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(54) COATED ABRASIVE ARTICLE AND METHOD OF MAKING THE SAME

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ARTICLE ABRASIF REVÊTU ET PROCÉDÉ DE FABRICATION DE CELUI-CI

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US-A1- 2010 107 509

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Description

TECHNICAL FIELD

[0001] The present disclosure relates to a coated abrasive article comprising abrasive particles retained by a binder material made from phenolic resin, free-radically polymerizable resin, and an organic polymeric rheology modifier, and methods of making the same.

BACKGROUND

[0002] 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.

[0003] 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.

[0004] It is generally desirable that the abrasive particles remain in their original orientation as embedded in the binder material precursor until it has been sufficiently cured to fix them in place. This is especially troublesome when the binder precursor material is too fluid so that the particles tip over by gravity, or if the binder precursor material is too hard such that the particles do not adhere to the binder precursor material and likewise tip over due to gravity.

[0005] Abrasive particle tipping after deposition is especially problematic with resole phenolic resin binder material precursors.

[0006] From US 2010/107509 A1 and WO 2010/002493 A1 there are known coated abrasive articles and methods of making the same.

SUMMARY

[0007] The present disclosure overcomes this problem by providing a curable composition suitable for use in manufacture of an abrasive article. The curable composition comprises a phenolic resin component, a free-radically polymerizable component, and an organic polymeric rheology modifier comprising an alkali-swellable/soluble polymer. The curable composition can be incorporated into coated abrasives with equal or better performance as compared to binder compositions of the types used in commercially successful coated abrasives.

[0008] 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.

[0009] In a first aspect, the present disclosure provides a method of making a coated abrasive article comprising sequential steps:

a) disposing a curable composition on a major surface of a backing, wherein the backing has first and second opposed major surfaces, wherein the curable composition comprises a phenolic resin component, a free-radically polymerizable component, and an organic polymeric rheology modifier, wherein the organic polymeric rheology modifier comprises an alkali-swellable/soluble polymer, and wherein, on a solids basis, the organic polymeric rheology modifier comprises from 0.001 to 5 weight percent of the phenolic resin component, the free-radically polymerizable component, and the organic polymeric rheology modifier combined;
b) adhering abrasive particles to the curable composition;
c) at least partially curing the free-radically polymerizable component; and
d) at least partially curing the phenolic resin component to provide an at least partially cured composition.

[0010] In some embodiments, the method further comprises:

disposing a size layer precursor onto at least a portion of the abrasive particles and said at least partially cured composition; and
at least partially curing the size layer precursor.

[0011] In another aspect, the present disclosure provides a method of making a coated abrasive article comprising sequential steps:

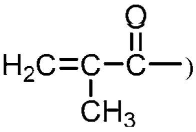
a) disposing a curable composition on a major surface of a backing, wherein the backing has first and second opposed major surfaces, wherein the curable composition comprises a phenolic resin component, a free-radically polymerizable component, and an organic polymeric rheology modifier, wherein the organic polymeric rheology modifier comprises an alkali-swellable/soluble polymer, and wherein, on a solids basis, the organic polymeric rheology modifier comprises from 0.001 to 5 weight percent of the phenolic resin component, the free-radically polymerizable component, and the organic polymeric rheology modifier combined;
b) at least partially curing the free-radically polymerizable component to provide a partially cured composition;
c) adhering abrasive particles to the partially cured composition; and
d) at least partially curing the phenolic resin component.

[0012] In another aspect, the present disclosure provides an abrasive article comprising abrasive particles adhered to a substrate by a binder material comprising an at least partially cured reaction product of components comprising a phenolic resin component, a free-radically polymerizable component, and an organic polymeric rheology modifier, wherein the organic polymeric rheology modifier comprises an alkali-swellable/soluble polymer, and wherein, on a solids basis, the organic polymeric rheology modifier comprises from 0.001 to 5 weight percent of the phenolic resin component, the free-radically polymerizable component, and the organic polymeric rheology modifier combined.
[0013] 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;

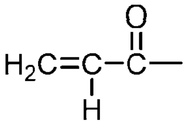
"alkali-swellable/soluble" means at least one of alkali-swellable or alkali-soluble (i.e., alkali-swellable and/or alkali-soluble);

"(meth)acryl" refers methacryl and/or acryl groups (i.e.,



$H_2C=C(CH_3)-C(=O)-$)

and/or



$H_2C=C(H)-C(=O)-$

"polymer" refers to an organic polymer unless otherwise clearly indicated; and

"weight percent" and "percent by weight" are interchangeable.

[0014] 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

[0015] FIG. 1 is a cross-sectional side view of an exemplary coated abrasive article 100 according to the present disclosure.
[0016] The figures may not be drawn to scale.

DETAILED DESCRIPTION

[0017] 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 (substrate) by make layer 150 and size layer 160.

[0018] Coated abrasive articles according to the present disclosure may include additional layers such as, for example, an optional supersize layer 180 that is superimposed on the abrasive layer, or a backing antistatic treatment layer may also be included, if desired.

[0019] 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.

[0020] Exemplary backings include: dense nonwoven fabrics (e.g., needletacked, meltspun, spunbonded, hydroentangled, or meltblown nonwoven fabrics), knitted fabrics, stitchbonded and/or woven fabrics; scrims; polymer films; treated versions thereof; and combinations of two or more of these materials.

[0021] 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 (for example, polyethylene terephthalate), polyamide (for example, hexamethylene adipamide, polycaprolactam), polypropylene, acrylic (formed from a polymer of acrylonitrile), 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.

[0022] 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.

[0023] The make layer can be formed by at least partially curing a make layer precursor that comprises a curable composition according to the present disclosure. The curable composition comprises a resole phenolic component, a free-radically polymerizable component, and an organic polymeric rheology modifier that aids in preserving the initial placement and orientation of the abrasive particles during manufacture.

[0024] Phenolic resins suitable for inclusion in the phenolic component 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.

[0025] 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.

[0026] 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).

[0027] A general discussion of phenolic resins and their manufacture is given in Kirk-Othmer, Encyclopedia of Chemical Technology, 4th Ed., John Wiley and Sons, 1996, New York, Vol. 18, pp. 603-644.

