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(54) **BONDED ABRASIVE ARTICLES AND METHODS**

GEBUNDENE SCHLEIFARTIKEL UND VERFAHREN

ARTICLES ABRASIFS AGGLOMÉRÉS ET PROCÉDÉS

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Description

BACKGROUND

[0001] Bonded abrasive articles have abrasive particles bonded together by a bonding medium. There is an increasing demand for high-performance abrasive articles such as grinding wheels that abrade material faster while meeting tight tolerances without damaging workpieces.

[0002] Abrasive articles such as stones, hones and wheels may be driven by a stationary-mounted motor such as, for example, a bench grinder, or attached and driven by a hand-operated portable grinder. Hand-operated portable grinders are typically held at a slight angle relative to the surface of the workpiece, and may be used to grind, for example, welding beads, flash, gates, and risers off castings. WO 2009/039381 A1 describes abrasive products, which in one form are bonded abrasive products that include a plurality of abrasive powders bonded together by a resin binder.

SUMMARY

[0003] Disposing a grinding layer at a surface of or within the interior of a bonded abrasive article was found to surprisingly enhance cutting and grinding performance compared to conventional bonded discs. In particular, among other advantages, the total cut surprisingly increased.

[0004] In one aspect, the present disclosure provides a bonded abrasive article comprising a matrix and a grinding layer. The matrix comprises matrix abrasive particles and a matrix binder. The grinding layer comprises erectly-oriented abrasive particles and a grinding layer binder. The grinding layer is disposed on an exterior surface of the bonded abrasive article or is disposed at least partly within the interior of the bonded abrasive article. In another aspect, the present disclosure provides a method of forming a bonded abrasive article, the method comprising: applying a matrix mixture to a grinding layer, the matrix mixture comprising a curable matrix binder and matrix abrasive particles, the grinding layer comprising erectly-oriented grinding abrasive particles; and curing the matrix binder (14).

[0005] In yet another aspect, the present disclosure provides a method of forming a bonded abrasive article, the method comprising applying a grinding layer precursor to a first major surface of a matrix, the matrix comprising matrix abrasive particles and a matrix binder; depositing erectly-oriented particles on the grinding layer precursor, applying a sizing layer on the erectly-oriented particles, and curing the grinding layer precursor to form a grinding layer attached to the first major surface.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] Repeated use of reference characters in the specification and drawings is intended to represent the same or analogous features or elements of the disclosure.

FIG. 1A is a schematic cross-sectional view of a bonded abrasive article according to an embodiment.
FIG. 1B is a schematic cross-sectional view of a bonded abrasive article according to an embodiment.
FIG. 2 is a schematic cross-sectional view of a bonded abrasive article according to an embodiment.
FIG. 3 is a schematic cross-sectional view of a bonded abrasive article according to an embodiment.
FIG. 4A is a schematic view of apparatus for erectly orienting abrasive particles.
FIG. 4B is a schematic cross-sectional view of an abrasive article with erectly-oriented abrasive particles.
FIG. 5A is a schematic top view of an article with erectly-oriented abrasive particles.
FIG. 5B is a schematic method of forming a bonded abrasive article according to an embodiment.
FIG. 5C is a perspective view of a bonded abrasive article according to an embodiment.
FIG. 5D is a perspective view of a bonded abrasive article according to an embodiment.

DEFINITIONS

[0007] "Bonded abrasive articles" are abrasive articles having bonded abrasives, including, without limitation, grinding wheels, grinding discs, grinding cylinders or abrasive articles in any other forms.

[0008] While the above-identified drawing figures set forth several embodiments of the present disclosure, other embodiments are also contemplated, as noted in the discussion. The figures may not be drawn to scale. Like reference numbers may have been used throughout the figures to denote like parts.

DETAILED DESCRIPTION

[0009] Referring now to **FIG. 1A,** an exemplary bonded abrasive article **10** according to one embodiment has a matrix

13 and a grinding layer **16.** The matrix **13** has two major opposing surfaces: a first major surface **21**, and a second major surface **23.** The grinding layer **16** has two opposing faces, a grinding face **19** and a back face **17.** The grinding face **19** comprises the distal tips of the erectly-oriented abrasive particles **18** and may be uneven or undulating depending on the abrasive particles employed. The back face **17** is typically substantially planar replicating, in one embodiment, the planar support surface the erectly-oriented abrasive particles are applied to. In an embodiment, the grinding layer **16** is disposed on the first major surface **21** or the second major surface **23** such that the back face **17** is proximal to the matrix **13** while the grinding face **19** is distal to the matrix **13.**

[0010] The matrix **13** includes matrix abrasive particles **12** and a matrix binder **14.** The matrix **13** may be shaped like a disc, a wheel, a cylinder or any other suitable shape known in the art. The matrix **13** may have openings, including central openings, such as central holes. The matrix **13** may have a depressed center with a central hole. The matrix **13** may have a backing, including paper, fabric, or film backings, or any other backing known in the art or described below or combinations thereof.

[0011] The matrix binder **14** holds the matrix abrasive particles **13** in a fixed configuration within the matrix **13** and provides a rigid structure to the matrix **13.** The matrix binder **14** may contain any suitable organic, resin, metallic, vitrified or any other binder known in the art such as binders described below or combinations thereof.

[0012] The matrix abrasive particles **12** may be any abrasive particles known in the art, including conventional crushed abrasive particles, shaped abrasive particles, or any abrasive particles described below or their combinations thereof. The matrix abrasive particles **12** may be randomly dispersed within the matrix **14**, or may be dispersed in a predetermined pattern within the matrix **14.** The matrix abrasive particles **12** may be randomly oriented within the matrix **14**, or may be oriented in predetermined orientations within the matrix **14.** Some, all or none of the matrix abrasive particles **12** may be oriented in substantially similar or parallel orientations within the matrix **13.** Some, all, or none of the matrix abrasive particles **12** may be of substantially same, similar or different sizes. Some, all, or none of the matrix abrasive particles **12** may have substantially same, similar or different shapes. The matrix abrasive particles **12** can contain abrasive particles of the same or different chemical compositions, with the same, similar, dissimilar or different chemical and physical properties such as electrostatic attraction, hardness, and fracture toughness. Some, all or none of the matrix abrasive particles **12** may be completely immersed within the matrix **14.** Some or all of the matrix abrasive particles **12** may be incompletely immersed within the matrix **14.** The matrix abrasive particles **12** abrade surfaces to a varying extent, such as low abrasion, medium abrasion, high abrasion or any other known abrasive extent, depending on factors such as size, geometry, orientation and material of the matrix abrasive particles **12,** and factors such as the pressure and speed at which surfaces are exposed to the matrix **13.**

[0013] The grinding layer **16** contains erectly-oriented abrasive particles **18** bonded and held in an erectly-oriented configuration by a grinding layer binder **20.** In an embodiment, the grinding layer **16** also contains abrasive particles that are not erectly-oriented. In an embodiment, the grinding layer **16** has a thickness that is less than the thickness of the matrix **13.** In an embodiment, the grinding layer **16** has a thickness that is 95%, or 90%, or 85%, or 80%, or 75%, or 70%, or 65% or 60% or 55% or 50% or any other percentage that is less than 100% but greater than 0% of the thickness of the matrix **13.** In another embodiment, the grinding layer binder **20** is sufficiently thick that all the erectly-oriented particles are immersed within the grinding layer **16.** In yet another embodiment, the grinding layer binder **20** has a thickness that is less than the height of the erectly-oriented particles **18** such that the erectly-oriented particles **18** at least partially protrude from the exposed surface of the grinding layer binder **20.**

[0014] The grinding layer **16** may optionally be bonded to the matrix **13** by an adhesive. The grinding layer **16** may optionally be bonded to the matrix **13** by the grinding layer binder **20.** The grinding layer **16** may be optionally bonded to the matrix **13** by an additional binder layer containing any suitable binder known in the art, including any one or more suitable binders described below, including organic, resin, metallic, or vitrified binders.

[0015] The grinding layer binder **20** holds the erectly-oriented abrasive particles **18** in a fixed configuration within the grinding layer **16.** The grinding layer binder **20** may contain any suitable organic, resin, metallic, vitrified or any other binder known in the art such as binders described below or those used in make coats or combinations thereof. The grinding layer binder **20** can be formed by coating a curable grinding layer precursor onto a major surface of the matrix **13.** The grinding layer precursor refers to coatable materials applied to the matrix **13** which can be hardened, for instance, by curing, to form the grinding layer **16.** The grinding layer binder **20** can also be formed by coating a grinding layer precursor onto any other suitable holding surface that can be used to assemble the grinding layer **16.** The grinding layer precursor or the grinding layer binder **20** may comprise, for example, glue, phenolic resin, aminoplast resin, urea-formaldehyde resin, melamine-formaldehyde resin, urethane resin, free-radically polymerizable polyfunctional (meth)acrylate (e.g., aminoplast resin having pendant alpha,beta-unsaturated groups, acrylated urethane, acrylated epoxy, acrylated isocyanurate), epoxy resin (including bis-maleimide and fluorene-modified epoxy resins), isocyanurate resin, and any binder described below or mixtures thereof.

[0016] Erectly-oriented abrasive particles **18** are abrasive particles having a predetermined axis that is erectly-oriented with respect to the grinding layer **16.** The predetermined axis can be any geometric axis passing through the article. In an embodiment, the predetermined axis is the longest axis passing through each of the erectly-oriented abrasive particles

18. In another embodiment, the predetermined axis is the shortest axis passing through each of the erectly-oriented abrasive particles **18.** In yet another embodiment, the predetermined axis is the axis that passes through a sharp abrasive vertex of each of the erectly-oriented abrasive particles **18.** In a further embodiment, the predetermined axis passes through the center of mass of each of the erectly-oriented abrasive particles **18.** In still other embodiments, the predetermined axis is any other geometric axis.

[0017] Erectly-oriented abrasive particles **18** include particles with a predetermined axis that can assume any suitable angle ranging from, without limitation, 30° to 90° with respect to the grinding layer **16.** For instance, in an embodiment, the predetermined axis is substantially normal to the grinding layer **16.** A substantially perpendicular or normal predetermined axis has an angle that is close to 90° or is a right angle within a predetermined tolerance with respect to the grinding layer **16.** In another embodiment, the predetermined axis assumes non-perpendicular angles that are less than 90°, for instance, any angle within the range of, without limitation, 30° to 89°.

[0018] In an embodiment, erectly-oriented abrasive particles **18** include abrasive particles that have at least one vertex that is elevated with respect to the grinding layer erectly-oriented abrasive particles **18** include abrasive particles. In another embodiment, erectly-oriented abrasive particles **18** include abrasive particles that have at least one vertex that protrudes from the grinding layer **16.** A vertex is any geometric vertex such as a tip, an end, a point, a protrusion or any other geometric vertex of an abrasive particle.

