ABRASIVE ARTICLES AND METHODS OF MAKING AND USING THE SAME

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ABSTRACT

A coated abrasive article having a reinforced vulcanized fiber backing with an abrasive layer affixed thereto and methods of making and using the same. The reinforced vulcanized fiber backing contains a reinforcing material that comprises a reaction product of a curable material.
Fig. 1
Prior Art

Fig. 2

Fig. 3
ABRASIVE ARTICLES AND METHODS OF MAKING AND USING THE SAME

BACKGROUND

[0001] Vulcanized fiber has been in commerce since the 19th century. The term “vulcanized fiber”, sometimes also referred to as “vulcanized fibre” or “fish paper”, refers to a leather-like material generally formed from cellulose by compressing layers of chemically treated (e.g., as with metallic chlorides) cellulose derived from paper, paper pulp, rayon or cloth. Due to its hydrophilic nature, vulcanized fiber is typically prone to absorb moisture.

[0002] Coated abrasive articles typically have an abrasive layer affixed to a backing. Vulcanized fiber has been used as a backing material for coated abrasive articles for more than 60 years. One well-recognized problem of using vulcanized fiber backings in abrasive articles is shape distortion (e.g., curling or cupping) of the coated abrasive article due to changes in environmental moisture content (e.g., humidity). Shape distortion may occur, for example, during manufacturing, during storage, or during use. Further, the shape distortion may occur toward and/or away from the abrasive layer. An example of such distortion of a prior art coated abrasive article having a vulcanized fiber backing is shown in FIG. 1, wherein the coated abrasive article exhibits curling directed away from the abrasive layer. If excessive shape distortion occurs during manufacturing of the coated abrasive article, then it is typically discarded as scrap material. Further, if excessive shape distortion occurs during storage, or in use, it typically results in product complaints, reduced product sales, and/or reduced product performance.

[0003] Attempts to solve the problem of shape distortion date back more than 50 years. For example, U.S. Pat. No. 2,431,258 to H. P. Kirchner, filed Feb. 5, 1946, issued Nov. 18, 1947 states in col. 2, lines 23-30: “Although it is possible by this process to make discs which are initially of the desired curvature, a great deal of trouble is experienced by abrasive manufacturers by reason of the fact that vulcanized fiber is very susceptible to changes in atmospheric moisture content, particularly when one side of the material has been coated as is the case with the abrasive discs of this invention.” In that patent, the problem was addressed by drying the article to achieve the desired level of curvature and then covering the vulcanized fiber backing with a sheet of material that is impermeable to moisture vapor. From that time until the present, there have been developed various other alternative moisture insensitive and dimensionally stable backings for coated abrasive articles incorporating vulcanized fiber.

[0004] Notwithstanding these various products, and primarily for economic reasons, vulcanized fiber backings are still used today in the commercial manufacture of coated abrasive articles primarily. For example, the major coated abrasives manufacturers each market coated abrasive products with vulcanized fiber backings that are prone to humidity problems, even though alternative moisture insensitive and dimensionally stable backings for coated abrasive articles are known. Accordingly, there remains a need in the coated abrasives industry for coated abrasive products with vulcanized fiber backings that are economical to manufacture and that are not prone to unacceptable levels of shape distortion with changes in humidity levels.

SUMMARY

[0005] In one aspect, the present invention provides a coated abrasive article comprising a reinforced vulcanized fiber backing having first and second major surfaces, the first major surface having an abrasive layer affixed thereto, wherein the reinforced vulcanized fiber backing has a reinforcing material distributed substantially throughout the vulcanized fiber backing, wherein the reinforcing material comprises from 0.1 to 20 percent by weight, based on the combined weight of the reinforcing material and vulcanized fiber backing, and wherein the reinforcing material comprises a reaction product of an aqueous organic curable material selected from the group consisting of phenolic resins, aldehydes, aminoplasts, urea-formaldehyde resins, polyaziridines, polyepoxides, polysiloxanes, curable latex emulsions, and combinations thereof.

[0006] In another aspect, the present invention provides a method of abrading a surface of a workpiece, the method comprising: providing a coated abrasive article according to the present invention, frictionally contacting the abrasive layer with a surface of the workpiece, and moving at least one of the abrasive layer and the surface of the workpiece relative to the other to abrade at least a portion of the surface of the workpiece.

[0007] In yet another aspect, the present invention provides a method of making a coated abrasive article, the method comprising:

[0008] impregnating a vulcanized fiber backing having first and second major surfaces with a curable material;

[0009] at least partially curing the curable material to provide a reinforcing material wherein the reinforcing material comprises from 0.1 to 20 percent by weight, based on the combined weight of the reinforcing material and vulcanized fiber backing, and wherein the reinforcing material comprises a reaction product of an aqueous organic curable material selected from the group consisting of phenolic resins, aldehydes, aminoplasts, urea-formaldehyde resins, polyaziridines, polyepoxides, polysiloxanes, curable latex emulsions, and combinations thereof; and

[0010] affixing an abrasive layer to the first major surface of the reinforced vulcanized fiber backing.

[0011] Coated abrasive articles according to the present invention typically exhibit a low degree of shape distortion with changes in humidity. Surprisingly, it is also found that such articles exhibit improved cut as compared to prior coated abrasives without reinforcing material in the vulcanized fiber backing.

[0012] As used herein,

[0013] the term “aqueous” means dissolved and/or dispersed in a liquid vehicle comprising water; and


BRIEF DESCRIPTION OF THE DRAWING

[0015] FIG. 1 is a photograph of a coated abrasive disc of the prior art;

[0016] FIG. 2 is a cross-sectional side view of an exemplary coated abrasive article according to the present invention;
FIG. 3 is a cross-sectional side view of an exemplary coated abrasive article according to the present invention; and

FIG. 4 is a photograph of a coated abrasive disc coated abrasive article according to Example 10.

DETAILLED DESCRIPTION

In general, coated abrasive articles have abrasive particles affixed to a backing. More typically, coated abrasive articles comprise a backing having two major opposed surfaces and an abrasive layer affixed to one major surface of the backing. The abrasive layer typically comprises abrasive particles and a binder, wherein the binder serves to secure the abrasive particles to the backing.