[0028] In typical embodiments, the phenolic resin component comprises from 75 to 99 weight percent of the phenolic resin component, the free-radically polymerizable component, and the organic polymeric rheology modifier combined (i.e., based on total combined weight of the phenolic resin component, the free-radically polymerizable component, and the organic polymeric rheology modifier); however, this is not a requirement.

[0029] The curable composition further comprises a free-radically photopolymerizable component, which may comprise at least one free-radical photoinitiator and at least one compound having at least one, preferably at least two, free-radically polymerizable groups per molecule. In some embodiments, on a solids basis, the free-radically polymerizable component comprises from 0.1 to 25 percent by weight, more typically 1 to 15 percent by weight, more typically 1 to 10 percent by weight, and even more typically 1 to 8 percent by weight, based on the total weight of the phenolic resin component, the free-radically polymerizable component, and the organic polymeric rheology modifier combined, although this is not a requirement.

[0030] While any free-radically polymerizable compound(s) such as N-vinyl compounds, vinyl ester, vinyl ethers, (meth)acrylamides, (meth)acrylic acid, (meth)acrylates, thiol-alkene comonomers, and thiol-alkyne comonomers can be used, compounds having at least one (preferably at least 2) (meth)acryl group are preferred, especially (meth)acrylic esters (i.e., poly(meth)acrylates).

[0031] The free-radically polymerizable component may comprise a blend of different (meth)acrylate monomers, (meth)acrylate oligomers, and/or (meth)acrylated polymers, each having the same or different number of (meth)acrylate groups. A wide variety of (meth)acrylate monomers, (meth)acrylate oligomers, and (meth)acrylated polymers are readily commercially available, for example, from such vendors Sartomer Company, Exton, Pennsylvania and Allnex, Frankfurt, Germany.

[0032] Exemplary (meth)acrylate monomers include ethylene glycol di(meth)acrylate, hexanediol di(meth)acrylate, triethylene glycol di(meth)acrylate, trimethylolpropane tri(meth)acrylate, glycerol tri(meth)acrylate, pentaerythritol tri(meth)acrylate, ethoxylated trimethylolpropane tri(meth)acrylate, neopentyl glycol di(meth)acrylate, pentaerythritol tetra(meth)acrylate, dipentaerythritol penta(meth)acrylate, sorbitol tri(meth)acrylate, sorbitol hexa(meth)acrylate, Bisphenol A di(meth)acrylate, ethoxylated Bisphenol A di(meth)acrylates, and mixtures thereof.

[0033] Exemplary useful (meth)acrylate oligomers include (meth)acrylated epoxy oligomers (e.g., Bisphenol-A based epoxy (meth)acrylate oligomers such as, for example, those marketed under the trade designations EBECRYL 3500, EBECRYL 3600, EBECRYL 3720, and EBECRYL 3700 by Allnex, aliphatic urethane acrylate oligomers (e.g., as marketed by Allnex under the trade designation EBECRYL 8402), aromatic urethane acrylate oligomers, and acrylated polyesters (e.g., as marketed by Allnex under the trade designation EBECRYL 870). Additional useful polyfunctional (meth)acrylate oligomers include polyether oligomers such as a polyethylene glycol 200 diacrylate, for example, as marketed by Sartomer Company under the trade designation SR 259; and polyethylene glycol 400 diacrylate, for example, as marketed by Sartomer Company under the trade designation SR 344.

[0034] The free-radically photopolymerizable component comprises at least one initiator of free-radical polymerization (e.g., a free-radical photoinitiator and/or a free-radical thermal initiator). The free-radical initiator is typically included in the curable composition (and hence also in the free-radically polymerizable component) in a sufficient amount to initiate free-radical polymerization upon exposure to heat and/or actinic electromagnetic radiation (e.g., ultraviolet and/or visible light) depending on the free-radical initiator used. For example, the free-radically initiator component may comprise from 0.1 to 5 percent by weight, 0.5 to 5 percent by weight, and more typically 0.5 to 3 percent by weight, based on the total weight of the phenolic resin component, the free-radically polymerizable component, and the organic polymeric rheology modifier combined, although this is not a requirement.

[0035] Useful free-radical photoinitiators include those known as useful for photocuring free-radically polyfunctional (meth)acrylates. Exemplary free-radical photoinitiators include benzoin and its derivatives such as [alpha]-methylbenzoin; [alpha]-phenylbenzoin; [alpha]-allylbenzoin; [alpha]-benzylbenzoin; benzoin ethers such as benzil dimethyl ketal benzoin methyl ether, benzoin ethyl ether, benzoin n-butyl ether; acetophenone and its derivatives such as 2-hydroxy-2-methyl-1-phenyl-1-propanone and 1-hydroxycyclohexyl phenyl ketone ; 2-methyl-1-[4(methylthio)phenyl]-2-(4-morpholinyl)-1-propanone; 2-benzyl-2-(dimethlamino)-1-[4-(4-morpholinyl)phenyl]-1-butanone.

[0036] Other useful free-radical photoinitiators include pivaloin ethyl ether, anisoin ethyl ether; anthraquinones, such as anthraquinone, 2-ethylanthraquinone, 1-chloroanthraquinone, 1,4-dimethylanthraquinone, and 1-methoxyanthraquinone; benzophenone and its derivatives; iodonium salts and sulfonium salts as described hereinabove; titanium complexes such as bis([eta]5-2,4-cyclopentadien-1-yl)bis[2,6-difluoro-3-(1H-pyrrol-1-yl)phenyl]titanium; mono- and bis-acylphosphines and phosphine oxides (e.g., as available as OMNIRAD TPO, OMNIRAD TPO-L1800, and OMNIRAD 819 from IGM resins, Waalwijk, The Netherlands.

[0037] Suitable sources of actinic radiation may include, for example, lasers, xenon flashlamps, microwave driven lamps having H-Type or D-Type bulbs, and medium pressure mercury arc lamps, and Light Emitting Diode (LED) lamps.

[0038] Exemplary free-radical thermal initiators include azo compounds (such as 2,2'-azobisisobutyronitrile (AIBN), 2,2'-azobis(2-methylbutyronitrile), 2,2'-azobis(2,4-dimethylvaleronitrile), and peroxide compounds (such as benzoyl peroxide or lauroyl peroxide) can be used.

