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(54) **CARBOXYLIC ACID ESTER
COLOR-STABILIZED PHENOLIC BOUND
ABRASIVE PRODUCTS AND METHODS FOR
MAKING SAME**

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(57) **ABSTRACT**

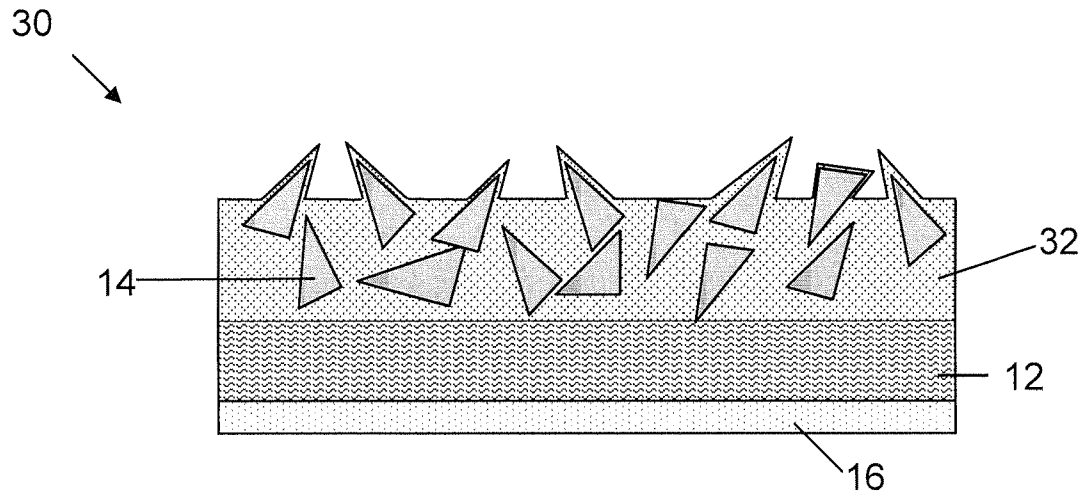
Described is a color-stable abrasive article that includes a phenolic resin binder; a color stabilizer, a colorant, and abrasive grains. The color stabilizer includes at least one carboxylic acid ester. The color-stable abrasive article is formed by a method including the steps of blending a resole and a color stabilizer to form a resole composition; contacting a plurality of abrasive particles with the resole composition; and curing the resole composition to produce the color-stable abrasive article. Thus provided are color stabilized phenolic bound abrasives and a method for making such abrasives that resist color change over time and upon exposure to high temperature and maintain the mechanical strength of a phenolic resin.

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Related U.S. Application Data

(60) Provisional application No. 61/199,472, filed on Nov. 17, 2008.