[0019] In an embodiment, all of the abrasive particles in the grinding layer **16** are erectly-oriented abrasive particles **18.** In another embodiment, at least 10% by weight of the abrasive particles in the grinding layer are erectly-oriented abrasive particles **18.** In yet another embodiment, at least 20% by weight, or at least 30% by weight, or at least 40% by weight, or at least 50% by weight, or at least 60% by weight, or at least 70% by weight, or at least 80% by weight, or at least 90% by weight of the abrasive particles are erectly-oriented abrasive particles. In other embodiments, the abrasive particles in the grinding layer contain any amount, ranging from 10% to 100% by weight, of erectly-oriented abrasive particles **18.**

[0020] The erectly-oriented particles **18** can comprise shaped abrasive particles or formed abrasive particles. In an embodiment, the shaped abrasive particles have polygonal faces and a polygonal base. In another embodiment, the shaped abrasive particles have a triangular face and a trapezoidal base. In other embodiments, the erectly-oriented abrasive particles **18** contain other abrasive particles known in the art, including conventional crushed abrasive particles, shaped abrasive particles, or any abrasive particles described below or their combinations thereof, disposed in the grinding layer **16** such that a predetermined axis of the particles is erectly-oriented. In one embodiment, the predetermined axis is perpendicular to one side of a triangular shaped abrasive particle and extends through the opposing vertex or tip of the triangular shaped abrasive particle such that the erectly-orientated abrasive particles are positioned as shown in **FIG. 1A.**

[0021] Abrasive particles can include shaped, fractured abrasive particles, as disclosed in U.S. Pat. No. 8,034,137; abrasive shards, shaped abrasive particles with openings, or dish shaped abrasive articles as disclosed in U.S. Pat. No. 8,123,828; dish-shaped abrasive particles with a recessed surface as disclosed in U.S. Pat. No. 8,142,891; shaped abrasive particles with an opening as disclosed in U.S. Pat. No. 8,142,532; shaped abrasive particles with grooves as disclosed in published U.S. Pat. Application No. 2010/0146867; shaped abrasive particles with a sloping sidewall as disclosed in U.S. Pat. No. 8,142,531; shaped abrasive particles with low roundness factor as disclosed in published U.S. Pat. Application No. 2010/0319269; dual tapered shaped abrasive particles as disclosed in P.C.T. Application No. PCT/US2010/057713; and shaped abrasive particles disclosed in published U.S. Pat. Application No. 2011/0146509.

[0022] The erectly-oriented abrasive particles **18** may be randomly dispersed across the grinding layer **16**, or may be dispersed in a predetermined pattern across the grinding layer **16.** The erectly-oriented particles **18** may be oriented in different orientations across the grinding layer **16** such that even though each of the erectly-oriented particles **18** is substantially erectly-oriented, each of the erectly-oriented particles **18** assumes different orientations. Some, all or none of the erectly-oriented abrasive particles **16** may be oriented in a substantially similar or parallel orientation across the grinding layer **16.** Some, all, or none of the erectly-oriented abrasive particles **18** may be of substantially the same, similar or different sizes. Some, all, or none of the erectly-oriented abrasive particles **18** may have substantially same, similar or different shapes. The erectly-oriented abrasive particles **18** can contain abrasive particles of the same or different chemical compositions, with the same, similar, dissimilar or different chemical and physical properties such as electrostatic attraction, hardness, and fracture toughness. The erectly-oriented abrasive particles **18** may abrade surfaces to varying extents, such as low abrasion, medium abrasion, high abrasion or any other known abrasive extent, depending on factors such as size, geometry, orientation and composition of the erectly-oriented abrasive particles **18**, and factors such as the pressure and speed at which surfaces are exposed to the grinding layer **16** containing the erectly-oriented abrasive particles **18.**

[0023] The matrix binder **14** and the grinding layer binder **20** may be the same or different (chemically or physically different). For example, the matrix binder **14** can be a first phenolic binder and the grinding layer binder **20** can be a second phenolic binder that is different from the first phenolic binder.

[0024] In an embodiment, an optional size layer **22** is optionally coated over the erectly-oriented particles **18** at the surface of the grinding layer **16.** The size layer **22** may be coated by any conventional technique, such as knife coating, spray coating, roll coating, curtain coating, rotogravure coating, and the like. The size layer **22** maintains the integrity of the grinding layer 16, including the erectly-oriented abrasive particles **18.** The size layer **22** may contain any suitable organic, resin, metallic, vitrified or any other sizing agent or binder known in the art such as binders described below or those used in sizing coats or combinations thereof. The size layer **22** can be formed by coating a curable size layer precursor onto the exposed surface of the grinding layer **16.** The size layer precursor refers to coatable materials applied to the grinding layer **16**, for example, over the top of the erectly-oriented abrasive particles **18.** The size layer precursor can be hardened, for instance, by curing, to form the size layer **22.** The size layer precursor or the size layer binder **20** may comprise, for example, glue, phenolic resin, aminoplast resin, urea-formaldehyde resin, melamine-formaldehyde resin, urethane resin, free-radically polymerizable polyfunctional (meth)acrylate (e.g., aminoplast resin having pendant alpha,beta-unsaturated groups, acrylated urethane, acrylated epoxy, acrylated isocyanurate), epoxy resin (including bis-maleimide and fluorene-modified epoxy resins), isocyanurate resin, or any binder described below or mixtures thereof.

[0025] The matrix binder **14**, the grinding layer binder **20**, or the size layer **22** can each further comprise additives known in the art, such as, for example, fillers, grinding aids, wetting agents, surfactants, dyes, pigments, coupling agents, or any other additives described herein and combinations thereof.

[0026] In an embodiment, the matrix **13** is a disc having a diameter of 7 inches with a central hole of diameter 7/8 inch. The grinding layer **16** is disposed on one of the major surfaces of the matrix **13.** The combined thickness of the matrix **13** and the grinding layer **16** is 1/8 inch. Thus the bonded abrasive article is of diameter 7 inches, with a central hole of diameter 7/8 inch. The bonded abrasive article can have a depressed central region, for instance, as in a type 27 disc.

[0027] **FIG. 1B** is a schematic cross-sectional view of a bonded abrasive article according to an embodiment. The bonded abrasive article comprises a matrix **14** and a grinding layer **16.** The matrix **14** is described above. Though **FIG. 1B** represents an embodiment in which the grinding layer **16** comprises erectly-oriented abrasive particles **18** comprising crushed abrasive particles, the erectly-oriented abrasive particles **18** can be any erectly-oriented abrasive particles **18** as described herein.

[0028] In an embodiment, the grinding layer **16** further optionally comprises a backing **24.** The backing **24** may be disposed at the back face **17** of the grinding layer **16**, such that the backing **24** is disposed between the matrix **13** and the back face **17.** The backing **24** may be continuous, for instance, extending continuously across the bottom unexposed surface between the grinding layer **16** and the matrix **13.** The backing **24** may be discontinuous, for instance, extending in regular or irregular patterns or patches across the bottom unexposed surface between the grinding layer **16** and the matrix **13.** The backing **24** helps in retaining the configuration of the grinding layer **16**, the grinding layer binder **18**, and the erectly-oriented abrasive particles **18.** The backing **24** may comprise any backing known in the art, including paper, fabric, or film backings, or any other backing known in the art or described below or combinations thereof. In another embodiment, the backing **24** can comprise a scrim material such as an open weave woven or knitted material to which the erectly-oriented abrasive particles are applied. The scrim backing for the grinding layer **16** can also be used to reinforce the matrix **14**; especially, when the grinding layer **16** is primarily disposed within the matrix **14.**

[0029] In an embodiment, the grinding layer **16** comprises the backing **24**, the grinding layer binder **20**, erectly-oriented abrasive particles **18**, and the size layer **22.** In another embodiment, the grinding layer **16** comprises a coated abrasive article comprising the backing **24**, the grinding layer binder **20**, erectly-oriented abrasive particles **18**, and the size layer **22.**

[0030] The grinding layer **16** is optionally attached to the matrix by an adhesive layer **26.** In an embodiment, the grinding layer **16** comprises the adhesive layer **26.** In another embodiment, the grinding layer **16** comprises both the backing 24 and the adhesive layer **26.** In yet another embodiment, the grinding layer **16** comprises an abrasive article and the adhesive layer **26**, the abrasive article comprising the backing **24**, the grinding layer binder **20**, erectly-oriented abrasive particles **18**, and the size layer **22**, wherein the adhesive layer **26** is disposed between the backing **24** and the matrix **13.**

[0031] The adhesive layer **26** can comprise any adhesive known in the art, including but not limited to pressure sensitive adhesives, curable epoxies, phenolics, resins, silicones, acrylics, and styrene-butadiene copolymers or combinations thereof.

[0032] **FIG. 2** is a schematic cross-sectional view of a bonded abrasive article according to an embodiment. The grinding layer **16** is disposed on a second major surface **23** of the matrix **13**, such that the matrix covers the grinding layer **16.** The grinding face **19** is proximal to the matrix **13** while the back face **17** of the grinding layer **16** is distal to the matrix **13.** In an embodiment, the grinding layer **16** comprises the optional sizing layer **22** described herein. In another embodiment, the grinding layer **16** comprises the optional backing **24** described herein.

[0033] In an embodiment, the grinding layer **16** is disposed partly within the interior of the matrix **13**, such that the matrix **13** covers at least a portion of the grinding face **19.** In another embodiment, the grinding layer **16** is disposed completely within the interior of the matrix **13** such that the matrix **13** substantially covers the grinding face **19.**

[0034] **FIG. 3** is a schematic cross-sectional view of a bonded abrasive article according to an embodiment. In an embodiment, the bonded abrasive article comprises a matrix 13, a first grinding layer **16'** and a second grinding layer

16" The first grinding layer **16'** comprises erectly-oriented abrasive particles **18'** and a grinding layer binder **20'.** The second grinding layer **16"** comprises erectly-oriented abrasive particles **18"** and a grinding layer binder **20".** The first grinding layer **16'** has a grinding face **19'** and a back face **17'.** The second grinding layer **16"** has a grinding face **19"** and a back face **17".** The first grinding layer **16'** is disposed at a first major surface **21** of the matrix such that the back face **17'** of the first grinding layer **16'** is proximal to the matrix **13** and the grinding face **19'** is distal to the matrix **13.** The second grinding layer **16"** is disposed at a second major surface **23** of the matrix such that the back face **17"** of the second grinding layer **16"** is distal to the matrix **13** and the grinding face **19"** is proximal to the matrix **13.** The matrix **13** covers the grinding face **19"** of the second grinding layer **16".** The second grinding layer **16"** comprises the backing **24".**

[0035] In an embodiment, the back face **17'** of the first grinding layer **16'** is bonded to the matrix **13.** In another embodiment, the first grinding layer **16'** comprises a backing **24** and the matrix **13** is bonded to the backing **24.** In yet another embodiment, the first grinding layer **16'** comprises a backing **24** and an adhesive layer **26** and the matrix **13** is bonded to the backing **24** by the adhesive layer **26.**

[0036] In an embodiment, multiple grinding layers **16** are disposed such that some, all or none of the multiple grinding layers **16** are disposed at the surface of matrix **13**, some, all or none of the multiple grinding layers **16** are disposed partly within the interior of matrix **13,** and some, all or none of the multiple grinding layers **16** are disposed completely within the interior of matrix **13.**

[0037] **FIG. 4A** is a schematic view of apparatus for erectly-orienting abrasive particles. In an embodiment, a method of forming a bonded abrasive articles comprises electrostatically erectly-orienting the abrasive particles **18'.** Abrasive particles **18'** are distributed on a first support **28.** A grinding layer binder precursor **20'** is coated on the first major surface **21** of the matrix **13.** In an embodiment, the grinding layer binder precursor **20'** is coated on the second major surface **23** of the matrix **13.** The coated major surface is maintained proximal to the abrasive particles **18'.** An electrostatic field is applied between the first support **28** and the matrix **13.** The electrostatic field erectly-orients the abrasive particles **18'** and causes them to be attracted towards the matrix **13** such that the abrasive particles **18'** attach to the coating of the grinding layer binder precursor **20'** while maintaining an erectly-oriented configuration.

