOL 882, ACRY SOL RM-2020, and ACRY SOL RM-8W.

Further details concerning HEURs can be found, for example, in U.S. Pat. Appl. Publ. No. 2017/0198238 (Kensicher et al.) and 2017/0130072 (McCulloch et al.) and U.S. Pat. Nos. 7,741,402 (Bobsein et al.) and 8,779,055 (Rabasco et al.).

The make layer, size layer, and optional supersize layer are formed by at least partially curing corresponding precursors (i.e., a make layer precursor, a size layer precursor, a supersize layer precursor).

The make layer, size layer, and optional supersize layer and their precursors may also contain additives such as fibers, lubricants, wetting agents, surfactants, pigments, dyes, antistatic agents (e.g., carbon black, vanadium oxide, and/or graphite), coupling agents (e.g., silanes, titanates, and/or zircoaluminates), plasticizers, suspending agents, and the like. The amounts of these optional additives are selected to provide the preferred properties. The coupling agents can improve adhesion to the abrasive particles and/or filler. The curable composition may be thermally-cured, radiation-cured, or a combination thereof.

The make layer, size layer, and optional supersize layer and their precursors may also contain filler

materials, diluent abrasive particles (e.g., as described hereinbelow), or grinding aids, typically in the form of a particulate material. Typically, the particulate materials are inorganic materials. Examples of useful fillers for this disclosure include: metal carbonates (e.g., calcium carbonate (e.g., chalk, calcite, marl, travertine, marble and limestone), calcium magnesium carbonate, sodium carbonate, magnesium carbonate), silica (e.g., quartz, glass beads, glass bubbles and glass fibers) silicates (e.g., talc, clays, (montmorillonite) feldspar, mica, calcium silicate, calcium metasilicate, sodium aluminosilicate, sodium silicate) metal sulfates (e.g., calcium sulfate, barium sulfate, sodium sulfate, aluminum sodium sulfate, aluminum sulfate), gypsum, vermiculite, wood flour, aluminum trihydrate, carbon black, metal oxides (e.g., calcium oxide (lime), aluminum oxide, titanium dioxide), and metal sulfites (e.g., calcium sulfite).

Heat energy is commonly applied to advance curing of the thermosetting/curable resins used in the make layer precursor/size layer precursor, and optionally in the supersize layer precursor; however, other sources of energy (e.g., microwave radiation, infrared light, ultraviolet light, visible light, may also be used). The selection will generally be dictated by the particular resin system selected.

Useful abrasive particles may be the result of a crushing operation (e.g., crushed abrasive particles that have been sorted for shape and size) or the result of a shaping operation (i.e., shaped abrasive particles) in which an abrasive precursor material is shaped (e.g., molded), dried, and converted to ceramic material. Combinations of abrasive particles resulting from crushing with abrasive particles resulting from a shaping operation may also be used. The abrasive particles may be in the form of, for example, individual particles, agglomerates, composite particles, and mixtures thereof.

The abrasive particles should have sufficient hardness and surface roughness to function as crushed abrasive particles in abrading processes. Preferably, the abrasive particles have a Mohs hardness of at least 4, at least 5, at least 6, at least 7, or even at least 8.

Suitable abrasive particles include, for example, crushed abrasive particles comprising fused aluminum oxide, heat-treated aluminum oxide, white fused aluminum oxide, ceramic aluminum oxide materials such as those commercially available as 3M CERAMIC ABRASIVE GRAIN from 3M Company, St. Paul, Minnesota, brown aluminum oxide, blue aluminum oxide, silicon carbide (including green silicon carbide), titanium diboride, boron carbide, tungsten carbide, garnet, titanium carbide, diamond, cubic boron nitride, garnet, fused alumina zirconia, iron oxide, chromia, zirconia, titania, tin oxide, quartz, feldspar, flint, emery, sol-gel-derived ceramic (e.g., alpha alumina), and combinations thereof. Examples of sol-gel-derived abrasive particles from which the abrasive particles can be isolated, and methods for their preparation can be found, in U.S. Pat. Nos. 4,314,827 (Leitheiser et al.); 4,623,364 (Cottringer et al.); 4,744,802 (Schwabel), 4,770,671 (Monroe et al.); and 4,881,951 (Monroe et al.). It is also contemplated that the abrasive particles could comprise abrasive agglomerates such, for example, as those described in U.S. Pat. Nos. 4,652,275 (Bloecher et al.) or 4,799,939 (Bloecher et al.). In some embodiments, the abrasive particles may be surface-treated with a coupling agent (e.g., an organosilane coupling agent) or other physical treatment (e.g., iron oxide or titanium oxide) to enhance adhesion of the crushed abrasive particles to the binder. The abrasive particles may be treated before combining them with

the binder, or they may be surface treated in situ by including a coupling agent to the binder.

Preferably, the abrasive particles (and especially the abrasive particles) comprise ceramic abrasive particles such as, for example, sol-gel-derived polycrystalline alpha alumina particles. Ceramic abrasive particles composed of crystallites of alpha alumina, magnesium alumina spinel, and a rare earth hexagonal aluminate may be prepared using sol-gel precursor alpha alumina particles according to methods described in, for example, U.S. Pat. No. 5,213,591 (Celikkaya et al.) and U.S. Publ. Pat. Appln. Nos. 2009/0165394 A1 (Culler et al.) and 2009/0169816 A1 (Erickson et al.). Further details concerning methods of making sol-gel-derived abrasive particles can be found in, for example, U.S. Pat. Nos. 4,314,827 (Leitheiser); 5,152,917 (Pieper et al.); 5,435,816 (Spurgeon et al.); 5,672,097 (Hoopman et al.); 5,946,991 (Hoopman et al.); 5,975,987 (Hoopman et al.); and 6,129,540 (Hoopman et al.); and in U.S. Publ. Pat. Appln. No. 2009/0165394 A1 (Culler et al.).