[0039] In addition to the resole phenolic component (typically diluted with water) and the free-radically polymerizable component, the curable composition contains an organic polymeric rheology modifier that comprises an alkali-swellable/soluble polymer. The organic polymeric rheology modifier comprises 0.001 to 5 weight percent of the phenolic resin component, the free-radically polymerizable component, and the organic polymeric rheology modifier combined. In some embodiments. the curable composition comprises 0.003 to 4 weight percent, 0.01 to 3 weight percent, or even 0.1 to 2 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, more than one free-radically polymerizable compound, and/or more than one organic polymeric rheology modifier may be used if desired.

[0040] 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).

[0041] 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.

[0042] 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.

[0043] As the concentration of neutralized polymer in an aqueous formulation increases, the polymer chains swell, thereby causing the viscosity to increase.

[0044] 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.

[0045] 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.

[0046] 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).

[0047] Exemplary commercially available HASE polymers include those marketed by Dow Chemical under the trade designations ACUSOL 801S, ACUSOL 805S, ACUSOL 820, and ACUSOL 823.

[0048] ASE and HASE rheology modifiers are pH-triggered thickeners. Whether the emulsion polymer in each is water-swellable 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.).

[0049] 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.

[0050] Exemplary commercially available HEUR polymers include those marketed by Dow Chemical under the trade designations ACUSOL 880, ACUSOL 882, ACRYSOL RM-2020, and ACRYSOL RM-8W.

[0051] 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.).

[0052] The make layer precursor 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.

[0053] The size layer precursor comprises a curable composition which may be the same or different than that of the make layer precursor. Examples of suitable curable compositions that may be included in 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, or combinations thereof. Useful binder precursors include thermally curable resins and free-radically polymerizable 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.).

[0054] Make and size layers and their precursors may contain 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). Catalysts and/or initiators may be added to thermosetting resins; for example, according to conventional practice and depending on the resin used.

[0055] Make and size layers and their precursors may contain filler materials, diluent abrasive particles (e.g., as described hereinbelow), and/or 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).

[0056] Heat energy (e.g., from an oven, heated roll, microwave radiation, and/or infrared radiation) and electromagnetic radiation (e.g., ultraviolet light and/or visible light), are commonly applied to advance curing of the make layer and/or size layer precursors (e.g., curable compositions according to the present disclosure); however, other sources of energy may also be used. The selection will generally be dictated by the particular resin system selected.

[0057] 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.

[0058] 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.

[0059] 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, 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.

[0060] 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 Al (Culler et al.).

[0061] 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.); and 8,142,532 (Erickson et al.); 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.

[0062] 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.

[0063] 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.

[0064] 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.

[0065] Typically, crushed abrasive particles are 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 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, JIS 60, JIS 80, JIS 100, JIS 150, JIS 180, JIS 220, JIS 240, JIS 280, JIS 320, JIS 360, JIS 400, JIS 500, 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.

[0066] 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 abrasive particles pass through a test sieve meeting ASTM E-11 specifications for the number 18 sieve and are retained on a test sieve meeting ASTM E-11 specifications 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 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.

[0067] 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 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.

[0068] 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.

[0069] Grinding aids can be particularly useful in coated abrasives. In coated abrasive articles, grinding aid is typically used in a supersize coat, which is applied over the surface of the abrasive particles. Sometimes, however, the grinding aid is added to the size coat. 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.

[0070] The make layer precursor, size layer precursor, and supersize layer and/or supersize layer precursor coatings may be coated by any suitable coating technique including, for example, roll coating, gravure roll coating, knife coating, curtain coating, and/or slot coating. Abrasive particles may be drop coated, electrostatically coated, and or mechanically positioned (e.g., by transfer from a production tool having shaped cavities containing the abrasive particles).

[0071] 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).

[0072] 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 articles according to the present disclosure with a surface of the workpiece, and moving at least one of the 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 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.

[0073] 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.

[0074] 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

[0075] In a first embodiment, the present disclosure provides a method of making a coated abrasive article comprising sequential steps:

a) disposing a curable composition on a major surface of a backing, wherein the backing has first and second opposed major surfaces, wherein the curable composition comprises a phenolic resin component, a free-radically polymerizable component, and an organic polymeric rheology modifier, wherein the organic polymeric rheology modifier comprises an alkali-swellable/soluble polymer, and wherein, on a solids basis, the organic polymeric rheology modifier comprises from 0.001 to 5 weight percent of the phenolic resin component, the free-radically polymerizable component, and the organic polymeric rheology modifier combined;
b) adhering abrasive particles to the curable composition;
c) at least partially curing the free-radically polymerizable component; and
d) at least partially curing the phenolic resin component to provide an at least partially cured composition.

[0076] In a second embodiment, the present disclosure provides a method according to the first 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.

[0077] In a third embodiment, the present disclosure provides a method according to the first or second embodiment, wherein, on a solids basis, the phenolic resin component comprises from 75 to 99 weight percent of the phenolic resin component, the free-radically polymerizable component, and the organic polymeric rheology modifier combined.

[0078] In a fourth embodiment, the present disclosure provides a method according to any of the first to third embodiments, wherein, on a solids basis, the free-radically polymerizable component comprises from 1 to 15 weight percent of the phenolic resin component, the free-radically polymerizable component, and the organic polymeric rheology modifier combined.

[0079] In a fifth embodiment, the present disclosure provides a method according to any of the first to fourth embodiments, wherein the abrasive particles comprise shaped abrasive particles.

[0080] In a sixth embodiment, the present disclosure provides a method according to the fifth embodiment, wherein the shaped abrasive particles comprise precisely-shaped abrasive particles.

[0081] In a seventh embodiment, the present disclosure provides a method according to any of the first to sixth embodiments, wherein the shaped abrasive particles comprise precisely-shaped triangular platelets.

[0082] In an eighth embodiment, the present disclosure provides a method according to any of the first to seventh embodiments, wherein the free-radically polymerizable component comprises a free-radically polymerizable compound and a free-radical photoinitiator.

[0083] In a ninth embodiment, the present disclosure provides a method according to any of the first to eighth embodiments, wherein the free-radically polymerizable compound comprises at least two (meth)acryl groups.

