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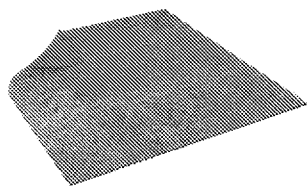


FIG. 1

(57) Abstract: The present invention is an abrasive composite including a first crosslinkable binder component, wherein when polymerized, has a glass transition temperature (T_g) below room temperature and a modulus of less than about 150 MPa; a second crosslinkable binder component having a T_g above room temperature; a material capable of initiating addition polymerization; and particulate grains having a Mohs hardness value of less than or equal to about 3.



NON-SCRATCH ABRASIVE COMPOSITE

Background

5 Consumer interest in non-scratch scouring/cleaning products for use in home cleaning is increasing due to the desire to protect high-value surfaces that are prone to damage from hard minerals and resins. In addition, it is also desirable if the cleaning product does not become soiled itself during the cleaning process. That is, it is desirable if the cleaning product either resists resist soil buildup on its surfaces or can be rinsed clean of
10 soils after use.

 An informal theory of abrasive performance posits that workpiece material removal rate is related to the abrasive material's mechanical properties (i.e., hardness), size, and shape (i.e., sharpness). On the other hand, the likelihood of an abrasive material producing scratches on a workpiece is generally discussed in terms of the relative hardness
15 of the abrasive material and the workpiece. Though size and shape certainly affect whether an abrasive will scratch and how noticeable the scratches are, actually forming a scratch requires the deformation of the workpiece by the abrasive material. For this to occur, the abrasive material must be stiffer than the workpiece. Thus, provided that the abrasive material is not so hard as to deform the workpiece, soils located on the surface of
20 the workpiece having a lower hardness than the workpiece itself can be effectively cleaned by an abrasive material boasting sizes and shapes amenable to high soil removal rates, namely relatively tall protrusions with relatively sharp edges, for example, square pyramid-shaped abrasive protrusions having heights of about 500 microns and base widths between 500-1200 microns, wherein formed edges have radii of curvature generally less
25 than 50 microns.

Brief Description of the Drawings

 This disclosure may be more completely understood in consideration of the following detailed description of various embodiments of the disclosure in connection with
30 the accompanying drawings, in which:

 FIG. 1 shows a perspective view of a first embodiment of a cleaning article of the present invention.

FIG. 2 shows a perspective view of a second embodiment of a cleaning article of the present invention.

FIG. 3 shows a perspective view of a third embodiment of a cleaning article of the present invention.

While the above-identified figures set forth several embodiments of the disclosure, other embodiments are also contemplated, as noted in the description. In all cases, this disclosure presents the invention by way of representation and not limitation. It should be understood that numerous other modifications and embodiments can be devised by those skilled in the art, which fall within the scope and spirit of the principles of the invention.

Summary

In one embodiment, the present invention is an abrasive composite including a first crosslinkable binder component wherein when polymerized, has a glass transition temperature (T_g) below room temperature and a modulus of less than about 150 MPa; a second crosslinkable binder component having a T_g above room temperature; a component capable of initiating addition polymerization; and particulate grains having a Mohs hardness value of less than or equal to about 3.

In another embodiment, the present invention is a structured abrasive article including a substrate and an abrasive composite adhered to the substrate. The abrasive composite includes a first crosslinkable binder component wherein when polymerized, has a glass transition temperature (T_g) below room temperature and a modulus of less than about 150 MPa; a second crosslinkable binder component having a T_g above room temperature; a component capable of initiating addition polymerization; and particulate grains having a Mohs hardness value of less than or equal to about 3.

Detailed Description

The present invention is an abrasive composite that can be used for cleaning or scouring that is substantially non-scratch and is able to be substantially rinsed clean of soils that accumulate on the surface of the abrasive composite during use. The abrasive composite is designed to have high scouring performance without appreciable damage to the underlying substrate being cleaned. In one embodiment, the abrasive composite can be used for home cleaning that entails substantially no or minimal damage to materials such

as, for example, poly(tetrafluoroethylene), stainless steel, and hard plastics. After being used to clean, the abrasive composite can be essentially rinsed clean of debris removed from the surfaces being cleaned. In addition, the abrasive composite of the present invention is durable and wears well.

5 The abrasive composite of the present invention is formed from dispersing a mineral or particulate grain phase in an organic binder phase. In the abrasive composite, relatively particulate grains are bound together by a binder that serves as a dispersing medium for the particulate grains and provides the means of attachment of the abrasive composites to a substrate or backing if desired. These particulate grains primarily act as a
10 filler and viscosity modifier in the uncured liquid precursor, in contrast to traditional coated or nonwoven abrasives, whose particulate grains generally have high values of Mohs hardness and are capable of removing significant material from a workpiece by gouging in a manner dependent on the particle grain's shape, hardness, and size and the pressure and geometry of the abrading operation. In this application, such gouges are
15 framed as "scratches", and while individual particulate grains with a low value of Mohs hardness may not produce a visible scratch in a test surface, the minerals can affect the scratching by modifying the mechanical properties of the composite in accordance with general mixing rules for composites. In one embodiment, the abrasive composites of the present invention contain particulate grains having a Mohs hardness of less than or equal
20 to about 3. In one embodiment, the particulate grain phase includes an inorganic mineral having a d_{90} of less than about 50 micron, and particularly less than about 30 micron, and a Mohs hardness value of less than or equal to about 3. Increases in the particle size distribution increases the probability of scratching and decreases control over the rheological properties of the liquid slurry prior to curing.