In one embodiment, the coated abrasive article has an abrasive layer comprising a make layer, a size layer, and abrasive particles. In making such a coated abrasive article, a make layer comprising a first binder precursor is applied to one major surface of the backing, and optionally partially cured. Abrasive particles are then at least partially embedded into the make layer (e.g., via electrostatic coating), and the first binder precursor is sufficiently cured (i.e., crosslinked) to secure the particles to the make layer. A size layer comprising a second binder precursor is then applied over the make layer and abrasive particles, followed by curing of the binder precursors. Such coated abrasive articles may further comprise an optional supersize disposed on at least a portion of the abrasive layer. If present, the supersize layer typically includes grinding aids and/or anti-loading materials.

In another embodiment, the coated abrasive article has an abrasive layer affixed to one major surface of the backing, wherein the abrasive layer is provided by applying a slurry comprised of binder precursor and abrasive particles onto a major surface of a backing, and then curing the binder precursor.

The backing comprises vulcanized fiber, a dense material of partially regenerated cellulose in which the fiber structure is retained and which is typically calendared to provide a relatively smooth surface. Vulcanized fiber is widely available from commercial sources such as, for example, Franklin Fibre—Lамиtex Corporation (Wilmington, Del.) or Yangmin Ind. Trade Co., Ltd. (Sanmenxia, Henan, China).

Typically, vulcanized fiber backing useful for preparing coated abrasive articles according to the present invention has a thickness in a range of from 0.02 to 5 millimeters, for example, from 0.05 to 2.5 millimeters or from 0.1 to 1 millimeter, although thinner and thicker vulcanized paper backings may also be used. Further, the density of the vulcanized fiber is typically in a range of from 0.9 to 1.5 grams per cubic centimeter, although higher and lower density vulcanized fiber may also be used.

The vulcanized fiber backing is impregnated (i.e., thoroughly permeated) with a curable material, typically comprising at least one curable resin, which then is at least partially cured, for example, by drying and heating to provide a reinforced vulcanized fiber backing. Impregnation of the vulcanized fiber with the curable material may be achieved by any suitable saturation coating method including, for example, roll coating, dip coating, or spraying. The curable material is typically impregnated into the vulcanized fiber such that it is distributed throughout the body of the vulcanized fiber, for example, in a substantially uniform manner. Typically, the variation in concentration of the curable material on going from one major surface of the backing to the other should not typically exceed about a factor of two, however any concentration gradient may be used as long as the resultant reinforcing material is distributed throughout the vulcanized fiber backing. Although substantially uniform distribution of both the curable material and the reinforcing material is typically preferred, it will be recognized that a minor amount of local variations or interruptions in the distribution (e.g., coating voids) may be tolerated without significant adverse effects.

At least one of the vulcanized fiber sheet and the reinforced vulcanized fiber backing may optionally further comprise additional backing treatments such as a backsize (i.e., a layer affixed to the major surface of the backing opposite the major surface having the abrasive layer), a presize (i.e., a layer affixed to the backing on the major surface having the abrasive layer), a tie layer (i.e., a layer between the abrasive layer and the major surface to which the abrasive layer is affixed), and/or a subsize treatment. A subsize is similar to a saturant (i.e., a backing treatment applied by a process that includes saturating the backing with the saturant) except that it is applied to a previously treated backing. An antistatic material may be included in any of these backing treatments. The addition of an antistatic material can reduce the tendency of the coated abrasive article to accumulate static electricity when sanding wood or wood-like materials. Additional details regarding antistatic backings and backing treatments can be found in, for example, U.S. Pat. No. 5,108,463 (Buchanan); U.S. Pat. No. 5,137,542 (Buchanan et al.); U.S. Pat. No. 5,328,716 (Buchanan); and U.S. Pat. No. 5,560,753 (Schnabel et al.); the disclosures of which are incorporated herein by reference.

Typically, the reinforcing material comprises from 0.1 to 20 percent by weight, based on the combined weight of the reinforcing material and vulcanized fiber backing. For example, the reinforcing material may comprise from 1 to 15 percent, or even from 5 to 15 percent, by weight, based on the combined weight of the reinforcing material and vulcanized fiber backing.

Typically, the reinforced vulcanized fiber backing will have a thickness in a range of from 0.15 to 1.8 millimeters, for example, 0.5 to 1.3 millimeters, or even 0.8 to 0.9 millimeters, although thicker and thinner reinforced vulcanized fiber backings may also be used.

The reinforcing material is distributed substantially throughout (i.e., through at least 80 percent by volume of) the reinforced vulcanized fiber backing. For example, the reinforcing material may be substantially uniformly distributed within the vulcanized fiber backing. The reinforcing material comprises at least one material that is a reaction product of at least one aqueous organic curable material selected from the group consisting of phenolic resins, aldehydes, aminoplasts, urea-formaldehyde resins, polyaziridines, polyepoxides, polysilyonates, curable latex emulsions, and combinations thereof. In some embodiments, the aqueous organic curable material may contain water miscible organic co-solvents. In addition, the reinforcing mate-
rial may include one or more optional additives such as, for example, fillers, plasticizers, antistatic agents, antioxidants, or colorants.

[0029] As used herein, the term “phenolic resin” refers to a synthetic thermostetting resin obtained by the reaction of a phenol with an aldehyde. For example, a portion of the phenol can be substituted with one or more other phenols such as resorcinol, m-cresol, 3,5-xylenol, t-butylphenol and p-phenylethanol. Likewise, a portion of the formaldehyde can be substituted with other aldehyde groups such as acetaldehyde, chloral, butyaldehyde, furfural or acrolein.

[0030] Examples of phenolic resins include resole-phenolic resins and novolok phenolic resins. Resole phenolic resins have a molar ratio of formaldehyde to phenol of greater than or equal to one to one, typically between 1.5:1 to 3.0:1.0. Novolak phenolic resins have a molar ratio of formaldehyde to phenol of less than one to one.

[0031] Typical resole phenolic resins contain a base catalyst. The presence of a basic catalyst speeds up the reaction or polymerization rate of the phenolic resin. The pH of resole phenolic resins is typically from 6 to 12, more typically from 7 to 10, and even more typically from 7 to 9. Examples of suitable basic catalysts include sodium hydroxide, potassium hydroxide, calcium hydroxide, magnesium hydroxide, barium hydroxide, and combinations thereof. Typical catalysts for the reaction of formaldehyde with phenol are chosen from group I and II metal salts, generally because of their high reactivity and low cost. Amines are also used to catalyze the phenylaldehyde reaction. The amount of basic catalyst is typically 5 percent by weight or less, more typically 2 percent by weight or less, and even more typically 1 percent by weight or less based on the weight of the phenolic resin. Resole phenolic resins are usually made from phenol and formaldehyde.