[0084] In a tenth embodiment, the present disclosure provides a method according to any of the first to ninth embodiments, the method further comprising:

disposing a size layer precursor onto at least a portion of the abrasive particles and said at least partially cured composition; and
at least partially curing the size layer precursor.

[0085] In an eleventh embodiment, the present disclosure provides an abrasive article comprising abrasive particles adhered to a substrate by a binder material comprising an at least partially cured reaction product of components comprising a phenolic resin component, a free-radically polymerizable component, and an organic polymeric rheology modifier, wherein the organic polymeric rheology modifier comprises an alkali-swellable/soluble polymer, and wherein, on a solids basis, the organic polymeric rheology modifier comprises from 0.001 to 5 weight percent of the phenolic resin component, the free-radically polymerizable component, and the organic polymeric rheology modifier combined.

[0086] In a twelfth embodiment, the present disclosure provides an abrasive article according to the eleventh 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.

[0087] In a thirteenth embodiment, the present disclosure provides an abrasive article according to the eleventh or twelfth embodiment, wherein, on a solids basis, the phenolic resin component comprises from 90 to 99 weight percent of the phenolic resin component, the free-radically polymerizable component, and the organic polymeric rheology modifier combined.

[0088] In a fourteenth embodiment, the present disclosure provides an abrasive article according to any of the eleventh to thirteenth embodiments, wherein, on a solids basis, the free-radically polymerizable component comprises from 1 to 15 weight percent of the phenolic resin component, the free-radically polymerizable component, and the organic polymeric rheology modifier combined.

[0089] In a fifteenth embodiment, the present disclosure provides an abrasive article according to any of the eleventh to fourteenth embodiments, wherein the abrasive particles comprise shaped abrasive particles.

[0090] In a sixteenth embodiment, the present disclosure provides an abrasive article according to the fifteenth embodiment, wherein the shaped abrasive particles comprise precisely-shaped abrasive particles.

[0091] In a seventeenth embodiment, the present disclosure provides an abrasive article according to the fifteenth embodiment, wherein the shaped abrasive particles comprise precisely-shaped triangular platelets.

[0092] In an eighteenth embodiment, the present disclosure provides an abrasive article method according to any of the eleventh to seventeenth embodiments, wherein the free-radically polymerizable compound comprises at least two (meth) acryl groups.

[0093] In a nineteenth embodiment, the present disclosure provides a method of making a coated abrasive article comprising sequential steps:

a) disposing a curable composition on a major surface of a backing, wherein the backing has first and second opposed major surfaces, wherein the curable composition comprises a phenolic resin component, a free-radically polymerizable component, and an organic polymeric rheology modifier, wherein the organic polymeric rheology modifier comprises an alkali-swellable/soluble polymer, and wherein, on a solids basis, the organic polymeric rheology modifier comprises from 0.001 to 5 weight percent of the phenolic resin component, the free-radically polymerizable component, and the organic polymeric rheology modifier combined;
b) at least partially curing the free-radically polymerizable component to provide a partially cured composition;
c) adhering abrasive particles to the partially cured composition; and
d) at least partially curing the phenolic resin component.

[0094] 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.

EXAMPLES

[0095] Unless otherwise noted, all parts, percentages, ratios, etc. in the Examples and the rest of the specification are by weight. Table 1, below, reports materials and abbreviations used in the examples.

TABLE 1

ABBREVIATION	DESCRIPTION AND SOURCE
ADD1	Alkali swellable acrylic polymer emulsion (ASE), aqueous emulsion with 28.75 % solids content, obtained as ACUSOL 835 from The Dow Chemical Company, Midland, Michigan.
ADD2	Surfactant obtained as Aerosol OT-NV from Cytec-Solvay Group, Stamford, Connecticut.
ADD3	Antifoam obtained as Antifoam Emulsion 1430 from Dow Chemical.
BK1	Y weight polyester backing described in backing described in Example 12 of U.S. Pat. No. 6,843,815 (Thurber et al.).
EMI	2,4-Diethylimidazole obtained as 2,4 EMI from Air Products, Allentown, Pennsylvania.
EP	Epoxy Resin obtained as EPIREZ 3522 W-60 from Hexion, Columbus, Ohio.
FIL1	Calcium silicate obtained as M400 WOLLASTOCOAT from NYCO, Willsboro, New York.
FIL2	Hydrophilic amorphous fumed silica obtained under the trade designation CAB-O-SIL M-5 from Cabot Corporation, Alpharetta, Georgia.
FIL3	Cryolite obtained as CRYOLITE RTN-C. Obtained from FREEBEE A/S, Ullerslev, Denmark.
FIL4	Potassium tetrafluoroborate obtained from AWSM industries, Paramus, New Jersey.
MEK	2-Butanone (ACS Certified) obtained as Alfa Aesar, Ward Hill, Massachusetts.
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.
PI	Photoinitiator 2,2-Dimethoxy-2-phenylactephenone obtained as Acetocure BDK from Aceto Corporation, Port Washington, New York.
RIO	Red iron oxide pigment obtained as KROMA RO-3097 from Elementis, East Saint Louis, Illinois.
RIO2	Red iron oxide pigment obtained as KROMA RO-8097 from Elementis, East Saint Louis, Illinois.
RS	Latex Dispersion obtained as Sure Tac 1585 from Dyna-Tech Adhesives, Grafton, West Virginia.
SAP1	Shaped abrasive particles 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 1.4mm (side length) × 0.35mm (thickness), with a draft angle approximately 98 degrees. Obtained from 3M, St. Paul, Minnesota.
TMPTA	Trimethylolpropane triacrylate obtained as SR351 from Sartomer, Exton, Pennsylvania.

Preparation of Resins

Comparative Make Resin A (CMR-A)

[0096] A 3-Liter plastic container was charged with 1562.5 grams (g) of PF and 74.8 g of water and stirred for 10 minutes with an overhead mechanical stirrer. Next, 1364.6 g of FIL1 was added over a 10-minute period. The resultant mixture was stirred for an additional 15 minutes with an overhead stirrer.