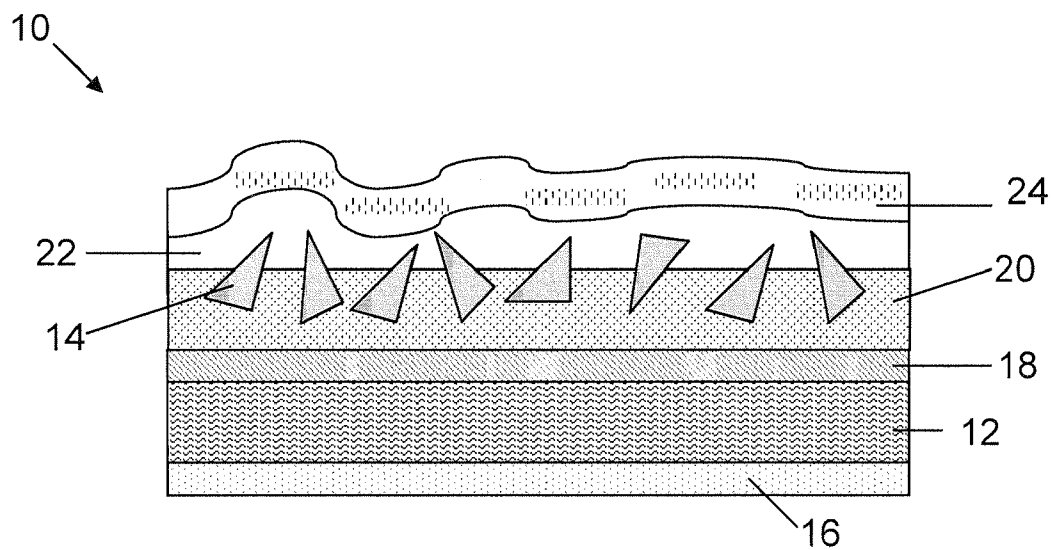


FIG. 1

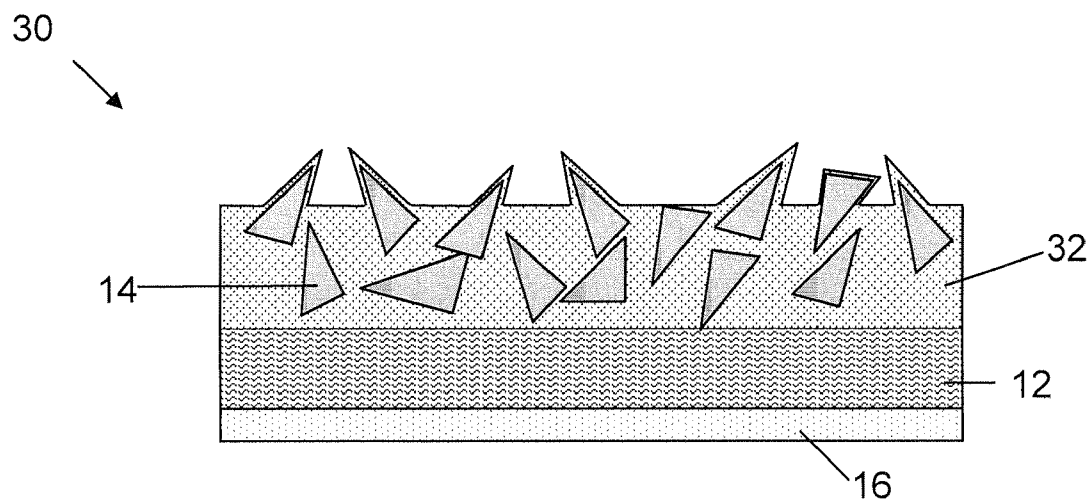


FIG. 2

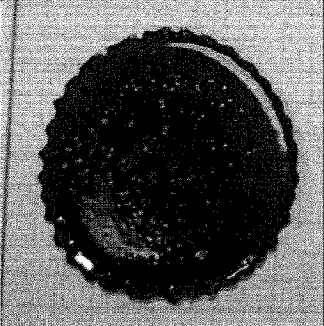
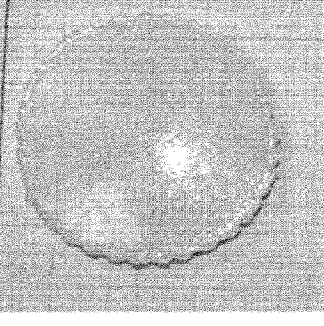
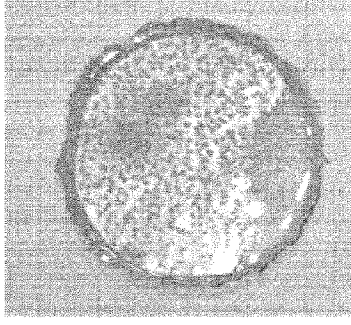
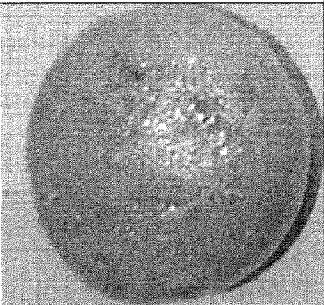
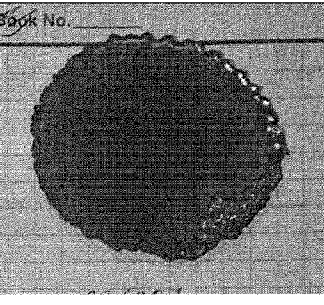
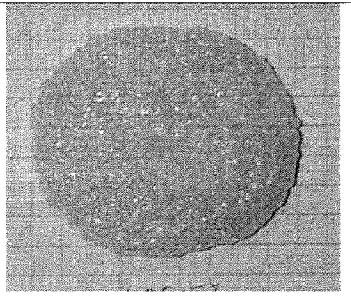

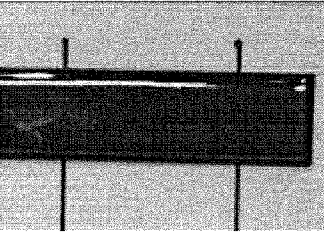
Color Stability		
Neat phenolic resin with additive (10% by weight)		
		
Control	Lactic Acid – 10% added	Ethyl lactate – 10% added
		
Ethyl acetoacetate 10% added	2(dimethylamino)ethylmethacr ylate – 10% added	2,2,5 trimethyl-1-3-dioxane-4-6- dione – 4% added
		