[0038] The electrostatic field can be generated using any known electrostatic field generating apparatus known in the art. For example, a useful electrostatic field generating apparatus includes electrodes having an electrical potential applied between them with one electrode placed above the matrix **13** and the opposing electrode placed below the first support **28.** The electrical potential can be supplied by a suitable A.C. or D.C. power supply. In an embodiment, shaped electrodes are used to apply the abrasive grains **18'** in a predetermined pattern, for example, as disclosed in U.S. Pat. No. 6,511,713.

[0039] In an embodiment, the first support **28** is stationary. In another embodiment, the first support **28** comprises a moving belt or surface. In an embodiment, the matrix **13** is stationary. In another embodiment, the matrix **13** is moved as the abrasive particles **18'** are electrostatically attracted towards the matrix **13.** In various embodiments, at least some, or a majority, or substantially all, of the abrasive particles **18'** are attracted to the matrix **13** and attach to the coating of the grinding layer precursor **20'.**

[0040] **FIG. 4B** is a schematic cross-sectional view of an abrasive article with erectly-oriented abrasive particles. The abrasive particles **18'**, having being attracted to the matrix **13** by the electrostatic field, form erectly-oriented abrasive particles **18** on the coating of the grinding layer binder precursor **20'** on one of the major surfaces **21** and **23** of the matrix **13.**

[0041] In an embodiment, the grinding layer binder precursor **20'** is hardened, for example, by curing, after the abrasive particles **18'** have been attached, while retaining their erectly-oriented configuration, to form the cured grinding layer binder **20** with erectly-oriented abrasive particles **18.** In another embodiment, the grinding layer binder precursor **20'** is partially cured before abrasive particles **18'** are attached to it, and completely cured after the abrasive particles **18'** are attached.

[0042] **FIGS. 5A, 5B, 5C** and **5D** show a method for preparing a bonded abrasive article according to an embodiment. **FIG. 5A** is a schematic perspective view of an abrasive article **32** prior to the application of a matrix **13.** The abrasive article **32** comprises a grinding layer **16**, and erectly-oriented abrasive particles **18.** The abrasive article **32** is shaped in the form of a disc, and has a mounting hole **30.** In an embodiment, the abrasive article **32** is shaped to conform to the shape of a type **27** grinding wheel. In another embodiment, the abrasive article **32** is shaped in the form of a disc with a diameter of 7 inches and a central hole of diameter 7/8 inch. In an embodiment, the abrasive article comprises optional backing **24.** In another embodiment, the abrasive article comprises optional sizing layer **22.**

[0043] **FIG. 5B** is a cross-sectional view of matrix precursor **13'** being applied to the abrasive article **32.** The abrasive article **32** comprises a grinding layer **16.** The grinding layer **16** comprises a grinding layer binder **20.** Matrix precursor **13'** is applied to the grinding face of the abrasive article **32.** Matrix precursor **13'** comprises curable matrix binder **14'** and matrix abrasive particles **12.** A predetermined amount of the matrix precursor **13'** can be applied to the surface of the abrasive article **32** by any method known in the art, including, without limitation, spreading, coating, dispersing or combinations thereof.

[0044] **FIG. 5C** is a cross-sectional view of matrix precursor **13'** being applied to the abrasive article **32.** The abrasive article **32** comprises a grinding layer **16.** The grinding layer **16** comprises a grinding layer binder **20.** Applied matrix precursor **13'** is settling and the curable matrix binder **14'** is being cured to form the matrix binder **14.** Matrix precursor **13'** comprises curable matrix binder **14'** and matrix abrasive particles **12.** In an embodiment, the matrix precursor **13'** condenses slightly on curing, so that the thickness of the matrix precursor **13'** comprising curable matrix binder **14'** is greater than the thickness of the matrix **13** comprising cured matrix binder **14.**

[0045] **FIG. 5D** is a perspective view of a bonded abrasive article according to an embodiment, after applying and curing a matrix precursor. Abrasive article **32** comprises a grinding layer **16,** erectly-oriented abrasive particles **18**, and a matrix **13.** Matrix **13** is formed on the grinding face of the abrasive article **32** by curing the curable matrix binder **14'** in the matrix precursor **13'.** The erectly-oriented abrasive particles **18** retain their original configuration. The matrix **13** is bonded to the grinding face **19** of the grinding layer **16** in the abrasive article **32.**

[0046] Abrasive particles, binders, fillers, backings, grinding aids and other additives that can be used in various embodiments are described below.

Abrasive Particles

[0047] Useful abrasive particles include conventional abrasive particles including any abrasive particles known in the abrasive art. 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 seeding or nucleating agents), and heat-treated aluminum oxide, silicon carbide, black silicon carbide, green silicon carbide, co-fused alumina-zirconia, diamond, ceria, titanium diboride, cubic boron nitride, boron carbide, garnet, flint, emery, sol-gel derived abrasive particles, and mixtures thereof. The abrasive particles may be in the form of, for example, individual particles, agglomerates, composite particles, and mixtures thereof.

[0048] Useful crushed abrasive particles include, for example, crushed particles of fused aluminum oxide, white fused aluminum oxide, ceramic aluminum oxide materials such as those commercially available under the trade designation 3M CERAMIC ABRASIVE GRAIN from 3M Company of St. Paul, Minnesota, titanium diboride, tungsten carbide, titanium carbide, sol-gel derived abrasive particles, iron oxide, chromia, zirconia, titania, silicates, tin oxide, silica (such as quartz, glass beads, glass bubbles and glass fibers) silicates (such as talc, clays (e.g., montmorillonite), feldspar, mica, calcium silicate, calcium metasilicate, sodium aluminosilicate, sodium silicate). Examples of sol-gel derived abrasive particles can be found in U.S. Patent Nos. 4,314,827 (Leitheiser et al), 4,623,364 (Cottringer et al); 4,744,802 (Schwabel), 4,770,671 (Monroe et al.); and 4,881,951 (Monroe et al.). It is also contemplated that the abrasive particles could comprise abrasive agglomerates such, for example, as those described in U.S. Patent Nos. 4,652,275 (Bloecher et al.) or 4,799,939 (Bloecher et al).

[0049] The abrasive particles may, for example, have an average diameter of at least about 0.1 micrometer, at least about 1 micrometer, or at least about 10 micrometers, and less than about 10,000 micrometers, or less than about 8,000 micrometers, or less than about 5,000 micrometers, although larger and smaller abrasive particles may also be used. For example, the conventional abrasive particles may have an abrasives industry specified nominal grade. Such abrasives industry accepted grading standards include those known as the American National Standards Institute, Inc. (ANSI) standards, Federation of European Producers of Abrasive Products (FEPA) standards, and Japanese Industrial Standard (JIS) standards. Exemplary ANSI grade designations (i.e., specified nominal grades) include: ANSI 12 (1842 μm), ANSI 16 (1320 μm), ANSI 20 (905 μm), ANSI 24 (728 μm), ANSI 36 (530 μm), ANSI 40 (420 μm), ANSI 50 (351 μm), ANSI 60 (264 μm), ANSI 80 (195 μm), ANSI 100 (141 μm), ANSI 120 (116 μm), ANSI 150 (93 μm), ANSI 180 (78 μm), ANSI 220 (66 μm), ANSI 240 (53 μm), ANSI 280 (44 μm), ANSI 320 (46 μm), ANSI 360 (30 μm), ANSI 400 (24 μm), and ANSI 600 (16 μm). Exemplary FEPA grade designations include P12 (1746 μm), P16 (1320 μm), P20 (984 μm), P24 (728 μm), P30 (630 μm), P36 (530 μm), P40 (420 μm), P50 (326 μm), P60 (264 μm), P80 (195 μm), P100 (156 μm), P120 (127 μm), P120 (127 μm), P150 (97 μm), P180 (78 μm), P220 (66 μm), P240 (60 μm), P280 (53 μm), P320 (46 μm), P360 (41 μm), P400 (36 μm), P500 (30 μm), P600 (26 μm), and P800 (22 μm). An approximate average particles size of reach grade is listed in parenthesis following each grade designation.

[0050] Useful abrasive particles also include formed ceramic abrasive particles and, in particular, shaped abrasive particles. Shaped abrasive particles can be prepared according to the disclosures of U.S. 8,142,531. The shaped abrasive particles were prepared by shaping alumina sol gel from, for example, equilateral triangle-shaped polypropylene mold cavities of side length 0.031 inch (0.79 mm) and a mold depth of 0.008 inch (0.2 mm). After drying and firing, such resulting shaped abrasive particles comprised triangular plates that were about 280 micrometers (longest dimension) and would pass through a 50-mesh sieve and be retained upon a 60-mesh sieve. In one embodiment, the triangular shaped abrasive particles comprise a first face, an opposing second face connected to the first face by a sidewall where the perimeter of each face is a triangular and desirably an equilateral triangle. In some embodiments, the sidewall, instead of having a 90 degree angle to both faces, is a sloping sidewall as disclosed in US 8,142,531 having a draft angle α between the second face and the sloping sidewall between about 95 degrees to about 130 degrees, which has been determined to greater enhance the cut rate of the triangular shaped abrasive particles.

[0051] As used herein "formed ceramic abrasive particle" means an abrasive particle having at least a partially replicated shape. One process to make a formed ceramic abrasive particle includes shaping the precursor ceramic abrasive particle in a mold having a predetermined shape to make ceramic shaped abrasive particles. Ceramic shaped abrasive particles, formed in a mold, are one species in the genus of formed ceramic abrasive particles. Other processes to make other species of formed ceramic abrasive particles include extruding the precursor ceramic abrasive particle through an orifice having a predetermined shape, printing the precursor ceramic abrasive particle though an opening in a printing screen having a predetermined shape, or embossing the precursor ceramic abrasive particle into a predetermined shape or pattern. Non-limiting examples of formed ceramic abrasive particles include shaped abrasive particles, such as triangular plates as disclosed in U.S. patents RE 35,570; 5,201,916; 5,984,998; 8,034,137; 8,123,828; 8,142,531; 8,142,532; and 8,142,891; and in U.S. patent publications 2009/0169816, 2010/0146867, and 2010/0319269 or elongated ceramic rods/filaments often having a circular cross section produced by Saint-Gobain Abrasives an example of which is disclosed in U.S. patent number 5,372,620. Formed ceramic abrasive particles are generally homogenous or substantially uniform and maintain their sintered shape without the use of a binder such an organic or inorganic binder that bond smaller abrasive particles into an agglomerated structure and excludes abrasive particles obtained by a crushing or comminution process that produces abrasive particles of random size and shape. In many embodiments, the formed ceramic abrasive particles comprise a homogeneous structure of sintered alpha alumina or consist essentially of sintered alpha alumina.

