DISCONTINUOUS ABRASIVE SURFACES HAVING CONTROLLED WEAR PROPERTIES

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ABSTRACT
Discontinuous abrasive surfaces are disclosed that may be employed in wet and/or dry applications. The discontinuous abrasive surfaces of the present invention may consist of abrasive containing protrusions attached to rigid or flexible surfaces arranged in one or more layers, or alternatively may be comprised of closed cell foam compositions impregnated with abrasive materials such as aluminum oxide. The closed cell foam compositions of the present invention may soften with water to provide a cushioning layer for abrasive particles at the working surface. The voids present in the discontinuous abrasive surfaces of the present invention serve to hold water in wet applications and remove debris. The resulting discontinuous abrasive particle releasing surfaces are long lasting and may be made low in cost.
DISCONTINUOUS ABRASIVE SURFACES HAVING CONTROLLED WEAR PROPERTIES

[0001] This is a Continuation-in-Part of prior application Ser. No. 11/828,270 filed on Jul. 25, 2007 which is a Continuation-in-Part of Ser. No. 11/503,058 filed Aug. 3, 2006, which claimed priority to provisional application No. 60/764,110 filed on Feb. 1, 2006 and provisional application No. 60/818,571 filed on Jul. 5, 2006; Ser. No. 11/846,073 filed on Aug. 28, 2007 which is a Continuation-in-Part of Ser. No. 11/828,270 filed on Jul. 25, 2007 which is a Continuation-in-Part of Ser. No. 11/503,058 filed Aug. 3, 2006, which claimed priority to provisional application No. 60/764,110 filed on Feb. 1, 2006 and provisional application No. 60/818,571 filed on Jul. 5, 2006.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] This invention relates to abrasive materials and surfaces. More particularly this invention relates to abrasive materials having surfaces that renew themselves during use. The abrasive materials and surfaces of the present invention have a discontinuous surface topography and may be comprised of abrasive particles along with other materials in numerous configurations. The abrasive materials and surfaces of the present invention have a rate of wear that may be controlled for specific applications. The controlled wear abrasive surfaces of the present invention may be suitable for either wet or dry applications. Discontinuous surface topography may be provided by numerous abrasive containing protrusions arranged in one or more layers, abrasive loaded ridge and cavity portions, or closed cell foam compositions impregnated with abrasive materials such as aluminum oxide. Voids present in the discontinuous abrasive surfaces of the present invention may serve to facilitate wear in a controlled manner, hold water in wet applications, and remove debris.

[0004] 2. Description of the Related Art

[0005] There are numerous methods that may be employed to sand surfaces. One of the more common methods employs sand paper. Sand paper is a thin sheet material usually made of paper that has an abrasive material securely bonded onto one side. Despite its name, the abrasive is rarely ever sand. Commonly used abrasives such as aluminum oxide and silicon carbide are significantly harder than sand and are therefore more effective. This may be especially true when sanding hard materials such as glass or steel.

[0006] Sand paper may be used by hand. This process is often referred to as hand sanding. The process of hand sanding involves using manual labor to repeatedly slide the sand paper back and forth and/or in a circular motion over the surface until smooth. Numerous textures of abrasives are available. Often sanding starts out with a relatively coarse grade of sand paper of about 80 grit followed by finer grades of several hundred grit to finish the job.

[0007] One drawback often associated with sand paper is the production of dust. Sanding surfaces often produces dust that clogs the sand paper and may create an inhalation hazard as well. This is especially true for sanding hazardous materials such as lead paint. One way to alleviate this problem is by using wet or dry Emery cloth. Wet or dry Emery cloth is an abrasive coated cloth having a wide variety of grades. It is designed for use with water thereby reducing clogging effects and significantly or even completely eliminating the production of air born dust.

[0008] Another drawback with using sand paper is the tendency for the abrasive to become dull and fall off from the sand paper backing surface.

[0009] Sanding by hand using sand paper is not always practical owing to the amount of labor required. This is especially true for large jobs that may take a long time resulting in fatigue.

[0010] In order to alleviate the worker fatigue issue in hand sanding operations, numerous power sanding techniques and/or equipment have been developed. Drum sanding, belt sanding, disc sanding, and orbital sanding are commonplace. These standard power sanding tools often employ some form of sand paper and therefore often suffer from many of the previously mentioned drawbacks. In particular is the need to change the sanding surface at regular intervals.

[0011] Numerous modifications to ordinary sand paper have been made in order to improve the overall process. For example, sand paper having a lowered surface density of abrasive particles is available. This particular sand paper is made by 3M Corporation of St. Paul Minn. and is designed for use in sanding relatively soft materials that quickly gum up ordinary sand paper. Significant improvements in sand paper life may be realized by reducing the tendency of particulate matter to clog the needed spaces between adjacent abrasive particles.

[0012] Another improvement that may be made to ordinary sand paper involves the use of flexible and conformable foam backing. Such backing materials allow the sand paper to conform to surface contours thereby more rapidly smoothing contoured surfaces. Individual pieces of sand paper may be applied to foam pads or conversely, foam pads having previously attached sand paper may be employed. For example, Finishing Buddies (Mona Lisa Products 10770 Moss Ridge Road Houston, Tex.; 77043) is a complete sanding tool kit consisting of a steel wool pad, oval sanding disc, and coarse, medium, and fine sanding pads. The oval pad is relatively rigid, and the three other sanding pads have a softer foam backing that has a greater degree of flexibility. This sanding kit is designed for slow hand sanding and finishing operations.

[0013] There are numerous flexible sanding surfaces, components, and articles comprised of abrasive materials fixedly attached to flexible foam backings. Of particular interest is a sanding system employing a relatively thin rigid foam backing disclosed in U.S. Pat. No. 6,923,840 and assigned to 3M Innovative Properties Company, St. Paul Minn. (US). U.S. Pat. No. 6,923,840 discloses a flexible abrasive product comprised of an open cell foam backing, a foraminous barrier coating, and a shaped foraminous abrasive coating. The top abrasive coating is discontinuous and allows for holding lubricants such as water as well as spaces for removal of debris.

[0014] U.S. Pat. No. 6,949,128 also assigned to 3M, discloses a method for making a foam backed abrasive article having embossed raised areas.
U.S. Pat. No. 3,401,490 discloses a method for forming an abrasive article having a resiliently yielding open cell melt base which is passed under a heated roll to melt the surface to a desired depth followed by application of abrasive particles to the melted surface. The result is a flexible foam based abrasive article capable of following irregular, uneven, or sunken surfaces.

U.S. Pat. No. 6,997,794 by James Matthew Penti discloses a disposable sanding device fabricated as a continuous rope like article adapted for selective segmentation. This device may employ a foam central portion along with an abrasive outer portion. In particular the flexible cylindrical geometry illustrated in several embodiments of the invention lends itself to the hand sanding of difficult to reach contours and may prove especially useful in woodworking applications.

There are numerous flexible foam based cleansing and scouring pads having added abrasive materials. An example of this can be found in U.S. Pat. No. 3,377,151. U.S. Pat. No. 3,377,151 discloses a method for making flexible resilient cleansing and scouring pads having an abrasive surface. A thermoplastic foam web material is hot laminated to abrasive web material. In addition, one or more cleansing materials may be added.

U.S. Pat. No. 3,619,843 discloses sponges having dry impregnated materials. In this invention, impregnated sponges are prepared by a process that deposits particular material on one surface of the sponge and subsequently pierces the sponge with spikes to form crevices followed by drawing particular material into the crevices. The result is a modified sponge suitable for surgical and sanitizing applications.

Also of interest are flexible open cell foam scouring and cleaning pads having numerous protrusions. These pads are disclosed in U.S. Pat. No. 4,055,029 by Heinz Kallbow, Lichgasse. The flexible pad has numerous protrusions on the working surface having an abrasive layer. U.S. Pat. No. 4,111,666 also by Heinz Kallbow discloses a method of manufacturing flexible abrasive cleaning pads along with improvements in tear resistance.

U.S. Pat. No. 4,421,526 discloses polyurethane foam cleaning pads composed of a densified flexible foam like polyurethane foam impregnated with various cleansing additives. Excessive mixing of the freshly blended polymers inhibits foam formation long enough to add the cleansing ingredients. The resulting pads have added strength due to collapsed, ruptured, and distorted cells along with fibers that result from the specific mixing process employed. The result is an unusually strong dense flexible cleaning pad capable of absorbing substantial amounts of water that releases additives along with absorbed water on gentle squeezing.

U.S. Pat. No. 4,594,362 discloses a dry type textile cleaning article comprised of a friable hydrophilic polyurethane foam with incorporated abrasive particles as well as other additives. The abrasive particles are chemically bonded to the foam using silane coupling agents thereby reducing their tendency to separate from the mass and subsequently damage cloth material.

While the above described examples of foam based abrasive articles provide a wide variety of uses, there exists a need in the art for lightweight semi-rigid or rigid closed cell foam abrasive articles suitable for hand and/or low speed wet/dry sanding, and/or wet/dry grinding, and/or wet/dry polishing operations.

Many of the above described examples outline the use of foam with abrasive materials in order to achieve certain advantageous and desirable properties. Still others outline some of the more simple methods and materials commonly employed in sanding, grinding, and polishing operations. While generally effective for sanding, grinding, and polishing, there exists a need in the industry for further improvements in low speed wet/dry sanding, grinding, and polishing operations. For example, lapping is a process that uses special equipment to grind surfaces to a high degree of flatness. Unfortunately, this equipment tends to be expensive and bulky. In addition, producing a good flat grind may require certain acquired skills to master. This results in difficulties for small shops and individuals in the hobby field in grinding surfaces flat.