25 Examples of particulate grains having a Mohs hardness of less than 3 include, but are not limited to: clays (such as kaolinite, montmorillonite, illite, chlorite clays, talc, soapstone), gypsum, calcium carbonate (such as limestone and marble), mica, halite, and jet. Additionally, numerous soft organic materials can provide the same functions as soft particulate mineral grains, such as crushed or ground shells of nuts/fruits including, but not
30 limited to: almond, argan, coconut, hazelnut, macadamia, pecan, pine, pistachio, and walnut; crushed or ground pits/kernels of fruits including, but not limited to: apricot, olive, peach, cherry, plum, palm, and tagua; crushed or ground corn cob; crushed or ground

shells of arthropods; wood flour; crushed or ground synthetic polymeric materials including but not limited to any thermoplastic polymer or any thermoset polymer; and crushed, ground, or unmodified naturally-derived polymeric materials including, but not limited to: polyhydroxyalkanoates; precision-shaped synthetic polymeric materials. In one
5 embodiment, the abrasive composite includes more than one type of particulate grain.

In one embodiment, the abrasive composite includes between about 26% and about 80%, particularly between about 47% and about 65%, and more particularly between about 52% and about 61% by weight particulate grains.

The binder of the abrasive composite must be capable of providing a medium in
10 which the particulate grains can be distributed. The binder generally includes a soft crosslinkable binder component, a hard crosslinkable binder component, and a material that is capable of initiating addition polymerization. The soft crosslinkable binder component, when polymerized, has a glass transition temperature (T_g) below room temperature (thereby being rubbery and capable of deformation) and a modulus of less
15 than about 150 MPa. In one embodiment, the soft crosslinkable binder component includes a urethane diacrylate or triacrylate. An example of a suitable soft crosslinkable binder component includes, but is not limited to, an aliphatic urethane diacrylate. In one embodiment, the soft crosslinkable binder component, when polymerized, has an elongation % at break of greater than about 25%.

20 The hard crosslinkable binder component has a T_g above room temperature (thereby being glassy and stiff). In one embodiment, the hard crosslinkable binder component includes a difunctional or trifunctional acrylate. An example of a suitable hard crosslinkable binder components includes, but is not limited to, trimethylolpropane triacrylate.

25 In one embodiment, the material capable of initiating addition polymerization is a UV photoinitiator.

Empirically, no single binder material subject to screening produced the desired combination of high cleaning performance and low surface scratching. Cleaning performance is benefitted by higher modulus, to the detriment of surface damage
30 avoidance, while lower modulus benefits the avoidance of surface damage, to the detriment of cleaning performance. By using a miscible blend of soft and hard binder components, the glass transition and stiffness of the binder mixture can be tuned to

optimize the balance of cleaning performance and surface damage, avoiding the more costly molecular engineering required to synthesize a single material having the desired glass transition temperature and modulus.

In one embodiment, the binder is capable of being cured or gelled relatively quickly so that the abrasive composite can be quickly fabricated. Some binders gel relatively quickly, but require a longer time to fully cure. Gelling preserves the shape of the composite until curing commences. Fast curing or fast gelling binders can result in coated abrasive articles having abrasive composites of high consistency. Examples of binders suitable for the present invention include, but are not limited to: thermoplastic resins, phenolic resins, aminoplast resins, urethane resins, epoxy resins, acrylate resins, acrylated isocyanurate resins, urea formaldehyde resins, isocyanurate resins, acrylated urethane resins, acrylated epoxy resins, hot melt glue, and mixtures thereof.

Depending on the binder used, the curing or gelling can be carried out by an energy source as known by one of skill in the art. For example, the energy source may include, but is not limited to: heat, infrared irradiation, electron beam, ultraviolet radiation, or visible radiation. A radiation-curable binder is any binder that can be at least partially cured or at least partially polymerized by radiation energy. Typically, these binders polymerize via a free radical mechanism.

If the binder is cured by ultraviolet radiation, a photoinitiator is required to initiate free radical polymerization. Examples of photoinitiators include, but are not limited to: organic peroxides, azo compounds, quinones, benzophenones, nitroso compounds, acryl halides, hydrazones, mercapto compounds, pyrylium compounds, triacrylimidazoles, bisimidazoles, chloralkyltriazines, benzil ketals, thioxanthenes, and acetophenone derivatives. Other examples include, but are not limited to: benzoin and its derivatives such as alpha-methylbenzoin; alpha-phenylbenzoin; alpha-allylbenzoin; alpha-benzylbenzoin; benzoin ethers such as benzil dimethyl ketal (e.g., as commercially available as IRGACURE 651 from Ciba Specialty Chemicals, Tarrytown, N.Y.), benzoin methyl ether, benzoin ethyl ether, benzoin n-butyl ether; acetophenone and its derivatives such as 2-hydroxy-2-methyl- 1-phenyl-1- propanone (e.g., as DAROCUR 1173 from Ciba Specialty Chemicals) and 1-hydroxycyclohexyl phenyl ketone (e.g., as IRGACURE 184 from Ciba Specialty Chemicals); 2-methyl- 1-[4-(methylthio)phenyl] -2-(4-morpholinyl)-1-propanone (e.g., as IRGACURE 907 from Ciba Specialty Chemicals); 2-benzyl-2-