Comparative Make Resin B (CMR-B)

[0097] A 3-Liter plastic container was charged with 1562.5 g of PF, Next, 1364.6 g of FIL1 was added over a 10-minute period. The resultant mixture was stirred for an additional 15 minutes with an overhead stirrer. Then, 50 g of TMPTA and 10 g of PI (PI was pre dissolved in 25 grams of MEK) were added, and resultant mixture stirred for 15 minutes with an overhead mechanical stirrer. Next, 74.8 grams of water was added, and the resultant mixture was stirred for an additional 15 minutes with an overhead stirrer.

Example Make Resin 1 (EMR-1)

[0098] A 3-Liter plastic container was charged with 1562.5 g of PF. Next, 1364.6 g of FIL1 was added over a 10-minute period. The resultant mixture was stirred for an additional 15 minutes with an overhead stirrer. Then, 50 g of TMPTA and 10 g of PI (PI was pre dissolved in 25 grams of MEK) were added, and the resultant mixture was stirred for 15 minutes with an overhead mechanical stirrer. Next, 6 grams of ADD1 and 8.8 grams of FIL2 were added, and the mixture stirred for 15 minutes with an overhead mechanical stirrer. Finally, 74.8 grams of water was added, and resultant mixture was stirred for an additional 15 minutes with an overhead stirrer.

Size Resin (SR)

[0099] A 3-Liter plastic container was charged with 1263.2 g of PF and 362.2 g of water and stirred for 10 minutes with an overhead mechanical stirrer. Next, 664.1 g of FIL1 and 664.1 g of FIL3 were added over a 10-minute period. Then, 46.2 g of RIO was added to the mixture, which was then stirred for 15 minutes with an overhead stirrer.

Supersize Resin (SSR)

[0100] A 3-Liter plastic container was charged with 438.0 g of EP, 173 g of water, 8.7 g of FIL 2, 55.1 g of RIO2, 13.8 g of EMI, 18.1 g of ADD2, 1.9 g of ADD3, and 319.4 g of RS. The resulting mixture was mixed for 10 minutes with an overhead mechanical stirrer. Next, 1972 g of FIL4 was added over a 15-minute period with continued mixing. The resultant mixture was stirred for an additional 15 minutes with an overhead stirrer.

COMPARATIVE COATED ABRASIVE EXAMPLES CCA AND CCB

[0101] Comparative coated abrasive examples CCA and CCB were prepared by coating make resin CMR-A onto backing BK1 using a 4-inch (10.2-cm) coating knife nominally set at an 8-mil (0.2 mm) gap. Next, the mineral SAP was electrostatically coated to a specific mineral weight. The resultant abrasive constructions were than partially cured at 90 °C for 90 minutes and 102 °C for 60 minutes. Next, the coated abrasives were coated using a 3-inch (7.6-cm) paint roller with size resin SR, and then cured at 90°C for 60 minutes and 102 °C for 60 minutes. Finally, the coated abrasive constructions were coated using supersize resin SSR and cured for 90 °C for 30 minutes, 102 °C for 12 hours, and 109 °C for 60 minutes. The specific coating weights are reported in Table 2.

Comparative Coated Abrasives C and D (CCC and CCD)

[0102] Comparative Coated Abrasives C and D (CCC and CCD) were prepared by coating make resin CMR-B onto backing BK1 using a 4-inch (10.2-cm) coating knife nominally set at an 8-mil (0.2 mm) gap. Next, the mineral SAP was electrostatically coated to a specific mineral weight. Next, samples were irradiated at 15 feet per minute (4.6m/min) with a Fusion Lamp-D bulb (600 watts/cm). The resultant abrasive constructions were then partially cured at 90 °C for 90 minutes and 102 °C for 60 minutes. Next, the coated abrasives were coated using 3-inch (7.6-cm) paint roller with size resin SR and then cured at 90°C for 60 minutes and 102°C for 60 minutes. Finally, the coated abrasive constructions were coated using supersize resin SSR and cured for 90°C for 30 minutes, 102°C for 12 hours and 109°C for 60 minutes. The specific coating weights are reported in Table 2

COATED ABRASIVE EXAMPLES CAE-1, CAE-2, AND CAE-3

[0103] Coated Abrasives Examples CAE-1, CAE-2, and CAE-3 were prepared by coating make resin MRE-1 onto backing BK1 using a 4" coating knife set at approximately an 8-mil gap. Next, the mineral SAP was electrostatically coated to a specific mineral weight. Next, samples were irradiated at 15 fpm with Fusion Lamp-D bulb (600 watts/cm). The resultant abrasive constructions were than partially cured at 90°C for 90 minutes and 102°C for 60 minutes. Next, the coated abrasives were coated using a 3" paint roller with size resin SR and then cured at 90°C for 60 minutes and 102°C for

60 minutes. Finally, the coated abrasive constructions were coated using supersize resin SSR and cured for 90°C for 30 minutes, 102°C for 12 hours and 109°C for 60 minutes. The specific coating weights are reported in Table 2, below.

TABLE 2

COATED ABRASIVE	MAKE RESIN	MAKE RESIN AMOUNT, g/m^2	MINERAL AMOUNT, g/m^2	SIZE AMOUNT, g/m^2	SUPERSIZE AMOUNT, g/m^2
CCA	CMR-A	209	601	508	491
CCB	CMR-A	209	512	491	529
CCC	CMR-B	193	550	500	525
CCD	CMR-B	193	529	517	496
CAE-1	EMR-1	189	533	520	508
CAE-2	EMR-1	189	542	512	533
CAE-3	EMR-1	189	454	508	491

Grinding Test Method

[0104] This grinding test was conducted on 10.16 cm by 91.44 cm belts converted from coated abrasive samples CCA, CCB, CCC, CCD, CAE-1, CAE-2, and CAE-3. The workpiece was a 304 stainless steel bar on which the surface to be abraded measured 1.9 cm x 1.9 cm. A 20.3 cm diameter 70 durometer rubber, 1;1 land to groove ratio, serrated contact wheel was used. The belt was run at 2750 rpm. The workpiece was applied to the center part of the belt at a normal force of 4.4 kg. The test consisted for measuring the weight loss of the workpiece after 15 seconds of grinding. The workpiece would then be cooled and tested again. The test concluded after 40 cycles. The total cut in grams is defined as total cut after 40 cycles.

[0105] Table 3 reports results of the Grinding Test. Coated Abrasive Examples CAE-1, CAE-2, and CAE-3 exhibited superior total cut performance over Comparative Coated Abrasive Examples CCA, CCB, CCC, and CCD.