Another example where further improvements in low speed wet/dry sanding, grinding, and polishing operations may be realized is in the area of sanding cloths. Flexible abrasive cloth materials such as emery rapidly become dull and shed abrasive particles. Because of this, sanding operations often require several pieces of emery cloth to complete. While making discrete zones of attached abrasive may serve to reduce the tendency of debris to build up in the sanding surface, the issue of rapid dulling and shedding of surface abrasive particles still remains a major issue to be resolved.

Finally, flexible abrasive surfaces employing foam have certain added benefits that may be realized in numerous applications. Many of the earlier patents referenced in this application fall under this class of abrasive surfaces.

Despite numerous advancements in the field of abrasives there is a need for discontinuous abrasive particle releasing surfaces for wet/dry sanding, grinding, and polishing operations.

It is an object of this invention to provide both wet and dry low speed abrasive surfaces.

It is a further object of this invention to provide numerous grades of wet and dry abrasive surfaces.

It is a further object of this invention to provide wet and dry abrasive surfaces resistant to excess build up of debris.

It is a further object of this invention to provide wet and dry abrasive surfaces in both rigid and flexible forms.

It is a further object of this invention to provide wet and dry abrasive surfaces that are low in cost.

It is a further object of this invention to provide simple methods for producing wet and dry abrasive surfaces.

It is a further object of this invention to provide wet and dry abrasive surfaces that can be used on the body.

Finally it is an object of this invention to provide wet and dry abrasive surfaces that may be used for extended periods of time without wearing out.

SUMMARY OF THE INVENTION

This invention therefore proposes discontinuous abrasive surfaces employing discrete areas containing abra-
sive particles that continuously renew themselves during use. The discontinuous abrasive surfaces of the present invention may consist of abrasive containing protrusions attached to rigid or flexible surfaces, a raised portion and a cavity portion, abrasive compositions containing hollow micro-particles such as hollow micro-spheres, or alternatively may be comprised of closed cell foam compositions impregnated with abrasive materials such as aluminum oxide. The closed cell foam compositions of the present invention may soften with water to provide a cushioning layer for abrasive particles at the working surface. The voids present in the discontinuous abrasive surfaces serve to hold water in wet applications and remove debris.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows a lapping surface suitable for grinding surfaces flat.

Fig. 2 shows a blank grinding block having an adhesive zone for mounting disposable lapping surfaces.

Fig. 3 shows a lapping block consisting of a lapping surface adhered to the top of a flat surfaced block.

Fig. 4 shows a cross sectional view of numerous surface protrusions embedded with hard abrasive particles.

Fig. 5 shows a cross sectional view of numerous flat topped surface protrusions embedded with hard abrasive particles.

Fig. 6 shows a sectional view of a low speed sanding disc for a rotary tool.

Fig. 7 shows a hand held abrasive foam sanding block of the present invention.

Fig. 8 shows a hand held abrasive article made entirely out of the foam based abrasive of the present invention.

Fig. 9 shows a sectional view of a low speed wet abrasive foam disc for use with a rotary tool.

Fig. 10 shows an abrasive fabric employing polymeric resin protrusions of the present invention embedded with coarse aluminum oxide.

Fig. 11 shows an abrasive loaded polymeric resin protrusion having a top surface portion containing a pattern of grooves and ridges.

Fig. 12 shows an abrasive fabric glove having numerous abrasive protrusions attached to working surfaces in accordance with the present invention.

Fig. 13 shows a sectional view of a low speed wet sanding disc for a rotary tool having a plurality of layers of surface protrusions comprised of hard abrasive particles dispersed within a softer material matrix.

Fig. 14 shows a sectional view of cloth material for low speed wet sanding having a plurality of layers of surface protrusions comprised of abrasive particles dispersed within a softer material matrix.

Fig. 15 shows a lapping surface of the present invention suitable for grinding surfaces flat having numerous cavities for holding water, and removal of debris.

Fig. 16 shows a sectional view of an abrasive material for wet application comprised of hard abrasive particles embedded within a softer polymeric matrix material along with added hollow micro-spheres.

Fig. 17 shows a sectional view of abrasive foam material having a softened top surface resulting from exposure to water.

Fig. 18 shows a sectional view of abrasive foam material having added water soluble particles that facilitates wear on exposure to water.

Fig. 19 shows a foam abrasive article that may be used to wet sand automotive surfaces.

Fig. 20 shows an abrasive pad for wet scouring applications having 400 grit silicon carbide abrasive particles along with hollow polymeric micro-spheres embedded in a water softening polymeric matrix.

Fig. 21 shows a foam abrasive composition having a wearable surface with small cells suitable for wet sanding of rough skin from the feet.

Fig. 22 shows a cross sectional view of a foot sanding tool of the present invention.

Fig. 23 shows a foot sanding tool of the present invention.

Fig. 24 shows a foot sanding tool having an abrasive surface shaped for sanding in between the toes of the feet.

Fig. 25 shows a cross sectional view of a compact foot sanding tool having a small cross section.

Fig. 26 shows a cross sectional view of a pumice foot sanding tool of the prior art.

Fig. 27 shows cross sectional view of a used pumice foot sanding tool of the prior art having entrapped pieces of dead skin on the surface.

Fig. 28 shows a cross sectional view of a used foot sanding tool of the present invention.

Fig. 29 shows a cross sectional view of an abrasive filled foam granule.

Fig. 30 shows a cross sectional view of an abrasive loaded soft hydrophilic granule.

Fig. 31 shows a cross sectional view of an abrasive loaded water soluble granule.

Fig. 32 shows an abrasive particle encapsulated with a water softening hydrophilic material.

Fig. 33 shows an abrasive particle encapsulated with a water soluble material.

Fig. 34 shows a cross sectional view of an abrasive protrusion embedded with abrasive foam filled granules of Fig. 29.

Fig. 35 shows a cross sectional view of an abrasive surface for wet application comprised of a substrate having numerous protrusions embedded with abrasive filled granules of Fig. 34.
FIG. 36 shows a cross sectional view of an abrasive surface for wet application having multiple layers of protrusions embedded with abrasive filled granules of FIG. 34.

FIG. 37 shows a cross sectional view of an abrasive protrusion embedded with abrasive loaded water softening hydrophilic granules of FIG. 30.

FIG. 38 shows a cross sectional view of an abrasive surface for wet application comprised of a substrate having numerous protrusions embedded with abrasive loaded water softening hydrophilic granules of FIG. 37.

FIG. 39 shows a cross sectional view of an abrasive surface for wet application comprised of a substrate having multiple layers of protrusions embedded with abrasive loaded water softening hydrophilic granules of FIG. 37.

FIG. 40 shows a cross sectional view of an abrasive protrusion embedded with abrasive loaded water soluble granules of FIG. 31.

FIG. 41 shows a cross sectional view of an abrasive surface for wet application comprised of a substrate having numerous protrusions of FIG. 40 embedded with abrasive loaded water soluble granules.

FIG. 42 shows a cross sectional view of an abrasive surface for wet application comprised of a substrate having multiple layers of protrusions of FIG. 40 embedded with abrasive loaded water soluble granules.

FIG. 43 shows a cross sectional view of an abrasive protrusion embedded with granules comprised of abrasive particles encapsulated with a water softening hydrophilic material of FIG. 32.

FIG. 44 shows a cross sectional view of an abrasive surface for wet application comprised of a substrate having numerous protrusions embedded with granules comprised of abrasive particles encapsulated with a water softening hydrophilic material of FIG. 43.

FIG. 45 shows a cross sectional view of an abrasive surface for wet application comprised of a substrate having multiple layers of protrusions embedded with granules comprised of abrasive particles encapsulated with a water softening hydrophilic material of FIG. 43.

FIG. 46 shows a cross sectional view of an abrasive protrusion loaded with abrasive particles encapsulated with a water soluble material of FIG. 33.

FIG. 47 shows a cross sectional view of an abrasive surface for wet application comprised of a substrate having numerous protrusions embedded with abrasive particles encapsulated with a water soluble material as shown in FIG. 46.

FIG. 48 shows a cross sectional view of an abrasive surface for wet application comprised of a substrate having multiple layers of protrusions embedded with abrasive particles encapsulated with a water soluble material as shown in FIG. 46.

FIG. 49 shows a cross sectional view of an abrasive protrusion comprised of hard abrasive particles dispersed within a softer material matrix.

FIG. 50 shows a cross sectional view of an abrasive protrusion comprised of hard abrasive particles along with hollow micro-particles dispersed within a softer material matrix.

FIG. 51 shows a cross sectional view of an abrasive surface comprised of a substrate having multiple layers of protrusions loaded with abrasive particles of FIG. 49.

FIG. 52 shows a cross sectional view of an abrasive surface comprised of a substrate having multiple layers of protrusions comprised of hard abrasive particles along with hollow micro-particles dispersed within a softer material matrix of FIG. 50.

FIG. 53 shows a cross sectional view of a nail file having an abrasive surface comprised of the abrasive composition of FIG. 51.

FIG. 54 shows a nail file having an abrasive surface comprised of the abrasive composition of FIG. 51.

FIG. 55 shows a cross sectional view of a nail file having an abrasive surface comprised of the abrasive composition of FIG. 52.