(dimethylamino)-1-[4-(4-morpholinyl)phenyl]-1-butanone (e.g., as IRGACURE 369 from Ciba Specialty Chemicals). Other examples include phosphorus-containing organic molecules, such as bis(2,4,6-trimethylbenzoyl)-phenylphosphineoxide (e.g. IRGACURE 819 from Ciba Specialty Chemicals) and ethyl (2,4,6-trimethylbenzoyl) phenyl phosphinate (e.g. TPO-L from Ciba Specialty Chemicals). Still more useful photoinitiators include, for example, pivaloin ethyl ether, anisoil ethyl ether, anthraquinones (e.g., anthraquinone, 2-ethylanthraquinone, 1-chloroanthraquinone, 1,4-dimethylanthraquinone, 1-methoxyanthraquinone, or benzanthraquinone), halomethyltriazines, benzophenone and its derivatives, iodonium salts and sulfonium salts, titanium complexes such as bis(eta5-2,4-cyclopentadien-1-yl)-bis[2,6-difluoro-3(1 H-pyrrol-1-yl)phenyl]titanium (e.g., as CGI 784DC from Ciba Specialty Chemicals); and halonitrobenzenes (e.g., 4-bromomethylnitrobenzene), mono- and bis-acylphosphines (e.g., as IRGACURE 1700, IRGACURE 1800, IRGACURE 1850, and DAROCUR 4265 all from Ciba Specialty Chemicals). In one embodiment, more than one photoinitiator is used. One or more spectral sensitizers (e.g., dyes) may be used in conjunction with the photoinitiator(s) to, for example, increase sensitivity of the photoinitiator to a specific source of actinic radiation.

In one embodiment, the abrasive composite includes between about 15 and about 35%, particularly between about 22 and about 28%, and more particularly between about 24 and about 27% by weight soft crosslinkable binder component. In one embodiment, the abrasive composite includes between about 8 and about 28%, particularly between about 10 and about 15%, and more particularly between about 11 and about 14% by weight hard crosslinkable binder component. In one embodiment, the abrasive composite includes between about 0.5 and about 5%, particularly between about 0.6 and about 1%, and more particularly between about 0.7 and about 0.9% by weight material capable of initiating addition polymerization.

The binder may be radiation-curable through an addition polymerization mechanism. To promote an association bridge between the binder and the particulate grains, a silane coupling agent may be included in the slurry of particulate grains and binder precursor. In one embodiment, the silane coupling agent may be present in an amount of between about 0 and about 1%, particularly between about 0.05 and about 0.4% by weight, and more particularly between about 0.1 and about 0.3% by weight. However, one of skill in the art will know that other amounts may also be used, depending, for

example, on the size of the minerals. Suitable silane coupling agents include, for example, methacryloxypropylsilane, vinyltriethoxysilane, vinyltris(2-methoxyethoxy)silane, 3,4-epoxycyclohexylmethyltrimethoxysilane, gammaglycidoxypentyl-trimethoxysilane, and gamma-mercaptopropyltrimethoxysilane (e.g., as available under the respective trade designations A- 174, A- 151, A-172, A-186, A-187, and A-189 from Witco Corp. of Greenwich, Conn.), allyltriethoxysilane, diallyldichlorosilane, divinyl-diethoxysilane, and meta, para-styrylethyl-trimethoxysilane (e.g., as commercially available under the respective trade designations A0564, D4050, D6205, and S1588 from United Chemical Industries, Bristol, Pa.), dimethyldiethoxysilane, dihydroxydiphenylsilane, triethoxysilane, trimethoxysilane, triethoxysilanol, 3-(2-aminoethylamino) propyltrimethoxysilane, methyltrimethoxysilane, vinyltriacetoxysilane, methyltriethoxysilane, tetraethyl orthosilicate, tetramethyl orthosilicate, ethyltriethoxysilane, amyltriethoxysilane, ethyltrichlorosilane, amyltrichlorosilane, phenyltrichlorosilane, phenyltriethoxysilane, methyltrichlorosilane, methyl-dichlorosilane, dimethyldichlorosilane, dimethyldiethoxysilane, and mixtures thereof.

Other materials can be added to the abrasive composite for special purposes including, but not limited to: monofunctional acrylic monomers, thermal free radical initiators, accelerators, polymer waxes or beads, leveling agents, wetting agents, matting agents, colorants, dyes, pigments, slip agents, adhesion promoters, fillers, rheology modifiers, thixotropic agents, plasticizers, UV absorbers, UV stabilizing agents, dispersants, antioxidants, antistatic agents, lubricants, opacifying agents, anti-foam agents, antimicrobial agents, fungicides, and combinations thereof. In one embodiment, the additives are organic. In one embodiment, the abrasive composite includes up to about 1%, particularly between about 0.1 and about 0.8%, and more particularly between about 0.2 and about 0.6% by weight dispersant. In one embodiment, the abrasive composite includes up to about 1%, particularly between about 0.05 and about 0.4%, and more particularly between about 0.1 and about 0.3% by weight coupling agent. In one embodiment, the abrasive composite includes up to about 1%, particularly up to about 0.3%, and more particularly up to about 0.2% by weight colorant. In one particular embodiment, the abrasive composite includes between about 15 and about 35% by weight, particularly between about 22 and about 28% by weight, and more particularly about 26.8% by weight soft crosslinkable binder component; between about 8 and about 28%,

particularly between about 22 and about 15%, and more particularly about 12.6% by weight hard crosslinkable binder component; between about 0.5 and about 5%, particularly between about 0.6 and about 1%, and more particularly about 0.8% by weight photoinitiator; between about 25 and about 55%, particularly between about 35 and about 45%; and more particularly about 42.1% by weight of a first particulate grain; and between about 1 and about 25%, particularly between about 12 and about 20%, and more particularly about 16.9% by weight of a second particulate grain.