In some preferred embodiments, useful abrasive particles (especially in the case of the abrasive particles) may be shaped abrasive particles can be found in U.S. Pat. Nos. 5,201,916 (Berg); 5,366,523 (Rowenhorst (Re 35,570)); and 5,984,988 (Berg). U.S. Pat. No. 8,034,137 (Erickson et al.) describes alumina abrasive particles that have been formed in a specific shape, then crushed to form shards that retain a portion of their original shape features. In some embodiments, the abrasive particles are precisely-shaped (i.e., the particles have shapes that are at least partially determined by the shapes of cavities in a production tool used to make them. Details concerning such abrasive particles and methods for their preparation can be found, for example, in U.S. Pat. Nos. 8,142,531 (Adefris et al.); 8,142,891 (Culler et al.); 8,142,532 (Erickson et al.); 9,771,504 (Adefris); and in U.S. Pat. Appl. Publ. Nos. 2012/0227333 (Adefris et al.); 2013/0040537 (Schwabel et al.); and 2013/0125477 (Adefris). One particularly useful precisely-shaped abrasive particle shape is that of a platelet having three-sidewalls, any of which may be straight or concave, and which may be vertical or sloping with respect to the platelet base; for example, as set forth in the above cited references. An exemplary such precisely-shaped abrasive particle 200 is shown in FIG. 2.

Surface coatings on the abrasive particles may be used to improve the adhesion between the abrasive particles and a binder material, or to aid in electrostatic deposition of the abrasive particles. In one embodiment, surface coatings as described in U.S. Pat. No. 5,352,254 (Celikkaya) in an amount of 0.1 to 2 percent surface coating to abrasive particle weight may be used. Such surface coatings are described in U.S. Pat. Nos. 5,213,591 (Celikkaya et al.); 5,011,508 (Wald et al.); 1,910,444 (Nicholson); 3,041,156 (Rowse et al.); 5,009,675 (Kunz et al.); 5,085,671 (Martin et al.); 4,997,461 (Markhoff-Matheny et al.); and 5,042,991 (Kunz et al.). Additionally, the surface coating may prevent shaped abrasive particles from capping. Capping is the term to describe the phenomenon where metal particles from the workpiece being abraded become welded to the tops of the abrasive particles. Surface coatings to perform the above functions are known to those of skill in the art.

In some embodiments, the abrasive particles may be selected to have a length and/or width in a range of from 0.1 micrometers to 3.5 millimeters (mm), more typically 0.05 mm to 3.0 mm, and more typically 0.1 mm to 2.6 mm, although other lengths and widths may also be used.

The abrasive particles may be selected to have a thickness in a range of from 0.1 micrometer to 1.6 mm, more typically from 1 micrometer to 1.2 mm, although other thicknesses may be used. In some embodiments, abrasive particles may have an aspect ratio (length to thickness) of at least 2, 3, 4, 5, 6, or more.

5 Abrasive particles may be independently sized according to an abrasives industry recognized specified nominal grade. Exemplary abrasive industry recognized grading standards include those promulgated by ANSI (American National Standards Institute), FEPA (Federation of European Producers of Abrasives), and JIS (Japanese Industrial Standard). Such industry accepted grading standards include, for example: ANSI 4, ANSI 6, ANSI 8, ANSI 16, ANSI 24, ANSI 30, ANSI 36, ANSI 40, ANSI 50, ANSI
10 60, ANSI 80, ANSI 100, ANSI 120, ANSI 150, ANSI 180, ANSI 220, ANSI 240, ANSI 280, ANSI 320, ANSI 360, ANSI 400, and ANSI 600; FEPA P8, FEPA P12, FEPA P16, FEPA P24, FEPA P30, FEPA P36, FEPA P40, FEPA P50, FEPA P60, FEPA P80, FEPA P100, FEPA P120, FEPA P150, FEPA P180, FEPA P220, FEPA P320, FEPA P400, FEPA P500, FEPA P600, FEPA P800, FEPA P1000, FEPA P1200; FEPA F8, FEPA F12, FEPA F16, and FEPA F24; and JIS 8, JIS 12, JIS 16, JIS 24, JIS 36, JIS 46, JIS 54,
15 JIS 60, JIS 80, JIS 100, JIS 150, JIS 180, JIS 220, JIS 240, JIS 280, JIS 320, JIS 360, JIS 400, JIS 600, JIS 800, JIS 1000, JIS 1500, JIS 2500, JIS 4000, JIS 6000, JIS 8000, and JIS 10,000. More typically, the crushed aluminum oxide particles and the non-seeded sol-gel derived alumina-based abrasive particles are independently sized to ANSI 60 and 80, or FEPA F36, F46, F54 and F60 or FEPA P60 and P80 grading standards.

20 Alternatively, the abrasive particles can be graded to a nominal screened grade using U.S.A. Standard Test Sieves conforming to ASTM E-11 "Standard Specification for Wire Cloth and Sieves for Testing Purposes". ASTM E-11 prescribes the requirements for the design and construction of testing sieves using a medium of woven wire cloth mounted in a frame for the classification of materials according to a designated particle size. A typical designation may be represented as -18+20 meaning that the shaped
25 abrasive particles pass through a test sieve meeting ASTM E-11 specification for the number 18 sieve and are retained on a test sieve meeting ASTM E-11 specification for the number 20 sieve. In one embodiment, the shaped abrasive particles have a particle size such that most of the particles pass through an 18 mesh test sieve and can be retained on a 20, 25, 30, 35, 40, 45, or 50 mesh test sieve. In various embodiments, the shaped abrasive particles can have a nominal screened grade
30 comprising: -18+20, -20+25, -25+30, -30+35, -35+40, -40+45, -45+50, -50+60, -60+70, -70+80, -80+100, -100+120, -120+140, -140+170, -170+200, -200+230, -230+270, -270+325, -325+400, -400+450, -450+500, or -500+635. Alternatively, a custom mesh size could be used such as -90+100.