Control after 6 hours at 250°F	Heptanoic Acid – 10% added after 6 hours at 250°F	

FIG. 3

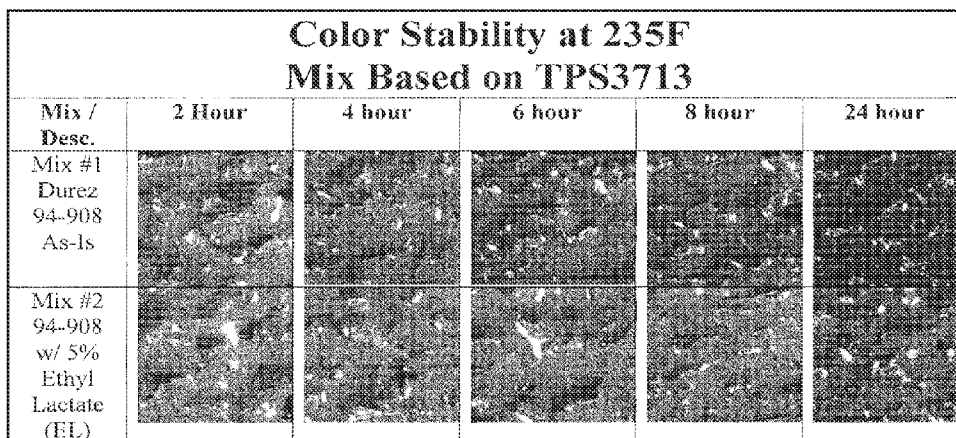


FIG. 4

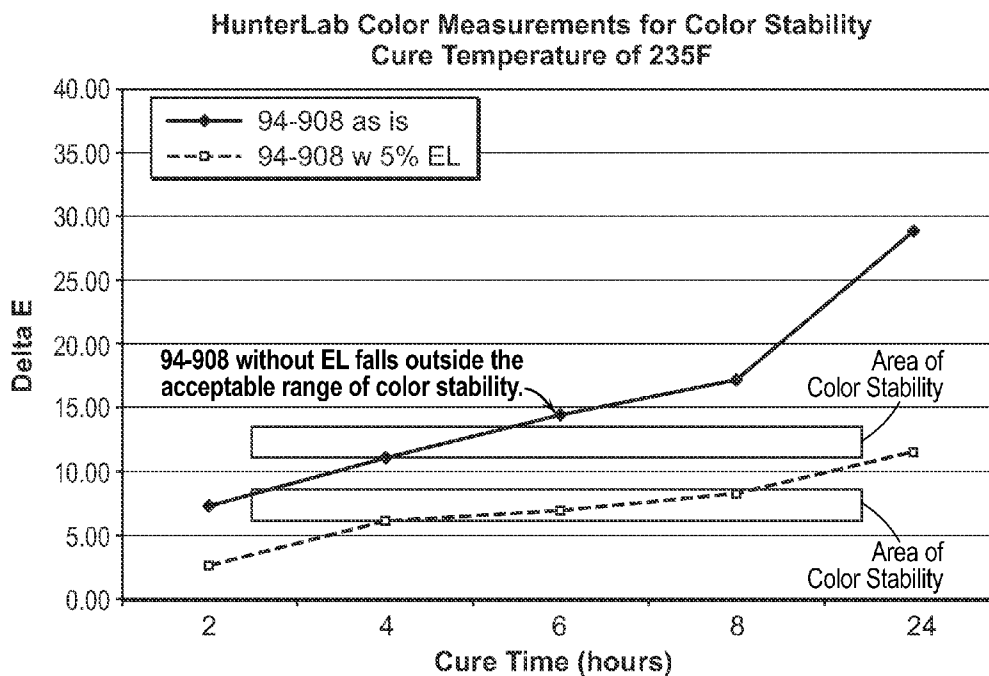


FIG. 5

**CARBOXYLIC ACID ESTER
COLOR-STABILIZED PHENOLIC BOUND
ABRASIVE PRODUCTS AND METHODS FOR
MAKING SAME**

RELATED APPLICATION(S)

[0001] This application claims the benefit of U.S. Provisional Application No. 61/199,472, filed on Nov. 17, 2008. The entire teachings of the above application are incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] The term “phenolic resin” describes a wide variety of resin products that result from the reaction product of phenols and aldehydes. Phenols react with formaldehydes under both acidic and basic conditions. If a based-catalyzed mixture of a phenol and a formaldehyde contains one or more moles of formaldehyde per moles of phenol, it will produce a thermosetting (one-step) resin, or “resole.” Common base compounds employed as catalysts for resole resins include the hydroxides of alkali metals, such as sodium, potassium, or lithium. While alkali metal hydroxide-catalyzed phenolic resins are commercially useful, they have an undesirable tendency to darken as they age, are heated or otherwise cured. The extent of darkening is known to be dependent on the curing or use temperature of the resin and the time of exposure to such temperature.

[0003] Alkali metal hydroxide-catalyzed phenolic resins are commonly used as a component of the bond system of abrasive products, such as coated, bonded, and three-dimensional, low density abrasive products. The resin darkening problem is particularly pronounced in coated abrasive and three-dimensional, low density abrasive products because of the more visible presence of the bond system. Also, since the darkening increases with temperature and exposure time, any variation in the temperature profile of the product results in color variation within the product itself. Color variation is particularly noticeable for light-colored products, causing such products to be unacceptable for aesthetic or other reasons.

[0004] Furthermore, abrasive bond systems may comprise colorants to identify the manufacturer, type of product, application, etc. The darkening of the resin can interfere with the desired coloration, causing the final product to have a different color from the colorant added. For example, a resin that normally turns yellow after curing will yield a green colored product when combined with a blue dye or pigment. On the other hand, if the same yellow resin is combined with a green dye or pigment, the resin will typically result in simply another shade of green.

[0005] One known method for imparting color stability in phenolic resoles include adding melamine formaldehyde resin into the formulation. While this achieves color stability, it also imparts brittleness, takes longer to cure, and results in mechanical weakness and therefore reduced grinding performance in the finished product.

[0006] Another proposed method includes the addition of an ammonium based salt to the phenolic resole. However, this method is not sufficiently effective in stabilizing the color of phenolic resin products having certain colorants, such as light blue and orange pigments or dyes.

[0007] What is needed is an effective phenolic resin color-stabilizer that reduces the aforementioned problems without imparting undesirable properties in the finished product.

SUMMARY OF THE INVENTION

[0008] In one aspect, the present invention is directed to a color-stable abrasive article that includes a phenolic resin binder; a color stabilizer, a colorant, and abrasive grains. The color stabilizer includes at least one carboxylic acid ester, ester, carboxylic acid, or a dione or acrylic group.

[0009] In another aspect, the present invention is directed to a method of making a color-stable abrasive article including the steps of blending a resole and a color stabilizer to form a resole composition; contacting a plurality of abrasive particles with the resole composition; and curing the resole composition to produce the color-stable abrasive article. The color stabilizer includes at least one carboxylic acid ester, ester, carboxylic acid, or a dione or acrylic group.