FIG. 56 shows a nail file having an abrasive surface comprised of the abrasive composition of FIG. 52.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 shows a lapping surface suitable for grinding surfaces flat. Lapping surface 2 is comprised of numerous protrusions 4 extending upward from rigid backing laminate 6. Protrusions 4 may take the form of numerous shapes including polygons such as squares and hexagons, spheres, as those shown in FIG. 4, and/or modified spheres such as those shown in FIG. 5. Furthermore, the top surfaces of protrusions 4 may have added grooves as shown in FIG. 11. It should be noted that protrusions 4 are separated from each other and therefore may be considered to be discontinuous providing lapping surface 2 with a discontinuous surface topography. The spaces formed between individual protrusions 4 provide means for holding water and for the rapid removal of debris. Protrusions 4 may be comprised of a relatively soft matrix material such as a polymer impregnated with abrasive particles possessing a degree of hardness significantly greater than that of the matrix material itself. The result is an abrasive particle releasing surface for low speed wet lapping operations providing good abrasive properties. It should be noted that it may be desirable to control the hardness of the protrusions themselves. Opposite first major surface 2 of rigid backing laminate 6 is a second major surface (not shown) this second major surface may have mounting hardware and/or materials such as pressure sensitive adhesives to facilitate mounting to a more rigid flat substrate surface.

Polymeric resin based materials such as epoxy may be cast in a suitable mold. For example, a laminate construction may be assembled having numerous protruding spherically shaped particles. The laminate may then be treated with a suitable release coating and used to make a silicone rubber mold. Once the mold is cured, the laminate may then be removed. The now vacant mold may then be used to cast a lapping surface. Abrasive powder may be first sprinkled evenly in the numerous voids in the mold that are to become protrusions. Abrasive loaded polymeric resin such as epoxy may then be added on top of the already existing free abrasive particles residing within the individual discrete protrusion cavities within the mold. If desired, further addition of abrasive particles to the epoxy resin in the
mold may then be carried out followed by allowing the above described composition to set into a hard mass.

[0095] West system 105 epoxy resin (West Systems Inc. PO Box 665 Bay City, Mich. 48707 USA) has been used for producing working prototypes employing aluminum oxide abrasive. It should be noted that aluminum oxide is a dense material and therefore tends toward settling to the bottom of the mold. Other dense abrasive materials include silicon carbide, zirconia, diamond, ceria, cubic boron nitride, garnet, ground glass, quartz, and combinations thereof. Since the bottom of the mold represents the tops of the protrusions in the final part, this method of manufacture may be employed to keep numerous abrasive particles on the outer exposed surfaces of the protrusions themselves. This particular configuration may help to facilitate the initial release of abrasive particles. This technique may be employed to improve the initial release of abrasive particles on first time use. Once the process of abrasive particle release starts, it becomes self sustaining.

[0096] Alternatively, it may be desirable to have the abrasive particles dispersed uniformly throughout the material matrix. A high loading density of abrasive particles within the uncured resin may help to keep abrasive particles more uniform throughout the mix by forming a paste. Rapid cure times and high resin viscosity may also contribute to the abrasive particles being dispersed in a substantially uniform manner throughout the material matrix.

[0097] When abrasive particles are uniformly distributed within the material matrix, the new surface may not have suitable initial abrasive properties owing to a glaze over the abrasive particles. In order to provide initial aggressive abrasive properties this glaze may be removed by sanding, sand blasting, cutting, or grinding.

[0098] During use, abrasive particles embedded within the material matrix become dislodged and contributed to the overall process of wearing down lapping surface 2. These abrasive particles may fall away from the working surface relatively quickly or remain on the working surface continuously grinding away at lapping surface 2. The grinding away of lapping surface 2 may help to facilitate the exposure and subsequent release of more abrasive particles from the material matrix. Additionally, the released abrasive particles may grind away at the substrate surface (not shown) that is lapped. This may result in the formation of a paste at the working surface during wet lapping. This paste may contain abrasive particles in free form and finely divided particles from both lapping surface 2 and the substrate surface (not shown). Paste formation may help to keep the abrasive particles active on the working surface and depends on numerous factors. These factors include surface topography, rate of lapping, and the amount of water used in the process. Depending on the process used, it may be desirable to enhance or retard the formation of abrasive paste at the working surface.

[0099] FIG. 2 shows a blank grinding block having an adhesive zone for mounting disposable lapping surfaces. Block 8 is shown having adhesive pattern 10 on top surface 12. Top surface 12 of block 8 is flat and rigid and therefore helps to maintain flatness of the final assembly. Top surface 12 of block 8 becomes a rigid backing when lapping surface 2 of FIG. 1 is attached to form lapping block 14 shown in FIG. 3.

[0100] FIG. 3 shows a lapping block abrasive article. Lapping block 14 consists of top exposed abrasive particle lapping surface portion 20 (lapping surface 2 of FIG. 1) attached to top flat surface portion 18 of base block portion 16. Exposed abrasive particle releasing lapping surface portion 20 is shown to be larger in area than side surface portion 16 and therefore may be considered a first major surface of lapping block 14. Lapping block 14 has a second major surface (not shown) oppositely facing first major surface 20. Lapping block 14 is shown having side surface portion 16 and top flat surface portion 18. Also shown is disposable lapping pad 20 attached to top surface 18 of block 16.

[0101] Lapping block 14 is suitable for lapping small articles flat. The article may be glued to a holder and lapped in a circular motion by hand, or alternatively lapped at a relatively slow rate by machine. Some articles may also be held directly by hand and subsequently lapped flat. In many instances water in pure form or with special additives may be employed in the process. Generally speaking the lapping surfaces of this invention will retain water in the voids between surface protrusions. Employing water as a lubricant may also help to flush debris from the area being used. When finished, the lapping surface may be cleaned of residual debris with running water. When the lapping surface portion 20 of lapping block 14 becomes worn out, it can be replaced at a reasonable cost. Removable attachment means such as pressure sensitive adhesives may be employed to achieve this end.

[0102] FIG. 4 shows a cross sectional view of numerous surface protrusions shown in discontinuous arrangement comprised of abrasive particles dispersed within a softer material matrix such as epoxy resin. Laminate backing portion 22 is shown along with attached protrusions 24. Attached protrusions 24 are shown having abrasive particles 25 embedded into softer material matrix portion 27.

[0103] FIG. 5 shows a cross sectional view of numerous protrusions having a flat top surface geometry shown in discontinuous arrangement comprised of abrasive particles dispersed within a softer material matrix such as epoxy resin. Laminate backing portion 26 is shown along with attached protrusions 28. Attached protrusions 28 are shown having abrasive particles 29 embedded into softer material matrix portion 31.

[0104] FIG. 6 shows a sectional view of a low speed sanding disc for a rotary tool. Abrasive particle releasing disc 33 is shown having abrasive releasing first major top surface portion 37 along with rigid backing portion 35 and central hole 39 for mounting to a shaft (not shown). Top abrasive releasing surface portion 37 is comprised of numerous protrusions 41 fixedly attached to rigid backing portion 35. Protrusions 41 are comprised of hard abrasive particles dispersed within a softer material matrix. Protrusions 41 are shown in greater detail in FIGS. 4 and 5. Bottom surface portion 47 of rigid backing portion 35 may be regarded as a second major surface portion.

[0105] Abrasive particle releasing disc 33 is suitable for wet rotary sanding operations. A shaft may be attached using central hole 39 and a threaded screw. The shaft may be subsequently fitted into the chuck of a low speed rotary tool such as a drill. A relatively low speed of about 50 to 500 RPM may be employed to wet sand numerous surfaces. It
should be noted that high RPM conditions of 1000 or more may result in excess loss of water employed in wet sanding operations.

[0106] FIG. 7 shows a hand held abrasive foam sanding block of the present invention for abrasive operations. Abrasive foam block 30 is shown having side portion 32 along with exposed abrasive particle releasing surface portion 34. Side portion 32 has a thin skin over the surface as a result of the molding process used to prepare abrasive foam block 30. Exposed abrasive particle releasing surface portion 34 is shown having closed foam cells 36 that have been severed by a sharp knife (not shown) and are therefore exposed. Exposed closed foam cells 36 are made of a rigid material such as polyurethane in order to maintain a rigid geometry during use and form a discontinuous surface for holding water and removing debris during wet abrasive operations. The closed cell foam material of exposed abrasive particle releasing surface portion 34 is shown to be larger in area than side surface portion 32 and therefore may be considered a first major surface of abrasive foam block 30. A second major surface (not shown) is on the opposite side from exposed particle releasing surface portion 34 of abrasive foam block 30. Surface portion 34 provided by exposed closed foam cells 36 may be considered a major surface having a discontinuous surface topography. A plurality of abrasive particles dispersed within abrasive foam block 30 are released from particle releasing surface portion 34 during use. Abrasive particles released from surface portion 34 during use may facilitate the further wearing away of surface portion 34 thereby releasing more abrasive particles.

[0107] FIG. 8 shows a hand held abrasive article made entirely out of the discontinuous rigid closed cell foam based abrasive material of FIG. 7. Hand held abrasive article 38 is shown having bottom portion 40 along with handle portion 42. Also shown are handle mounts 44 used to attach handle portion 42 to bottom portion 40. It should be noted that hand held abrasive article 38 may be one continuous piece consisting of abrasive foam material that has been formed in a single operation in a suitable mold (not shown). Exposed discontinuous hard abrasive particle releasing surface 49 of hand held abrasive article 38 forms a first major surface and may be used for wet abrasive operations. Second major surface 51 is shown opposite of first major surface 49. Second major surface 51 serves as the attachment surface for handle 42 using handle mounts 44.

[0108] The abrasive foam compositions of the present invention are intended for low speed wet mechanical as well as wet hand sanding, grinding, and polishing operations. In general, no reinforcement is needed and the compositions may be adjusted to attain desirable levels of rigidity, strength, and rate of wear. Various compositions may be used with different foam densities. The foam materials used in the present invention may be formed from numerous polymeric materials, however special attention will now be paid to polyurethane foam compositions.