[0032] 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.

[0033] Examples of useful aldehydes include monoaldehydes such as formaldehyde and acetaldehyde and dialdehydes such as glyoxal, malonaldehyde, succinaldehyde, and glutaraldehyde.

[0034] Examples of useful aminoplasts include those available under the trade designations “CYMEL 373” and “CYMEL 323” from Cytex Inc., Stamford, Conn.

[0035] Examples of useful urea-formaldehyde resins include that marketed under the trade designation “AL3029R” from Borden Chemical (Columbus, Ohio), and those marketed under the trade designations “AMRES LOPR”, “AMRES PR247HV” and “AMRES PR335CU” from Georgia Pacific Corp. (Atlanta, Ga.).

[0036] Examples of useful polyziridines include trimethylolpropane tri-(N-ziridinyl)propionate and pentaerythritol-tris-(N-ziridinyl)propionate, available from Bayer Corporation (Pittsburgh, Pa.) under the trade designations “XAMA-220” and “XAMA-7”, respectively; (tris [1-(2-ethyl)aziridinyl])phosphine oxide, available from Aceto Chemical Corporation (Lake Success, N.Y.) under the trade designation “MAPO”, and a polyziridine available from NeoResins, Inc. (Wilmington, Mass.) under the trade designation “CROSSLINKER CX-100”.

[0037] Examples of useful polyisocyanates include monomeric, oligomeric, and polymeric polyisocyanates (e.g., disocyanates and triisocyanates), and mixtures and blocked versions thereof. Polyisocyanates may be aliphatic, aromatic, and/or a mixture thereof.

[0038] Examples of useful polyepoxides include monomeric polyepoxides, oligomeric polyepoxides, polymeric polyepoxides, and mixtures thereof. The polyepoxides may be aliphatic, aromatic, or a mixture thereof.

[0039] Examples of aliphatic polyepoxides monomers include epoxycyclohexane-carboxylates (e.g., 3,4-epoxycyclohexyl)methyl 3,4-epoxycyclohexanecarboxylate (e.g., as available under the trade designation “ERL-4221” from Dow Chemical Co. (Midland, Mich.), 3,4-epoxy-2-methylcyclohexylmethyl 3,4-epoxy-2-methylcyclohexanecarboxylate, bis(3,4-epoxy-6-methylcyclohexyl)methyladipate, 3,4-epoxy-6-methylcyclohexylmethyl 3,4-epoxy-6-methylcyclohexanecarboxylate (e.g., as available under the trade designation “ERL-4201” from Dow Chemical Co.); vinylcyclohexene dioxide (e.g., as available under the trade designation “ERL-4206” from Dow Chemical Co.); bis(2,3-epoxycycloprene)ether (e.g., as available under the trade designation “ERL-0400” from Dow Chemical Co.); bis(3,4-epoxy-6-methylcyclohexylmethyl)adipate (e.g., as available under the trade designation “ERL-4289” from Dow Chemical Co.); dipentene dioxide (e.g., available, for example, under the trade designation “ERL-4269” from Dow Chemical Co.); 2-(3,4-epoxycyclohexyl-5,1’-spiro-3’,4’-epoxycyclohexane-1,3-dioxane, and 2,2-bis(3,4-epoxycyclohexyl)propane, and polyepoxide resins derived from epichlorhydrin.

[0040] Examples of aromatic polyepoxides include polyglycidyl ethers of polyhydric phenols such as: Bisphenol A-type resins and their derivatives, including such epoxy resins having the trade designation “EPON” available from Resolution Performance Products, Houston, Tex.; epoxy cresol-novolac resins; Bisphenol-F resins and their derivatives; epoxy phenol-novolac resins; and glycidyl esters of aromatic carboxylic acids (e.g., phthalic acid diglycidyl ester, isophthalic acid diglycidyl ester, trimellitic acid trisyl ester, and pyromellitic acid tetraglycidyl ester), and mixtures thereof. Commercially available aromatic polyepoxides include, for example, those having the trade designation “ARALDITE” available from Ciba Specialty Chemicals, Tarntown, N.Y.; aromatic polyepoxides having the trade designation “EPON” available from Resolution Performance Products; and aromatic polyepoxides having the trade designations “DER”, “DENO”, and “QUATREX” available from Dow Chemical Co.

[0041] Polyepoxide(s) are typically combined with a curing agent such as for example, a polyamine, polyamide, polythiol, or an acidic catalyst, although may not be required for curing.

[0042] Examples of useful curable latex emulsions include those curable latex emulsions derived from styrene, butadi-
ene, acrylonitrile, chloroprene, polyesters, polyurethanes, polyvinyl acetate, vinyl esters, and/or methacrylate esters, acrylamides, acrylic and/or methacrylic acid, and copolymers thereof. Mixtures of curable latex emulsions may also be used.

[0043] Commercially available curable latex emulsions include, for example, those available under the trade designations “RHOPLEX” and “ACRYCILS” from Rohm and Haas Company (Philadelphia, Pa.); “FLEXCRYL” and “VALTAC” from Air Products & Chemicals Inc. (Allentown, Pa.); “SYNTHEMUL”, “TYCRYL”, and “TYLAC” from Dow Reischold Specialty Latex, LLC (Research Triangle Park, N.C.); “HYCAR”, “CARBOCURE”, “GOOD-RITE”, “SANOCURE” and “VYCAR” from NOVEON (Cleveland, Ohio); “CHEMIGUM” commercially available from Goodyear Tire and Rubber Co. (Akron, Ohio); “NEOCURE”, “NEOCRL” commercially available from ICI; and “BUTAFON” commercially available from BASF. Unless the latex is self-crosslinking, it is typically used in combination with at least one additive (e.g., a crosslinker) that facilitates curing or it may also be used in combination with another curable material.