A grinding aid is a material that has a significant effect on the chemical and physical processes of abrading, which results in improved performance. Grinding aids encompass a wide variety of different
35 materials and can be inorganic or organic based. Examples of chemical groups of grinding aids include waxes, organic halide compounds, halide salts and metals and their alloys. The organic halide compounds will typically break down during abrading and release a halogen acid or a gaseous halide compound.

Examples of such materials include chlorinated waxes like tetrachloronaphthalene, pentachloronaphthalene, and polyvinyl chloride. Examples of halide salts include sodium chloride, potassium cryolite, sodium cryolite, ammonium cryolite, potassium tetrafluoroborate, sodium tetrafluoroborate, silicon fluorides, potassium chloride, and magnesium chloride. Examples of metals include, tin, lead, bismuth, cobalt, antimony, cadmium, iron, and titanium.

Other miscellaneous grinding aids include sulfur, organic sulfur compounds, graphite, and metallic sulfides. A combination of different grinding aids may be used, and in some instances, this may produce a synergistic effect.

Grinding aids can be particularly useful in coated abrasives. In coated abrasive articles, grinding aid is typically used in a supersize layer, which is applied over the surface of the size layer. Sometimes, however, the grinding aid is added to the size layer. Typically, the amount of grinding aid incorporated into coated abrasive articles are about 50-800 grams per square meter (g/m^2), preferably about 80-475 g/m^2 , however, this is not a requirement.

Further details regarding coated abrasive articles and methods of their manufacture can be found, for example, in U.S. Pat. Nos. 4,734,104 (Broberg); 4,737,163 (Larkey); 5,203,884 (Buchanan et al.); 5,152,917 (Pieper et al.); 5,378,251 (Culler et al.); 5,436,063 (Follett et al.); 5,496,386 (Broberg et al.); 5,609,706 (Benedict et al.); 5,520,711 (Helmin); 5,961,674 (Gagliardi et al.), and 5,975,988 (Christianson).

Coated abrasive articles according to the present disclosure are useful, for example, for abrading a workpiece. Such a method may comprise frictionally contacting an abrasive article according to the present disclosure with a surface of the workpiece, and moving at least one of the coated abrasive article and the surface of the workpiece relative to the other to abrade at least a portion of the surface of the workpiece. Methods for abrading with coated abrasive articles according to the present disclosure include, for example, snagging (i.e., high-pressure high stock removal) to polishing (e.g., polishing medical implants with coated abrasive belts), wherein the latter is typically done with finer grades (e.g., ANSI 220 and finer) of abrasive particles. The size of the abrasive particles used for a particular abrading application will be apparent to those skilled in the art.

Abrading may be carried out dry or wet. For wet abrading, the liquid may be introduced supplied in the form of a light mist to complete flood. Examples of commonly used liquids include water, water-soluble oil, organic lubricant, and emulsions. The liquid may serve to reduce the heat associated with abrading and/or act as a lubricant. The liquid may contain minor amounts of additives such as bactericide, antifoaming agents, and the like.

Examples of workpieces include aluminum metal, carbon steels, mild steels (e.g., 1018 mild steel and 1045 mild steel), tool steels, stainless steel, hardened steel, titanium, glass, ceramics, wood, wood-like materials (e.g., plywood and particle board), paint, painted surfaces, and organic coated surfaces. The applied force during abrading typically ranges from about 1 to about 100 kilograms (kg), although other

pressures can also be used.

SELECT EMBODIMENTS OF THE PRESENT DISCLOSURE

In a first embodiment, the present disclosure provides a method of making a coated abrasive article comprising:

providing a backing having first and second opposed major surfaces, wherein a make layer is disposed on at least a portion of the first major surface and bonds abrasive particles to the backing;

coating a size layer precursor over at least a portion of the make layer and the abrasive particles, wherein the size layer precursor comprises a resole phenolic resin and an organic polymeric rheology modifier, wherein the organic polymeric rheology modifier comprises an alkali-swellable/soluble polymer, and, on a solids basis, and wherein the amount of the resole phenolic resin comprises from 75 to 99.99 weight percent of the combined weight of the resole phenolic resin and the organic polymeric rheology modifier; and

at least partially curing the size layer precursor to provide a size layer; and

optionally coating an optional supersize layer precursor over at least a portion of the size layer and at least partially curing the optional supersize layer precursor to provide an optional supersize layer,

wherein at least one of the size layer precursor or the optional supersize layer precursor comprises a resole phenolic resin and an organic polymeric rheology modifier, wherein the organic polymeric rheology modifier comprises an alkali-swellable/soluble polymer, and, on a solids basis, and wherein the amount of the resole phenolic resin comprises from 75 to 99.99 weight percent of the combined weight of the resole phenolic resin and the organic polymeric rheology modifier.

In a second embodiment, the present disclosure provides a method according to the first embodiment, wherein at least one of said at least partially curing the size layer precursor or said at least partially curing the supersize layer precursor occurs in a festoon oven.

In a third embodiment, the present disclosure provides a method according to the first or second embodiment, wherein at least one of the size layer precursor or the optional supersize layer precursor has a basis weight of 5 to 1100 grams per square meter.

In a fourth embodiment, the present disclosure provides a method according to any of the first to third embodiments, wherein the organic polymeric rheology modifier is selected from the group consisting of alkali-swellable/soluble acrylic polymers, hydrophobically-modified alkali-swellable/soluble acrylic polymers, hydrophobically-modified ethoxylated urethane polymers, and combinations thereof.