TABLE 3

EXAMPLE	TOTAL CUT, g
COMPARATIVE CCA	676
COMPARATIVE CCB	692
COMPARATIVE CCC	807
COMPARATIVE CCD	780
CAE-1	827
CAE-2	865
CAE-3	831

[0106] 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.

Claims

1. A method of making a coated abrasive article (100) comprising sequential steps:

a) disposing a curable composition on a major surface (170) of a backing (120), wherein the backing has first and second opposed major surfaces, wherein the curable composition comprises a phenolic resin component, a free-radically polymerizable component, and an organic polymeric rheology modifier, wherein the organic polymeric rheology modifier comprises an alkali-swellable/soluble polymer, and wherein, on a solids basis, the organic polymeric rheology modifier comprises from 0.001 to 5 weight percent of the phenolic resin component, the free-radically polymerizable component, and the organic polymeric rheology modifier combined;

b) adhering abrasive particles (140) to the curable composition;
c) at least partially curing the free-radically polymerizable component; and
d) at least partially curing the phenolic resin component to provide an at least partially cured composition.

2. 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 combinations thereof.

3. The method of claim 1, wherein, on a solids basis, the phenolic resin component comprises from 75 to 99 weight percent of the phenolic resin component, the free-radically polymerizable component, and the organic polymeric rheology modifier combined.

4. The method of claim 1, wherein, on a solids basis, the free-radically polymerizable component comprises from 1 to 25 weight percent of the phenolic resin component, the free-radically polymerizable component, and the organic polymeric rheology modifier combined.

5. The method of claim 1, wherein the abrasive particles (140) comprise shaped abrasive particles; optionally wherein the shaped abrasive particles comprise precisely-shaped abrasive particles; optionally wherein the shaped abrasive particles comprise precisely-shaped triangular platelets.

6. The method of claim 1, wherein the free-radically polymerizable component comprises a free-radically polymerizable compound and a free-radical photoinitiator.

7. The method of claim 6, wherein the free-radically polymerizable compound comprises at least two (meth)acryl groups.

8. The method of claim 1, the method further comprising:

disposing a size layer precursor onto at least a portion of the abrasive particles and said at least partially cured composition; and
at least partially curing the size layer precursor.

9. An abrasive article (100) comprising abrasive particles (140) adhered to a substrate by a binder material comprising an at least partially cured reaction product of components comprising a phenolic resin component, a free-radically polymerizable component, and an organic polymeric rheology modifier, wherein the organic polymeric rheology modifier comprises an alkali-swellable/soluble polymer, and wherein, on a solids basis, the organic polymeric rheology modifier comprises from 0.001 to 5 weight percent of the phenolic resin component, the free-radically polymerizable component, and the organic polymeric rheology modifier combined.

10. The abrasive article (100) of claim 9, 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.

11. The abrasive article (100) of claim 9, wherein, on a solids basis, the phenolic resin component comprises from 75 to 99 weight percent of the phenolic resin component, the free-radically polymerizable component, and the organic polymeric rheology modifier combined.

12. The abrasive article (100) of claim 9, wherein, on a solids basis, the free-radically polymerizable component comprises from 1 to 25 weight percent of the phenolic resin component, the free-radically polymerizable component, and the organic polymeric rheology modifier combined.

13. The abrasive article (100) of claim 9, wherein the abrasive particles (140) comprise shaped abrasive particles; optionally wherein the shaped abrasive particles comprise precisely-shaped abrasive particles; optionally wherein the shaped abrasive particles comprise precisely-shaped triangular platelets.

14. The abrasive article (100) of claim 13, wherein the free-radically polymerizable compound comprises at least two (meth)acryl groups.

15. A method of making a coated abrasive article (100) comprising sequential steps:

a) disposing a curable composition on a major surface (170) of a backing (120), wherein the backing has first and second opposed major surfaces, wherein the curable composition comprises a phenolic resin component, a free-radically polymerizable component, and an organic polymeric rheology modifier, wherein the organic polymeric rheology modifier comprises an alkali-swellable/soluble polymer, and wherein, on a solids basis, the organic polymeric rheology modifier comprises from 0.001 to 5 weight percent of the phenolic resin component, the free-radically polymerizable component, and the organic polymeric rheology modifier combined;
b) at least partially curing the free-radically polymerizable component to provide a partially cured composition;
c) adhering abrasive particles (140) to the partially cured composition; and
d) at least partially curing the phenolic resin component.

Patentansprüche

1. Ein Verfahren zum Herstellen eines beschichteten Schleifgegenstands (100), aufweisend die sequenziellen Schritte:

   a) Anordnen einer härtbaren Zusammensetzung auf einer Hauptoberfläche (170) eines Trägers (120), wobei der Träger eine erste und eine zweite gegenüberliegende Hauptoberfläche aufweist, wobei die härtbare Zusammensetzung eine Phenolharzkomponente, eine radikalisch polymerisierbare Komponente und einen organischen polymeren Rheologiemodifikator aufweist, wobei der organische polymere Rheologiemodifikator ein alkaliquellbares/lösliches Polymer aufweist, und wobei, auf Feststoffbasis, der organische polymere Rheologiemodifikator 0,001 bis 5 Gewichtsprozent der Phenolharzkomponente, der radikalisch polymerisierbaren Komponente und des organischen polymeren Rheologiemodifikators kombiniert aufweist;
   b) Anhaften von Schleifteilchen (140) an der härtbaren Zusammensetzung;
   c) mindestens teilweises Aushärten der radikalisch polymerisierbaren Komponente; und
   d) mindestens teilweises Aushärten der Phenolharzkomponente, um eine mindestens teilweise ausgehärtete Zusammensetzung bereitzustellen.

2. Das Verfahren nach Anspruch 1, wobei der organische polymere Rheologiemodifikator aus der Gruppe ausgewählt ist, bestehend aus alkaliquellbaren/löslichen Acrylpolymeren, hydrophob modifizierten alkaliquellbaren/löslichen Acrylpolymeren, hydrophob modifizierten ethoxylierten Urethanpolymeren und Kombinationen davon.