[0052] The formed ceramic abrasive particles can be graded to a nominal screened grade using U.S.A. Standard Test Sieves conforming to ASTM E-11 "Standard Specification for Wire Cloth and Sieves for Testing Purposes." ASTM E-11 proscribes the requirements for the design and construction of testing sieves using a medium of woven wire cloth mounted in a frame for the classification of materials according to a designated particle size. A typical designation may be represented as -18+20 meaning that the formed ceramic abrasive particles pass through a test sieve meeting ASTM E-11 specifications for the number 18 sieve and are retained on a test sieve meeting ASTM E-11 specifications for the number 20 sieve. In one embodiment, the formed ceramic abrasive particles have a particle size such that most of the formed ceramic abrasive particles pass through an 18 mesh test sieve and can be retained on a 20, 25, 30, 35, 40, 45, or 50 mesh test sieve. In various embodiments of the invention, the formed ceramic abrasive particles can have a nominal screened grade comprising: -18+20 (925 μm), -20+25 (780 μm), -25+30 (655 μm), -30+35 (550 μm), -35+40 (463 μm), -40+45 (390 μm), -45+50 (328 μm), -50+60 (275 μm), -60+70 (231 μm), -70+80 (196 μm), -80+100 (165 μm), -100+120 (138 μm), -120+140 (116 μm), -140+170 (98 μm), -170+200 (83 μm), -200+230 (69 μm), - 230+270 (58 μm), -270+325 (49 μm), -325+400 (42 μm), -400+450 (35 μm), -450+500 (29 μm), or -500+635 (23 μm).

[0053] The average particle size is the expected average size of abrasive particles conforming to the industry specified grade or in the case of sieves, the average between the size of the screen opening the particle passed through and the size of the screen opening the particle was retained on. The number in parenthesis following the grade or screen designation is the average abrasive particle size in μm.

Filler particles

[0054] Filler particles may be blended with abrasive particles in the abrasive article. Examples of useful fillers include metal carbonates (such as calcium carbonate, calcium magnesium carbonate, sodium carbonate, magnesium carbonate), silica (such as quartz, glass beads, glass bubbles and glass fibers), silicates (such as talc, clays, montmorillonite, feldspar, mica, calcium silicate, calcium metasilicate, sodium aluminosilicate, sodium silicate), metal sulfates (such as calcium sulfate, barium sulfate, sodium sulfate, aluminum sodium sulfate, aluminum sulfate), gypsum, vermiculite, sugar, wood flour, aluminum trihydrate, carbon black, metal oxides (such as calcium oxide, aluminum oxide, tin oxide, titanium dioxide), metal sulfites (such as calcium sulfite), thermoplastic particles (such as polycarbonate, polyetherimide, polyester, polyethylene, poly(vinylchloride), polysulfone, polystyrene, acrylonitrile-butadiene-styrene block copolymer, polypropylene, acetal polymers, polyurethanes, nylon particles) and thermosetting particles (such as phenolic bubbles, phenolic beads, polyurethane foam particles and the like). The filler may also be a salt such as a halide salt. Examples of halide salts include sodium chloride, potassium cryolite, sodium cryolite, ammonium cryolite, potassium tetrafluoroborate, sodium tetrafluoroborate, silicon fluorides, potassium chloride, magnesium chloride. Examples of metal fillers include, tin, lead, bismuth, cobalt, antimony, cadmium, iron and titanium. Other miscellaneous fillers include sulfur, organic sulfur compounds, graphite, lithium stearate and metallic sulfides.

[0055] In some embodiments, the abrasive particles are treated with a coupling agent (e.g., an organosilane coupling agent) to enhance adhesion of the abrasive particles to the binder. The abrasive particles may be treated before combining them with the binder material, or they may be surface treated in situ by including a coupling agent to the binder material.

Grinding Aids

[0056] In some embodiments, bonded abrasive wheels according to the present disclosure contain additional grinding aids such as, for example, polytetrafluoroethylene particles, cryolite, sodium chloride, FeS2 (iron disulfide), or KBF4; typically in amounts of from 1 to 25 percent by weight, more typically 10 to 20 percent by weight, subject to weight range requirements of the other constituents being met. Grinding aids are added to improve the cutting characteristics of the cut-off wheel, generally by reducing the temperature of the cutting interface. The grinding aid may be in the form of single particles or an agglomerate of grinding aid particles. Examples of precisely shaped grinding aid particles are taught in U.S. Patent Publ. No. 2002/0026752 A1 (Culler et al).

Backings

[0057] Useful backings include, for example, paper, fabric, scrim or open weave backings, or film backings. Suitable film backings include polymeric films and primed polymeric films, especially those used in the abrasive arts. Useful polymeric films include, for example, polyester films (e.g., an ethylene-acrylic acid copolymer primed polyethylene terephthalate), polyolefin films (e.g., polyethylene or polypropylene films), and elastic polyurethane films. The film backing may be a laminate of two polymeric films. Examples of elastomeric polyurethanes that may be used to form films include those available under the trade designation ESTANE from B.F. Goodrich and Co. of Cleveland, OH and those described in U.S. Pat. Nos. 2,871,218 (Schollenberger); 3,645,835 (Hodgson); 4,595,001 (Potter et al.); 5,088,483 (Heinecke); 6,838,589 (Liedtke et al.); and RE 33,353 (Heinecke). Pressure-sensitive adhesive-coated polyurethane elastomer films are commercially available from 3M Company under the trade designation TEGADERM Useful polymeric films are generally from about 0.02 to about 0.5 millimeters in thickness, for example, from 0.02 millimeter to 0.1 millimeter in thickness; however, this is not a requirement.

Binder

[0058] The binder material typically comprises a glassy inorganic material (e.g., as in the case of vitrified abrasive wheels), metal, or an organic resin (e.g., as in the case of resin-bonded abrasive wheels).

[0059] Glassy inorganic binders may be made from a mixture of different metal oxides. Examples of these metal oxide vitreous binders include silica, alumina, calcia, iron oxide, titania, magnesia, sodium oxide, potassium oxide, lithium oxide, manganese oxide, boron oxide, phosphorous oxide, and the like. Specific examples of vitreous binders based upon weight include, for example, 47.61 percent S1O2, 16.65 percent AI2O3, 0.38 percent Fe2 O3, 0.35 percent T1O2, 1.58 percent CaO, 0.10 percent MgO, 9,63 percent Na20, 2.86 percent]¾0, 1.77 percent L12O, 19.03 percent B2O3, 0.02 percent Mn02, and 0.22 percent P2O5 ; and 63 percent S1O2, 12 percent AI2O3, 1.2 percent CaO, 6.3 percent Na20, 7.5 percent]¾0, and 10 percent B2O3. During manufacture of a vitreous bonded abrasive wheel, the vitreous binder, in a powder form, may be mixed with a temporary binder, typically an organic binder. The vitrified binders may also be formed from a frit, for example anywhere from about one to 100 percent frit, but generally 20 to 100 percent frit. Some examples of common materials used in frit binders include feldspar, borax, quartz, soda ash, zinc oxide, whiting, antimony trioxide, titanium dioxide, sodium silicofluoride, flint, cryolite, boric acid, and combinations thereof. These materials are usually mixed together as powders, fired to fuse the mixture and then the fused mixture is cooled. The cooled mixture is crushed and screened to a very fine powder to then be used as a frit binder. The temperature at which these frit bonds are matured is dependent upon its chemistry, but may range from anywhere from about 600° C to about 1800° C.

[0060] Examples of metal binders include tin, copper, aluminum, nickel, and combinations thereof.

[0061] Organic binder materials are typically included in an amount of from 5 to 30 percent, more typically 10 to 25, and more typically 15 to 24 percent by weight, based on the total weight of the bonded abrasive wheel. Phenolic resin is the most commonly used organic binder material, and may be used in both the powder form and liquid state. Although phenolic resins are widely used, it is within the scope of this disclosure to use other organic binder materials including, for example, epoxy resins, urea- formaldehyde resins, rubbers, shellacs, and acrylic binders. The organic binder material may also be modified with other binder materials to improve or alter the properties of the binder material. Useful phenolic resins include novolac and resole phenolic resins. Novolac phenolic resins are characterized by being acid-catalyzed and having a ratio of formaldehyde to phenol of less than one, typically between 0.5: 1 and 0.8:1. Resole phenolic resins are characterized by being alkaline catalyzed and having a ratio of formaldehyde to phenol of greater than or equal to one, typically from 1 : 1 to 3 : 1. Novolac and resole phenolic resins may be chemically modified (e.g., by reaction with epoxy compounds), or they may be unmodified. Exemplary acidic catalysts suitable for curing phenolic resins include sulfuric, hydrochloric, phosphoric, oxalic, and p-toluenesulfonic acids. Alkaline catalysts suitable for curing phenolic resins include sodium hydroxide, barium hydroxide, potassium hydroxide, calcium hydroxide, organic amines, or sodium carbonate.

[0062] Phenolic resins are well-known and readily available from commercial sources. Examples of commercially available novolac resins include DUREZ 1364, a two-step, powdered phenolic resin (marketed by Durez Corporation of Addison, Texas under the trade designation VARCUM (e.g., 29302), or HEXION AD5534 RESIN (marketed by Hexion Specialty Chemicals, Inc. of Louisville, Kentucky). Examples of commercially available resole phenolic resins useful in practice of the present disclosure include those marketed by Durez Corporation under the trade designation VARCUM (e.g., 29217, 29306, 29318, 29338, 29353); those marketed by Ashland Chemical Co. of Bartow, Florida under the trade designation AEROFENE (e.g., AEROFENE 295); and those marketed by Kangnam Chemical Company Ltd. of Seoul, South Korea under the trade designation "PHENOLITE" (e.g., PHENOLITE TD-2207).

[0063] Curing temperatures of organic binder material precursors will vary with the material chosen and wheel design. Selection of suitable conditions is within the capability of one of ordinary skill in the art. Exemplary conditions for a phenolic binder may include an applied pressure of about 20 tons per 4 inches diameter (224 kg/cm^) at room temperature followed by heating at temperatures up to about 185°C for sufficient time to cure the organic binder material precursor.

[0064] Bonded abrasive articles according to various embodiments may take any of a variety of conventional forms. Preferred abrasive articles are in the form of wheels. Abrasive wheels are typically in the form of a disc or right cylinder having dimensions that may be very small, e.g., a cylinder height on the order of a few millimeters or very large, e.g., a meter or more, and a diameter which may be very small, e.g., on the order of a few centimeters, or very large, e.g., tens of centimeters. Wheels typically have a central opening for support by an appropriate arbor or other mechanical holding means to enable the wheels to be rotated during use. Wheel dimensions, configurations, means of support, and means of rotation are all well known in the art.

[0065] The abrasive particles may, for example, be uniformly or non-uniformly distributed throughout the bonded abrasive article. For example, if the bonded abrasive article is a grinding wheel or a cut-off wheel, the abrasive particles may be concentrated toward the middle (e.g., located away from the outer faces of a grinding or cut-off wheel), or only in the outer edge, i.e., the periphery, of a grinding or cut-off wheel. The depressed-center portion may contain a lesser amount of abrasive particles. In another variation, first abrasive particles may be in one side of the wheel with different abrasive particles on the opposite side. However, typically all the abrasive particles are homogenously distributed among each other, because the manufacture of the wheels is easier, and the cutting effect is optimized when the two types of abrasive particles are closely positioned to each other.