[0010] In yet another aspect, the present invention is directed to a method for abrading a work surface including applying color-stable abrasive article to a work surface in an abrading motion to remove a portion of the work surface. The abrasive product includes a binder having a phenolic resin; a color-stabilizer that includes at least one includes at least one carboxylic acid ester, ester, carboxylic acid, or a dione or acrylic group; and abrasive grains.

[0011] Thus provided are color stabilized phenolic bound abrasives and a method for making such abrasives that resist color change over time and upon exposure to high temperature and maintain the mechanical strength of a phenolic resin.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The foregoing will be apparent from the following more particular description of example embodiments of the invention, as illustrated in the accompanying drawings in which like reference characters refer to the same parts throughout the different views. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating embodiments of the present invention.

[0013] FIG. 1 is a schematic representation of a cross-sectional view of one embodiment of coated abrasive tools of the invention.

[0014] FIG. 2 is a schematic representation of a cross-sectional view of another embodiment of coated abrasive tools of the invention.

[0015] FIG. 3 contains photographs comparing cured phenolic resin samples containing no color stabilizer and color stabilizers of the present invention.

[0016] FIG. 4 contains photographs comparing the color change of an embodiment of the present invention and a control over time during curing.

[0017] FIG. 5 is a graphical representation of the color change in the samples of FIG. 4 over time.

DETAILED DESCRIPTION OF THE INVENTION

[0018] The teachings of all patents, published applications and references cited herein are incorporated by reference in their entirety. In particular, U.S. Ser. No. 61/199,471, entitled, “Acrylate Color-Stabilized Phenolic Bound Abrasive Products and Methods for Making Same,” of Wijaya, which application is filed concurrently herewith, is incorporated by reference herein in its entirety.

[0019] The present invention relates to abrasive articles which include a phenolic resin binder that is color-stabilized by at least one carboxylic acid ester. The color-stabilized abrasive article further includes a colorant and abrasive grains. As used herein, an abrasive article or resin is considered to be “color-stable” if it has essentially the same color after about 8 hours of curing at about 235° F. as it does after about 2 hours of curing at about 235° F.

[0020] The term “phenolic resin” refers to any resinous reaction product of a phenol, such as phenol, resorcinol, alkyl-substituted phenol such as cresol, xlenol, p-tert-butylphenol, and p-phenylphenol and the like, with an aldehyde, such as formaldehyde, acetaldehyde and furfuraldehyde, and the like. “Color-stabilized alkali metal hydroxide catalyzed phenolic resin” refers to a cured alkali metal hydroxide phenolic resin which is color-stabilized by a color stabilizing agent.

[0021] The abrasive products are characterized by having a phenolic resin binder, one or more carboxylic acid ester color-stabilizers, one or more optional colorants, abrasive grains, a support member or backing, and can further include curing agents, non-reactive thermoplastic resins, fillers, grinding aids, and other additives.

Structure and Methods of Making the Abrasive Article

[0022] In one embodiment, the color-stable abrasive article includes a phenolic resin binder, a color stabilizer, and an abrasive material. The color-stable abrasive article can be either a bonded, structured, or coated abrasive.

[0023] Coated abrasive tools of the invention can include a substrate, an abrasive material and at least one phenolic resin binder to hold the abrasive material to the substrate. As used herein, the term “coated abrasive tool” encompasses a non-woven abrasive tool. The abrasive material, such as abrasive grains, particles or agglomerate thereof, can be present in one layer (e.g., resin-abrasive layer) or in two layers (e.g., make coat and size coat) of the coated abrasive tools. Examples of such coated abrasive tools that can be made by the methods of the invention are shown in FIGS. 1 and 2. Referring to FIG. 1, in coated abrasive tool 10, substrate 12 is treated with optional backsize coat 16 and optional presize coat 18. Overlaying the optional presize coat 18 is make coat 20 to which abrasive material 14, such as abrasive grains or particles, are applied. Size coat 22 is optionally applied over make coat 20 and abrasive material 14. Overlaying size coat 22 is optional supersize coat 24. Depending upon their specific applications, coated abrasive tool 10 may or may not include backsize coat 16 and/or presize coat 18. Also, depending upon their specific applications, coated abrasive tools 10 may or may not include size coat 22 and/or supersize coat 24. Shown in FIG. 2 is an example of coated abrasive tools that can be formed by the methods of the invention, where coated abrasive tool 30 includes a single layer of an abrasive material and adhesive(s) (binder-abrasive layer 32) and optionally backsize coat 16. Optionally, presize coat 18, size coat 22 and supersize coat 24, as shown in FIG. 1, can be included in coated abrasive tool 30. The coated abrasive article can include a color stable phenolic resin binder in at least one layer selected from the group consisting of a binder-abrasive layer, a backsize coat, a presize coat, a make coat, a size coat, and a supersize coat.

[0024] In embodiments including size coats and supersize coats, such as that shown in FIG. 1, abrasive materials can be applied separately by gravity, electrostatic deposition, air

stream, or as a slurry together with the polyurethane adhesive compositions. The make coat 20 adheres the abrasive material to the surface of the substrate, and can be formed by impregnating the support substrate with the phenolic resin binder without abrasive grains.

[0025] In the embodiment of FIG. 2, the support substrate may be impregnated with a resin/abrasive slurry that includes an abrasive material and a resin composition including a phenolic resin binder and a color-stabilizer, to form a binder/abrasive layer 32.

[0026] In one embodiment, a method of making a color-stable abrasive article includes: blending a resole and a color-stabilizer comprising at least one carboxylic acid ester to form a resole composition; contacting a plurality of abrasive particles with the resole composition; and curing the resole composition to produce the color-stable abrasive product. In addition to the coated abrasives described above, color-stable abrasive articles formed by this method include, for example, structured abrasives and bonded abrasives.