[0109] Polyurethane foam comprises a class of two component reactive foaming agent that when combined react with each other to polymerize and produce gaseous products during the polymerization process. The result is polyurethane foam. The polyurethane foam compositions employed in the present invention are rigid closed cell foams. The above described rigid polyurethane foam compositions may be comprised of a first component isocyanate containing prepolymer resin and a second component reactive prepolymer resin containing numerous hydroxyl groups. The isocyanate containing prepolymer resin may contain the higher oligomers of methyl disiocyanate along with other reactive diisocyanates such as 4,4’ diphenylmethane diisocyanate. The second component hydroxyl group prepolymer resin may contain reactive oligomers having poly hydroxy functionality such as hydroxy terminated polyglycol ethers. Rigid closed cell polyurethane pour foam materials are commercially available in various foam densities. Foam density may be considered to be the overall density of the fully cured foam. Foam density is often given in units of pounds per cubic foot. A low density 2 pound foam refers to a foam having a cured density of 2 pounds per cubic foot. Such foam materials are often employed where lightweight properties are desirable. It should be noted that ordinary water has a density of about 62 pounds per cubic foot and therefore a 2 pound foam would be 30% the density of water.

[0110] Generally speaking, the lower the density of the foam, the more rapid will be the wear rate of the abrasive foam composition. Furthermore, the addition of excess abrasive materials to the polymeric foam compositions of the present invention may result in rapid wear degradation of the foam and associated rapid release of abrasive particles. These abrasive particles may then find their way into crevices thereby enhancing sanding, grinding and polishing operations. In order to achieve this end, the abrasive materials may each have a percent composition in the mix that has the above described unique desirable properties. Outlined below are several examples of the abrasive loaded polyurethane closed cell foam compositions of the present invention.

[0111] Additionally, it may be desirable to modify the hardness of the exposed abrasive surface during wet operations. When a surface is wet sanded with sand paper, the sand paper starts out having a high degree of abrasive properties. This may be due to the abrasive particles themselves having a high degree of exposure on the paper surface. During sanding, these abrasive particles become dull. Additionally, the spaces between abrasive particles tend to fill with debris. After a relatively short timeframe the sand paper may lose enough abrasive qualities to render it no longer useful. At this point the sand paper is discarded and replaced with a new piece to continue with the sanding operation. Because the sand paper becomes less abrasive during use, a fresh piece of sand paper of the same grit will start sanding more aggressively than the last used piece.

[0112] The abrasive foam compositions of the present invention may differ substantially from sand paper. In particular, the grit used in the foam composition behaves finer than if it were used to make sand paper. For example, a foam sanding block of the present invention having embedded within the foam material matrix a 220 grit silicon carbide abrasive may behave in a similar manner to fresh sand paper of 400 grit or finer. Because of this, it is important to bear in mind that the abrasive particle size used may be sufficient to produce surface scratches. One way of alleviating this issue is to render the working surface of the abrasive foam somewhat soft and pliable on exposure to water. The depth of this zone of softness need not be very deep so long as it
provides a cushion effect for the abrasive particles when they become exposed and subsequently released.

[0113] With rigid closed cell polyurethane foam systems, this may be accomplished by using a slight excess of one component. For example, if a slight excess of the hydroxyl functional polyol component is used, the molecular weight will be significantly reduced and the resulting polymeric foam rendered somewhat hydrophilic. The mixture need not be modified very much from the ideal mixture quoted by the manufacturer. An excess of 10% of either component will drastically affect molecular weight. This has to do with the inherent properties of condensation polymers. In order for a two component reactive condensation polymer to achieve a high molecular weight, exact proportions need to be combined and subsequently allowed to react to completion. If the mixture is off by even a small amount, the reaction stops as soon as the first reactant runs out. The result is limited molecular weight with the polymeric chains terminated by the excess reactant. If the excess reactant has hydrophilic properties (polyol reactant) then the resultant polymer may exhibit increased hydrophilic properties. Additionally, one or more reactive hydrophilic polyol additives may be employed that chemically bond to polymers to modify the mix.

[0114] Under certain circumstances, polyurethane foam compositions containing abrasive materials like silicon carbide may be produced having a controlled limited molecular weight combined with hydrophilic properties. Such compositions may be prepared by using a slight excess of the polyol reactant that may be on the order of a few percent to about 10 percent by weight of the mix.

[0115] Foam abrasive surfaces of articles made in this way may soften on exposure to water rendering them somewhat compressible. This compressibility may be used to provide a cushion effect to abrasive particles released from the working surface during use. This cushion effect may help to prevent deep surface scratches that may otherwise be produced by rubbing abrasive particles between two hard surfaces. It is important to bear in mind that the abrasive foam compositions of the present invention have abrasive properties resembling sand paper of a much finer grit than what was employed in the mix. This effect may be quite substantial. The actual grit size may be over twice as coarse as the rating of the sanding surface. For example, an abrasive foam sanding surface of the present invention having an abrasive particle size of 200 grit may have similar abrasive properties to fresh sand paper having an abrasive particle size of 400 grit or finer.

**EXAMPLE 1**

[0116] 5.0 grams of foam A (2 pound per cubic foot density pour foam type rigid closed cell) polyurethane foam pre-polymer from Plastic Depot (2900 San Fernando Blvd Burbank, Calif. 91054) were placed into a small plastic cup. To this were added 5.0 grams of 70 grit aluminum oxide abrasive. The mixture was then stirred with a wooden popsicle stick until uniform. In a separate plastic cup were placed 5.0 grams of foam B polyurethane pre-polymer from the same source as the foam A. To this were added 5.0 grams of 70 grit aluminum oxide abrasive and the mixture stirred until uniform. The two mixtures were then combined and stirred until uniform. The resultant mixture was then poured into a small polyethylene container and allowed to foam and subsequently cure. The cured foam composition was then allowed to sit overnight to stabilize. The foam abrasive composition was then removed from the polyethylene container. A small section of the outside portion was cut off with a sharp knife to expose the foam cells underneath the outside skin. A small amount of water was placed on this exposed surface. This wet exposed surface was then used to sand the paint off of a soda can. Removal of the thin paint layer occurred within a few seconds leaving a scratched surface behind. It should be noted that the aluminum surface underneath the paint did not bind up as often happens with sand paper but rather tended to disperse in the water and accumulate in the exposed voids of the foam.

**EXAMPLE 2**

[0117] The experiment of example 1 was repeated with increasing concentrations of 70 grit aluminum oxide abrasive. At a concentration of 70% by weight, the foam composition became exceedingly weak and readily broke off when wet sanding rough surfaces. The resulting particles formed a mixture of broken off foam and free aluminum oxide abrasive. This particular mixture was exceedingly efficient at sanding rough and irregular surfaces.

**EXAMPLE 3**

[0118] The experiment of example 2 was then repeated with 100 grit aluminum oxide abrasive. It was found that a concentration of aluminum oxide of 66% was required to attain similar results.

**EXAMPLE 4**

[0119] The experiment of example 3 was repeated with finely divided aluminum oxide polishing powder. It was found that a concentration of this finely divided aluminum oxide of about 50% by weight was required to disrupt the polyurethane foam to a level sufficient to cause its break up during use. The resulting use of this composition produced good polishing properties to rough wet surfaces.

**EXAMPLE 5**

[0120] 5.0 grams of foam A polyurethane foam pre-polymer from Plastic Depot (2900 San Fernando Blvd Burbank, Calif. 91054) were placed into a small plastic cup. To this were added 8.0 grams of finely divided ferric oxide abrasive. The mixture was then stirred with a wooden popsicle stick until uniform. In a separate plastic cup were placed 5.0 grams of foam B polyurethane pre-polymer from the same source as the foam A. To this were added 8.0 grams of finely divided ferric oxide abrasive and the mixture stirred until uniform. The two mixtures were then combined and stirred until uniform. The resultant mixture was then poured into a small polyethylene container and allowed to foam and subsequently cure. The cured foam composition was then allowed to sit overnight to stabilize. The foam abrasive composition was then removed from the polyethylene container. A small section of the outside portion was cut off with a sharp knife to expose the foam cells underneath the outside skin. A small amount of water was placed on this exposed surface. This wet exposed surface was then used to polish rough sanded automotive paint. Polishing was quick with noticeable results occurring within a few seconds leaving a
polished surface behind. It should be noted that the resulting debris tended to disperse in the water and accumulate in the exposed voids of the foam.

[0121] FIG. 9 shows a sectional view of a low speed wet abrasive foam disc for use with a rotary tool. Abrasive particle releasing foam disc 53 is shown having abrasive releasing first major top surface portion 55 along with rigid backing portion 57 and central hole 59 for mounting to a shaft (not shown). Top abrasive releasing surface portion 55 is comprised of numerous abrasive particles embedded into closed cell foam attached to rigid backing portion 57. Bottom surface portion 61 of rigid backing portion 57 may be regarded as a second major surface portion.

[0122] Abrasive particle releasing disc 53 is suitable for wet rotary sanding operations. A shaft may be attached using central hole 59 and a threaded screw. The shaft may be subsequently fitted into the chuck of a low speed rotary tool such as a drill. A relatively low speed of about 50 to 500 RPM may be employed to wet sand numerous surfaces. It should be noted that high RPM conditions of 1000 or more may result in excess loss of water employed in wet sanding operations.