While the abrasive composite includes a binder phase and a mineral phase, the mineral phase does not contribute to the scouring ability of the abrasive composite and functions more as a filler. Rather, the scouring performance arises from the properties of the binder phase and the mineral phase as a whole.

In one embodiment, the abrasive composites are used to form a structured abrasive article including a plurality of precisely shaped abrasive composites attached to a substrate. "Precisely shaped abrasive composite", as used herein, refers to abrasive composites having a shape that has been formed by curing one or more binder components of a flowable mixture also containing soft mineral grains while the mixture is both being borne on a backing and filling a cavity on the surface of a production tool. Such precisely shaped abrasive composites have precisely the same shape as that of the cavity. In one embodiment, the abrasive composites can be pyramidal, the dimensions of which are substantially precise.

When forming a structured abrasive article, the plurality of precisely shaped abrasive composites is attached to at least one major surface of a substrate. The precisely shaped abrasive composites provide three-dimensional shapes that project outward from the surface of the substrate. The abrasive composites can be disposed on the substrate in either a pattern (i.e., non-random array) or a random array. In one embodiment, the abrasive composites are disposed on the substrate in a non-random array that exhibits some degree of repetitiveness.

Materials suitable for the substrate of the present invention include, but are not limited to: polymeric film, paper, cloth, metallic film, vulcanized fiber, nonwoven substrates, combinations thereof, and chemically treated versions thereof. In one embodiment, the substrate is a polymeric film, such as polyester or polyurethane film. In one embodiment, the substrate is transparent to ultraviolet radiation. In one embodiment,

the substrate is coated with an adhesion-promoting layer, such as poly(ethylene-co-acrylic acid) or a UV-curable “tie coat” layer, or undergo adhesion-promoting surface modification, such as corona or flame treatment or electron beam irradiation. The substrate can be laminated to another substrate after the coated abrasive article is formed. For
5 example, the substrate can be laminated to a flexible or stiff polyurethane foam material, providing a means for effective manipulation of the abrasive by the user.

Production tools may be used to form abrasive articles having precisely shaped abrasive coatings or to produce precisely shaped abrasive composites. A production tool has a surface defining a main plane, which contains a plurality of cavities distending as
10 indentations from the main plane. These cavities define the inverse shape of the abrasive composite and are responsible for generating the shape, size, and placement of the abrasive composites. The cavities can be provided in essentially any geometric shape that is the inverse of a geometric shape which is suitable for an abrasive composite or abrasive composite particle. For example, the abrasive composites may be cubic, cylindrical,
15 prismatic, hemispheric, rectangular, pyramidal, truncated pyramidal, conical, truncated conical, and post-like with a flat top surface. The dimensions of the cavities are selected to achieve the desired areal density of abrasive composites. In one embodiment, the cavities can be present in a dot like pattern where adjacent cavities butt up against one another. In one embodiment, the shape of the cavities is selected such that the surface area of the
20 abrasive composite decreases away from the backing.

The production tool can take the form of a belt, sheet, continuous sheet or web, coating roll such as a rotogravure roll, sleeve mounted on a coating roll, or die. In one embodiment, the production tool is replicated from a master tool. The master tool can be fabricated by any conventional technique known to those of skill in the art, including but
25 not limited to: photolithography, knurling, engraving, hobbing, electroforming, and diamond turning. U.S. Patent No. 5,851,247 (Stoetzel et al.) describes a production tool made of thermoplastic material that can be replicated from a master tool, and is hereby incorporated by reference. When a production tool is replicated from a master tool, the master tool is provided with the inverse of the pattern which is desired for the production
30 tool. In one embodiment, the master tool is made of a nickel-plated metal, such as nickel-plated aluminum, nickel-plated copper, or nickel-plated bronze. A production tool can be replicated from a master tool by pressing a sheet of thermoplastic material against the

master tool while heating the master tool and/or the thermoplastic sheet such that the thermoplastic material is embossed with the master tool pattern. Alternatively, the thermoplastic material can be extruded or cast directly onto the master tool. The thermoplastic material is then cooled to a solid state and is separated from the master tool to produce a production tool. The production tool may optionally contain a release coating to permit easier release of the abrasive article. Examples of suitable release coatings include, but are not limited to: silicones and fluorochemicals. Preferred methods for the production of production tools are disclosed in U.S. Pat. Nos. 5,435,816 (Spurgeon et al.), 5,658,184 (Hoopman et al.), and in U.S. Ser. No. 08/923, 862, "Method and Apparatus for Knurling a Workpiece, Method of Molding an Article with Such Workpiece, and Such Molded Article" (Hoopman), filed Sep. 3, 1997), the disclosures of which are incorporated herein by reference.

The rheology of the abrasive composite prior to curing is critical to its ability to be coated in high fidelity to a production tool's cavities if used to form an abrasive article. In one embodiment, the structured abrasive article can be made by first introducing a flowable and curable slurry containing a mixture of a binder precursor and a plurality of minerals into cavities contained on an outer surface of a production tool to fill such cavities. A substrate is then introduced to the outer surface of the production tool over the filled cavities such that the slurry wets one major surface of the substrate to form an intermediate article. The binder is then cured before the intermediate article departs from the outer surface of the production tool to form a coated, structured abrasive article. The coated, structured abrasive article is then removed from the surface of the production tool.

In another embodiment, the structured abrasive article can be made by first introducing a flowable and curable slurry containing a mixture of a binder precursor and plurality of minerals onto a front side of a substrate such that the slurry wets the front side of the substrate to form an intermediate article. The slurry is then introduced to the bearing side of the intermediate article to an outer surface of a production tool having a plurality of cavities in its outer surface such that the cavities are filled. The binder precursor is then cured before the intermediate article departs from the outer surface of the production tool to form a coated, structured abrasive article. The coated, structured abrasive article is then removed from the surface of the production tool.