[0044] Examples of commercially available self-crosslinking latexes include those emulsions having the trade designations “CARBOCURE TSR-72” and “CARBOCURE TSR-201”; styrene butadiene emulsions having the trade designation “GOOD-RITE SB-1168”, “GOOD-RITE SB-076”, “GOOD-RITE 1800x75”; a polyurethane dispersion having the trade designation “SANOCURE A-4010” (acrylic urethane hybrid); a polyvinyl acetate emulsion having the trade designation “VYCAR VA-0450”; and a poly(vinyl chloride)-acrylic copolymer having the trade designation “VYCAR TN-810”, all marketed by NOVEON, Cleveland, Ohio.

[0045] The curable material may optionally contain one or more curatives, for example, as described above, or in addition thereto. The choice of curative is typically determined by the curable material selected and may include, for example, acid, base, photocatalyst, hardeners, crosslinkers, and mixtures thereof.

[0046] As noted above, coated abrasive articles typically have an abrasive layer affixed to a backing. Typically, the abrasive layer comprises make and size layers and abrasive particles or, alternatively, a layer of abrasive particles dispersed in a binder.

[0047] According to one embodiment of the present invention, the coated abrasive article has an abrasive layer comprising make and size layers and abrasive particles as shown, for example, in FIG. 2. Referring now to FIG. 2, exemplary coated abrasive article 200 comprises a nonwoven fiber backing 212 having first and second opposed major surfaces 231, 232, respectively. Reinforcing material 211 is distributed substantially throughout the nonwoven fiber backing 212. Optional backsize 213 is disposed on second major surface 232, and optional presize 215 is affixed to first major surface 231. Overlapping optional presize 215 and affixed to backing 212 is abrasive layer 230 comprising: make layer 216 in which are embedded abrasive grits 218, and size layer 217 which overlays and is affixed to make layer 216 and abrasive grits 218. Optional supersize 219 overlays size layer 217.

[0048] The basis weight of the make layer utilized may depend, for example, on the intended use(s), type(s) of abrasive particles, and nature of the coated abrasive article being prepared, but generally will be in the range of from 1, 2, or 5 to 20, 25, 400, or even 600 grams per square meter (i.e., gsm). The make layer is generally applied as a make layer precursor that upon subsequent solidification (e.g., by curing or cooling) forms a layer of binder material of sufficient strength to secure abrasive particles to the backing. The make layer precursor may be applied by any known coating method for applying a make layer precursor to a backing, including, for example, roll coating, extension die coating, curtain coating, knife coating, gravure coating, and spray coating. Examples of make layer precursors include curable materials comprising phenolics, aminoplasts, poly(meth)acrylates, polyelepxides, polysisoycaynates, hide glue, and combinations thereof.

[0049] After applying a make layer precursor to the reinforced vulcanized fiber backing, and prior to solidification of the make layer precursor (e.g., by curing), abrasive particles are deposited onto the make layer.

[0050] Exemplary useful abrasive particles include fused aluminum oxide based materials such as aluminum oxide, ceramic aluminum oxide (which may include one or more metal oxide modifiers and/or seeders or nucleating agents), and heat-treated aluminum oxide, silicon carbide, co-fused alumina-zirconia, diamond, ceria, titanium diboride, cubic boron nitride, boron carbide, garnet, flint, emery, sol-gel derived abrasive particles, and blends thereof. Examples of sol-gel abrasive particles include those described in U.S. Pat. No. 4,314,827 (Leitheiser et al.); U.S. Pat. No. 4,518,397 (Leitheiser et al.); U.S. Pat. No. 4,623,364 (Cottinger et al.); U.S. Pat. No. 4,744,802 (Schwabel); U.S. Pat. No. 4,770,671 (Monroe et al.); U.S. Pat. No. 4,881,951 (Wood et al.); U.S. Pat. No. 5,011,508 (Wald et al.); U.S. Pat. No. 5,090,968 (Pellow); U.S. Pat. No. 5,139,978 (Wood); U.S. Pat. No. 5,201,916 (Berg et al.); U.S. Pat. No. 5,227,104 (Bauer); U.S. Pat. No. 5,366,523 (Rowenhorst et al.); U.S. Pat. No. 5,429,647 (Larmie); U.S. Pat. No. 5,498,267 (Larmie); and U.S. Pat. No. 5,551,963 (Larmie); the disclosures of which are incorporated herein by reference. The abrasive particles may be in the form of, for example, individual particles, agglomerates, abrasive composite particles, and mixtures thereof.

[0051] Exemplary agglomerates are described, for example, in U.S. Pat. No. 4,652,275 (Bloecher et al.) and U.S. Pat. No. 4,799,939 (Bloecher et al.), the disclosures of which are incorporated herein by reference. It is also within the scope of the present invention to use dilute erodible agglomerate grains as described, for example, in U.S. Pat. No. 5,078,753 (Broberg et al.), the disclosure of which is incorporated herein by reference. Abrasive composite particles comprise abrasive grains in a binder.

[0052] Exemplary abrasive composite particles are described, for example, in U.S. Pat. No. 5,549,062 (Holmes et al.), the disclosure of which is incorporated herein by reference.

[0053] Coating weights for the abrasive particles may depend, for example, on the specific coated abrasive article desired, the process for applying the abrasive particles, and the size of the abrasive particles, but typically range from 1 to 2000 grams per square centimeter (gsm).

[0054] The basis weight of the size layer will also necessarily vary depending on the intended use(s), type(s) of
abrasive particles, and nature of the coated abrasive article being prepared, but generally will be in the range of from 1 or 5 gsm to 300, or even 800 gsm, or more.

[0055] The size layer is generally applied as a size layer precursor that upon subsequent solidification (e.g., by curing or cooling) forms a layer of binder material of sufficient strength to secure the abrasive particles to the make layer. The size layer precursor may be applied by any known coating method for applying a size layer precursor to a backing, including, for example, roll coating, extrusion die coating, curtain coating, knife coating, gravure coating, and spray coating. Examples of size layer precursors include curable materials comprising at least one of phenolic resins, aminoplasts, poly(meth)acrylates, polyepoxides, polyisocyanates, hide glue, urea-formaldehyde resins, melamine-formaldehyde resins, and combinations thereof.