In a fifth embodiment, the present disclosure provides a method according to any of the first to fourth embodiments, wherein, on a solids basis, the amount of the resole phenolic resin comprises from 85 to 99.99 weight percent of the combined weight of the resole phenolic resin and the organic polymeric rheology modifier.

In a sixth embodiment, the present disclosure provides a method according to any of the first to fifth embodiments, wherein the abrasive particles comprise shaped abrasive particles.

In a seventh embodiment, the present disclosure provides a method according to the sixth embodiment, wherein the shaped abrasive particles comprise precisely-shaped abrasive particles.

In an eighth embodiment, the present disclosure provides a method according to the sixth embodiment, wherein the shaped abrasive particles comprise precisely-shaped three-sided platelets.

5 In a ninth embodiment, the present disclosure provides a coated abrasive article comprising:
a backing having first and second opposed major surfaces,
a make layer disposed on at least a portion of the first major surface and bonding abrasive particles to the backing;

10 a size layer overlaid on at least a portion of the make layer and the abrasive particles; and
an optional supersize layer,

wherein at least one of the size layer or the optional supersize layer comprises an at least partially cured resole phenolic resin and an organic polymeric rheology modifier, and wherein the amount of the at least partially cured resole phenolic resin comprises from 75 to 99.99 weight percent of the combined weight of the at least partially cured resole phenolic resin and the organic polymeric rheology modifier.

15 In a tenth embodiment, the present disclosure provides a coated abrasive article according to the ninth embodiment, wherein the organic polymeric rheology modifier is selected from the group consisting of alkali-swellable/soluble acrylic polymers, hydrophobically-modified alkali-swellable/soluble acrylic polymers, hydrophobically-modified ethoxylated urethane polymers, and combinations thereof.

20 In an eleventh embodiment, the present disclosure provides a coated abrasive article according to the ninth or tenth embodiment, wherein the amount of the at least partially cured resole phenolic resin comprises from 85 to 99.99 weight percent of the combined weight of the at least partially cured resole phenolic resin and the organic polymeric rheology modifier.

In a twelfth embodiment, the present disclosure provides a coated abrasive article according to any of the ninth to eleventh embodiments, wherein the abrasive particles comprise shaped abrasive particles.

25 In a thirteenth embodiment, the present disclosure provides a coated abrasive article according to the twelfth embodiment, wherein the shaped abrasive particles comprise precisely-shaped abrasive particles.

30 In a fourteenth embodiment, the present disclosure provides a coated abrasive article according to the twelfth embodiment, wherein the shaped abrasive particles comprise precisely-shaped three-sided platelets.

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.

35 EXAMPLES

Unless otherwise noted, all parts, percentages, ratios, etc. in the Examples and the rest of the specification are by weight.

TABLE OF MATERIALS USED IN THE EXAMPLES

ABBREVIATION	DESCRIPTION AND SOURCE
PF	Resole resin (75 wt. % in water), a phenol: formaldehyde (molar ratio of 1:1.5 to 1:2.1) condensate catalyzed by 1 to 5% metal hydroxide. Obtained from Georgia Pacific, Atlanta, Georgia.
ADD 1	A hydrophobically modified alkali swellable acrylic polymer emulsion (HASE) obtained as ACUSOL 820 from The Dow Chemical Company, Midland, Michigan. Obtained as an aqueous emulsion with 29.77 % solids content.
ADD 2	An alkali swellable acrylic polymer emulsion (ASE) obtained as ACUSOL 835 from The Dow Chemical Company. Obtained as an aqueous emulsion with 28.75 % solids content.
ADD 3	An alkali swellable acrylic polymer emulsion (ASE) obtained as RHEOVIS AS 1130 from BASF, Florham Park, New Jersey. Obtained as an aqueous emulsion with 31.3 % solids content.
ADD 4	Hydrophilic amorphous fumed silica obtained as CAB-O-SIL M-5 from Cabot Corporation, Alpharetta, Georgia.
ADD 5	Hydrophilic amorphous fumed silica dispersed in water at 18% solids obtained under the trade designation Cab-O-Sperse from Cabot Corporation.
FIL1	Calcium silicate obtained under the trade designation M400 WOLLASTOCOAT. Obtained from NYCO, Willsboro, New York.
FIL2	Cryolite obtained under the trade designation CRYOLITE RTN-C. Obtained from FREEBEE A'S, Ullerslev, Denmark.
FIL3	Potassium tetrafluoroborate obtained from AWSM industries, Paramus, NJ, under trade designation potassium fluoroborate.
FIL4	Calcium silicate obtained as 400 WOLLASTOCOAT 10014 from NYCO, Willsboro, New York

RIO	Red iron oxide pigment obtained under the trade designation KROMA RO-3097, from Elementis, East Saint Louis, Illinois.
Surf 1	Surfactant obtained under trade designation Aerosol OT-NV, from Cytec-Solvay Group, Stamford, Connecticut.
Surf 2	Surfactant obtained under trade designation Foamstar ST 2425 (formerly ST 125), from BASF Corporation.
SAP1	Shaped abrasive particles were prepared according to the disclosure of U.S. Pat. No. 8,142,531 (Adefris et al). The shaped abrasive particles were prepared by molding alumina sol gel in equilateral triangle-shaped polypropylene mold cavities. After drying and firing, the resulting shaped abrasive particles, which were shaped as truncated triangular pyramids, were about 1.4 mm (side length) × 0.35 mm (thickness), with a draft angle approximately 98 degrees.