In both of the methods described, in one embodiment, the steps are carried out in a continuous manner, providing an efficient method of making the structured abrasive article of the present invention.

5 In practice, the structured abrasive article is used as a cleaning article. The cleaning article can take a variety of forms, including, but not limited to: a wipe construction, a hand pad, or a handled good. In the wipe construction, shown in FIG. 1, the cleaning article includes the abrasive composite and the substrate. When in the form of a wipe, the substrate may include a substantially thin and flexible material such as, but not limited to: a nonwoven, a woven, a foam, etc.

10 When the cleaning article is in the form of a hand pad, as shown in FIG. 2, the structured abrasive article may be attached to a substrate, such as a conformable material including to allow a user to have a better grip on the cleaning article. Any material can be used that allows the structured abrasive article to conform around surfaces to be cleaned. In one embodiment, the substrate may include, but is not limited to, foam or soft polymer
15 network including a rubber/elastomer or gel material. This allows the user to better manipulate the structured abrasive article for more effective cleaning. In such a construction, the cleaning article would include the abrasive composite positioned adjacent a first side of the substrate and the second side of the substrate positioned adjacent the foam layer. The foam layer may be attached to the substrate by any means known to those
20 of skill in the art, including, but not limited to, mechanical or adhesive means.

In use, the structured abrasive article may be attached to a grip or handle, as seen in FIG. 3. The structured abrasive article may be permanently or releasably attached to the grip or handle by an attachment mechanism. The grip or handle may be attached to the structured abrasive article by any means known to those of skill in the art. Exemplary
25 attachment methods include mechanical means or adhesive means. One exemplary mechanical attachment mechanism includes using plastic snaps. For example, the structured abrasive article can be attached to the grip or handle by engagement of an insertable portion of the grip or handle into a shoe or cup attached to the structured abrasive article. The shoe or cup may be attached to the structured abrasive article
30 through adhesive or mechanical means. To effect this engagement, the user inserts the insertable portion of the grip or handle into the cup or shoe of the structured abrasive article and pushes or exerts force to guide the grip or handle firmly into/onto the cup or

shoe. The user's force causes the at least one snap in the insertable portion of the grip or handle to flex or push inwardly. This permits the insertable portion to slide into the cup or shoe. When the snaps align with corresponding slots on the cup or shoe, the snaps enter into the slots and return generally to their original non-flexed (relaxed) position. In this way, the snaps engage with the slots of the cup or shoe attached to the structured abrasive article. In this engaged position, the snaps attach the structured abrasive article to the grip or handle and holds the structured abrasive article in place.

In one embodiment when the structured abrasive article is attached to a grip or handle, an additional layer is positioned between the structured abrasive article and the handle or grip. For example, a layer of foam, soft polymer, or other conformable material may be positioned between the structured abrasive article and the grip or handle. In this embodiment, the foam layer may be attached to the structured abrasive article by any means known in the art, including, but not limited to, mechanical or adhesive means. The grip or handle is then attached (permanently or releasably) to the foam layer. The overall structure of the cleaning article includes the abrasive composite positioned adjacent to a first side of the substrate, a second side of the substrate positioned adjacent a first side of the foam layer, and a second side of the foam layer positioned adjacent and attached to the handle or grip.

In some embodiments, the attachment mechanism includes an actuation button or switch on the grip or handle. When the actuation button is pushed, the structured abrasive article is ejected or released from attachment to the grip or handle. In this embodiment, the user can activate the activation mechanism by activating button or switch and can then insert the insertable portion of the grip or handle into the shoe or cup of the structured abrasive article. When the button or switch is activated, the snaps on the grip or handle flex or push inwardly. This enables the structured abrasive article to easily slide onto the grip or handle. Once the structured abrasive article is on the grip or handle, the user releases or slides the button or switch into its original position. This causes the snaps to engage with the slots on the shoe or cup and hold the structured abrasive article firmly in place on the grip or handle.

To detach the structured abrasive article from the grip or handle, the user activates the button or switch. This generates enough force to push or flex the snaps inward and to release the snaps from the slots. The snaps are capable of flexural motion such that they

can flex inward, providing additional “give” to release the structured abrasive article from the grip or handle. Once the snaps are pushed inward, the structured abrasive article slides off of the insertable portion. In this way, the structured abrasive article is easily detached from the grip or handle without requiring the user to touch the structured abrasive article.

5 Various modifications and changes may be made to the specific embodiment described without departing from the spirit and scope of the present disclosure.

The grip or handle may be made of any suitable material. In some embodiments, the grip or handle may be molded. In some embodiments, the grip or handle is made of a polymeric material such as acrylonitrile butadiene (ABS), polyethylene, polypropylene, 10 polycarbonate, or high impact polystyrene. In some embodiments, the handle may feature “overmolded” components designed to enhance the user’s grip on the tool. Such components are generally made from urethane-based elastomers or hydrocarbon-based block copolymer elastomers like styrene-isoprene-styrene (SIS), styrene-butadiene-styrene (SBS), or styrene-ethylene-butylene-styrene (SEBS) materials.

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Examples

The present invention is more particularly described in the following examples that are intended as illustrations only, since numerous modifications and variations within the scope of the present invention will be apparent to those skilled in the art. Unless otherwise 20 noted, all parts, percentages, and ratios reported in the following examples are on a weight basis.