[0123] FIG. 10 shows an abrasive fabric 46. Abrasive fabric 46 is comprised of a flexible water absorbent fabric such as cloth backing layer 48 along with attached abrasive loaded polymeric resin protrusions 50. Abrasive polymeric resin 46 is shown as a discontinuous surface that releases hard abrasive particles during low speed wet sanding, grinding, and polishing operations. The separation of individual abrasive loaded polymeric resin portions 50 between each other forms a discontinuous surface. Also shown is material matrix portion 52 in the form of a polymer resin such as epoxy embedded with coarse aluminum oxide abrasive 54 having a hardness significantly greater than polymer matrix portion 52. Abrasive fabric 46 may be used for machine driven sanding surfaces such as belts and discs as well as hand sanding applications.

[0124] It should be noted that the protrusions themselves provide points of high pressure that facilitate wet sanding and grinding operations. It should also be noted that water absorbent flexible fabric 48 employed allows individual abrasive loaded polymeric resin protrusions to follow surface contours during wet sanding operations in addition to absorbing and releasing excess water during these same operations. This may be used to significantly control the moisture of surfaces during wet sanding operations. Individual protrusions 54 may have grooves like those shown in FIG. 11.

[0125] FIG. 11 shows an abrasive loaded polymeric resin protrusion 56 having a top surface portion 58 containing a pattern of grooves 60. Grooves 60 provide means for holding water and for the subsequent removal of debris in wet low speed sanding, grinding, and polishing operations. Furthermore, ridges 62 resulting from grooves 60 in top surface portion 58 provide for increased pressure at the start of wet sanding operations. This added pressure helps to facilitate the process of dislodging abrasive particles 62 and assures a good start to the wet sanding process. Once ridges 64 wear, abrasive particles 62 will continue to be released during use.

[0126] The above described abrasive loaded polymeric resin protrusions of FIG. 9 were prepared in the following manner. A mold pre-form was made in the following manner. Pre-form may be defined in this context to be “The original part from which a casting is made for the purpose of producing a mold.” A 4"x6" piece of flat glass was thoroughly cleaned and dried. To this surface were attached Vitreous Glass Mosaic Tiles (Landscape 1.82”, 1/8 L3 from Mosaic Merantile). The tiles were evenly spaced in eleven rows of seven having their widest side facing down against the glass surface. Two part five minute epoxy resin was then used to firmly attach the tiles to the glass surface. It should be noted that the tiles themselves were 0.4” square at the bottom tapered evenly to 0.325” square at the top, and had an overall thickness of 0.15”. The top surface had three ridges as shown in FIG. 9. Once hard, the epoxy was allowed to further cure overnight. A thin layer of vegetable oil was applied to the entire tile coated glass surface and the glass placed smooth side down in a 5"x7" polyethylene flat bottom container. One hundred and fifty grams of two part silicone RTV rubber molding compound (PD-1000-A) from Plastic Depot 2907 San Fernando BLVD Burbank, Calif. 91504 Tel: 818-843-3030) were mixed thoroughly in accordance with the enclosed instructions and carefully poured over the mold pre-form in the polyethylene container. The silicone rubber was allowed to cure at room temperature for twenty four hours. The mold was then removed from the polyethylene container and peeled off from its pre-form. The silicone mold was then thoroughly washed with a strong detergent to remove residual vegetable oil and subsequently allowed to dry.

[0127] Fifteen grams of West systems 105 epoxy resin were mixed with 3.0 grams of West systems 205 fast curing catalyst. The mixture was stirred thoroughly followed by the addition of 39 grams of 70 grit coarse aluminum oxide abrasive. The mixture was then stirred until completely uniform. Immediately after mixing the resultant abrasive paste was placed into the voids in the silicone mold. A flat edge was then dragged against the mold surface to level the resin mixture in the voids. The resin was allowed to cure for twenty four hours. Once cured, the abrasive protrusions were removed from the mold and inspected for quality. The best sixty samples were then ground flat on their largest side and attached to the front surface of a cotton glove using West systems 105 epoxy resin and 205 hardener. Unfortunately, the glove tended to absorb the low viscosity resin. The abrasive protrusions were then removed and wiped clean with a paper towel. The glove with the still wet adhesive was then stuffed with paper towels to prevent the resin from gluing the glove shut. The resin was allowed to harden somewhat. The paper towels in the glove were then removed and the resin on the glove allowed to thoroughly cure. Five minute epoxy was then applied to the widest side of each abrasive protrusion and the protrusions glued to the glove at the positions corresponding to the previously cured spots of resin on the glove. This approach worked exceptionally well with the resultant glove having sixty abrasive protrusions firmly attached to the required areas for hand sanding operations.

[0128] The above described glove was then tested against numerous surfaces including automotive paint on plastic, automotive paint on metal, aluminum, painted aluminum, and glass. This testing was carried out with and without water. The dry sanding produced numerous coarse scratches in the above mentioned surfaces while the wet sanding was more rapid and complete with more uniform fluer sanding.
It should be noted that this particular sanding glove rapidly wet sanded all of the above described surfaces by hand in a matter of seconds.

[0129] FIG. 12 shows an abrasive fabric glove having numerous discrete abrasive protrusions attached to major working surfaces in accordance with the present invention. Sanding glove 62 is shown having abrasive loaded polymeric resin protrusions 64 that are discontinuous from each other and attached to glove 66 with epoxy resin 68. Also shown are ridges 70 on protrusions 64. Ridges 70 on protrusions 64 provide points of high pressure and help to hold water during the first use. Protrusions 64 consist of polymeric resin portion 72 along with abrasive particle portion 74 thereby forming a mixture of hard abrasive particles dispersed within a softer epoxy resin material matrix.

[0130] FIG. 13 shows a sectional view of a low speed wet sanding disc for a rotary tool having a plurality of layers of surface protrusions comprised of hard abrasive particles dispersed within a softer material matrix. Abrasive particle releasing disc 76 is shown having abrasive releasing first major top surface portion 78 along with rigid backing portion 80 and central hole 82 for mounting to a shaft (not shown). Top abrasive releasing surface portion 78 is comprised of numerous protrusions 82 fixedly attached to rigid backing portion 80 forming a first layer 84. A second layer 86 of protrusions 88 are also shown. Protrusions 88 forming second layer 86 are shown fixedly attached to protrusions 82 of first layer 84. Protrusions 82 and 88 are comprised of hard abrasive particles dispersed within a softer material matrix. Protrusions 82 and 88 are shown in greater detail in FIGS. 4 and 5. Bottom surface portion 90 of rigid backing portion 80 may be regarded as a second major surface portion.

[0131] Multiple layers of abrasive protrusions may be formed by casting individual abrasive loaded pellets in a suitable mold followed by bonding them together using a suitable bonding agent. For example, a silicone mold may be used to cast spherical shaped abrasive loaded pellets. These pellets may then be coated with a thin layer of an uncured polymeric resin. The coated pellets may then be placed into a mold and pressed together until the resin hardens. The multilayer abrasive piece may then be removed from the mold and subsequently bonded to its intended surface. Alternatively, the surface for bonding to the multiple layers of abrasive loaded pellets may be placed into a suitable mold and the resin coated pellets poured directly onto the surface of the part and allowed to cure. The part with its attached abrasive surface may then be removed from the mold as a complete part.

[0132] FIG. 14 shows a sectional view of fabric material for low speed wet sanding and grinding having a plurality of layers of surface protrusions comprised of abrasive particles dispersed within a softer material matrix. Abrasive particle releasing fabric 92 is shown having abrasive releasing first major top surface portion 94 along with flexible water absorbent fabric portion 96. Top abrasive releasing surface portion 94 is comprised of numerous protrusions 98 fixedly attached to flexible water absorbent fabric portion 96 forming a first layer 100. A second layer 102 of protrusions 104 are also shown. Protrusions 104 forming second layer 102 are shown fixedly attached to protrusions 98 of first layer 100. Protrusions 98 and 104 are comprised of hard abrasive particles dispersed within a softer material matrix. Protrusions 98 and 104 are shown in greater detail in FIGS. 4 and 5. Bottom surface portion 106 of flexible water absorbent fabric portion 96 may be regarded as a second major surface portion.

[0133] The above descriptions of FIGS. 13 and 14 outline a plurality of layers. These may be formed by forming a first layer of abrasive containing protrusions followed by adhesion of a second layer on top of the first layer using a suitable adhesive material such as epoxy.

[0134] FIG. 15 shows a lapping surface of the present invention suitable for grinding surfaces flat having numerous cavities for holding water, and removal of debris. FIG. 15 shows a lapping block 108 consisting of top exposed abrasive particle lapping top surface portion 112 of lapping block 108. Exposed abrasive particle releasing lapping surface portion 112 is shown to be larger in area than side surface portion 110 and therefore may be considered a first major surface of lapping block 108. Lapping block 108 has a second major surface (not shown) oppositely facing first major surface 112. Lapping block 108 is shown having side surface portion 110 and flat abrasive particle releasing surface portion 112.

[0135] Lapping block 108 is suitable for lapping small articles flat. As with lapping block 14 of FIG. 3, the article may be glued to a holder and lapped in a circular motion by hand, or alternatively lapped at a relatively slow rate by machine. Some articles may also be held directly by hand and subsequently lapped flat. In many instances water in pure form or with special additives may be employed in the process. Generally speaking the lapping surfaces of this invention will retain water in surface cavities 114 of top surface portion 112 of lapping block 108. Employing water as a lubricant may also help to flush debris from the area being used. When finished, the lapping surface may be cleaned of residual debris with running water.

[0136] Abrasive particle releasing lapping surface portion 112 of lapping block 108 is shown having a relatively large percentage of the particle releasing surface 112 flat with a relatively small percentage of lapping surface 112 comprised of cavities. Particle releasing lapping surface 112 of lapping block 108 has a discontinuous surface topography due to the presence of surface cavities 114.