Preparation of Size and Supersize Examples and Comparative Examples

5 Examples and comparative examples were prepared by massing all components into 3-Liter or 70-mm diameter polypropylene straight-walled jars according to the amounts indicated in Tables 1-4. Jars or containers were mixed with an overhead stirrer. If the mixture was not used for testing immediately it was stored in a refrigerator at 10 °C until use.

TABLE 1

SIZE RESIN PRECURSOR COMPONENT	COMPARATIVE EXAMPLE	
	CE-A	CE-B
PF (amount in grams)	1263.2	1062.4
FIL1 (amount in grams)	664.1	1643.4
FIL 2 (amount in grams)	664.1	0
RIO (amount in grams)	46.4	49.8
Water (amount in grams)	362.2	244.4
% Solids	77.4	83

TABLE 2

SIZE RESIN PRECURSOR COMPONENT	COMPARATIVE EXAMPLE				
	CE-C	CE-D	CE-E	CE-F	CE-G
CE-A (amount in grams)	199.50	199.00	198.50	198.00	99.50
ADD 4 (amount in grams)	0.50	1.00	1.50	2.00	
ADD 5 (amount in grams)					3.00
% Total Solids	77.46	77.51	77.57	77.63	75.66

5

TABLE 3

SIZE RESIN PRECURSOR COMPONENT	COMPARATIVE EXAMPLE	
	CE-H	CE-I
CE-B (amount in grams)	199.00	99.50
ADD 4 (amount in grams)	1.00	
ADD 5 (amount in grams)		3.00
% Total Solids	83.09	81.10

TABLE 4

EXAMPLES EX-1 THROUGH EX-13													
SIZE LAYER PRECURSOR COMPONENT	EX-1	EX-2	EX-3	EX-4	EX-5	EX-6	EX-7	EX-8	EX-9	EX-10	EX-11	EX-12	EX-13
CE-A (amount in grams)	99.25	99.75	99.75	99.75	99.75	99.75	99.75	99.75	99.25	99.75	99.75	99.75	99.75
ADD 1 (amount in grams)					0.20	0.10	0.05						
ADD 2 (amount in grams)	0.8g	0.41	0.20	0.10	0.05								
ADD 3 (amount in grams)									0.80	0.41	0.20	0.10	0.05
% Total Solids	77.01	77.20	77.30	77.35	77.38	77.30	77.35	77.38	77.03	77.21	77.31	77.35	77.38

TABLE 5
EXAMPLES EX-14 TO EX-16

SIZE LAYER PRECURSOR COMPONENT	EX-14	EX-15	EX-16	EX-17	EX-18	EX-19	EX-20	EX-21	EX-22	EX-23	EX-24	EX-25	EX-26
CE-B (amount in grams)	99.25	99.75	99.75	99.75	99.75	99.75	99.75	99.75	99.25	99.75	99.75	99.75	99.75
ADD 1 (amount in grams)						0.20	0.10	0.05					
ADD 2 (amount in grams)	0.80	0.41	0.20	0.10	0.05								
ADD 3 (amount in grams)									0.80	0.41	0.20	0.10	0.05
% Total Solids	82.57	82.78	82.89	82.95	82.97	82.89	82.95	82.97	82.59	82.79	82.90	82.95	82.97

TABLE 6

SIZE LAYER PRECURSOR COMPONENT	EXAMPLES	
	EX-27	EX-28
CE-A (amount in grams)	198.00	
CE-B (amount in grams)		198.00
ADD 2 (amount in grams)	3.40	3.40
% Total Solids	76.58	82.08

TABLE 7

SUPERSIZE LAYER PRECURSOR COMPONENT	COMPARATIVE EXAMPLE CE-J
PF (amount in grams)	149
FIL3 (amount in grams)	433
SURF 1 (amount in grams)	8.63
SURF 2 (amount in grams)	2.75
Water (amount in grams)	160
% Total Solids	73.82

5

TABLE 8

SUPERSIZE LAYER PRECURSOR COMPONENT	COMPARATIVE EXAMPLE	
	CE-K	CE-L
CE-J (amount in grams)	99.60	99.75
ADD 4 (amount in grams)	0.40	0.25
% Total Solids	73.92	73.89

TABLE 9

SUPERSIZE LAYER PRECURSOR COMPONENT	EXAMPLE	
	EX-29	EX-30
CE-I (amount in grams)	98.00	99.00
ADD 2 (amount in grams)	2.00	1.00
% Total Solids	72.92	73.37

Inclined Plane Flow Test for Size and Supersize Layer Precursor Examples and Comparative Examples

The incline flow rate test involved placing 0.1 gram drop of resin at specified temperature onto horizontal positioned glass slide and then quickly tilting glass slide on incline device set at 48.7° angle from horizontal for one minute. The distance the resin travels in one minute is measured in millimeters (mm). The smaller the distance the less likely size or supersize resin will have excessive flow and cause bottom loop puddling in the festoon curing ovens. The incline data for Size Resin examples and comparative examples are reported in Tables 10 and 11. Supersize Resin examples and comparative examples are shown in Table 12.