Materials

Abbreviation	Description and Source	Purpose
AUDA	Aliphatic urethane diacrylate, obtained under the trade designation EBECRYL 8402 from Allnex USA, Inc, Alpharetta, GA	Difunctional acrylate monomer (soft, rubbery)
TMPTA	Trimethylolpropane triacrylate, obtained under the trade designation SR351H from Sartomer Americas, Inc., Exton, PA	Trifunctional acrylate monomer (hard, stiff)
PI	Ethyl (2,4,6-trimethylbenzoyl) phenyl phosphinate photoinitiator, obtained under the trade designation TPO-L from IGM Resins BV, Netherlands	Photoinitiator
DISP	Phosphonated copolymer dispersant, obtained under the trade designation SOLPLUS D520 from Lubrizol Corporation, Wickliffe, OH	Dispersant, viscosity modifier
CA	Gamma-Methacryloxypropyltrimethoxy silane coupling agent, obtained under the trade designation SILQUEST A-174NT from Momentive Performance Materials, Inc. Waterford, NY	Coupling agent, viscosity modifier
TA	Calcium sulfate dihydrate (gypsum), obtained under the trade designation Terra Alba No.1 from USG Corporation, Chicago, IL	Filler, viscosity modifier
PCC	Precipitated calcium carbonate, obtained under the trade designation ALBAFIL T10 from Specialty Minerals, Inc., Bethlehem, PA	Filler, viscosity modifier

Test Methods

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Article Cleaning Efficacy Test (food soil cleaning)

The article cleaning efficacy test was performed in a generally similar manner as that described in U.S. Patent No. 5,626,512 (Palaikis et al). A 5 mm thick, 4 inch diameter stainless steel disc was coated with a food soil mixture made up of 120 grams milk, 60 grams cheddar cheese, 120 grams hamburger, 120 grams tomato juice, 120 grams cherry juice, 20 grams flour, and 100 granulated sugar, and one egg. The coated panel was baked in an oven at 230°C for one hour. The above coating and curing process was repeated three times to achieve uniform coat on the panel. Acceptable food soil coating weight should be at least equal to 0.9 grams. Test samples measuring about 1 in², comprising precisely shaped abrasive composites affixed to polymeric film, were cut from a larger sample of each abrasive article. The sample contacted the food soil disc by virtue of force transmitted through a 1 inch thick piece of foam by a single finger-like projection

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(having approximately 0.08 inch² contact area with the sample) having 5 pounds of weight on top of it. The assembly comprising the weight, finger-like projection, foam, and abrasive sample were pushed/pulled by hand, using a track as guide. over the coated panel until the abraded region of the coated panel was clean (no coated material visually remained on the panel). The travel length was 2 inches. The number of cycles (back and forth equals one cycle with a rate of approximately 45 cycles per minute) required to result in a clean panel was recorded.

Scratch-Testing Procedure

Test samples, comprising precisely shaped abrasive composites affixed to polymeric film, measuring about 3 cm² were cut from a larger sample of each abrasive article. The test samples were pushed with the side of the tester's thumb into the test surface, exerting about five pounds of force, and pushed and pulled back and forth over the surface for five seconds. Then, the surfaces were visually examined for changes in surface finish. The poly(tetrafluoroethylene) (PTFE) surface tested was that of a nonstick frying pan, and the chrome surface was that of a drip pan for an electric coil cooking range.

Durability Test (abrasion weight loss)

This test was used to determine the durability of the abrasive articles and involved rubbing each abrasive article sample back and forth over an abrading material with the percent weight loss noted after the test. A lower percent weight loss indicated a more durable product. Wear testing was performed in a generally similar manner as described in U.S. Pat. No. 5,681,361 (Sanders, Jr.) The test sample size was 2.5 inches x 9.0 inches (63.5 mm x 228.6 mm). The downward load applied to the test sample was 2.25 kg. The percent weight loss was determined after 100 linear passes back and forth (travel length was about 14 inches) over a conditioned (broken-in) M125 Diamond Cloth belt (3M Company, St. Paul, MN) in the presence of warm water.

Examples EX1-EX7Preparation of binder precursor with dispersed soft mineral grains

Liquid components AUDA, TMPTA, PI, DISP, and CA were added to a
 5 SPEEDMIXER cup and mixed at 2400 rpm for 60 seconds in a DAC 400.2 VAC-P
 SPEEDMIXER (FlackTek, Inc, Landrum, SC). Then TA and PCC were added to the cup,
 completing a total batch size of 200 grams, and the mixture was mixed for 30 seconds at
 1200 rpm. The mixture was then placed in an oven at 150°F (66°C) for 30 minutes, after
 which it was mixed for 3 minutes at 2400 rpm to provide a liquid slurry of a binder
 10 precursor and a plurality of soft mineral grains.