[0066] Optionally, bonded abrasive articles according to various embodiments may further comprise a scrim that reinforces the bonded abrasive article; for example, disposed on one or two major surfaces of the bonded abrasive article, or disposed within the bonded abrasive article. Examples of scrims include a woven or a knitted cloth. The fibers in the scrim may be made from glass fibers (e.g., fiberglass), organic fibers such as polyamide, polyester, or polyimide. In some instances, it may be desirable to include reinforcing staple fibers within the bonding medium, so that the fibers are homogeneously dispersed throughout the bonded abrasive article.

EXAMPLES

[0067] Objects and advantages of this disclosure are further illustrated by the following non-limiting examples. The particular materials and amounts thereof recited in these examples as well as other conditions and details, should not be construed to unduly limit this disclosure. Unless otherwise noted, all parts, percentages, ratios, etc. in the Examples and the rest of the specification are by weight.

Materials

[0068]

ABBREVIATION	DESCRIPTION
AP1	alumina abrasive particle, TREIBACHER 36 BFRPL, obtained from Treibacher Schleifmettel, AG, Villach, Austria
AP2	ceramic alumina abrasive particle, 3M™ CERAMIC ABRASIVE GRAIN 321, GRADE 36, from 3M, Saint Paul, Minnesota
PR1	liquid phenolic resin, DUREZ 8121, obtained from Sumitomo Bakelite North America, Manchester Connecticut
PR2	powder phenolic resin, VARCUM 29302, obtained from Sumitomo Bakelite North America
CRY1	sodium hexafluoroaluminate (cryolite), obtained from FREEBEE A/S, Farum, Denmark
PR3	resole phenolic resin, 70% solids condensate of a 1.96:1 formaldehyde:phenol mixture with 2% potassium hydroxide catalyst (on weight of phenol) in water
SCRIM	fiberglass mesh, obtained as STYLE 4400 from Industrial Polymers and Chemicals, Inc., Shrewsbury, Massachusetts

(continued)

ABBREVIATION	DESCRIPTION
SAP1	Grade 36+ shaped abrasive particles prepared according to the disclosure of U.S. Pat. No. 8,142,531 having a side length of about 0.8mm and about 0.2 mm thick, and a sidewall angle of 98 degrees.
AP3	abrasive particles, available as ESK, RBT9 BROWN CORUNDUM # 30 from Treibacher Schleifmettel AG
AP4	abrasive particles, available as FRSK SEMI-FRIABLE CORUNDUM #36 from Treibacher Schleifmettel AG
AP5	abrasive particles, available as WHITE ALUMINUM OXIDE FEPA grade 800 from Stanchem Sp. Zo.o., Lublin, Poland
PR1	liquid phenolic resin, available as PA 5614G from PA Resins AB, Stockholm, Sweden
PR2	phenolic resin powder available as DYNEA 8551G from Dynea Oy Corp.
PR4	phenolic resin powder available as DYNEA 8126G from Dynea Oy Corp.
CRY2	Sodium hexafluoroaluminate, obtained as Cryolite from Solvay Fluor GmbH, Hannover, Germany
CACO	calcium carbonate, obtained as HUBERCARB Q4 from Huber Engineered Materials, Quincy Illinois
CRY3	potassium fluoroaluminate, particle size distribution d_{10} = 2.58 micrometers, d_{50}=11.5 micrometers, d_{90}=36.6 micrometers, from KBM Afflips B.V., Oss, The Netherlands.
CB	carbon black pigment, available as CORAX N339 from Carbon Black Polska Sp. Z o.o., Jaslo, Poland
silane	adhesion promoter, DYANSYLAN from Evonik Industries AG, Hanau-Wolfgang, Germany.
solvent	furfuryl alcohol
oil	paraffin oil
water	tap water
SURF	ethoxylated oleic acid surfactant, obtained as EMULAN A from BASF, Ludwigshafen, Germany

Abrasive Article Preparation

Examples 1 - 8

[0069] Abrasive articles of Example 1 through Example 8 were prepared using conventional and shaped abrasive particles of various sizes.

Example 1

[0070] An abrasive article was prepared in the form of a depressed-center grinding wheel (a type-27 grinding wheel) as follows.

Mix 1 was formed by mixing 860 grams of AP1 and 55 grams of PR1 using an air mixer.
Mix 2 was prepared by mixing 155 grams PR2, 155 grams CRY1 for 1 minute in a paddle type mixer.
Mix 3 was prepared by mixing Mix 1 and Mix 2 in a paddle type mixer for 10 minutes.
Mix 4 was prepared by mixing 860 grams SAP1 and 55 grams of PR1 with a high shear air mixer.
Mix 5 was prepared by combining Mix 2 and Mix 4 and mixing in a paddle type mixer for 10 minutes.
Mix 6 was prepared by combining 700g of Mix 3 and 300g of Mix 5 and mixing in a paddle type mixer for 10 minutes.

[0071] A 6.75 in. (17.1 cm) diameter disc of SCRIM was placed in a 7" (18 cm) cavity die. 250 grams of Mix 6 was spread out evenly on the scrim and a second 6.75 in. SCRIM was placed on top of the mixture. The filled cavity mold was then pressed at 40 ton/38 sq. inch (14.51 MPa) to form a disc.

[0072] Multiple resulting discs were then placed on a spindle between depressed center aluminum plates in order to be pressed into type 27 depressed-center grinding wheels. The discs were compressed at 5 ton/38 sq. inch (1.81 MPa). The compressed discs were cured in an oven by heating for 7 hours at 79° C, 3 hours at 107° C, 18 hours at 185° C, and followed by a ramp down over 4 hours to 27° C to form cured discs. The cured discs had a diameter of 180mm and a thickness of 4 mm, with a central hole of diameter 7/8" (2,22 cm)

[0073] The cured discs were spray coated with 15 grams of a make resin mix consisting of 51 parts PR3, 42 parts CACO, 6 parts water, and 1 part SURF to be ready for electrostatic mineral coat. A layer of about 47 grams of SAP1 was deposited on top of the sample. Then the discs were cured at 226° F (108 °C) for 90 minutes.

[0074] The mineral coated discs were then sized by spraying the size resin mix consisting of 45 parts PR3, 53 parts CRY2, and 2 parts CB, followed by curing at 190° F (88 °C) for 80 minutes. Finally, the dried discs were cured for 12 hours at 212° F (100 °C) to form grinding wheels.

[0075] The grinding wheels were tested by grinding by hand for ten 1- minute cycles on a mild steel bar 0.5" (1,27 cm) thick and 18" (45,72 cm) long using a 6000 RPM air grinder (Ingersoll-Rand) The grinder weight resulted in an applied load of 13 lbs. (5.9 kg) The weight of the steel bar was measured before and after each cycle to measure the cut. The grinding was repeated 16 times from end to end per cycle, approximately 1 minute each. The weight lost from the grinding disc was recorded after each test. The grinding test results are summarized in Table 1.

Example 2

[0076] Grinding wheels were prepared as in Example I, with additional spray coating with 15 grams of the make resin mix of Example 1, in preparation for electrostatic mineral coat after the first curing. A second layer of SAP1 was deposited on top of the first layer of SAP1, weighing about 47 g. Then the sample was cured at 226° F (108 C) for 90 minutes.

[0077] The mineral coated discs were then sized by spraying the size resin mix of Example 1, followed by curing at 190° F (88 C) for 80 minutes.

[0078] Finally, the dried discs were cured for 12 hours at 212° F(100 C) to form grinding wheels. The grinding test results are summarized in Table 1.

Example 3

[0079] Grinding wheels were prepared as in Example 1, substituting the electrostatic mineral coated SAP1 with AP2. The grinding test results are summarized in Table 1.

Example 4

[0080] Grinding wheels were prepared as in Example 1, but Mix 6 was substituted by Mix 7 (40 parts Mix3 and 60 parts Mix4). The grinding test results are summarized in Table 1.

Example 5

[0081] Grinding wheels were prepared as in Example 4, substituting the electrostatic mineral coated precision shaped grain mineral layer with AP2. The grinding test results are summarized in Table 1.

Example 6

[0082] A depressed-center grinding wheel was prepared according to the following procedure.

[0083] Mix 8 was prepared by mixing 430 grams of SAP1, 430 grams of AP1, 72 grams of PR1, and 2 grams of CB for 1 minute using a high shear air mixer

[0084] Mix 9 was prepared by mixing 175 grams of PR2 and 151 grams CRY1 for 1 minute in a paddle type mixer.

[0085] Mix 10 was prepared by combining Mix 8 and Mix 9 and mixing in a paddle type mixer for 10 minutes.

[0086] Mix 10 was then screened through a screen with 2x2 mm openings to remove agglomerates. This screened mixture was then pressed in 178 mm diameter dies. SCRIM was placed in the die, 200 grams of Mix 10 was spread out evenly and a second fiberglass mesh was placed on top of the mix. A metal center hole bushing was added. This mix was then pressed at 40 ton/ 38 sq. inch (14.5 MPa) to form discs.

[0087] These discs were placed on a spindle between depressed center aluminum plates in order to be pressed to form type 27 depressed-center grinding wheels. A stack of 5 plates and pressed discs were compressed at 5 ton/38 sq.inch (1.8 MPa). The discs were cured in an oven for 7 hours at 79° C, 3 hours at 107° C, 18 hours at 185° C, and ramp down over 4 hours to 27° C. The cured discs had a diameter of 180mm and a thickness of 4 mm, with a central hole of diameter 22,32 mm.

[0088] The working surface of the disc was coated SAP1 by the following procedure. The discs were spray coated with 15 gm of the make resin mix of Example 1. A layer of SAP1 weighing about 42 grams was deposited on top of the disc. Then the disc was cured at 226° F (108 C) for 75 minutes. Next, in order to have the sized sample, the mineral coated disc was sprayed with the size resin mix of Example 1. Then, it was cured at 190° F (88 C) for 80 minutes.

[0089] Finally, the dried discs were cured for 12 hours at 212° F (100 C) to produce grinding wheels for testing.

[0090] The grinding wheels were tested by grinding by hand for ten 1- minute cycles on a mild steel bar 0.5" (1,27 cm) thick and 18" (45,72 cm) long using a 6000 RPM air grinder (Ingersoll-Rand) The grinder weight resulted in an applied pressure of 13 lbs (5,9 kg). The weight of the steel bar was measured before and after each cycle to measure the cut. The grinding was repeated 16 times from end to end per cycle, approximately 1 minute each. The weight lost from the grinding disc was recorded after each test. The grinding test results are summarized in Table 2.

Example 7

[0091] Commercially available depressed center grinding wheels (92309, 7"x1/8"x7/8", (17,8 cm x 0,3 cm x 2,2 cm) 3M Company, Thailand) were coated using the method of Example 6. The grinding test results are summarized in Table 2.

Example 8

[0092] 7" x 1/8" x 7/8" (17,8 cm x 0,3 cm x 2,2 cm) discs were prepared by mixing 23 parts AP3, 38 parts SAP1, 15 parts AP4, 4 parts PR1, 6 parts PR2, 4 parts PR4, 3 parts CRY3, 2 parts AP5, 4 parts CRY2, 0.1 part CB, 0.2 parts silane, 0.3 parts solvent, and 0.4 parts oil. The components were mixed for 10 minutes. The prepared discs were compressed, coated and cured into grinding wheels as in Example 6. The grinding test results are summarized in Table 2.