TABLE 10

EXAMPLE / COMPARATIVE EXAMPLE	INCLINE PLANE FLOW TEST DATA FOR SIZE LAYER PRECURSORS BASED ON COMPARATIVE EXAMPLE CE-A	
	% SOLID ADDITIVE/% TOTAL SOLIDS	INCLINE TEST AT 41°C - DISTANCE TRAVELED (MM)
CE-A	0	44
CE-C	0.32	46
CE-D	0.65	28
CE-E	0.97	11
CE-F	1.29	10
CE-G	0.7	36
EX-1	0.3	0
EX-2	0.15	0
EX-3	0.07	5
EX-4	0.04	5
EX-5	0.02	0
EX-6	0.08	4
EX-7	0.04	0
EX-8	0.02	5
EX-9	0.32	0

EX-10	0.17	0
EX-11	0.08	4
EX-12	0.04	7
EX-13	0.02	3

TABLE 11

EXAMPLE / COMPARATIVE EXAMPLE	INCLINE PLANE FLOW TEST DATA FOR SIZE LAYER PRECURSORS BASED ON COMPARATIVE EXAMPLE CE-B	
	% SOLID ADDITIVE/% TOTAL SOLIDS	INCLINE TEST AT 41°C - DISTANCE TRAVELED (MM)
CE-B	0	44
CE-M	0.6	28
CE-P	0.65	35
EX-14	0.28	15
EX-15	0.14	0
EX-16	0.07	0
EX-17	0.03	0
EX-18	0.02	6
EX-19	0.07	0
EX-20	0.04	0
EX-21	0.02	0
EX-22	0.3	6
EX-23	0.16	7
EX-24	0.08	0
EX-25	0.04	4
EX-26	0.02	17

TABLE 12

EXAMPLE / COMPARATIVE EXAMPLE	INCLINE PLANE FLOW TEST DATA FOR SUPERSIZE LAYER PRECURSORS BASED ON COMPARATIVE EXAMPLE CE-J	
	% SOLID ADDITIVE/% TOTAL SOLIDS	INCLINE TEST AT ROOM TEMPERATURE - DISTANCE TRAVELED (MM)
CE-J	0	34
CE-K	0.54	17
CE-L	0.34	16

EX-29	0.79	6
EX-30	0.39	8

Viscosity Measurement Test Method

The flow characteristics of the phenolic copolymer mixtures were characterized by continuous flow rheometry using a TA Instruments Discovery Hybrid Rheometer 3 (TA Instruments, New Castle, Delaware) equipped with a stainless steel concentric cylinder geometry utilizing a conical end rotor with a 28.01 mm diameter and 41.96mm height, cup with a 30.35 mm diameter, and a TA instruments DHR & AR-Series Smart Swap Concentric Cylinder Peltier jacket for temperature control. Samples approximately 24 milliliters in volume were loaded onto the geometry cup via polypropylene syringe and the rotor was brought to a gap height 5.919 mm. An aluminum collar was fitted on the top of the cup to minimize water evaporation from the sample, while allowing free rotation of the rotor. Individual samples were thermally equilibrated in the instrument for 300 seconds before testing. The stress dependent flow behavior of the mixtures was investigated at 20, 40, and 60 °C using a logarithmic ramp over 180 seconds from 0.001 – 3000 pascals (Pa) applied stress selecting 10 individual rates per decade. Table 13, below, reports the viscosity measured at 0.01 s⁻¹ and 100 s⁻¹ for all samples tested.

15

TABLE 13

EXAMPLE / COMPARATIVE EXAMPLE	TEMPERATURE, °C	VISCOSITY, Pa·s	
		10 ⁻² s ⁻¹	10 ² s ⁻¹
CE-B	20	27.84	1.307
CE-A	20	158.00	0.600
EX 28	20	506.30	11.780
	40	838.60	5.707
	60	1550.00	3.568
EX 27	20	40.39	2.554
	40	21.17	1.106
	60	52.34	0.479

Preparation of Coated Abrasive Size and Supersize Resin Examples and Comparative Examples

Make Layer Precursor

5 A make layer precursor was prepared charging a 17-liter pail with 7812 grams of PF, 6823 grams of FIL4 and 364 grams of water. The resin was mixed with an overhead stirrer for 30 minutes at room temperature.

Size Layer Precursor - Comparative Example CE-M

10 Coated abrasive examples and comparative examples were prepared by roll coating make resin (described above) onto a continuous 30.48 cm wide polyester backing (described in Example 12 of U.S. Pat. No. 6,843,815 Thurber et al.) at a coating weight of 210 grams per square meter (gsm) followed by electrostatically coating mineral SAP1 at a weight of 605 gsm. The coated material was cured at 90°C for 90 minutes and at 102°C for 60 minutes. The resultant material was then roll coated with size resin Comparative Example CE-A at a size weight of 567 gsm. The material was final cured at 90°C for 60
15 minutes and at 102°C for 12 hours.

Size Layer Precursor - Example EX-31

20 Coated abrasive examples and comparative examples were prepared by roll coating make resin (described above) onto a continuous 30.48 cm wide polyester backing (described in Example 12 of U.S. Pat. No. 6,843,815 Thurber et al.) at a coating weight of 210 gsm followed by electrostatically coating mineral SAP1 at a weight of 605 gsm. The coated material was cured at 90°C for 90 minutes and at 102°C for 60 minutes. The resultant material was then roll coated with size resin Example EX-27 at a size weight of 567 gsm. The material was final cured at 90°C for 60 minutes and at 102°C for 12 hours.

25 The coated abrasive Comparative Example CE-M showed typical bottom loop puddling while Example EX-31 had no observed puddling.

Supersize Layer Precursor - Comparative Example CE-N

30 Coated abrasive examples and comparative examples were prepared by roll coating make resin (described above) onto a continuous 30.48 cm wide polyester backing (described in Example 12 of U.S. Pat. No. 6,843,815 Thurber et al.) at a coating weight of 210 gsm followed by electrostatically coating mineral SAP1 at a weight of 605 gsm. The coated material was cured at 90°C for 90 minutes and at 102°C for 60 minutes. The resultant material was then roll coated with size resin Comparative Example CE-A at a size weight of 567 gsm. The material was cured at 90°C for 1 hour and at 102°C for 1 hour.
35 The resultant material was then coated with supersize resin Comparative Example CE-J at coating weight of 462 gsm using a 30.48 cm paint roller. The coated abrasive was final cured at 90°C for 60 minutes and at 102°C for 12 hours.