[0027] With respect to structured abrasives, the article is formed by any of those techniques known in the art in which abrasive structures are shaped prior to curing. Such techniques include, for example, embossing techniques. In one embodiment, for instance, a mixture including a phenolic resin binder, at least one compound selected from the group consisting of a carboxylic acid ester, an ester, a carboxylic acid, a compound including a dione, a compound including an acrylic group, and combinations of thereof, optional colorants, and abrasive grains, can be contacted with a backing and a production tool wherein the mixture adheres to one surface of the backing. Abrasive structures are thus formed that have the shape of an inside surface of the production tool.

[0028] A bonded abrasive article can be formed by preparing an agglomerate that includes the phenolic resin binder, at least one compound selected from the group consisting of a carboxylic acid ester, an ester, a carboxylic acid, a compound including a dione group, a compound including an acrylic group and combinations of thereof, optional colorants, and abrasive grains. The agglomerate is then shaped using any of the techniques known in the art for preparing a bonded abrasive. Suitable techniques for preparing bonded abrasives are further described, for example, in U.S. Pat. No. 5,738,696 of Wu; U.S. Pat. No. 5,738,697 of Wu, et al.; and U.S. Pat. No. 6,679,758 of Bright, et al.; and U.S. Patent Publication No. 2003/0192258 A1 of Simon, the entire contents of each of which are incorporated herein by reference.

[0029] A work surface is abraded by applying the color-stable abrasive article to a work surface in an abrading motion to remove a portion of the work surface.

Phenolic Resin Binder

[0030] Typical phenolic resins employed in the present invention are resoles, which result from the alkali metal hydroxide catalyzed reaction of phenol and formaldehyde in a mole ratio of phenol:formaldehyde of about 1:1 to about 1:3 moles and a mole ratio of phenol:alkali metal hydroxide of about 1:1 to about 100:1. The color of such resole, or base-catalyzed phenolic resin is stabilized by the addition of one or more carboxylic esters. Durez Varcum Resin No. 94908, manufactured by Durez Corporation is one example of a water-based, single-staged liquid phenolic resin that can be used as the binder.

Color-Stabilizer

[0031] The color-stabilizers employed in the present invention include carboxylic acid esters, esters, carboxylic acids,

compounds containing a dione group, compounds containing an acrylic group, and combinations of thereof. For example, suitable compounds include but are not limited to methyl lactate, ethyl lactate, n-propyl lactate, butyl lactate, 2-ethylhexyl lactate, heptanoic acid, lactic acid, ethyl acetoacetate, 2,2,5-trimethyl-1-3-dioxane-4-6-dione, and 2-(dimethylamino) ethylmethacrylate.

[0032] In certain embodiments, the color-stabilizer is present in an amount between about 1% and about 40% by weight of the phenolic resin. In other embodiments, the color-stabilizer is present in an amount between about 4% and about 10% by weight of the phenolic resin.

[0033] Ethyl lactate has been found to be particularly effective. For example, one embodiment of the invention includes:

Ingredient	%
Durez 94-908 PF resin	53.89
Ethyl Lactate	2.72
Tamol 165A	0.8
Nalco 2341	0.29
Blue Dye/Pigment	4.81
Syn. Cryolite	37.3
Cab-O-Sil	0.19

[0034] Heptanoic acid, lactic acid, ethyl acetoacetate, 2,2,5-trimethyl-1-3-dioxane-4-6-dione, 2-(dimethylamino)ethylmethacrylate have demonstrated to be effective color stabilizer agents when added in amounts as little as 5% or 10% of the total weight of the resin

Colorant

[0035] The abrasive product can include a colorant, for example, dyes or pigments. Generally, a portion of the colorant can be visible through the cured resin. In some embodiments, a portion of the colorant is included in the cured resin, in an optional support substrate, and/or in a coating between the optional support substrate and the cured resin. In particular embodiments, the colorant can include organic polycyclic dyes, organic monoazo dyes, organic diazo dyes, organo-metal complexes, inorganic pigments such as metal oxides or complexes. Dyes can be perinone, anthraquinone, azo dye complexes and thioindigoid.

[0036] A fluorescent colorant is a dye or pigment containing a fluorescent organic molecule. Detailed descriptions of fluorescent colorants can be found in Zollinger, H., "Color Chemistry: Synthesis, Properties, and Applications of Organic Dyes and Pigments", 2nd Ed., VCH, New York, 1991, the entire teachings of which are incorporated herein by reference. As used herein, a fluorescent colorant can be, for example, a xanthene, thioxanthene, fluorene (e.g., fluoresceins, rhodamines, eosines, phloxines, uranines, succineins, sacchareins, rosamines, and rhodols), naphthylamine, naphthylimide, naphtholactam, azalactone, methine, oxazine, thiazine, benzopyran, coumarin, aminoketone, anthraquinone, isoviolanthrone, anthrapyridone, pyranine, pyrazolone, benzothiazene, perylene, or thioindigoid. More preferably, a fluorescent colorant is selected from the group consisting of xanthenes, thioxanthenes, benzopyrans, coumarins, aminoketones, anthraquinones, isoviolanthrones, anthrapyridones, pyranines, pyrazolones, benzothiazenes, thioindigoids and fluorenes. Most preferably, the fluorescent colorant is a thioxanthene or thioxanthene.