[0137] FIG. 16 shows a sectional view of an abrasive material for wet application comprised of hard abrasive particles embedded within a softer polymeric matrix material along with added hollow micro-particles in the form of hollow micro-spheres. Abrasive material 116 is shown in cross sectional view. Abrasive material 116 is shown having abrasive particles 118 embedded within polymeric matrix material 120. Abrasive particles may comprise a material selected from the group consisting of aluminum oxide, silicon carbide, zirconia, diamond, ceria, cubic boron nitride, garnet, ground glass, quartz, and combinations thereof. Also shown are hollow micro-spheres 122. Major surface 124 is shown having numerous cavities 126. Cavities 126 are also shown. Cavities 126 may result from wearing open hollow micro-spheres 122 during use. Alternatively, cavities 126 may be formed during manufacture by cutting or wearing of the surface prior to use. Cavities 126 are shown providing discontinuous surface topography to major surface 124.
Numerous materials including polyurethane and epoxy resins may be used for polymer matrix material 116. Of particular interest is the use of polyurethane condensation polymers having both rapid wear and hydrophilic properties. Polyurethane condensation polymers may be prepared having a slight excess of polyol reactant thereby providing reduced molecular weight as well as hydrophilic properties. Alternatively, one or more reactive hydrophilic polyol additives may be employed.

FIG. 17 shows a sectional view of abrasive foam material having a softened top surface resulting from exposure to water. Abrasive foam material 128 is shown having abrasive particles 130 distributed uniformly throughout softer polymer matrix portion 132. Abrasive particles 130 may comprise a material selected from the group consisting of aluminum oxide, silicon carbide, zirconia, diamond, ceria, cubic boron nitride, garnet, ground glass, quartz, and combinations thereof. Also shown are foam voids 134. Also shown is top major surface portion 136. Top major surface portion 136 is shown having a discontinuous surface topography resulting from the presence of numerous exposed foam voids 138. Top major surface portion 136 is shown having expanded outer layer portion 140. Expanded outer layer portion 140 results from the interaction of water with top major surface portion 136. Expanded outer layer portion 140 is shown having a limited thickness owing to the closed cell nature of abrasive foam material 128. Expanded outer layer portion 140 becomes the working surface during use. Expanded outer layer portion 140 may have unique cushion properties to abrasive particles released from the working surface during use.

Several formulations were used for making high foam density abrasive articles employing 8 pound per cubic foot density rigid closed cell polyurethane two component pour foam. The 8 pound per cubic foot rigid closed cell polyurethane pour foam used was from Silpack INC 470 East Bonita AVE., Pomona, Calif. 91767. Their telephone number is (909) 625-0056. The product name is 8/7 rigid foam SP-328-8. This product comes in two components. Component A and component B. They are formulated to combine into equal volumes. Component A has a density of 8.5 pounds per gallon. Component B has a density of 7.5 pounds per gallon. Blending these foam components into equal parts by weight results in an excess of component B (the poly hydroxyl functional component). This results in a final foam having significantly reduced molecular weight along with enhanced hydrophilic properties. When prepared in this manner, blended with abrasive materials, cured into a hard mass, and cut open. The resulting exposed abrasive surface will soften on exposure to water and cushion abrasive particles released during use.

The following formulations were used to make large hand Sanders.

100 grams of SP-328-8 A from Silpack were placed into a polypropylene plastic bowl. To this were added 183 grams of 220 grit silicon carbide abrasive from Lortone. A wooden tongue depressor was used to blend the abrasive and resin. 183 more grams of 220 grit silicon carbide were added to completely cover the surface of the mix. 100 grams of resin SP-328-8 B from Silpack were then carefully poured on top of the abrasive. This top layer of abrasive prevents the resins from mixing until vigorously stirred to break the layer. This provides some extra time to mix and pour before the foam starts to set. The contents of the plastic bowl were then rapidly blended together by mixing with the original tongue depressor. After about 45 seconds of mixing, the contents of the bowl were then poured into a silicone rubber mold to cast the part. After a few hours of room temperature cure, the part was removed from the mold. The working surface had a large excess of foam protruding outward. This foam was trimmed off with a saw to expose the active working abrasive surface. The experiment was repeated using 320 grit and 400 grit silicon carbide abrasive. The amount of abrasive for the finer grit values was reduced slightly. The following formulations were used. For the 320 grit sanding tool, 100 grams of resin A, 170 grams of 320 grit silicon carbide abrasive, another 170 grams of silicon carbide abrasive and 100 grams of resin B. For the 400 grit sanding tool, 100 grams of resin A, 160 grams of 400 grit silicon carbide abrasive, another 160 grams of 400 grit silicon carbide abrasive and 100 grams of resin B.

The three resulting tools were allowed to cure for an additional 48 hours. The exposed working surface of each tool was sanded with water and allowed to stand for several minutes. The wet working surface softened to a limited depth. The wet surfaces of the tools were then used to sand down numerous painted metal surfaces. The 220 grit hand sanding tool behaved like new 400 grit wet sand paper. The 320 grit hand sanding tool behaved like new 600 grit wet sand paper. The 400 grit hand sanding tool behaved like new 800 grit wet sand paper.

The above described tools were used for a significant period of time (about half an hour). During this time-frame the sanding remained consistent. Although there were abrasive particles released from the working surface of the tool, they were cushioned by the thin soft outer tool layer. No deep scratches were observed in the painted metal surfaces that had been sanded in this manner.

During use, abrasive particles were released from the working surface of the tool. These abrasive particles sanded down the paint while at the same time renewing the abrasive surface by sanding down the foam of the tool. This clearly indicates that this particular rigid polymeric closed cell foam composition is wearable at the major surface by the plurality of the abrasive particles released. This debris formed an abrasive paste with the wet surface. Some of this abrasive paste found its way into the surface irregularities of the tools thereby keeping abrasive particles active on the working surface. It should be noted that the abrasive particles released in free form facilitated in wearing away the major working surface of these tools. Additionally it should be noted that the release of abrasive particles from the major working surfaces of these tools creates additional voids. These additional voids further facilitated to wear away major working surfaces of these tools. The abrasive particles released in free form helped to further abrade the major working surfaces of these tools. Once the sanding operation was complete, the tools were rinsed off with water and allowed to dry.

FIG. 18 shows a sectional view of abrasive foam material having added water soluble particles that facilitates wear on exposure to water. Abrasive foam material 142 is shown having abrasive particles 144 distributed uniformly throughout softer polymer matrix portion 146. Also shown
are foam voids 150. Also shown is top major surface portion 152. Top major surface portion 152 is shown having a discontinuous surface topography resulting from the presence of numerous exposed foam voids 154. Also shown are water soluble particles 148. Water soluble particles 148 are shown distributed throughout softer polymer matrix portion 146. During use water soluble particles 148 become exposed to water and dissolve away thereby creating voids and helping to facilitate the break up of polymer matrix portion 146.

Numerous materials may be used for water soluble particles 148. Included in this list are sugar (both powdered and granular), dextrin, non-ionic, anionic, and cationic water soluble surfactants (surfactant materials may provide further benefits as well). It should be noted that compounds containing hydroxylic groups may interact with the isocyanate component of polyurethane resin systems.

FIG. 19 shows a foam abrasive article that may be used to wet sand non-porous surfaces. Foam abrasive article 156 is shown comprising a main portion 158 and a major surface working portion 160. Also shown is side groove 162. Side groove 162 provides an ergonomic fit to the hand for easier use. Foam abrasive article 156 may be composed of the rigid abrasive containing polymeric closed cell foam composition of FIG. 17 and may have added water soluble particles added as well to facilitate wearing away of major surface working portion 160. Foam abrasive article 156 is shown formed entirely from the foam abrasive material itself with no separate backing or handle required.

FIG. 20 shows an abrasive pad for wet scouring applications having 400 grit silicon carbide abrasive particles along with hollow polymeric micro-particles in the form of hollow micro-spheres embedded in a water softening polymeric matrix. Abrasive article wet scouring pad 164 is shown comprised of flexible cloth backing 166 along with major abrasive surface portion 168. Grooves 170 are shown in major surface portion 168 and help to provide flexibility as well as providing a discontinuous surface topography. Major abrasive surface portion 168 is made from the material shown in FIG. 16 and therefore has a discontinuous surface topography resulting from the presence of a plurality of cavities representing surface voids.

The above described abrasive scouring pad 164 was produced in the following manner. 17 grams of 341-A polyurethane resin from Plastic Depot (2907 San Fernando Blvd. Burbank, Calif. 91504. Telephone number (818) 843-3030) were mixed with 17 grams of 341-B polyurethane resin until uniform. To this mixture were rapidly added 63 grams of 400 grit silicon carbide along with 3 grams of West System 407 low density fairing filler. West systems INC. P.O. box 665. Bay City Mich. 48707 USA. Telephone number (866) 937-8797. The mixture was rapidly mixed until uniform and spread out onto a piece of 8"x10" denim cloth before the urethane resin mixture became too viscous to handle. The spread out area was then allowed to cure for one hour. Once cured, the rigid construction was rendered flexible by bending to form numerous cracks and grooves into the major abrasive surface portion of the abrasive article.

This scouring pad was then cut into 2"x2" pieces. One of these pieces was used to scour dirty dishes. This pad slowly wore out over a period of 60 days. After this timeframe, the pad was discarded.

FIG. 21 shows an abrasive composition suitable for wet sanding of rough skin from the feet. Composition 172 consists of rigid closed cell foam matrix material 174 having closed cell voids 176 along with medium grit abrasive particles 178. Medium grit abrasive particles 178 may have a grit value of particle size ranging from about 80 grit to about 400 grit.