3. Das Verfahren nach Anspruch 1, wobei, auf Feststoffbasis, die Phenolharzkomponente 75 bis 99 Gewichtsprozent der Phenolharzkomponente, der radikalisch polymerisierbaren Komponente und des organischen polymeren Rheologiemodifikators kombiniert aufweist.

4. Das Verfahren nach Anspruch 1, wobei, auf Feststoffbasis, die radikalisch polymerisierbare Komponente 1 bis 25 Gewichtsprozent der Phenolharzkomponente, der radikalisch polymerisierbaren Komponente und des organischen polymeren Rheologiemodifikators kombiniert aufweist.

5. Das Verfahren nach Anspruch 1, wobei die Schleifteilchen (140) geformte Schleifteilchen aufweisen; optional wobei die geformten Schleifteilchen präzise geformte Schleifteilchen aufweisen; optional wobei die geformten Schleifteilchen präzise geformte dreieckige Plättchen aufweisen.

6. Das Verfahren nach Anspruch 1, wobei die radikalisch polymerisierbare Komponente eine radikalisch polymerisierbare Verbindung und einen radikalischen Photoinitiator aufweist.

7. Das Verfahren nach Anspruch 6, wobei die radikalisch polymerisierbare Verbindung mindestens zwei (Meth)acrylgruppen aufweist.

8. Das Verfahren nach Anspruch 1, das Verfahren ferner aufweisend:

   Anordnen eines Deckschichtvorläufers auf mindestens einem Abschnitt der Schleifteilchen und der mindestens teilweise ausgehärteten Zusammensetzung; und
   mindestens teilweises Aushärten des Deckschichtvorläufers.

9. Ein Schleifgegenstand (100), aufweisend Schleifpartikel (140), die an einem Substrat haften, durch ein Bindemittelmaterial, aufweisend ein mindestens teilweise ausgehärtetes Reaktionsprodukt von Komponenten, aufweisend eine Phenolharzkomponente, eine radikalisch polymerisierbare Komponente und einen organischen polymeren Rheo-

logiemodifikator, wobei der organische polymere Rheologiemodifikator ein alkali-quellbares/lösliches Polymer aufweist, und wobei, auf Feststoffbasis, der organische polymere Rheologiemodifikator 0,001 bis 5 Gewichtsprozent der Phenolharzkomponente, der radikalisch polymerisierbaren Komponente und des organischen polymeren Rheologiemodifikators kombiniert aufweist.

10. Der Schleifgegenstand (100) nach Anspruch 9, wobei der organische polymere Rheologiemodifikator aus der Gruppe ausgewählt ist, bestehend aus alkaliquellbaren/löslichen Acrylpolymeren, hydrophob modifizierten alkaliquellbaren/löslichen Acrylpolymeren, hydrophob modifizierten ethoxylierten Urethanpolymeren und Kombinationen davon.

11. Der Schleifgegenstand (100) nach Anspruch 9, wobei, auf Feststoffbasis, die Phenolharzkomponente 75 bis 99 Gewichtsprozent der Phenolharzkomponente, der radikalisch polymerisierbaren Komponente und des organischen polymeren Rheologiemodifikators kombiniert aufweist.

12. Der Schleifgegenstand (100) nach Anspruch 9, wobei, auf Feststoffbasis, die radikalisch polymerisierbare Komponente 1 bis 25 Gewichtsprozent der Phenolharzkomponente, der radikalisch polymerisierbaren Komponente und des organischen polymeren Rheologiemodifikators kombiniert aufweist.

13. Der Schleifgegenstand (100) nach Anspruch 9, wobei die Schleifteilchen (140) geformte Schleifteilchen aufweisen; optional wobei die geformten Schleifteilchen präzise geformte Schleifteilchen aufweisen; optional wobei die geformten Schleifteilchen präzise geformte dreieckige Plättchen aufweisen.

14. Der Schleifgegenstand (100) nach Anspruch 13, wobei die radikalisch polymerisierbare Verbindung mindestens zwei (Meth)acrylgruppen aufweist.

15. Ein Verfahren zum Herstellen eines beschichteten Schleifgegenstands (100), aufweisend die sequenziellen Schritte:

a) Anordnen einer härtbaren Zusammensetzung auf einer Hauptoberfläche (170) eines Trägers (120), wobei der Träger eine erste und eine zweite gegenüberliegende Hauptoberfläche aufweist, wobei die härtbare Zusammensetzung eine Phenolharzkomponente, eine radikalisch polymerisierbare Komponente und einen organischen polymeren Rheologiemodifikator aufweist, wobei der organische polymere Rheologiemodifikator ein alkali-quellbares/lösliches Polymer aufweist, und wobei, auf Feststoffbasis, der organische polymere Rheologiemodifikator 0,001 bis 5 Gewichtsprozent der Phenolharzkomponente, der radikalisch polymerisierbaren Komponente und des organischen polymeren Rheologiemodifikators kombiniert aufweist;
b) mindestens teilweises Aushärten der radikalisch polymerisierbaren Komponente, um eine teilweise ausgehärtete Zusammensetzung bereitzustellen;
c) Anhaften von Schleifpartikeln (140) an der teilweise ausgehärteten Zusammensetzung; und
d) mindestens teilweises Aushärten der Phenolharzkomponente.

Revendications

1. Procédé de fabrication d’un article abrasif revêtu (100), comprenant les étapes séquentielles consistant à :

a) disposer une composition durcissable sur une surface principale (170) d’un support (120), dans lequel le support a une première et une seconde surfaces principales opposées, dans lequel la composition durcissable comprend un composant de résine phénolique, un composant polymérisable par radicaux, et un modificateur rhéologique polymère organique, dans lequel le modificateur rhéologique polymère organique comprend un polymère gonflable/soluble dans l’alcali, et dans lequel, sur une base de solides, le modificateur rhéologique polymère organique comprend de 0,001 à 5 % en poids du composant de résine phénolique, du composant polymérisable par radicaux libres et du modificateur rhéologique polymérique organique combinés ;
b) faire adhérer les particules abrasives (140) à la composition durcissable ;
c) durcir au moins partiellement le composant polymérisable par radicaux; et
d) durcir au moins partiellement le composant de résine phénolique pour obtenir une composition au moins partiellement durcie.