[0056] Details concerning coated abrasive articles comprising abrasive particles and make and size layers, and optional supersize are well known and are described, for example, in U.S. Pat. No. 4,734,104 (Broberg); U.S. Pat. No. 4,737,163 (Larkey); U.S. Pat. No. 5,203,884 (Buchanan et al.); U.S. Pat. No. 5,152,917 (Pieper et al.); U.S. Pat. No. 5,378,251 (Culler et al.); U.S. Pat. No. 5,417,726 (Stout et al.); U.S. Pat. No. 5,436,063 (Follett et al.); U.S. Pat. No. 5,496,386 (Broberg et al.); U.S. Pat. No. 5,609,706 (Benedit et al.); U.S. Pat. No. 5,202,711 (Helmin); U.S. Pat. No. 5,954,844 (Law et al.); U.S. Pat. No. 5,961,674 (Gagliardi et al.); U.S. Pat. No. 4,751,138 (Tumey et al.); U.S. Pat. No. 5,766,277 (DeVoe et al.); U.S. Pat. No. 6,077,601 (DeVoe et al.); U.S. Pat. No. 6,228,133 (Tharber et al.); and U.S. Pat. No. 5,975,988 (Christianson); the disclosures of which are incorporated herein by reference.

[0057] According to another embodiment of the present invention, the coated abrasive article has an abrasive layer comprising a layer of abrasive particles dispersed in a binder as shown, for example, in FIG. 3. Referring now to FIG. 3, exemplary coated abrasive article 300 comprises vulcanized fiber backing 312 having first and second opposed major surfaces 331, 332, respectively. Reinforcing material 311 is distributed substantially throughout backing 312. Optional backsize 313 is disposed on second major surface 332, and optional presize 315 is affixed to first major surface 331. Overlaping optional presize 315 and affixed to backing 312 is abrasive layer 330, which comprises a plurality of abrasive grits 318 distributed throughout binder 309.

[0058] In some embodiments of coated abrasive articles according to the present invention, the size layer comprises a dispersion of abrasive particles in a binder (typically coated as a slurry of abrasive particles in a binder precursor. Slurry coating techniques are well known in the abrasive art, and include those described, for example, in U.S. Pat. No. 5,378,251 (Culler et al.); U.S. Pat. No. 5,942,015 (Culler et al.); and U.S. Pat. No. 6,277,160 (Stubbins et al.); the disclosures of which are incorporated herein by reference. Examples of suitable binder precursors include curable materials comprising phenolics, aminoplasts, poly(meth)acrylates, polyepoxides, polyisocyanates, and combinations thereof. Abrasive particles used in this embodiment include all of those previously listed hereinabove.

[0059] Coated abrasive articles according to the present invention can be converted, for example, into belts, tapes, rolls, discs (including perforated discs), and/or sheets. An exemplary coated abrasive disc according to one embodiment of the present invention is shown in FIG. 4.

[0060] According to the present invention, it is found that problems of cupping and/or curling due to moisture absorption are greatly reduced, generally to a degree that they are no longer objectionable to users. This is surprising since the moisture uptake of the inventive coated abrasives is typically virtually the same as for corresponding coated abrasives of the prior art.

[0061] Further, it is also surprisingly observed that coated abrasives according to the present invention typically have improved cut as compared to corresponding coated abrasives of the prior art.

[0062] For belt applications, two free ends of the abrasive sheet may be joined together using known methods to form a spliced belt. A spliced belt may also be formed as described, for example, in U.S. Pat. No. 5,573,619 (Benedict et al.), the disclosure of which is incorporated herein by reference.

[0063] Coated abrasive articles according to the present invention are useful for abrading a workpiece. One such method includes frictionally contacting at least a portion of the abrasive layer of a coated abrasive article with at least a portion of a surface of the workpiece, and moving at least one of the coated abrasive article or the workpiece relative to the other to abrade at least a portion of the surface.

[0064] Examples of workpiece materials include metal, metal alloys, exotic metal alloys, ceramics, glass, wood, wood-like materials, composites, painted surfaces, plastics, reinforced plastics, stone, and/or combinations thereof. The workpiece may be flat or have a shape or contour associated with it. Examples of specific workpieces include metal components, plastic components, particleboard, camshafs, crankshafts, furniture, and turbine blades.

[0065] Coated abrasive articles according to the present invention may be used by hand and/or used in combination with a machine. At least one or both of the coated abrasive article and the workpiece is generally moved relative to the other when abrading. Abrading may be conducted under wet or dry conditions. Exemplary liquids for wet abrading include water, water containing conventional rust inhibiting compounds, lubricant, oil, soap, and cutting fluid. The liquid may also contain defoamers, degreasers, and/or the like.

[0066] Objects and advantages of this invention 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 invention.

EXAMPLES

[0067] Unless otherwise noted, all parts, percentages, ratios, etc. in the examples and the rest of the specification are by weight, and all reagents used in the examples were obtained, or are available, from general chemical suppliers such as, for example, Sigma-Aldrich Company, Saint Louis, Mo., or may be synthesized by conventional methods.
The following abbreviations are used throughout the Examples that follow:

VF vulcanized fiber web, 0.6 mm (33 mil) thick, obtained under the trade designation “DYNOS FIBRE” from Troplast A.G., Troisdorf, Germany
PAZ polazidine, obtained under the trade designation “XR9000” from H.B. Fuller Company, Vadnais Heights, Minnesota
SS sodium silicate, 37% aqueous solution “N” obtained from PQ Corporation, Valley Forge, Pa.
X100 nonionic surfactant, “Triton X-100”, obtained from Hach Corp., Ames, IA
PR 75% aqueous solution of phenol-formaldehyde resin having a phenol to formaldehyde ratio of 1.5–2.1:1, catalyzed with 2.5% potassium hydroxide
PS propylene glycol monomethyl ether, obtained under the trade designation “POLYSOLV MPM” from Arch Chemicals Inc., Brandenburg, Kentucky
AR thermostable acrylic latex, obtained under the trade designation “CARBOCURE TSR 72” from Noveon Inc., Cleveland, Ohio
RNF moisture-resitant vulcanized fiber, both sides coated with polyurethane, obtained under the trade designation “RNF-77” from Toyo Fibre (USA) Inc., Schaumburg, Illinois
NFK moisture-resistant vulcanized fiber, believed to be impregnated with a dicyandiamide/formaldehyde resin, obtained under the trade designation “NFK-88” from Toyo Fibre (USA) Inc.
AP ceramic aluminum oxide abrasive particles, grade 36, obtained under the trade designation “CUBITRON” from 3M Company, Saint Paul, Minnesota
Caco calcium carbonate filler obtained under the trade designation “HUBERCARB Q325” from J. M. Huber Corporation, Fairmount, Georgia
CRY filler, obtained under the trade designation “CRYOLITE TYPE RTN-C” from Koppers Trading, Pittsburgh, Pennsylvania