Closed cell voids 176 are shown to be rather small in size indicating that a relatively dense closed cell foam material was used. A two component rigid closed cell polyurethane foam having a density ranging from about 8 pounds per cubic foot to about 20 pounds per cubic foot results in a relatively low wearing surface having small voids. Unlike traditional pumice stone foot stones, the smaller voids in the abrasive foot sanding composition of the present invention reduces the likelihood of holding particles of dead skin. Furthermore, the abrasive foot sanding foam material of the present invention tends to wear away during use thereby releasing trapped particles of dead skin and removing them from the working surface.

Additionally, the abrasive foot sanding foam material of the present invention may have additives to impart disinfectant properties, added scent, and added color. Possible disinfectants include Isothiazoline, powdered chlorine bleach (such as calcium hypochlorite), and Calcium Peroxide. Possible scents include rose oil, citrus oil, and the like.

The abrasive foot sanding foam material of the present invention may also be formed from a two component rigid closed cell polyurethane foam whereby the polyol reactant is used in excess to provide a hydrophilic surface that softens on exposure to water, and is free from residual isocyanate.

FIG. 22 shows a cross sectional view of a foot sanding tool of the present invention. Foot sanding tool 180 is shown having abrasive foot sanding foam composition 182 encased into rigid outer portion 184. Working surface 186 of foot sanding tool 180 is shown having voids 188 on top of working surface 186 of abrasive foot sanding foam composition 182. Rigid outer portion 184 of foot sanding tool 180 provides strength and utility to foot sanding tool 180.

FIG. 23 shows a foot sanding tool of the present invention. Foot sanding tool 190 is shown having abrasive foot sanding foam composition 192 attached to rigid outer portion 194 of foot sanding tool 190.

FIG. 24 shows a foot sanding tool having an abrasive surface shaped for sanding in between the toes of the feet. Foot sanding tool 196 is shown having abrasive foot sanding foam portion 198 attached to handle portion 200.Abrasive foot sanding form portion 198 of foot sanding tool 196 is shaped to go between the toes of the feet and remove dead skin.

FIG. 25 shows a cross sectional view of a compact foot sanding tool having a small cross section. Foot sanding tool 202 is shown having foot sanding foam composition 204 mounted into hard outer portion 206. Also shown is cover 208 in a partially open configuration. Hinge 210 provides a pivot point for cover 208 thereby allowing it to be opened and closed. Cover 208 of foot sanding tool 202 may be closed in order to protect foot sanding foam com-
position 204 from damage and to prevent foot sanding foam composition 204 from damaging other surfaces.

FIG. 26 shows a cross sectional view of a pumice foot sanding tool of the prior art. Pumice foot sanding tool 212 is shown having mineral portion 214 and voids 216. Pumice is a lightweight stone having a closed cell configuration of voids. Pumice stone has abrasive qualities due to sharp edges formed around these voids. While effective for foot sanding applications, the relatively large bubbles combined with its low wear rate tends toward the build up of dead skin. This build up of dead skin may provide a breeding ground for numerous microorganisms like bacteria and fungi. Salons that use pumice stone to grind away dead skin from the feet may use the same pumice stone on many clients thereby potentially providing a source of foot contamination.

FIG. 27 shows cross sectional view of a used pumice foot sanding tool of the prior art having entrapped pieces of dead skin on the surface. Used pumice foot sanding tool 218 is shown having top surface 220 having cavities 222 resulting from closed cell voids 224. Also shown are pieces of dead skin 226 trapped in cavities 222.

FIG. 28 shows a cross sectional view of a used foot sanding tool of the present invention. Used foot sanding tool 228 is shown having foot sanding foam composition 230 mounted into hard outer portion 232. Also shown is worn surface 234 along with tiny exposed cavities 236.

FIG. 29 shows a cross sectional view of an abrasive filled foam granule. Abrasive filled foam granule 238 is shown having hard abrasive particles dispersed throughout foam material matrix 244. Also shown are closed cell voids 242. Abrasive filled foam granules like abrasive filled foam granule 238 may be prepared by mixing abrasive materials with liquid resin polyurethane rigid closed cell foam forming materials, allowing the mass to foam and cure, and sanding the resulting abrasive foam to form it into a powder. Particle size may be adjusted by using various grit values of the sanding surface. Hydrophilic and/or other properties may be imparted to the abrasive foam granules by additives and/or modification of the polyurethane foam composition.

FIG. 30 shows a cross sectional view of an abrasive loaded soft hydrophilic granule. Abrasive loaded soft hydrophilic granule 246 is shown having numerous hard abrasive particles 248 dispersed throughout water softening hydrophilic polymer matrix portion 250. Numerous materials may be used as water softening hydrophilic polymer matrix portion 250. Materials that soften and swell with water but do not dissolve are well known in the art. Examples of water softening hydrophilic polymers include polyacrylamide gel, acrylic acid copolymers, and crosslinked polyvinyl alcohol.

FIG. 31 shows a cross sectional view of an abrasive loaded water soluble granule. Abrasive loaded water soluble granule 252 is shown having numerous hard abrasive particles 254 dispersed throughout water soluble matrix portion 256. Numerous water soluble materials may be used for matrix portion 256. Materials that dissolve in water are well known in the art. Examples of water soluble materials include sugar, acrylate acid and its water soluble salts, numerous grades of polyvinyl alcohol, and dextrin. Abrasive loaded water soluble granules may be used to release abrasive particles in free form on exposure to water. These granules may be useful in wet abrasive applications.

FIG. 32 shows an abrasive particle encapsulated with a water softening hydrophilic material. Encapsulated abrasive particle 258 may be considered to be a granule and is shown having abrasive particle 260 encapsulated by a water softening hydrophilic material 262.

FIG. 33 shows an abrasive particle encapsulated with a water soluble material. Encapsulated abrasive particle 264 may be considered to be a granule and is shown having abrasive particle 266 encapsulated by a water soluble material 268. Encapsulated abrasive water soluble granules may be used to release abrasive particles in free form on exposure to water. These granules may be useful in wet abrasive applications.

FIG. 34 shows a cross sectional view of an abrasive surface for wet application comprised of a substrate having numerous protrusions embedded with abrasive foam filled granules of FIG. 29. Abrasive protrusion 270 is shown having abrasive foam filled granules 272 embedded throughout matrix material 274. During use, abrasive foam filled granules 272 become exposed and provide abrasive properties in a controlled manner. In particular, foam filled granules 272 are of lower density and are softer than matrix material 274. This particular configuration may be employed to impart mild abrasive properties in wet applications.

FIG. 35 shows a cross sectional view of an abrasive surface for wet application comprised of a substrate having numerous protrusions embedded with abrasive filled granules of FIG. 34. Abrasive surface 276 is shown having numerous protrusions 278 embedded with abrasive foam filled granules as described in detail in accordance with FIG. 35. Numerous protrusions 278 are shown extending in an outward direction from substrate portion 280.

FIG. 36 shows a cross sectional view of an abrasive surface for wet application having multiple layers of protrusions embedded with abrasive filled granules of FIG. 34. Abrasive surface 282 is shown having multiple layers of protrusions 284 extending in an outward direction from substrate 286.

FIG. 37 shows a cross sectional view of an abrasive protrusion embedded with abrasive loaded water softening hydrophilic granules of FIG. 30. Abrasive protrusion 288 is shown having numerous abrasive loaded hydrophilic granules 290 embedded within a material matrix portion 292. The material matrix 292 is a harder material matrix than the material matrix within the granules. Abrasive loaded hydrophilic granules 290 are described in detail in FIG. 30.

FIG. 38 shows a cross sectional view of an abrasive surface for wet application comprised of a substrate having numerous protrusions embedded with abrasive loaded water softening hydrophilic granules of FIG. 37. Abrasive surface 294 is shown having numerous protrusions 296 extending in an outward direction from substrate 298. Numerous protrusions 296 are shown having numerous abrasive loaded hydrophilic granules embedded within a material matrix as shown in FIG. 37.

FIG. 39 shows a cross sectional view of an abrasive surface for wet application comprised of a substrate having multiple layers of protrusions embedded with abrasive loaded water softening hydrophilic granules of FIG. 37. Abrasive surface 300 is shown having multiple layers of protrusions 302 extending in an outward direction from substrate 304. Multiple layers of protrusions 302 are shown.
having numerous abrasive loaded hydrophilic granules embedded within a material matrix as shown in FIG. 37.

[0174] FIG. 40 shows a cross sectional view of an abrasive protrusion embedded with abrasive loaded water soluble granules of FIG. 31. Abrasive protrusion 306 is shown having numerous abrasive loaded water soluble granules 308 embedded within material matrix portion 310. Abrasive loaded water soluble particles 308 are described in detail in FIG. 31.

[0175] FIG. 41 shows a cross sectional view of an abrasive surface for wet application comprised of a substrate having numerous protrusions embedded with abrasive loaded water soluble granules of FIG. 40. Abrasive surface 312 is shown having numerous protrusions 314 extending in an outward direction from substrate 316. Numerous protrusions 314 are shown having numerous abrasive loaded water soluble granules embedded within a material matrix as shown in FIG. 40.

[0176] FIG. 42 shows a cross sectional view of an abrasive surface for wet application comprised of a substrate having multiple layers of protrusions of FIG. 40 embedded with abrasive loaded water soluble granules. Abrasive surface 318 is shown having multiple layers of protrusions 320 extending in an outward direction from substrate 322. Multiple layers of protrusions 320 are shown having numerous abrasive loaded water soluble granules embedded within a material matrix as shown in FIG. 40.