Supersize Layer Precursor - Example EX-32

Coated abrasive examples and comparative examples were prepared by roll coating make resin (described above) onto a continuous 30.48 cm wide polyester backing (described in Example 12 of U.S. Pat. No. 6,843,815 Thurber et al.) at a coating weight of 210 gsm followed by electrostatically coating mineral SAP1 at a weight of 605 gsm. The coated material was cured at 90°C for 90 minutes and at 102°C for 60 minutes. The resultant material was then roll coated with size resin Comparative Example CE-A at a size weight of 567 gsm. The material was cured at 90°C for 1 hour and at 102°C for 1 hour. The resultant material was then coated with supersize resin Example EX-29 at coating weight of 462 gsm using a 30.48 cm paint roller. The coated abrasive was final cured at 90°C for 60 minutes and at 102°C for 12 hours.

All cited references, patents, and patent applications in this application that are incorporated by reference, are incorporated in a consistent manner. In the event of inconsistencies or contradictions between portions of the incorporated references and this application, the information in this application 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.

What is claimed is:

1. A method of making a coated abrasive article comprising:
providing a backing having first and second opposed major surfaces, wherein a make layer is
5 disposed on at least a portion of the first major surface and bonds abrasive particles to the backing;
coating a size layer precursor over at least a portion of the make layer and the abrasive particles,
wherein the size layer precursor comprises a resole phenolic resin and an organic polymeric rheology
modifier, wherein the organic polymeric rheology modifier comprises an alkali-swellable/soluble
10 polymer, and, on a solids basis, and wherein the amount of the resole phenolic resin comprises from 75 to
99.99 weight percent of the combined weight of the resole phenolic resin and the organic polymeric
rheology modifier; and
at least partially curing the size layer precursor to provide a size layer; and
optionally coating an optional supersize layer precursor over at least a portion of the size layer
and at least partially curing the optional supersize layer precursor to provide an optional supersize layer,
15 wherein at least one of the size layer precursor or the optional supersize layer precursor comprises
a resole phenolic resin and an organic polymeric rheology modifier, wherein the organic polymeric
rheology modifier comprises an alkali-swellable/soluble polymer, and, on a solids basis, and wherein the
amount of the resole phenolic resin comprises from 75 to 99.99 weight percent of the combined weight of
the resole phenolic resin and the organic polymeric rheology modifier.
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2. The method of claim 1, wherein at least one of said at least partially curing the size layer
precursor or said at least partially curing the supersize layer precursor occurs in a festoon oven.
3. The method of claim 1, wherein at least one of the size layer precursor or the optional supersize
25 layer precursor has a basis weight of 5 to 1100 grams per square meter.
4. The method of claim 1, wherein the organic polymeric rheology modifier is selected from the
group consisting of alkali-swellable/soluble acrylic polymers, hydrophobically-modified alkali-
swellable/soluble acrylic polymers, hydrophobically-modified ethoxylated urethane polymers, and
30 combinations thereof.
5. The method of claim 1, wherein, on a solids basis, the amount of the resole phenolic resin
comprises from 85 to 99.99 weight percent of the combined weight of the resole phenolic resin and the
organic polymeric rheology modifier.
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6. The method of claim 1, wherein the abrasive particles comprise shaped abrasive particles.

7. The method of claim 6, wherein the shaped abrasive particles comprise precisely-shaped abrasive particles.
8. The method of claim 6, wherein the shaped abrasive particles comprise precisely-shaped three-sided platelets.
9. A coated abrasive article comprising:
a backing having first and second opposed major surfaces,
a make layer disposed on at least a portion of the first major surface and bonding abrasive particles to the backing;
a size layer overlaid on at least a portion of the make layer and the abrasive particles; and
an optional supersize layer,
wherein at least one of the size layer or the optional supersize layer comprises an at least partially cured resole phenolic resin and an organic polymeric rheology modifier, and wherein the amount of the at least partially cured resole phenolic resin comprises from 75 to 99.99 weight percent of the combined weight of the at least partially cured resole phenolic resin and the organic polymeric rheology modifier.
10. The coated abrasive article of claim 9, wherein the organic polymeric rheology modifier is selected from the group consisting of alkali-swallowable/soluble acrylic polymers, hydrophobically-modified alkali-swallowable/soluble acrylic polymers, hydrophobically-modified ethoxylated urethane polymers, and combinations thereof.
11. The coated abrasive article of claim 9, wherein the amount of the at least partially cured resole phenolic resin comprises from 85 to 99.99 weight percent of the combined weight of the at least partially cured resole phenolic resin and the organic polymeric rheology modifier.
12. The coated abrasive article of claim 9, wherein the abrasive particles comprise shaped abrasive particles.
13. The coated abrasive article of claim 12, wherein the shaped abrasive particles comprise precisely-shaped abrasive particles.
14. The coated abrasive article of claim 12, wherein the shaped abrasive particles comprise precisely-shaped three-sided platelets.