Table 1: Formulas for Examples EX1-EX7

	AUDA (wt%)	TMPTA (wt%)	PI (wt%)	DISP (wt%)	CA (wt%)	TA (wt%)	PCC (wt%)
EX1	13.20	26.39	0.81	0.40	0.20	39.33	19.67
EX2	23.76	15.84	0.81	0.40	0.20	39.33	19.67
EX3	27.41	12.18	0.81	0.40	0.20	39.33	19.67
EX4	29.69	9.90	0.81	0.40	0.20	39.33	19.67
EX5	27.41	12.18	0.81	0.40	0.20	57.82	1.18
EX6	27.41	12.18	0.81	0.40	0.20	53.10	5.90
EX7	27.41	12.18	0.81	0.40	0.20	49.17	9.83

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Preparation of coated abrasive articles

Coated abrasive articles were prepared using a method similar to those described in
 U.S. Pat. No. 5,152,917 (Pieper et al) (for example, see Examples 1-5) and U.S. Pat. No.
 7,267,700 (Collins et al) (for example, see Column 11, lines 9-34). A production tool was
 20 provided having an outer surface that had a plurality of cavities that corresponded to the
 inverse shape of the desired abrasive composite shape. The cavities each had a shape
 resembling that of a pyramid with a base length of 400-700 microns and a height of 450
 microns. For each of the Example EX1-X7 formulas, a liquid slurry of the binder
 precursor and plurality of soft mineral grains was coated into the cavities of the production
 25 tool. A backing was then introduced to the outer surface of the production tool over the
 filled cavities such that the slurry wetted one major surface of the backing to form an
 intermediate article. The backing was a polyester film (3mil thick) with a corona-treated
 poly(ethylene-co-acrylic acid) primer layer (0.81 mil thick) to prime the film. Next, the
 production tool containing the slurry and the soft mineral grains was exposed to UV

radiation to cure the binder precursor. Then the abrasive article was removed from the production tool.

The abrasive articles of Examples EX1-EX7 were then tested for cleaning efficacy (food soil cleaning), scratching properties, and durability (abrasion weight loss) using the above Test Methods. For comparison, Comparative Example CE1 was also tested. Comparative Example CE1 was a standard density foam of a melamine-formaldehyde thermoset resin, obtained from BASF in 1 inch thickness. Results are provided in Table 2.

Table 2: Cleaning ability, scratching properties, and durability test results

	UADA:TMPT A	TA:PCC	Food soil cleaning cycles	Scratches Teflon?	Scratches polished chrome?	Abrasion weight loss (wt%)
EX1	0.50	2	8	Yes	No	16.0
EX2	1.50	2	12	No	No	12.8
EX3	2.25	2	23	No	No	13.4
EX4	3.00	2	34	No	No	14.4
EX5	2.25	49	79	No	No	8.1
EX6	2.25	9	58	No	No	6.5
EX7	2.25	5	39	No	No	5.6
CE1	NA	NA	280	No	No	55

Note that the non-scratch properties of the abrasive articles can be tuned by adjusting the UADA:TMPTA and/or TA:PCC ratios. Increases in each ratio lead to a softer, more compliant abrasive article that will generally scratch less, yet also require more effort when used to clean a surface.

Various modifications and alterations to this disclosure will become apparent to those skilled in the art without departing from the scope and spirit of this disclosure. It should be understood that this disclosure is not intended to be unduly limited by the illustrative embodiments and examples set forth herein and that such examples and embodiments are presented by way of example only with the scope of the disclosure intended to be limited only by the claims set forth herein as follows. All references cited in this disclosure are herein incorporated by reference in their entirety.

What is claimed is:

1. An abrasive composite comprising:
a first crosslinkable binder component, wherein when polymerized, has a glass
5 transition temperature (T_g) below room temperature and a modulus of less
than about 150 MPa;
a second crosslinkable binder component having a T_g above room temperature;
a material capable of initiating addition polymerization; and
particulate grains having a Mohs hardness value of less than or equal to about 3.
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2. The abrasive composite of claim 1, wherein the first crosslinkable binder
component comprises urethane diacrylate or triacrylate.
3. The abrasive composite of claim 1, wherein when polymerized, the first
15 crosslinkable binder component has an elongation percent at break of greater than about
25%.
4. The abrasive composite of claim 1, wherein the second crosslinkable binder
component comprises a difunctional or trifunctional acrylate.
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5. The abrasive composite of claim 1, wherein the material capable of initiating
addition polymerization comprises a UV photoinitiator.
6. The abrasive composite of claim 1, wherein the particulate grains comprise an
25 inorganic mineral having a d_{90} of less than about 50 micron.
7. The abrasive composite of claim 1, wherein the abrasive composite includes
between about 15 and about 35% by weight of the first crosslinkable binder component.
- 30 8. The abrasive composite of claim 1, wherein the abrasive composite includes
between about 8 and about 28% by weight of the second crosslinkable binder component.

9. The abrasive composite of claim 1, wherein the abrasive composite includes between about 0.5 and about 2% by weight of the material capable of initiating addition polymerization.
- 5 10. The abrasive composite of claim 1, wherein the abrasive composite includes between about 26 and about 80% by weight of the particulate grains.
11. The abrasive composite of claim 1, wherein the particulate grains comprise gypsum.
- 10 12. The abrasive composite of claim 1, comprising at least a first particulate grain and a second particulate grain.
13. A structured abrasive article comprising:
- 15 a substrate; and
an abrasive composite adhered to the substrate, wherein the abrasive composite comprises:
a first crosslinkable binder component, wherein when polymerized, has a
glass transition temperature (T_g) below room temperature and a
20 modulus of less than about 150 MPa;
a second crosslinkable binder component having a T_g above room
temperature;
a material capable of initiating addition polymerization; and
particulate grains having a Mohs hardness value of less than or equal to
25 about 3.
14. The structured abrasive article claim 13, wherein the structured abrasive article is attached to a handle.
- 30 15. The structured abrasive article of claim 13, wherein the structured abrasive article is releasably attached to a handle.

16. The structured abrasive article claim 14, wherein the structured abrasive article is attached to the handle by mechanical means.

5 17. The structured abrasive article claim 14, wherein the structured abrasive article is attached to the handle by an adhesive.