2. Procédé selon la revendication 1, dans lequel le modificateur de rhéologie polymère organique est choisi dans le groupe constitué de polymères acryliques solubles dans l’alcali, polymères acryliques solubles dans l’alcali modifiés par hydrophobie, polymères d’uréthane éthoxylés modifiés par hydrophobie et combinaisons de ceux-ci.

3. Procédé selon la revendication 1, dans lequel, sur une base solide, le composant de résine phénolique comprend de 75 à 99 % en poids du composant de résine phénolique, du composant polymérisable par radicaux et du modificateur de rhéologie polymère organique combinés.

4. Procédé selon la revendication 1, dans lequel, sur une base solide, le composant polymérisable par radicaux comprend de 1 à 25 pour cent en poids du composant de résine phénolique, du composant polymérisable par radicaux et du modificateur de rhéologie polymère organique combinés.

5. Procédé selon la revendication 1, dans lequel les particules abrasives (140) comprennent des particules abrasives façonnées ; éventuellement, dans lequel les particules abrasives façonnées comprennent des particules abrasives façonnées de façon précise ; éventuellement, dans lequel les particules abrasives façonnées comprennent des plaquettes triangulaires façonnées de façon précise.

6. Procédé selon la revendication 1, dans lequel le composant polymérisable par radicaux libres comprend un composé polymérisable par radicaux et un photo-initiateur radicalaire.

7. Procédé selon la revendication 6, dans lequel le composé polymérisable par radicaux libres comprend au moins deux groupes (méth)acrylates.

8. Procédé selon la revendication 1, le procédé comprenant en outre :

la disposition d'un précurseur de couche d'encollage sur au moins une partie des particules abrasives et ledit durcissement au moins partiellement de la composition durcissable ; et
le durcissement au moins partiellement du précurseur de couche d'encollage.

9. Article abrasif (100) comprenant des particules abrasives (140) adhérant à un substrat par un matériau liant comprenant un produit de réaction au moins partiellement durci de composants comprenant un composant de résine phénolique, un composant polymérisable par radicaux, et un modificateur rhéologique polymère organique, dans lequel le modificateur rhéologique polymère organique comprend un polymère gonflable/soluble dans l'alcali, et dans lequel, sur une base de solides, le modificateur rhéologique polymère organique comprend de 0,001 à 5 % en poids du composant de résine phénolique, du composant polymérisable par radicaux et du modificateur rhéologique polymérique organique combinés.

10. Article abrasif (100) selon la revendication 9, dans lequel le modificateur de rhéologie polymère organique est choisi dans le groupe constitué de polymères acryliques solubles dans l'alcali, polymères acryliques solubles dans l'alcali modifiés par hydrophobie, polymères d'uréthane éthoxylés modifiés par hydrophobie et combinaisons de ceux-ci.

11. Article abrasif (100) selon la revendication 9, dans lequel, sur une base solide, le composant de résine phénolique comprend de 75 à 99 pour cent en poids du composant de résine phénolique, du composant polymérisable par radicaux et du modificateur de rhéologie polymère organique combinés.

12. Article abrasif (100) selon la revendication 9, dans lequel, sur une base solide, le composant polymérisable par radicaux comprend de 1 à 25 pour cent en poids du composant de résine phénolique, du composant polymérisable par radicaux et du modificateur de rhéologie polymère organique combinés.

13. Article abrasif (100) selon la revendication 9, dans lequel les particules abrasives (140) comprennent des particules abrasives façonnées; éventuellement, dans lequel les particules abrasives façonnées comprennent des particules abrasives façonnées de façon précise ; éventuellement, dans lequel les particules abrasives façonnées comprennent des plaquettes triangulaires façonnées de façon précise.

14. Article abrasif (100) selon la revendication 13, dans lequel le composé polymérisable par radicaux comprend au moins deux groupes (méth)acrylates.

15. Procédé de fabrication d'un article abrasif revêtu (100), comprenant les étapes séquentielles consistant à :

a) disposer une composition durcissable sur une surface principale (170) d'un support (120), dans lequel le support a une première et une seconde surfaces principales opposées, dans lequel la composition durcissable comprend un composant de résine phénolique, un composant polymérisable par radicaux, et un modificateur

rhéologique polymère organique, dans lequel le modificateur rhéologique polymère organique comprend un polymère gonflable/soluble dans l'alcali, et dans lequel, sur une base de solides, le modificateur rhéologique polymère organique comprend de 0,001 à 5 % en poids du composant de résine phénolique, du composant polymérisable par radicaux et du modificateur rhéologique polymérique organique combinés ;
b) durcir au moins partiellement le composant à polymérisable par radicaux pour obtenir une composition partiellement durcie ;
c) faire adhérer des particules abrasives (140) à la composition partiellement durcie ; et
d) le durcissement au moins partiel du composant de résine phénolique.

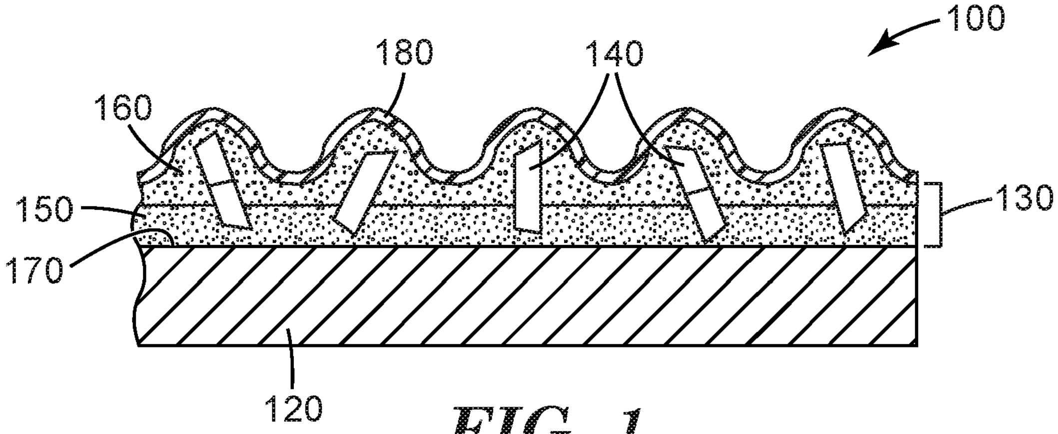


FIG. 1

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