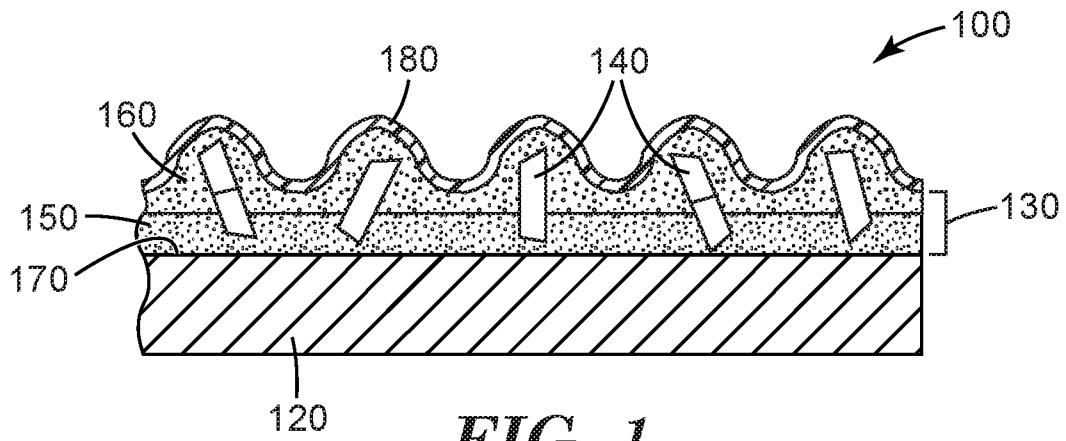


FIG. 1

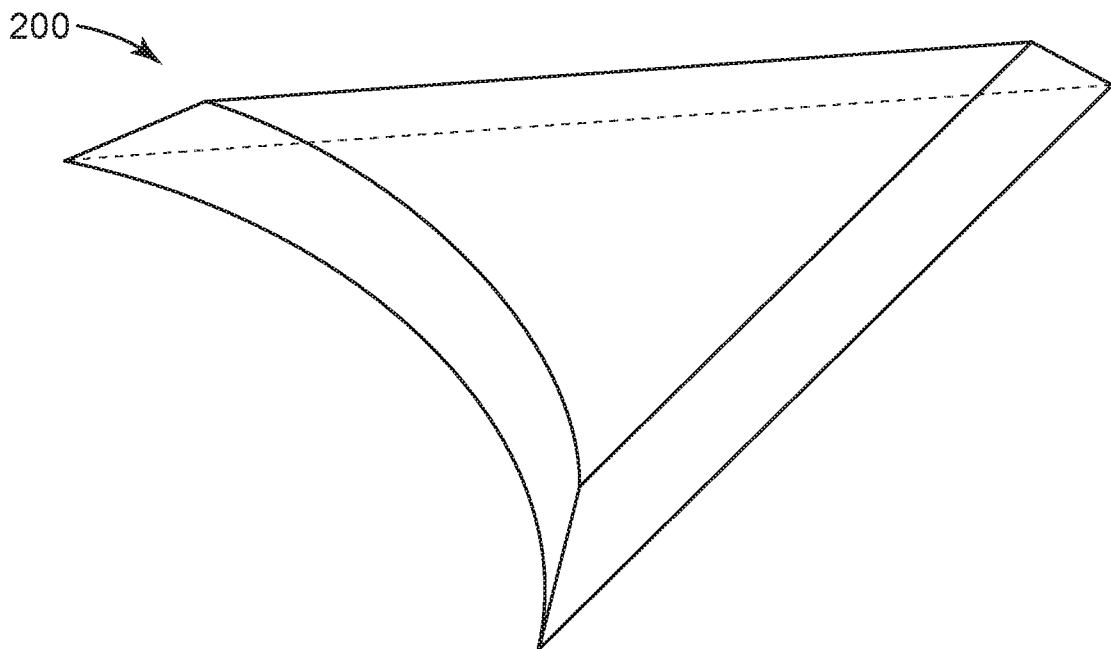


FIG. 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2021/050793

A. CLASSIFICATION OF SUBJECT MATTER
INV. B24D3/28 B24D3/34 B24D11/00 B24D18/00
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)
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.
X	US 2017/129075 A1 (ALI M B; BODEN J T ET AL.) 11 May 2017 (2017-05-11)	9-14
A	paragraphs [0030] - [0033], [0086] - [0088]; figure 1	1-8
A	----- WO 96/06711 A1 (MINNESOTA MINING & MFG [US]) 7 March 1996 (1996-03-07) the whole document	1-14
A	----- US 2010/151195 A1 (CULLER SCOTT R [US] ET AL) 17 June 2010 (2010-06-17) figures 1A,1B,1C	6-8, 12-14

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
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- "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 21 April 2021	Date of mailing of the international search report 03/05/2021
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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 Koller, Stefan
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No PCT/IB2021/050793

Patent document cited in search report	Publication date	Patent family member(s)	Publication date	
US 2017129075	A1	11-05-2017	BR 112018009260 A2 CN 108349070 A EP 3370919 A1 JP 2018532604 A US 2017129075 A1 WO 2017078978 A1	06-11-2018 31-07-2018 12-09-2018 08-11-2018 11-05-2017 11-05-2017

WO 9606711	A1	07-03-1996	AU 3360895 A BR 9508654 A CA 2197214 A1 DE 69513297 T2 EP 0777554 A1 FI 970835 A JP 3685804 B2 JP H10505008 A KR 970705457 A US 5591239 A WO 9606711 A1	22-03-1996 28-10-1997 07-03-1996 21-06-2000 11-06-1997 27-02-1997 24-08-2005 19-05-1998 09-10-1997 07-01-1997 07-03-1996

US 2010151195	A1	17-06-2010	BR PI0922319 A2 CA 2746931 A1 CN 102282230 A DE 202009019189 U1 DE 202009019191 U1 DE 202009019192 U1 EP 2373755 A2 EP 3444313 A1 ES 2687263 T3 JP 5415558 B2 JP 2012512044 A KR 20110100278 A PL 2373755 T3 US 2010151195 A1 US 2012144754 A1 WO 2010077491 A2	05-06-2018 08-07-2010 14-12-2011 16-04-2018 26-04-2018 26-04-2018 12-10-2011 20-02-2019 24-10-2018 12-02-2014 31-05-2012 09-09-2011 30-11-2018 17-06-2010 14-06-2012 08-07-2010