[0037] One skilled in the art understands that, for many, commercially available colorants, the specific chemical structure of individual derivatives within a class, e.g., thioxanthene derivatives, may not be publicly available. Thus, specific fluorescent colorants are typically referred to by Colour Index (C.I.) name, as defined in "Colour Index International", 4th Ed. American Association of Textile Chemists and Colorists, Research Triangle Park, NC, 2002. The Colour Index is also available online at www.colour-index.org. The entire teachings of the Colour Index are incorporated herein by reference.

[0038] Examples of preferred fluorescent colorants include C.I. Solvent Orange 63 (Hostasol Red GG, Hoechst AG, Frankfurt, Germany), C.I. Solvent Yellow 98 (Hostasol Yellow 3G, Hoechst AG, Frankfurt, Germany), and C.I. Solvent Orange 118 (FL Orange SFR, Keystone Aniline Corporation, Chicago, Ill.).

[0039] The amount of colorant that can be employed depends on the particulars of the intended use, the characteristics of the colorant, the other components in the composition, and the like. One skilled in the art will know how to judge these details to determine the amount of colorant for a particular use. Typically, the amount of colorant will be a weight fraction of the total composition of between about 0.01 and about 2%, more preferably between about 0.05 and about 0.5%, and most preferably, about 0.2%.

[0040] In specific embodiments, the colorant is a red, orange, yellow, green, blue, indigo, or violet colorant. In specific embodiments, the colorant is fluorescent, for example, a fluorescent red, fluorescent orange (blaze orange), fluorescent yellow, fluorescent green, or the like.

[0041] Examples of suitable colorants include Elcoment Orange GS (Blaze); Elcoment Green Nort Liq.; and especially Elcoment Blue RS, all of which are available from Greenville Colorants located in Greenville, S.C.; and Akrosperse E5137, which is available from Akrochem Corp. located in Akron, Ohio.

[0042] The colorant can be employed to identify the abrasive product, e.g., for commercial branding, for usage indication such as wet, dry, wood, metal, or the like, or for identification of grit size, or the like.

Abrasive Materials

[0043] Abrasive grains can include of any one or a combination of grains, including, but not limited to, silica, alumina (fused or sintered), zirconia, zirconia/alumina oxides, silicon carbide, garnet, diamond, cubic boron nitride (CBN), silicon nitride, ceria, titanium dioxide, titanium diboride, boron carbide, tin oxide, tungsten carbide, titanium carbide, iron oxide, chromia, flint, and emery. For example, the abrasive grains may be selected from a group consisting of silica, alumina, zirconia, silicon carbide, silicon nitride, boron nitride, garnet, diamond, cofused alumina zirconia, ceria, titanium diboride, boron carbide, flint, emery, alumina nitride, and a blend thereof. In some instances, dense abrasive grains comprised principally of alpha-alumina and/or gamma alumina can be used.

[0044] The abrasive grains can also include abrasive agglomerate grains, also known as agglomerated abrasive grains. Abrasive agglomerate grains include abrasive particles adhered together by a particle binder material. The abrasive particles present in abrasive agglomerate grains can include one or more of the abrasives known for use in abrasive tools such as, for example, silica, alumina (fused or sintered),

zirconia, zirconia/alumina oxides, silicon carbide, garnet, diamond, cubic boron nitride (CBN), silicon nitride, ceria, titanium dioxide, titanium diboride, boron carbide, tin oxide, tungsten carbide, titanium carbide, iron oxide, chromia, flint, emery, and combinations thereof. The abrasive particles can be of any size or shape. The abrasive agglomerate grains can be adhered together by a particle binder material such as, for example, a metallic, organic, or vitreous material, or a combination of such materials. Abrasive agglomerate grains suitable for use in the present invention are further described in U.S. Pat. No. 6,797,023, to Knapp, et al., the entire contents of which are incorporated herein by reference.

[0045] The abrasive grains can have one or more particular shapes. Example of such particular shapes include rods, triangles, pyramids, cones, solid spheres, hollow spheres and the like. Alternatively, the abrasive grains can be randomly shaped.

[0046] Typically, the abrasive grains have an average grain size not greater than 2000 microns such as, for example, not greater than about 1500 microns. In another example, the abrasive grain size is not greater than about 750 microns, such as not greater than about 350 microns. In some embodiments, the abrasive grain size may be at least 0.1 microns, such as from about 0.1 microns to about 1500 microns, and, more typically, from about 0.1 microns to about 200 microns or from about 1 micron to about 100 microns. The grain size of the abrasive grains is typically specified to be the longest dimension of the abrasive grain. Generally, there is a range distribution of grain sizes. In some instances, the grain size distribution is tightly controlled.

Support Member/Backing

[0047] The abrasive articles can include a support member, or backing. The backing can be flexible or rigid. The backing can be made of any number of various materials including those conventionally used as backings in the manufacture of coated abrasives. Suitable backings can include polymeric films (for example, a primed film), such as polyolefin films (e.g., polypropylene including biaxially oriented polypropylene), polyester films (e.g., polyethylene terephthalate), polyamide films, or cellulose ester films; metal foils; meshes; foams (e.g., natural sponge material or polyurethane foam); cloth (e.g., woven, non-woven, fleeced, stitch bonded, or quilted, or cloth made from fibers or yarns comprising polyester, nylon, silk, cotton, poly-cotton or rayon); paper; vulcanized paper; vulcanized rubber; vulcanized fiber; nonwoven materials; a treated backing thereof; or any combination thereof.