Comparative Example 1

[0093] Grinding wheels were prepared as Example 1, without the grinding layer. The grinding test results are summarized in Table 1.

Comparative Example 2

[0094] Grinding wheels were prepared as in Example 4, without the grinding layer. The grinding test results are summarized in Table 1.

Comparative Example 3

[0095] 7"x1/8"x7/8" (17,8 cm x 0,3 cm x 2,2 cm) depressed center grinding wheels were prepared as in Example 6, without the additional coated abrasive layer. The grinding test results are summarized in Table 2.

Comparative Example 4

[0096] Commercially available depressed center grinding wheels (92309, 7"x1/8"x7/8", (17,8 cm x 0,3 cm x 2,2 cm) 3M Company, Thailand) without the added grinding layer of Example 6. The grinding test results are summarized in Table 2.

Comparative Example 5

[0097] 7"x1/8"x7/8" (17,8 cm x 0,3 cm x 2,2 cm) depressed center grinding wheels were prepared as in Example 8, but without the coated abrasive layer. The grinding test results are summarized in Table 2.

Table 1

	Example 1	Example 2	Example 3	Example 4	Example 5	Comparative Example 1	Comparative Example 2
Disc Wear (grams)	14.3	19.6	18.6	12.5	18.3	10.1	10.3

(continued)

	Example 1	Example 2	Example 3	Example 4	Example 5	Comparative Example 1	Comparative Example 2
Cut cycle 1	43.2	48.7	37.6	53	33.2	39.9	53.3
Cut cycle 2	35	42.3	42.2	48.2	31.9	29.1	37.9
Cut cycle 3	36.3	45	32.5	49.2	34.2	27.6	30.4
Cut cycle 4	32	42.2	27	48.2	37.1	24.7	27
Cut cycle 5	28	43.5	28.2	40.1	30.8	21.6	28.3
Cut cycle 6	28.4	43.5	30.6	36.3	33.4	25.3	25.1
Cut cycle 7	28.8	37.8	28.3	38.7	30.5	23.7	26.2
Cut cycle 8	26.3	39.1	28.9	36	27	23.2	28.6
Cut cycle 9	26.3	31.9	25.9	35.2	33.7	26.5	28.9
Cut cycle 10	28.7	31.5	25.1	33.4	33.3	24.7	30.2
Total Cut (gms)	**313**	**405.5**	**306.3**	**418.3**	**325.1**	**266.3**	**315.9**
G Ratio	**22**	**21**	**16**	**33**	**18**	**26**	**30**

Table 2

	Example 6	Example 7	Example 8	Comparative Example 3	Comparative Example 4	Comparative Example 5
Disc Wear, grams	**14.14**	**15**	**16.1**	**8.57**	**9**	**7.1**
Cutcycle 1	57.7	70.4	74.6	36.6	32	26.6
Cutcycle 2	56.3	57.2	66.5	27	21.5	25.8
Cutcycle 3	48	50	51.9	35.1	19.6	21.8
Cutcycle 4	45.2	42.2	38.1	30	13.3	16
Cutcycle 5	41.2	32.1	37.9	28.1	18.1	13.2
Cutcycle 6	42.7	26.1	46.6	29.6	15.1	24.7

(continued)

	Example 6	Example 7	Example 8	Comparative Example 3	Comparative Example 4	Comparative Example 5
Cutcycle 7	42	27.1	34.2	28.5	15.4	29
Cutcycle 8	36.3	29.8	28.5	26.4	12.9	19.1
Cutcycle 9	36.4	21.3	32	25.4	15.1	17.3
Cutcycle 10	33.2	25.5	28.9	22.1	18.8	15.4
Total Cut, grams	**439**	**382**	**439**	**289**	**182**	**209**
G Ratio	**31**	**25**	**27**	**34**	**20**	**29**

Comparison of Examples	**% Total Cut Improvement**
Example 1 compared to Comparative Example 1	18 %
Example 2 compared to Comparative Example 1	52 %
Example 3 compared to Comparative Example 1	15 %
Example 4 compared to Comparative Example 2	32 %
Example 5 compared to Comparative Example 2	3 %

Discussion of Test Results

[0098] Table 3 presents a comparative analysis of the grinding performance of grinding wheels according to Examples 1 through 5 and Comparative Examples 1 through 2.

Table 3

Comparison of Examples	**% Total Cut Improvement**
Example 1 compared to Comparative Example 1	18 %
Example 2 compared to Comparative Example 1	52 %
Example 3 compared to Comparative Example 1	15 %
Example 4 compared to Comparative Example 2	32 %
Example 5 compared to Comparative Example 2	3 %

[0099] As can be seen in Table 3, grinding wheels according to various embodiments exhibit significantly improved total cut and grinding performance.

[0100] Other modifications and variations to the present disclosure may be practiced by those of ordinary skill in the art, without departing from the scope of the present disclosure, which is more particularly set forth in the appended claims. The preceding description, given in order to enable one of ordinary skill in the art to practice the claimed disclosure, is not to be construed as limiting the scope of the disclosure, which is defined by the appended claims.

Claims

1. A bonded abrasive article (10) comprising:

   a matrix (13) comprising matrix abrasive particles (12) and a matrix binder (14);
   characterized in that the bonded abrasive article (10) further comprises a grinding layer (16) comprising erectly-oriented abrasive particles (18) and a grinding layer binder (20);
   wherein the grinding layer (16) is disposed on an exterior surface of the bonded abrasive article (10) or is disposed at least partly within the interior of the bonded abrasive article (10).

2. The bonded abrasive article (10) of claim 1,
   the grinding layer (16) further comprising a grinding face (19) and a back face (17);
   wherein the grinding layer (16) is disposed on a first major surface (21) of the matrix (13); and wherein the back face (17) is proximal to the matrix (13) and the grinding face (19) is distal to the matrix (13).

3. The bonded abrasive article (10) of claim 1,
   the grinding layer (16) further comprising a grinding face (19) and a back face (17), wherein the grinding layer (16) is disposed at least partly within the interior of the bonded abrasive article (10); and
   wherein the back face (17) is distal to the matrix (13) and the grinding face (19) is proximal to the matrix (13).

4. The bonded abrasive article (10) of claim 1, wherein the erectly-oriented abrasive particles (18) comprise electrostatically erectly-oriented abrasive particles.

5. The bonded abrasive article (10) of claim 1, wherein either or both of the matrix abrasive particles (12) and the erectly-oriented abrasive particles (18) comprise precision-shaped abrasive particles.

6. A grinding wheel comprising the bonded abrasive article (10) of claim 1, wherein the grinding wheel has a mounting hole (30).

7. The bonded abrasive article (10) of claim 1, wherein
   the grinding layer (16) further comprises a backing (24); and
   wherein the grinding layer binder (20) binds the erectly-oriented abrasive particles (18) to the backing (24).

8. The bonded abrasive article (10) of claim 1, wherein the grinding layer (16) is attached to the bonded abrasive article (10) by an adhesive layer (26).

9. The bonded abrasive article (10) of claim 1, the grinding layer (16) further comprising a sizing layer (22).

10. The bonded abrasive article (10) of claim 1, wherein the grinding layer (16) is disposed completely within the interior of the matrix (13).

11. The bonded abrasive article (10) of claim 1,
    further comprising a second grinding layer (16"); the second grinding layer (16") further comprising a grinding face (19") and a back face (17"),
    wherein the second grinding layer (16") is disposed on a second major surface (23) of the matrix (13), wherein the back face (17") is distal to the matrix (13) and the grinding face (19") is proximal to the matrix (13).

12. A method of forming a bonded abrasive article (10), the method comprising:

    applying a matrix mixture to a grinding layer (16),
    the matrix mixture comprising a curable matrix binder (14) and matrix abrasive particles (12),
    the grinding layer (16) comprising erectly-oriented grinding abrasive particles (18); and
    curing the matrix binder (14).

13. The method of claim 12, wherein the grinding layer (16) further comprises a backing (24) and a grinding layer binder (20).

14. The method of claim 12, wherein the grinding layer (16) comprises a grinding face (19), wherein the applying further

comprises contacting the matrix mixture with the grinding face (19).

15. The method of claim 12, wherein the grinding layer (16) comprises a back face (17), wherein the applying further comprises contacting the matrix mixture with the back face (17).

16. The method of claim 12, wherein the grinding layer (16) comprises a back face (17) and a grinding face (19), wherein the applying further comprises contacting the matrix mixture with the back face (17) and the grinding face (19).

17. A method of forming a bonded abrasive article (10), the method comprising:

applying a grinding layer precursor to a first major surface (21) of a matrix (13), the matrix comprising matrix abrasive particles (12) and a matrix binder (14);
depositing erectly-oriented particles (18) on the grinding layer precursor,
applying a sizing layer (22) on the erectly-oriented particles (18), and
curing the grinding layer precursor to form a grinding layer (16) attached to the first major surface (21).

18. The method of claim 17, wherein the depositing comprises: electrostatically erectly-orienting abrasive particles (18) on the grinding layer (16).

Patentansprüche

1. Ein gebundener Schleifartikel (10), umfassend:

eine Matrix (13), die Matrixschleifteilchen (12) und ein Matrixbindemittel (14) umfasst; **dadurch gekennzeichnet, dass** der gebundene Schleifartikel (10) ferner eine Schleifschicht (16) umfasst, die aufrecht ausgerichtete Schleifteilchen (18) und ein Schleifschichtbindemittel (20) umfasst;
wobei die Schleifschicht (16) auf einer Außenoberfläche des gebundenen Schleifartikels (10) angeordnet ist oder mindestens teilweise innerhalb des Inneren des gebundenen Schleifartikels (10) angeordnet ist.

2. Der gebundene Schleifartikel (10) nach Anspruch 1,
wobei die Schleifschicht (16) ferner eine Schleiffläche (19) und eine Rückseitenfläche (17) umfasst; wobei die Schleifschicht (16) auf einer ersten Hauptoberfläche (21) der Matrix (13) angeordnet ist; und wobei die Rückseitenfläche (17) proximal zu der Matrix (13) ist und die Schleiffläche (19) distal zu der Matrix (13) ist.

3. Der gebundene Schleifartikel (10) nach Anspruch 1,
wobei die Schleifschicht (16) ferner eine Schleiffläche (19) und eine Rückseitenfläche (17) umfasst, wobei die Schleifschicht (16) mindestens teilweise innerhalb des Inneren des gebundenen Schleifartikels (10) angeordnet ist; und
wobei die Rückseitenfläche (17) distal zu der Matrix (13) ist und die Schleiffläche (19) proximal zu der Matrix (13) ist.

4. Der gebundene Schleifartikel (10) nach Anspruch 1, wobei die aufrecht ausgerichteten Schleifteilchen (18) elektrostatisch aufrecht ausgerichtete Schleifteilchen umfassen.

5. Der gebundene Schleifartikel (10) nach Anspruch 1, wobei eines oder beide der Matrixschleifteilchen (12) und der aufrecht ausgerichteten Schleifteilchen (18) präzisionsgeformte Schleifteilchen umfassen.