18. The structured abrasive article of claim 13, further comprising a conformable layer positioned adjacent the substrate.

10 19. The structured abrasive article of claim 18, further comprising a handle, wherein the conformable layer is positioned between the structured abrasive article and the handle.

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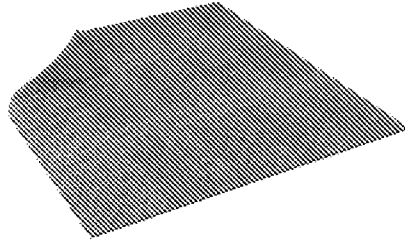


FIG. 1

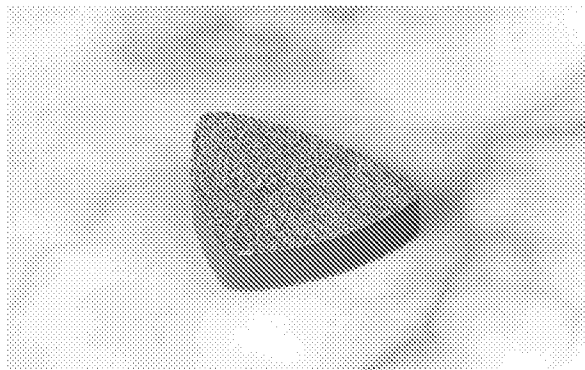


FIG. 2

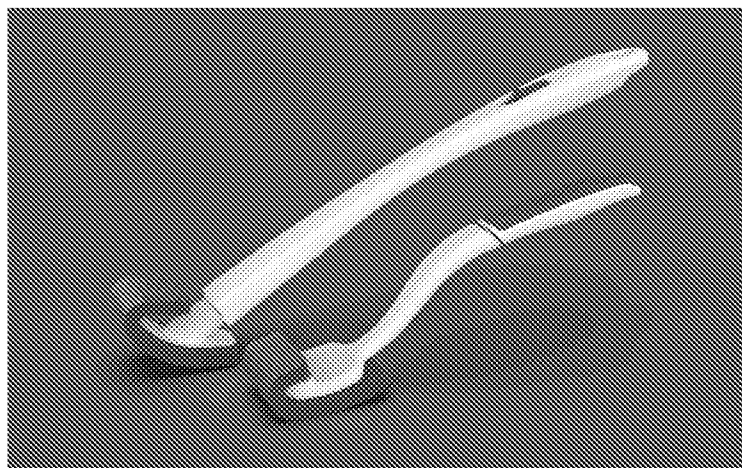


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2021/056100

A. CLASSIFICATION OF SUBJECT MATTER INV. B24D3/28 B24D3/00 B24D11/06 B24D15/04 A47L13/00 ADD.																																						
According to International Patent Classification (IPC) or to both national classification and IPC																																						
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) B24D A47L Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data																																						
C. DOCUMENTS CONSIDERED TO BE RELEVANT <table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>X</td> <td>CA 3 105 329 A1 (3M INNOVATIVE PROPERTIES CO [US]) 14 November 2019 (2019-11-14)</td> <td>1-3,</td> </tr> <tr> <td>Y</td> <td>paragraphs [0002] - [0005], [0007]</td> <td>12-19</td> </tr> <tr> <td>Y</td> <td>----- EP 1 904 577 A2 (3M INNOVATIVE PROPERTIES CO [US]) 2 April 2008 (2008-04-02)</td> <td>4-11</td> </tr> <tr> <td>Y</td> <td>paragraphs [0020], [0027], [0028]</td> <td>4,5,9</td> </tr> <tr> <td>Y</td> <td>----- EP 1 855 841 A1 (SAINT GOBAIN ABRASIVES INC [US]) 21 November 2007 (2007-11-21)</td> <td>6,10</td> </tr> <tr> <td>Y</td> <td>paragraphs [0035], [0101]</td> <td>7,8</td> </tr> <tr> <td>Y</td> <td>----- US 2020/070312 A1 (SHAFER KATHLEEN S [US] ET AL) 5 March 2020 (2020-03-05)</td> <td>11</td> </tr> <tr> <td>Y</td> <td>paragraph [0081]</td> <td></td> </tr> <tr> <td>Y</td> <td>----- EP 1 159 109 A1 (3M INNOVATIVE PROPERTIES CO [US]) 5 December 2001 (2001-12-05)</td> <td></td> </tr> <tr> <td>Y</td> <td>paragraph [0063]</td> <td></td> </tr> <tr> <td>Y</td> <td>-----</td> <td></td> </tr> </tbody> </table>			Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	X	CA 3 105 329 A1 (3M INNOVATIVE PROPERTIES CO [US]) 14 November 2019 (2019-11-14)	1-3,	Y	paragraphs [0002] - [0005], [0007]	12-19	Y	----- EP 1 904 577 A2 (3M INNOVATIVE PROPERTIES CO [US]) 2 April 2008 (2008-04-02)	4-11	Y	paragraphs [0020], [0027], [0028]	4,5,9	Y	----- EP 1 855 841 A1 (SAINT GOBAIN ABRASIVES INC [US]) 21 November 2007 (2007-11-21)	6,10	Y	paragraphs [0035], [0101]	7,8	Y	----- US 2020/070312 A1 (SHAFER KATHLEEN S [US] ET AL) 5 March 2020 (2020-03-05)	11	Y	paragraph [0081]		Y	----- EP 1 159 109 A1 (3M INNOVATIVE PROPERTIES CO [US]) 5 December 2001 (2001-12-05)		Y	paragraph [0063]		Y	-----	
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Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Bonetti, Serena																																				

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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