[0048] The backing can have at least one of a saturant, a presize layer or a backsize layer. The purpose of these layers typically is to seal the backing or to protect yarn or fibers in the backing. If the backing is a cloth material, at least one of these layers typically is used. The addition of the presize layer or backsize layer may additionally result in a "smoother" surface on either the front or the back side of the backing. Other optional layers known in the art can also be used (for example, a tie layer; see U.S. Pat. No. 5,700,302 of Stoetzel, et al., the entire contents of which are incorporated herein by reference).

[0049] In some embodiments, the abrasive articles are intended for use as fine grinding materials and hence a very smooth surface can be preferred. Examples of such smooth surfaced backings include finely calendered papers, plastic films or fabrics with smooth surface coatings.

[0050] The backing can have antistatic properties. The addition of an antistatic material can reduce the tendency of the 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 of Buchanan, et al.; U.S. Pat. No. 5,137,542 of Buchanan, et al.; U.S. Pat. No. 5,328,716 of Buchanan; and U.S. Pat. No. 5,560,753 of Buchanan, et al., the entire contents of which are incorporated herein by reference.

[0051] The backing can include a fibrous reinforced thermoplastic such as described, for example, in U.S. Pat. No. 5,417,726 of Stout, et al., or an endless spliceless belt, as described, for example, in U.S. Pat. No. 5,573,619 of Benedict, et al., the entire contents of which are incorporated herein by reference. Likewise, the backing can include a polymeric substrate having hooking stems projecting therefrom such as that described, for example, in U.S. Pat. No. 5,505,747 of Chesley, et al., the entire contents of which are incorporated herein by reference. Similarly, the backing can include a loop fabric such as that described, for example, in U.S. Pat. No. 5,565,011 of Follett, et al., the entire contents of which are incorporated herein by reference.

Other Components

[0052] The abrasive articles of the present invention can also include various other components, such as curing additives, non-reactive thermoplastic resins, fillers, grinding aids; and other additives.

[0053] In some embodiments, the abrasive article includes a curing additive, such as a photoinitiator, which generates free radicals when exposed to radiation, e.g., UV radiation. Free-radical generators can include organic peroxides, azo compounds, quinones, benzophenones, nitroso compounds, acryl halides, hydrozones, mercapto compounds, pyrylium compounds, triacrylimidazoles, bisimidazoles, chloroalkyl-triazines, benzoin ethers, benzil ketals, thioxanthenes and acetophenones, including derivatives of such compounds. Among these the most commonly employed photoinitiators are the benzil ketals such as 2,2-dimethoxy-2-phenyl acetophenone (available from Ciba Specialty Chemicals under the trademark IRGACURE® 651) and acetophenone derivatives such as 2,2-diethoxyacetophenone ("DEAP", which is commercially available from First Chemical Corporation), 2-hydroxy-2-methyl-1-phenyl-propan-1-one ("HMPP," which is commercially available from Ciba Specialty Chemicals under the trademark DAROCUR® 1173), 2-benzyl-2-N,N-dimethylamino-1-(4-morpholinophenyl)-1-butanone, (which is commercially available from Ciba Specialty Chemicals under the trademark IRGACURE® 369); and 2-methyl-1-(4-(methylthio)phenyl)-2-morpholinopropan-1-one, (available from Ciba Specialty Chemicals under the trademark IRGACURE® 907).

[0054] The abrasive articles can include a non-reactive thermoplastic resin such as, for example, polypropylene glycol, polyethylene glycol, and polyoxypropylene-polyoxyethylene block copolymer.

[0055] Fillers include organic fillers, inorganic fillers, and nano-fillers. Examples of suitable fillers include, but are not limited to, metal carbonates such as calcium carbonate and sodium carbonate; silicas such as quartz, glass beads, glass bubbles; silicates such as talc, clays, calcium metasilicate; metal sulfate such as barium sulfate, calcium sulfate, alumi-

num sulfate; metal oxides such as calcium oxide, aluminum oxide; aluminum trihydrate, and combinations thereof.

[0056] The abrasive articles can include a grinding aid to increase the grinding efficiency and cut rate. Useful grinding aids can be inorganic, such as halide salts, e.g., sodium cryolite and potassium tetrafluoroborate; or organic based, such as chlorinated waxes, e.g., polyvinyl chloride. In one particular embodiment, the abrasive article includes cryolite and potassium tetrafluoroborate with particle size ranging from about 1 micron to about 80 microns, most typically from about 5 microns to about 30 microns. The concentration of grinding aid in a make coat is generally not greater than about 50 wt %, for example, the concentration of grinding aid is often about 0.1 wt % to 50 wt %, and most typically about 10 wt % to 30 wt % (all wt % based on make coat weight including abrasive grains).

[0057] Examples of additional additives include coupling agents, such as silane coupling agents, e.g., A-174 and A-1100 available from Osi Specialties, Inc., titanate, and zircoaluminates; anti-static agents, such as graphite, carbon black, and the like; suspending agent, such as fumed silica, e.g., Cab-O-Sil M5, Aerosil 200; anti-loading agents such as zinc stearate and calcium stearate; lubricants such as wax, PTFE powder, polyethylene glycol, polypropylene glycol, and polysiloxanes; wetting agents; pigments; dispersants; and defoamers.

EXEMPLIFICATION

Example 1

[0058] The invention will now be further and specifically described by the following examples which are not intended to be limiting.