Test Methods

Curl Test Method 1

Controlled humidity chambers were constructed using saturated salt solutions as described in ASTM E104-02. A 23% relative humidity (RH) chamber was made using saturated potassium acetate, a 43% RH chamber was made using saturated potassium carbonate and an 85% RH chamber was made using saturated potassium chloride. The chambers consisted of a 5-gallon pail with a sealable lid containing a shallow reservoir of the saturated salt solution. Test disc samples were suspended in the chamber by means of a horizontal wire, which was passed through the disc center hole and was secured to the rim of the pail.

One side of each of the example treated fiber discs was completely covered with aluminum foil tape (“Scotch Brand 425”, 3M Company), to simulate the rigid restraining effect of an abrasive coating. The tape coated discs were compressed between metal plates until flat and conditioned in the 43% RH chamber for a week. The initial curl of each disc was then measured. Four samples were used for each of the example compositions. Curl was measured by placing each fiber disc on a flat surface, concave side down, and measuring the distance through the center hole from the flat surface to the uppermost surface of the fiber disc. Curl was measured in millimeters.

Half of each example disc population (2 discs) was then put in either the 23% RH or 85% RH chamber. After 2 weeks, the example fiber discs were removed and their degree of curl was again measured and the change in curl from the initial conditions was calculated. Curl index was calculated for each fiber disc by adding the absolute values of the changes in shape for both the 85% RH and 23% RH tests. The curl index was used as an indicator of shape stability.

Curl Test Method 2

Curl of abrasive discs was measured after equilibration for at least one week under ambient relative humidity conditions of 20% RH. The abrasive discs were placed on a flat surface, concave side down, and the displacement between the surface and uppermost surface of the disc was measured through the center hole expressed in millimeters. Curl away from the abrasive face is positive and toward the abrasive face is negative.

The discs were then placed in a thermostatically controlled oven, concave side up, for 3 hours at 60°C, to dry the fiber and initiate curl. The discs were removed from the oven and curl was measured again as above. The change in curl was then calculated by subtracting the initial curl from the final curl.

Grinding Performance Test

This test was designed to measure the effectiveness of an abrasive disc construction for the removal of metal from a workpiece by measuring how the cut rate changes with time and the total amount of metal usefully removed over the life of the abrasive disc. The coated abrasive disc was mounted on a beveled aluminum back up pad and driven at a speed of 5,500 rpm. A portion of the disc overlaying the beveled edge of the back up pad was contacted with the face of a 1.25 cm by 18 cm 1018 mild steel workpiece at about 6.2 kg load. Each disc was used to grind a separate workpiece for one-minute intervals for a total of 20 minutes or until the disc failed or the cut rate dropped below 20 grams per minute. The amount of metal removed from each workpiece was recorded. The initial cut was reported as the amount of metal removed during the first one-minute interval. The final cut was reported as the amount of metal removed during the final one-minute interval. The total cut was the cumulative amount of metal removed from the workpieces over the entire useful life of the abrasive disc or 20 one-minute
intervals, whichever was reached first. The cut data is reported in grams of workpiece metal removed.

General Procedure for Preparing Polyaziridine Impregnated Vulcanized Fiber Discs

Crosslinked Vulcanized fiber discs were prepared by saturation with aqueous solutions of known polyaziridine concentration. Six 17.8 cm (7 in.) diameter discs cut from VF were submerged in aqueous solutions of PAZ containing 0.1 percent by weight X100. After 2 hours, the saturated fiber discs were removed from the liquid and excess superficial solution was wiped from the disc surface with a paper towel. The difference between the dry disc weight and the saturated disc weight was recorded and the weight percent aziridine incorporated in the disc was calculated from this weight gain and the percent aziridine in the saturating solution. The discs were allowed to air dry overnight. The treated discs were then placed in between metal plates and compressed until flat. The compressed assembly was maintained for 24 hours at 85% relative humidity (RH) to allow the discs to assume a flat shape. The aziridine in the discs was then thermally reacted by heating the compressed disc assembly to 100°C for 1 hour and 125°C for 24 hours.

Impregnated Backings 1-4

Polyaziridine impregnated vulcanized fiber discs were prepared according to the Procedure for Preparing Polyaziridine Impregnated Vulcanized Fiber Discs using the polyaziridine solutions of specific concentrations, and resulting in incorporation levels as indicated in Table I (below).

<table>
<thead>
<tr>
<th>IMPREGNATED BACKING</th>
<th>CONCENTRATION OF PAZ, percent by weight</th>
<th>INCORPORATION LEVEL, percent by weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>0.36</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>1.37</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>2.25</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>4.54</td>
</tr>
</tbody>
</table>

Comparative Backing A

As a control for the effect of water saturation, fiber discs (17.8 cm (7 in.) diameter with a 2.2 cm (7/8 inch) diameter center hole) were saturated with a solution of 0.1 percent by weight X100 in deionized water. The discs were allowed to air dry and were dried in an oven for 1 hour at 100 and 24 hours at 125°C. While compressed to a flat shape.

General Procedure for Preparing Phenolic Resin Impregnated Vulcanized Fiber Discs

Method 1

In this method of saturation, phenolic resin was incorporated into vulcanized fiber in a vacuum chamber. A phenolic resin solution was prepared using PR. Three hundred grams of this phenolic solution was diluted with 80 grams of deionized water. The diluted resin solution was added to a glass crystallization dish of sufficient diameter to contain and submerge a 17.8 cm (7 in.) diameter VF disc. A single fiber disc was added to the container and the whole assembly was placed in a vacuum chamber equipped with a pump. The air was evacuated from the chamber for a period of 2 minutes, and then air was readmitted to restore atmospheric pressure. This cycle was repeated three times. The fiber disc was then removed from the phenolic solution and superficial resin was removed by pressing between layers of paper toweling. The individual discs were restrained in a flat shape between metal plates and dried for 2 hours at 90°C followed by cure for 12 hours at 105°C.