6. Eine Schleifscheibe, umfassend den gebundenen Schleifartikel (10) nach Anspruch 1, wobei die Schleifscheibe ein Montageloch (30) aufweist.

7. Der gebundene Schleifartikel (10) nach Anspruch 1, wobei die Schleifschicht (16) ferner einen Träger (24) umfasst; und wobei das Schleifschichtbindemittel (20) die aufrecht ausgerichteten Schleifteilchen (18) an den Träger (24) bindet.

8. Der gebundene Schleifartikel (10) nach Anspruch 1, wobei die Schleifschicht (16) durch eine Klebstoffschicht (26) an dem gebundenen Schleifartikel (10) befestigt ist.

9. Der gebundene Schleifartikel (10) nach Anspruch 1, wobei die Schleifschicht (16) ferner eine Leimungsschicht (22) umfasst.

10. Der gebundene Schleifartikel (10) nach Anspruch 1, wobei die Schleifschicht (16) vollständig innerhalb des Inneren der Matrix (13) angeordnet ist.

11. Der gebundene Schleifartikel (10) nach Anspruch 1,
ferner umfassend eine zweite Schleifschicht (16"); wobei die zweite Schleifschicht (16")
ferner eine Schleiffläche (19") und eine Rückseitenfläche (17") umfasst,
wobei die zweite Schleifschicht (16") auf einer zweiten Hauptoberfläche (23) der Matrix (13) angeordnet ist, wobei die Rückseitenfläche (17") distal zu der Matrix (13) ist und die Schleiffläche (19") proximal zu der Matrix (13) ist.

12. Ein Verfahren zum Bilden eines gebundenen Schleifartikels (10), wobei das Verfahren umfasst:

Aufbringen einer Matrixmischung auf eine Schleifschicht (16),
wobei die Matrixmischung ein härtbares Matrixbindemittel (14) und Matrixschleifteilchen (12) umfasst, wobei die Schleifschicht (16) aufrecht ausgerichtete Schleifteilchen (18) umfasst; und
Härten des Matrixbindemittels (14).

13. Das Verfahren nach Anspruch 12, wobei die Schleifschicht (16) ferner einen Träger (24) und ein Schleifschichtbindemittel (20) umfasst.

14. Das Verfahren nach Anspruch 12, wobei die Schleifschicht (16) eine Schleiffläche (19) umfasst, wobei das Aufbringen ferner das Inkontaktbringen der Matrixmischung mit der Schleiffläche (19) umfasst.

15. Das Verfahren nach Anspruch 12, wobei die Schleifschicht (16) eine Rückseitenfläche (17) umfasst, wobei das Aufbringen ferner das Inkontaktbringen der Matrixmischung mit der Rückseitenfläche (17) umfasst.

16. Das Verfahren nach Anspruch 12, wobei die Schleifschicht (16) eine Rückseitenfläche (17) und eine Schleiffläche (19) umfasst, wobei das Aufbringen ferner das Inkontaktbringen der Matrixmischung mit der Rückseitenfläche (17) und der Schleiffläche (19) umfasst.

17. Ein Verfahren zum Bilden eines gebundenen Schleifartikels (10), wobei das Verfahren umfasst:
Aufbringen eines Schleifschichtvorläufers auf eine erste Hauptoberfläche (21) einer Matrix (13), wobei die Matrix Matrixschleifteilchen (12) und ein Matrixbindemittel (14) umfasst; Abscheiden von aufrecht ausgerichteten Teilchen (18) auf dem Schleifschichtvorläufer, Aufbringen einer Leimungsschicht (22) auf die aufrecht ausgerichteten Teilchen (18) und Härten des Schleifschichtvorläufers, um eine Schleifschicht (16) zu bilden, die an der ersten Hauptoberfläche (21) befestigt ist.

18. Das Verfahren nach Anspruch 17, wobei das Abscheiden umfasst: elektrostatisches Ausrichten von Schleifteilchen (18) auf der Schleifschicht (16).

Revendications

1. Article abrasif lié (10) comprenant :

une matrice (13) comprenant des particules abrasives de matrice (12) et un liant matriciel (14) ;
caractérisé en ce que l'article abrasif lié (10) comprend en outre une couche abrasive (16) comprenant des particules abrasives orientées de façon droite (18) et un liant de couche abrasive (20) ;
dans lequel la couche abrasive (16) est disposée sur une surface extérieure de l'article abrasif lié (10) ou est disposée au moins partiellement à l'intérieur de l'article abrasif lié (10).

2. Article abrasif lié (10) selon la revendication 1,
la couche abrasive (16) comprenant en outre une face abrasive (19) et une face arrière (17) ;
dans lequel la couche abrasive (16) est disposée sur une première surface principale (21) de la matrice (13) ; et dans lequel la face arrière (17) est proximale par rapport à la matrice (13) et la face abrasive (19) est distale par rapport à la matrice (13).

3. Article abrasif lié (10) selon la revendication 1,
la couche abrasive (16) comprenant en outre une face abrasive (19) et une face arrière (17), la couche abrasive (16) étant disposée au moins partiellement à l'intérieur de l'article abrasif lié (10) ; et
la face arrière (17) étant distale par rapport à la matrice (13) et la face abrasive (19) étant proximale par rapport à la matrice (13).

4. Article abrasif lié (10) selon la revendication 1, dans lequel les particules abrasives orientées généralement droites (18) comprennent des particules abrasives orientées droites de manière électrostatique.

5. Article abrasif lié (10) selon la revendication 1, dans lequel l'une ou les deux des particules abrasives de matrice (12) et des particules abrasives orientées droites (18) comprennent des particules abrasives façonnées avec précision.

6. Meule comprenant l'article abrasif lié (10) selon la revendication 1, dans laquelle la meule présente un trou de montage (30).

7. Article abrasif lié (10) selon la revendication 1,
dans lequel la couche abrasive (16) comprend en outre un support (24) ; et
dans lequel le liant de la couche abrasive (20) lie les particules abrasives orientées droites (18) au support (24).

8. Article abrasif lié (10) selon la revendication 1, dans lequel la couche abrasive (16) est fixée à l'article abrasif lié (10) par une couche adhésive (26).

9. Article abrasif lié (10) selon la revendication 1, la couche abrasive (16) comprenant en outre une couche d'encollage (22).

10. Article abrasif lié (10) selon la revendication 1, dans lequel la couche abrasive (16) est disposée complètement à l'intérieur de la matrice (13).

11. Article abrasif lié (10) selon la revendication 1,
comprenant en outre une deuxième couche abrasive (16") ;
la deuxième couche abrasive (16") comprenant en outre une face abrasive (19") et une face arrière (17"),
dans lequel la deuxième couche abrasive (16") est disposée sur une deuxième surface principale (23) de la matrice (13), dans lequel la face arrière (17") est distale par rapport à la matrice (13) et la face abrasive (19") est proximale par rapport à la matrice (13).

12. Procédé de formation d'un article abrasif lié (10), le procédé comprenant :

  l'application d'un mélange de matrice sur une couche abrasive (16) ;
  le mélange de matrice comprenant un liant matriciel durcissable (14) et des particules abrasives de matrice (12),
  la couche abrasive (16) comprenant des particules abrasives orientées droites (18) ; et
  le durcissement du liant matriciel (14).

13. Procédé selon la revendication 12, dans lequel la couche abrasive (16) comprend en outre un support (24) et un liant de couche abrasive (20).

14. Procédé selon la revendication 12, dans lequel la couche abrasive (16) comprend une face abrasive (19), dans lequel l'application comprend en outre la mise en contact du mélange de matrice avec la face abrasive (19).

15. Procédé selon la revendication 12, dans lequel la couche abrasive (16) comprend une face arrière (17), dans lequel l'application comprend en outre la mise en contact du mélange de matrice avec la face arrière (17).

16. Procédé selon la revendication 12, dans lequel la couche abrasive (16) comprend une face arrière (17) et une face abrasive (19), dans lequel l'application comprend en outre la mise en contact du mélange de matrice avec la face arrière (17) et la face abrasive (19).

17. Procédé de formation d'un article abrasif lié (10), le procédé comprenant :

l'application d'un précurseur de couche abrasive à une première surface principale (21) d'une matrice (13), la matrice comprenant des particules abrasives de matrice (12) et un liant matriciel (14) ;
le dépôt de particules orientées droites (18) sur le précurseur de la couche abrasive, l'application d'une couche d'encollage (22) sur les particules orientées droites (18), et
le durcissement du précurseur de couche abrasive pour former une couche abrasive (16) fixée à la première surface principale (21).

18. Procédé selon la revendication 17, dans lequel le dépôt comprend : des particules abrasives orientées droites de manière électrostatique (18) sur la couche abrasive (16).