[0059] The following compounds were tested for performance as color stabilizer agents: heptanoic acid, lactic acid, ethyl acetoacetate, 2,2,5-trimethyl-1-3-dioxane-4-6-dione, and 2-(dimethylamino)ethylmethacrylate. Formulations containing neat phenolic resin and the color stabilizer agent (between 4% and 10% per resin weight) were prepared and cured at 180° C. for 12 hours; heptanoic acid was cured at 250° F. for 6 hours. The cured samples are shown in FIG. 3.

Example 2

[0060] Ethyl lactate was tested as a color stabilizer agent in a phenolic resin size coat formulation and compared to a control formulation that did not include ethyl lactate. The formulations are described below:

Control Size Formulation (considered "non-color stable")	
Ingredient	%
Durez 94-908 PF resin	55.39
Tamol 165A	0.81
Nalco 2341	0.32
Blue Dye/Pigment	4.94
Syn. Cryolite	38.34
Cab-O-Sil	0.20

Color Stable Size Formulation (includes Ethyl lactate)

Ingredient	%
Durez 94-908 PF resin	53.89
Ethyl Lactate	2.72
Tamol 165A	0.8
Nalco 2341	0.29
Blue Dye/Pigment	4.81
Syn. Cryolite	37.3
Cab-O-Sil	0.19

[0061] Both of these formulations were applied to a pre-made coated abrasive sample. The samples included a backing on which a make coat and grain had been coated and cured to the normal extent before a typical size coat would be applied during a typical manufacturing process.

[0062] After the two size coats had been applied to the pre-made coated abrasive and given a standard size cure, 5 samples of each were placed into an oven at 235° F. and a single sample was pulled from the oven after 2, 4, 6, 8 and 24 hours of dwell time to emulate a "post cure" process. The visual comparison of the color shift is shown in FIG. 4.

[0063] In addition to this qualitative comparison of color shift, a more quantitative measurement was made using a MiniScan XE Plus Colorimeter supplied by HunterLab, the results of which are provided in FIG. 5.

[0064] FIG. 5 shows the reduction in total color shift, delta E, with the use of ethyl lactate. Typical processing conditions of post cure would be between 4 and 8 hours. In this case, the observable delta E for the non-color stable size during this time period increased from 11.14 to 17.18, yielding a difference of 6.04. With the use of ethyl lactate at 5% by weight of the resin, the delta E increased only from 6.12 to 8.31, yielding a 2.19 difference, thus showing a significant reduction in color shift.

EQUIVALENTS

[0065] While this invention has been particularly shown and described with references to example embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the scope of the invention encompassed by the appended claims.

What is claimed is:

1. A color-stable abrasive article, comprising:
 - a) a binder comprising a phenolic resin;
 - b) a color-stabilizer that includes at least one carboxylic acid ester; and
 - c) abrasive grains.

2. The color-stable abrasive article of claim 1, wherein the color-stabilizer includes a compound selected from the group consisting of carboxylic acid esters, esters, carboxylic acids, compounds including a dione group, compounds including an acrylic group, and combinations of thereof.

3. The color-stable abrasive article of claim 2, wherein the color-stabilizer includes a lactate.

4. The color-stable abrasive article of claim 2, wherein the color-stabilizer includes at least one compound selected from the group consisting of heptanoic acid, lactic acid, ethyl acetoacetate, 2,2,5-trimethyl-1-3-dioxane-4-6-dione, ethyl lactate, and 2-(dimethylamino)ethylmethacrylate.

5. The color-stable abrasive article of claim 1, wherein the phenolic resin is a resole.

6. The color-stable abrasive article of claim 1, wherein the color-stabilizer is present in an amount between about 1% and about 40% by weight of the phenolic resin.

7. The color-stable abrasive article of claim 6, wherein the color-stabilizer is present in an amount between about 4% and about 10% by weight of the phenolic resin.

8. The color-stable abrasive article of claim 1, further comprising a support member.

9. The color-stable abrasive article of claim 1, further comprising a co-solvent.

10. The color-stable abrasive article of claim 9, wherein the co-solvent is glycol.

11. The color-stable abrasive article of claim 1, further comprising a curing additive.

12. The color-stable abrasive article of claim 11, wherein the curing additive includes one or more additives selected from the group of peroxide and a UV photo-initiator.

13. The color-stable abrasive article of claim 1, having no visually perceptible color change after about 8 hours of curing at about 235° F. relative to the same article after about 2 hours of curing at about 235° F.

14. The color-stable abrasive article of claim 1, further comprising a colorant.

15. The color-stable abrasive article of claim 1, wherein the article is a bonded, structured, or coated abrasive article.

16. The color-stable abrasive article of claim 15, wherein the phenolic resin binder and color stabilizer are present in at least one layer selected from the group consisting of a binder-abrasive layer, a backsize coat, a presize coat, a make coat, a size coat, and a supersize coat.

17. A method of making a color-stable abrasive article, comprising the steps of:

- a) blending a resole and a color-stabilizer comprising at least one carboxylic acid ester to form a resole composition;
- b) contacting a plurality of abrasive particles with the resole composition; and
- c) curing the resole composition to produce the color-stable abrasive article.

18. A method for abrading a work surface, comprising applying color-stable abrasive article to a work surface in an abrading motion to remove a portion of the work surface, the abrasive product including:

- a) a binder comprising a phenolic resin;
- b) a color-stabilizer that includes a compound selected from the group consisting of carboxylic acid esters, esters, carboxylic acids, compounds including a dione group, compounds including an acrylic group, and combinations of thereof; and
- c) abrasive grains.

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