Method 2

PR was diluted with water and placed in a shallow pan. Six weighed 17.8 cm (7 in.) diameter VF discs were submerged in this solution for a period of 18 hours. Superficial solution was wiped from the surface of the discs with paper toweling and the discs were reweighed. The percent incorporation of phenolic resin in the fiber was calculated from the weight increase and the solution concentration. The discs were air dried and then cured as described in Method 1.

Method 3

PR was diluted a 1:1 (wt./wt.) blend of PS and water, and placed in a shallow pan. Six weighed 17.8 cm (7 in.) diameter VF discs were submerged in this solution for a period of 18 hours. Superficial solution was wiped from the surface of the discs with paper toweling and the discs were reweighed. The percent incorporation of phenolic resin in the fiber was calculated from the weight increase and the solution concentration. The discs were air dried and then cured as described in Method 1.

Impregnated Backings 5-8

Phenolic resin impregnated vulcanized fiber discs were prepared according to the Procedure for Preparing Phenolic Resin Impregnated Vulcanized Fiber Discs using the phenolic resin solutions of specific concentrations, and resulting in incorporation levels as indicated in Table II (below).

<table>
<thead>
<tr>
<th>IMPREGNATED BACKING</th>
<th>CONCENTRATION OF PHENOLIC RESIN, percent by weight</th>
<th>INCORPORATION LEVEL, percent by weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>3</td>
<td>11.0</td>
</tr>
<tr>
<td>6</td>
<td>3</td>
<td>15.0</td>
</tr>
<tr>
<td>7</td>
<td>3</td>
<td>37.5</td>
</tr>
<tr>
<td>8</td>
<td>2</td>
<td>60.0</td>
</tr>
</tbody>
</table>

Impregnated Backing 9

Acrylic latex impregnated vulcanized fiber discs were prepared by saturation with AR. Six 17.8 cm (7 in.) diameter discs cut from VF were submerged in AR. After 2 hours, the saturated fiber discs were removed from the liquid and excess superficial solution was wiped from the disc surface with a paper towel. The discs were allowed to air dry overnight. The treated discs were then placed in between metal plates and compressed until flat. The compressed assembly was maintained for 24 hours at 85 percent relative humidity to allow the discs to assume a flat shape. The latex in the discs was then thermally reacted by heating the compressed disc assembly to 100°C for 1 hour.
Impregnated Backing A

This was NFK as received from the manufacturer, cut into 17.8 cm (7 in.) diameter test discs having a 2.2 cm (7/8-inch) diameter center hole.

Comparative Backing B

This was VF as received from the manufacturer, cut into 17.8 cm (7 in.) diameter test discs having a 2.2 cm (7/8 inch) diameter center hole.

Example 11

This was RNF as received from the manufacturer, cut into 17.8 cm (7 in.) diameter test discs having a 2.2 cm (7/8-inch) diameter center hole.

Impregnated Backings 1-4 and 6-9 and Comparative Backings A and B were measured for shape stability using Curl Test Method 1. The results are shown in Table III below.

Coated Abrasive Disc Preparation Method

A make resin was coated onto one surface of the fiber backing disc being tested to a level of 170 grams/meter$^2$ (gsm) based on wet weight. The make resin consisted of 48 percent by weight PR and 52 percent by weight CACO, which was diluted to 81 percent by weight solids with water. Immediately after coating the make resin, AP was electrostatically coated onto the make resin to an add on weight of 780 gsm. The coated disc was then heated at 77°C for 15 minutes and then at 93°C for 90 minutes to partially cure the make resin. A size resin was then coated over the surface of the make resin and mineral grain to a target weight of 530 gsm wet weight. The size resin consisted of 32% PR and 68% CRY, diluted to 78% solids with water. The size resin was cured at 77°C for 1 hour and then 102°C for 16 hours. The resultant coated abrasive discs were flexed twice in orthogonal directions over a 2.54-centimeter (1-inch) diameter rod before testing. For reference, coated abrasive disc prepared from backings are designated as the corresponding Examples. Hence, Impregnated Backing 1 leads to Example 1 and Comparative Backing B leads to Comparative Example B.

Example coated abrasive discs 5-11 and Comparative Example B were evaluated for shape stability using Curl Test Method 2. Results are reported in Table IV (below).

<table>
<thead>
<tr>
<th>Example</th>
<th>Change in Curl, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0, -1, 0, 1</td>
</tr>
<tr>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>1, 1</td>
</tr>
<tr>
<td>8</td>
<td>0, 0</td>
</tr>
<tr>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>10</td>
<td>2, 4</td>
</tr>
<tr>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td>Comparative</td>
<td>10, 11</td>
</tr>
</tbody>
</table>

The grinding performance cut rate data for the coated abrasive discs were measured according to the Grinding Performance Test, the results of which are reported in Table V (below).

<table>
<thead>
<tr>
<th>EXAMPLE</th>
<th>TOTAL CUT, g</th>
<th>INITIAL CUT, g</th>
<th>FINAL CUT, g</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>195.56*</td>
<td>97.5</td>
<td>90.06</td>
</tr>
<tr>
<td>3</td>
<td>76*</td>
<td>76</td>
<td>76</td>
</tr>
<tr>
<td>4</td>
<td>300.18*</td>
<td>102.1</td>
<td>81.46</td>
</tr>
<tr>
<td>5</td>
<td>1493.3</td>
<td>103.89</td>
<td>25.39</td>
</tr>
<tr>
<td>6</td>
<td>1043.7</td>
<td>94.59</td>
<td>14.11</td>
</tr>
<tr>
<td>7</td>
<td>972.1</td>
<td>101.3</td>
<td>12.3</td>
</tr>
<tr>
<td>8</td>
<td>1107.15</td>
<td>102.92</td>
<td>11.4</td>
</tr>
<tr>
<td>9</td>
<td>1007.86</td>
<td>98.8</td>
<td>7.37</td>
</tr>
<tr>
<td>10</td>
<td>274.78*</td>
<td>97.81</td>
<td>78.07</td>
</tr>
<tr>
<td>11</td>
<td>643.95*</td>
<td>102.36</td>
<td>105.74</td>
</tr>
<tr>
<td>12</td>
<td>1280.1*</td>
<td>103</td>
<td>79.6</td>
</tr>
<tr>
<td>13</td>
<td>1570.06</td>
<td>102.54</td>
<td>37.94</td>
</tr>
<tr>
<td>14</td>
<td>509.8*</td>
<td>97.4</td>
<td>107.1</td>
</tr>
<tr>
<td>15</td>
<td>1193.62</td>
<td>98.39</td>
<td>59.09</td>
</tr>
<tr>
<td>Comparative</td>
<td>94.61</td>
<td>17.78</td>
<td></td>
</tr>
<tr>
<td>Example B</td>
<td>1089.09</td>
<td>109.77</td>
<td>12.89</td>
</tr>
<tr>
<td>1126.76</td>
<td>102.5</td>
<td>14.17</td>
<td></td>
</tr>
<tr>
<td>1109.0</td>
<td>91.7</td>
<td>19.3</td>
<td></td>
</tr>
</tbody>
</table>