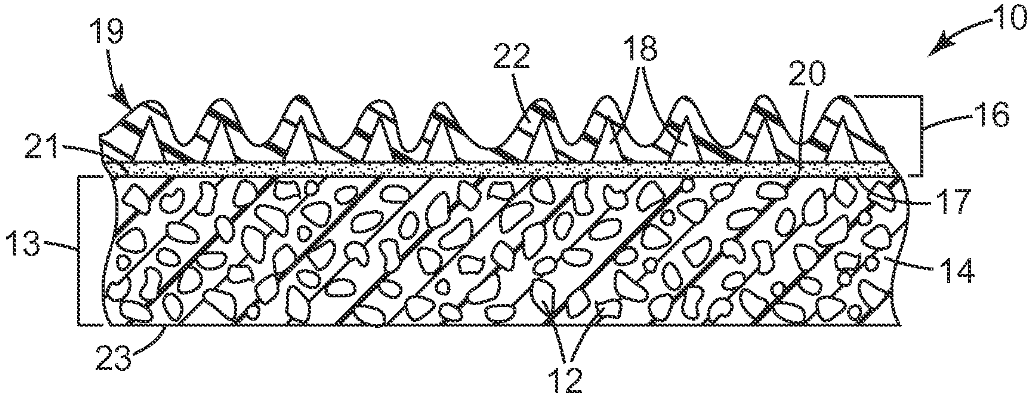

Fig. 1A

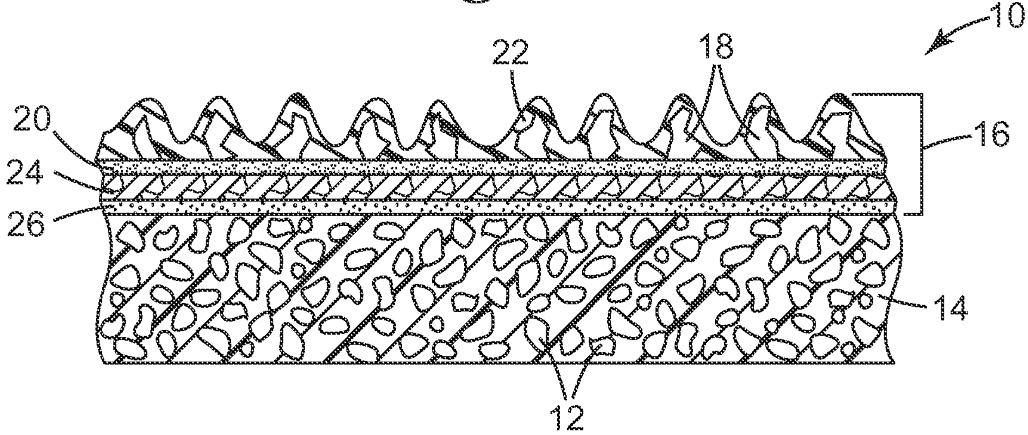

Fig. 1B

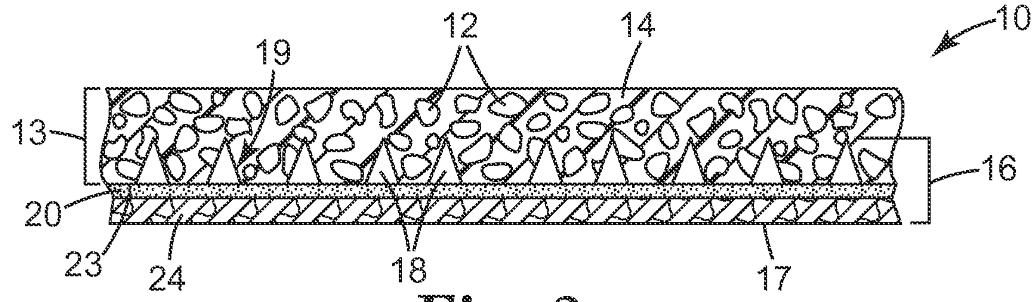

Fig. 2

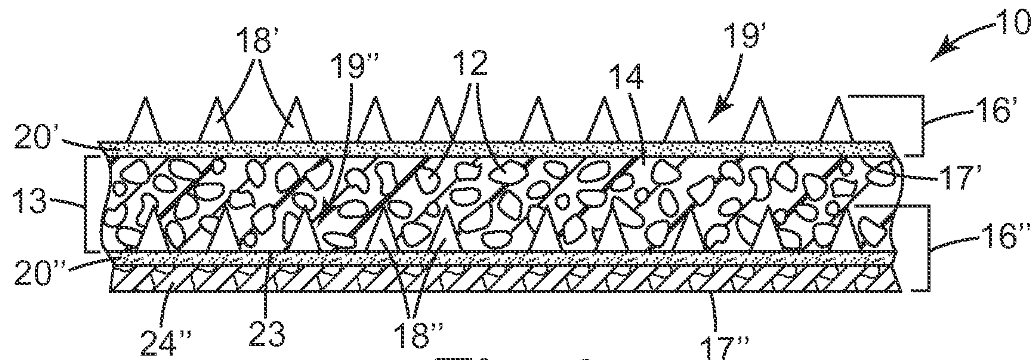

Fig. 3

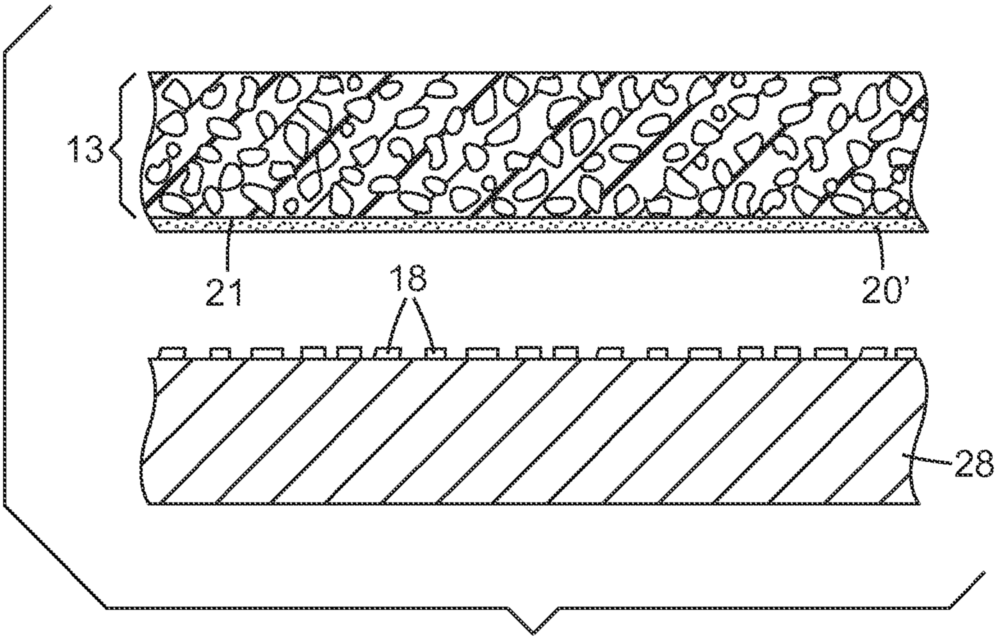

Fig. 4A

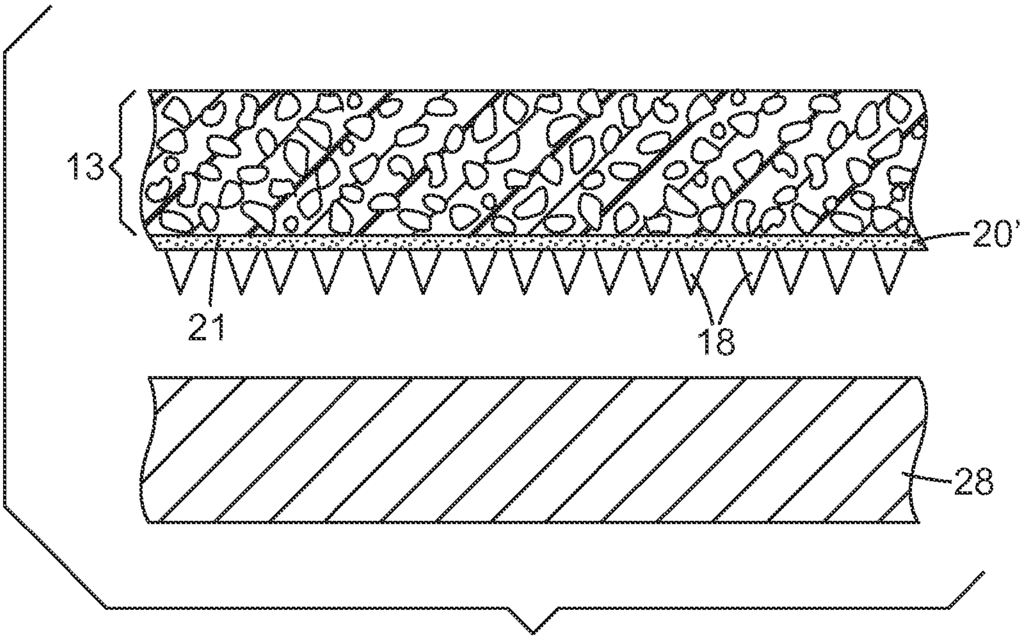

Fig. 4B

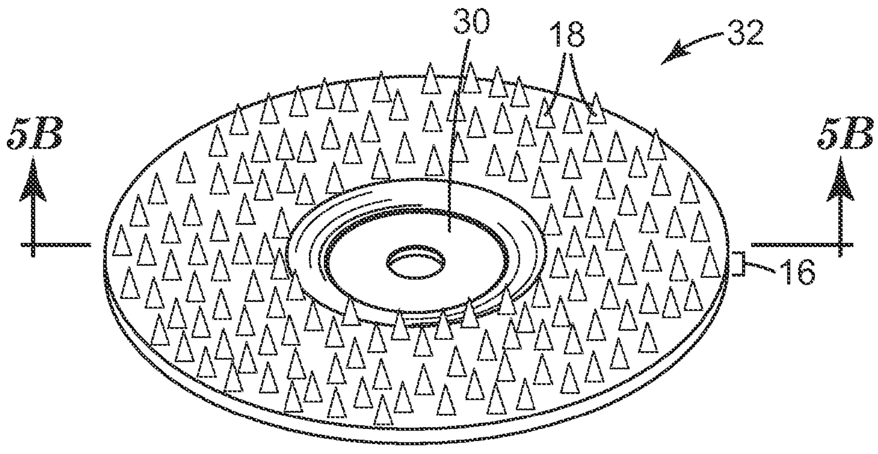

Fig. 5A

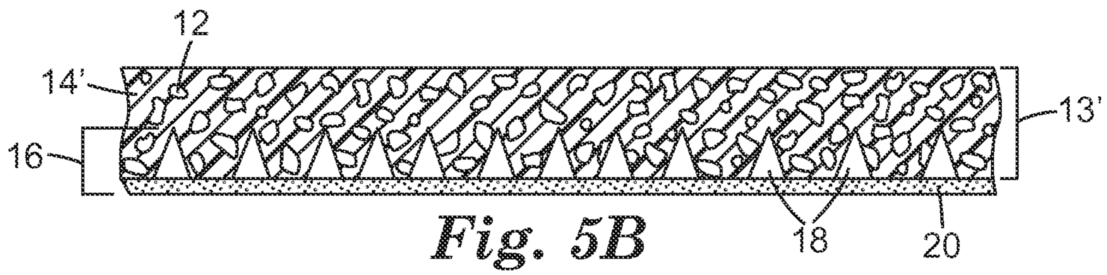

Fig. 5B

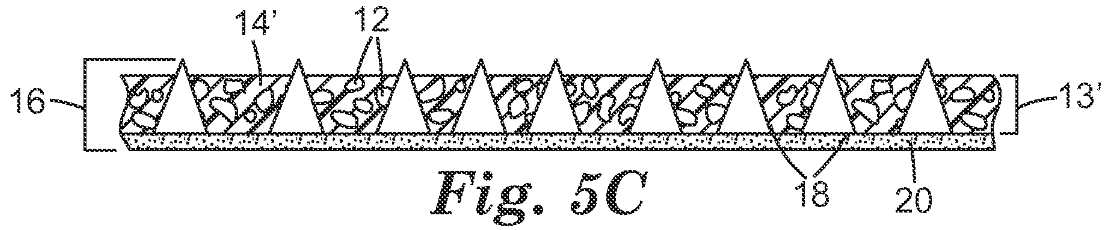

Fig. 5C

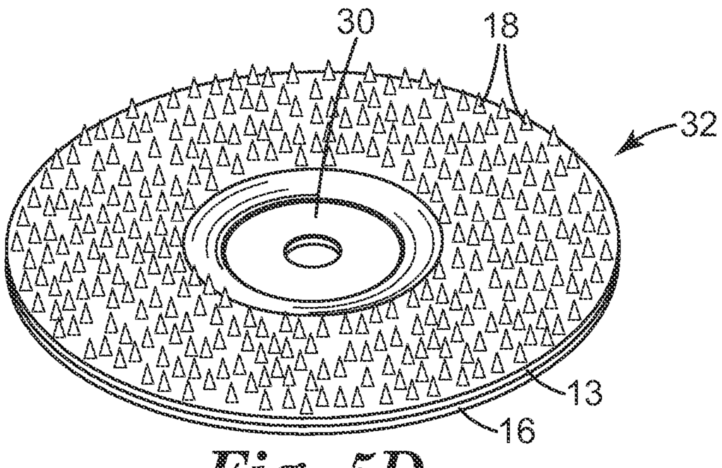

Fig. 5D

REFERENCES CITED IN THE DESCRIPTION

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