[0177] FIG. 43 shows a cross sectional view of an abrasive protrusion embedded with abrasive particles encapsulated with a water softening hydrophilic material of FIG. 32. Abrasive protrusion 324 is shown to be embedded with encapsulated abrasive particles 326. Also shown is material matrix portion 328.

[0178] FIG. 44 shows a cross sectional view of an abrasive surface for wet application comprised of a substrate having numerous protrusions embedded with abrasive particles encapsulated with a water softening hydrophilic material of FIG. 43. Abrasive surface 330 is shown having numerous protrusions 332 extending in an outward direction from substrate 334. Numerous protrusions 332 are shown having numerous abrasive particles encapsulated with a water softening hydrophilic material of FIG. 43.

[0179] FIG. 45 shows a cross sectional view of an abrasive surface for wet application comprised of a substrate having multiple layers of protrusions embedded with abrasive particles encapsulated with a water softening hydrophilic material of FIG. 43. Abrasive surface 336 is shown having multiple layers of protrusions 338 extending in an outward direction from substrate 340. Protrusions 338 are shown having numerous abrasive particles encapsulated with a water softening hydrophilic material of FIG. 43. These encapsulated abrasive particles may be considered to be granules.

[0180] FIG. 46 shows a cross sectional view of an abrasive protrusion embedded with abrasive particles encapsulated with a water soluble material of FIG. 33. Abrasive protrusion 342 is shown to be embedded with encapsulated abrasive particles 344. Encapsulated abrasive particles 344 may be considered to be granules. Also shown is material matrix portion 346.

[0181] FIG. 47 shows a cross sectional view of an abrasive surface for wet application comprised of a substrate having numerous protrusions embedded with abrasive particles encapsulated with a water soluble material of FIG. 46. Abrasive surface 348 is shown having numerous protrusions 350 extending in an outward direction from substrate 352. Numerous protrusions 350 are shown having numerous abrasive particles encapsulated with a water soluble material of FIG. 46. Encapsulated abrasive particles may be considered to be granules.

[0182] FIG. 48 shows a cross sectional view of an abrasive surface for wet application comprised of a substrate having multiple layers of protrusions embedded with abrasive particles encapsulated with a water soluble material of FIG. 46. These encapsulated particles may be considered to be granules. Abrasive surface 354 is shown having multiple layers of protrusions 356 extending in an outward direction from substrate 358. Protrusions 356 are shown having numerous abrasive particles encapsulated with a water soluble material of FIG. 46.

[0183] FIG. 49 shows a cross sectional view of an abrasive protrusion comprised of hard abrasive particles dispersed within a softer material matrix. Protrusion 360 is shown having hard abrasive particles 362 dispersed within a softer material matrix portion 364.

[0184] FIG. 50 shows a cross sectional view of an abrasive protrusion comprised of hard abrasive particles along with hollow micro-particles dispersed within a softer material matrix. Protrusion 366 is shown having abrasive particles 368 along with hollow micro-particles 370 dispersed throughout material matrix portion 372.

[0185] FIG. 51 shows a cross sectional view of an abrasive surface comprised of a substrate having multiple layers of protrusions loaded with abrasive particles of FIG. 49. Abrasive surface 374 is shown having abrasive loaded protrusions 376 arranged in multiple layers extending in an outward direction from substrate 378. Abrasive loaded protrusions 376 are shown in greater detail in FIG. 49. Depending on the application, abrasive surface 374 may be used wet or dry.

[0186] FIG. 52 shows a cross sectional view of an abrasive surface comprised of a substrate having multiple layers of protrusions comprised of hard abrasive particles along with hollow micro-particles dispersed within a softer material matrix of FIG. 50. Abrasive surface 380 is shown having abrasive loaded protrusions 382 comprised of hard abrasive particles along with hollow micro-particles dispersed within a softer material matrix arranged in multiple layers extending in an outward direction from substrate 384. Abrasive loaded protrusions 382 are shown in greater detail in FIG. 50. Depending on the application, abrasive surface 380 may be used wet or dry.

[0187] FIG. 53 shows a cross sectional view of a nail file having an abrasive surface comprised of the abrasive composition of FIG. 51. Nail file 386 is shown having abrasive surface 388 along with hard outer handle portion 390. Abrasive surface 390 is composed of multiple layers of abrasive loaded protrusions as shown in FIG. 51. Multiple layers of abrasive loaded protrusions offer the advantage of controlling the thickness of wearable abrasive compositions while at the same time controlling the size of spaces between adjacent protrusions. For example, small protrusions provide small spaces between them. If small protrusions are
used in a single layer a surface having a limited thickness results. Therefore multiple layers of abrasive loaded protrusions provide for simultaneous control in the size of spaces between adjacent protrusions and the overall thickness of the abrasive material. This may become especially important in abrasive compositions designed for relatively high rates of wear.

[0188] FIG. 54 shows a nail file having an abrasive surface comprised of the abrasive composition of FIG. 51. Nail file 392 is shown having abrasive surface 394 along with hard outer handle portion 396. Abrasive surface 396 is composed of multiple layers of abrasive loaded protrusions as shown in FIG. 51.

[0189] FIG. 55 shows a cross sectional view of a nail file having an abrasive surface comprised of the abrasive composition of FIG. 52. Nail file 398 is shown having abrasive surface 400 along with hard outer handle portion 402. Abrasive surface 400 is composed of multiple layers of abrasive loaded protrusions as shown in FIG. 52.

[0190] FIG. 56 shows a nail file having an abrasive surface comprised of the abrasive composition of FIG. 52. Nail file 404 is shown having abrasive surface 406 along with hard outer handle portion 408. Abrasive surface 406 is composed of multiple layers of abrasive loaded protrusions as shown in FIG. 52.

[0191] Those skilled in the art will understand that the preceding exemplary embodiments of the present invention provide foundation for numerous alternatives and modifications. These other modifications are also within the scope of the limiting technology of the present invention. Accordingly, the present invention is not limited to that precisely shown and described herein but only to that outlined in the appended claims.

What is claimed:

1. An abrasive article for dry sanding application comprising:
   a backing having a first major surface and a second major surface;
   a plurality of abrasive particle releasing protrusions attached to said backing to at least one said major surface, said plurality of particle releasing protrusions are comprised of abrasive particles dispersed within a softer material matrix and said particle releasing protrusions are formed into a plurality of layers.
   The abrasive article for dry sanding application of claim 1 wherein said protrusions are further comprised of hollow micro-particles.
   The abrasive article for dry sanding application of claim 2 wherein said hollow micro-particles are hollow microspheres.
   The abrasive article for dry sanding application of claim 1 wherein said backing is rigid.
   The abrasive article for dry sanding application of claim 1 wherein said backing is flexible.
   The abrasive article of claim 1 wherein said abrasive article is a nail file.
   An abrasive composition for sanding applications comprising:
   a plurality of abrasive loaded granules, comprised of an abrasive particle embedded within a softer material matrix;
   and a harder material matrix having a hardness greater than said softer material matrix wherein said plurality of abrasive loaded granules are embedded within said harder material matrix.

8. The abrasive composition of claim 7 wherein said abrasive loaded granules are comprised of a plurality of abrasive particles embedded within said softer material matrix.

9. The abrasive composition of claim 7 wherein said softer material matrix is hydrophilic.

10. The abrasive composition of claim 9 wherein said hydrophilic softer material matrix softens on exposure to water.

11. The abrasive composition of claim 9 wherein said hydrophilic softer material matrix expands on exposure to water.

12. The abrasive composition of claim 7 wherein said softer material matrix is a closed cell foam.

13. The abrasive composition of claim 7 wherein said softer material matrix is water soluble.

14. The abrasive composition of claim 13 further comprising a backing with at least one major surface, said major surface attached to a layer of said plurality of abrasive loaded granules embedded within said harder material matrix.

15. The abrasive composition of claim 13 further comprising a backing with at least one major surface, said major surface attached to a plurality of protrusions wherein said plurality of protrusions are comprised of said plurality of abrasive loaded granules embedded within said harder material matrix.

16. The abrasive composition of claim 15 wherein said plurality of protrusions are formed into a plurality of layers.

17. The abrasive composition of claim 7 further comprising a backing with at least one major surface, said major surface attached to a layer of said plurality of abrasive loaded granules embedded within said harder material matrix.

18. The abrasive composition of claim 7 further comprising a backing with at least one major surface, said major surface attached to a plurality of protrusions wherein said plurality of protrusions are comprised of said plurality of abrasive loaded granules embedded within said harder material matrix.

19. The abrasive composition of claim 18 wherein said plurality of protrusions are formed into a plurality of layers.

20. An abrasive article for body sanding application comprising:
   a rigid high-density polymeric closed cell foam substrate having at least one major surface, said at least one major surface having a discontinuous surface topography; and
   a plurality of abrasive particles dispersed within said rigid polymeric closed cell foam, wherein said rigid polymeric closed cell foam is wearable at said major surface by said plurality of abrasive particles.
21. The abrasive article of claim 20 wherein said rigid high-density polymeric closed cell foam is a polyurethane foam having a density from about 8 pounds per cubic foot to about 20 pounds per cubic foot, whereby voids within said rigid high-density polymeric closed cell foam have a reduced size relative to a lower density foam.

22. The abrasive article of claim 21 wherein said polyurethane foam is formed with an excess of hydroxy functional polyol reactant whereby said major surface is facilitated in softening upon exposure to water and said major surface is free from unreacted isocyanate.

23. The abrasive article of claim 20 further comprising of a disinfectant.

24. The abrasive article of claim 20 further comprising of a scent.