*Indicates that the test disc broke or was damaged during testing and the test was stopped.

The grinding performance cut rate data for the coated abrasive discs of Example 5 and Comparative Example B were measured according to the Grinding Performance Test, the results of which are reported in Table VI (below).

<table>
<thead>
<tr>
<th>INTERVAL</th>
<th>EXAMPLE 5</th>
<th>COMPARATIVE EXAMPLE B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>104</td>
<td>86</td>
</tr>
<tr>
<td>5</td>
<td>104</td>
<td>90</td>
</tr>
<tr>
<td>10</td>
<td>84</td>
<td>63</td>
</tr>
<tr>
<td>15</td>
<td>57</td>
<td>34</td>
</tr>
<tr>
<td>20</td>
<td>32</td>
<td>10</td>
</tr>
</tbody>
</table>
What is claimed is:

1. A coated abrasive article comprising a reinforced vulcanized fiber backing having first and second major surfaces, the first major surface having an abrasive layer affixed thereto, wherein the reinforced vulcanized fiber backing has a reinforcing material distributed substantially throughout the vulcanized fiber backing, wherein the reinforcing material comprises from 0.1 to 20 percent by weight, based on the combined weight of the reinforcing material and vulcanized fiber backing, and wherein the reinforcing material comprises a reaction product of an aqueous organic curable material selected from the group consisting of phenolic resins, aldehydes, aminoplasts, urea-formaldehyde resins, polyaziridines, polyepoxides, polyisocyanates, curable latex emulsions, and combinations thereof.

2. A coated abrasive article according to claim 1, wherein the reinforcing material is distributed substantially uniformly throughout the vulcanized fiber backing.

3. A coated abrasive article according to claim 1, wherein the reinforcing material comprises at least one material that is a reaction product of at least one curable material selected from the group consisting of phenolic resins, aminoplasts, urea-formaldehyde resins, curable latex emulsions, and combinations thereof.

4. A coated abrasive article according to claim 1, wherein the abrasive article comprises an abrasive disc.

5. A coated abrasive article according to claim 1, wherein the abrasive article comprises an endless abrasive belt.

6. A coated abrasive article according to claim 1, wherein the reinforcing material comprises from 5 to 15 percent by weight, based on the combined weight of the reinforcing material and vulcanized fiber backing.

7. A coated abrasive article according to claim 1, wherein the reinforced vulcanized fiber backing has a thickness in a range of from 0.15 to 1.8 millimeters.

8. A coated abrasive article according to claim 1, wherein the abrasive layer comprises make and size layers.

9. A coated abrasive article according to claim 1, wherein the abrasive layer comprises abrasive particles distributed in a binder.

10. A coated abrasive article according to claim 1, wherein the abrasive layer comprises a reaction product of components comprising at least one of a polyepoxide, a poly(meth)acrylate, urea-formaldehyde resin, melamine-formaldehyde resin, phenolic resin, or a combination thereof.

11. A coated abrasive article according to claim 1, wherein the abrasive article further comprises at least one of a presize, subsize, backsize, tie layer or supersize.

12. A method of abrading a surface of a workpiece, the method comprising:

- providing a coated abrasive article according to claim 1;
- frictionally contacting the abrasive layer with a surface of the workpiece; and
- moving at least one of the abrasive layer and the surface of the workpiece relative to the other to abrade at least a portion of the surface of the workpiece.

13. A method of making a coated abrasive article, the method comprising:

- impregnating a vulcanized fiber backing having first and second major surfaces with a curable material;
- at least partially curing the curable material to provide a reinforcing material wherein the reinforcing material comprises from 0.1 to 20 percent by weight, based on the combined weight of the reinforcing material and vulcanized fiber backing, and wherein the reinforcing material comprises a reaction product of an aqueous organic curable material selected from the group consisting of phenolic resins, aldehydes, aminoplasts, urea-formaldehyde resins, polyaziridines, polyepoxides, polyisocyanates, curable latex emulsions, and combinations thereof; and
- affixing an abrasive layer to the first major surface of the reinforced vulcanized fiber backing.

14. A method of making a coated abrasive article according to claim 13, wherein the curable material is selected from the group consisting of phenolic resins, aminoplasts, urea-formaldehyde resins, curable latex emulsions, and combinations thereof.

15. A method of making a coated abrasive article according to claim 13, wherein the reinforcing material comprises from 5 to 15 percent by weight, based on the combined weight of the reinforcing material and vulcanized fiber backing.

16. A method of making a coated abrasive article according to claim 13, wherein the resin impregnated vulcanized fiber backing has a thickness in a range of from 0.15 to 1.8 millimeters.

17. A method of making a coated abrasive article according to claim 13, wherein the abrasive layer comprises make and size layers.

18. A method of making a coated abrasive article according to claim 17, further comprising applying a supersize to the size layer.

19. A method of making a coated abrasive article according to claim 13, wherein the abrasive layer comprises a slurry layer.

20. A method of making a coated abrasive article according to claim 13, wherein the abrasive article comprises an abrasive disc.

21. A method of making a coated abrasive article according to claim 13, wherein at least one of the make or size layers comprises a reaction product of components comprising at least one of a polyepoxide, a poly(meth)acrylate, urea-formaldehyde resin, melamine-formaldehyde resin, phenolic resin, or a combination thereof.

* * * * *