

- 1 -

SMEAR-FREE NONWOVEN COMPOSITE ABRASIVES

RELATED APPLICATION(S)

This application claims the benefit of U.S. Provisional Application No. 61/290,669, filed on December 29, 2009.

5 The entire teachings of the above application are incorporated herein by reference.

BACKGROUND OF THE INVENTION

Nonwoven composite abrasives commonly are employed to polish or finish a wide range of metallic surfaces. While suitable for polishing most metals, 10 conventional nonwoven abrasives have a tendency to leave a visible residue on the metal surface of high-temperature alloys, such as titanium-based alloys. This residue is typically known as "smear" and its presence is considered deleterious. The amount of smear present typically is directly proportional to the density of the nonwoven composite abrasive employed to polish the metal.

15 Smear has been identified as being composed primarily of polyurethane resin, often with trace amounts of nylon. Polyurethane resin is a common bonding adhesive used in nonwoven abrasives, while nylon is a fiber that is employed as a substrate for composite abrasives.

In order to reduce smearing, external lubricants, such as talc, kaolin, metallic 20 stearates (such as zinc stearate, calcium stearate or lithium stearate) and tetrafluoroethylene (such as in powder form) often are added to the polyurethane adhesive. The amount of these external lubricants, however, typically has a limited effect on reducing the presence of smear, and significantly reduces the product life of the nonwoven composite abrasive as a consequence of concomitant increased 25 product shed.

Therefore, a need exists to significantly reduce or eliminate the above-referenced problems associated with nonwoven composite abrasives.

SUMMARY OF THE INVENTION

The present invention generally is directed to a surface-treating article, a method of forming the surface-treating article, and to a method used to abrade a work piece.

5 In one embodiment, the invention is a surface-treating article that includes an organic matrix substantially engulfed by a binder. The binder includes a reaction product of a blocked polyurethane prepolymer and a mixture of aromatic amines. The aromatic amines contain polymethylene polyaniline having a functionality greater than 4.

10 In another embodiment, the invention is a method of forming a surface-treating article. The method of forming the article includes combining a blocked polyurethane prepolymer and a mixture of aromatic amines, wherein the aromatic amines contain polymethylene polyaniline having a functionality greater than 4 to thereby form a binder precursor. The binder precursor is combined with abrasive
15 particles and then cured to thereby form the surface-treating article.

 In another embodiment, a method of abrading a work piece includes applying to a work piece a surface-treating article that includes an organic matrix substantially engulfed by a binder formed from a reaction product of a blocked polyurethane prepolymer and a mixture of aromatic amines, wherein the aromatic
20 amines contain polymethylene polyaniline having a functionality greater than 4.

 The present invention has many advantages. For example, the surface-treating article of the invention is essentially smear free. Further, the surface-treating article provides a balance of cut rate and shed that significantly increases product life of the surface-treating article. The surface-treating article has improved
25 thermal resistance such that the end user does not encounter premature melting of the surface-treating article.

DETAILED DESCRIPTION OF THE INVENTION

 The features and details of the invention will now be more particularly described with reference to the accompanying drawings and pointed out in the
30 claims. It will be understood that the particular embodiments of the invention are

- 3 -

shown by way of illustration and not as limitations of the invention. The novel features of this invention can be employed in various embodiments without departing from the scope of the invention.

5 The invention generally is directed to a surface-treating article for use in polishing and finishing a wide range of metallic surfaces, such as surfaces of titanium-based alloys. The invention also is directed to methods of forming and methods of use of the surface-treating article of the invention.

10 In one embodiment, the invention is directed to a surface-treating article that includes an organic matrix substantially engulfed by a binder. The organic matrix components includes phenoxy resin, antioxidant, rheology modifier, plasticizer, and filler. The binder includes a reaction product of a blocked polyurethane prepolymer and a mixture of aromatic amines. Examples of suitable blocked polyurethane prepolymers include at least one member selected from the group consisting of toluene diisocyanate or methylene diisocyanate, poly butyl glycol ether or polyester
15 polyol, polycaprolactone, and methyl ethyl ketoxime.

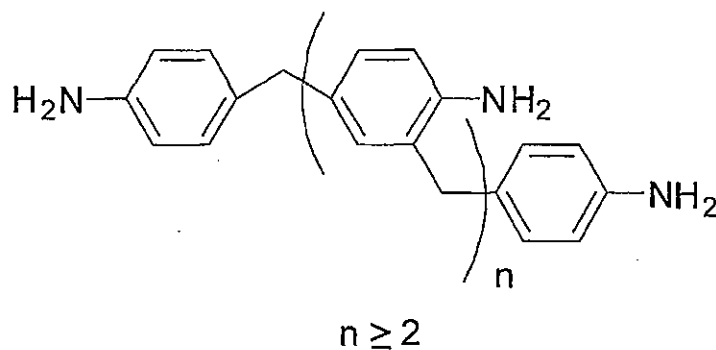
Suitable aromatic amines include those that are known to those of skill in the art of surface-treating articles. Examples of suitable aromatic amines include aromatic amines having a mixture of the following structural formula:



20 Methylenedianiline (MDA)

and

- 4 -



Polymethylene polyanilines

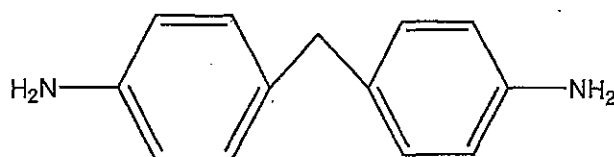
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When $n > 2$, the chemical compound is considered to have functionality greater than 4, as the chemical compound has more than four amino functional groups that will react with the polyurethane prepolymer. In one embodiment, n is greater than 2. In another embodiment, n can be greater than 3, 4, 5, 6, 7, 8, 9 or 10.

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Examples of suitable polymethylene polyanilines are those that are known to those of skill in the art of surface-treating articles, such as commercially available polymethylene polyanilines made by Air Products having the following structural formula:

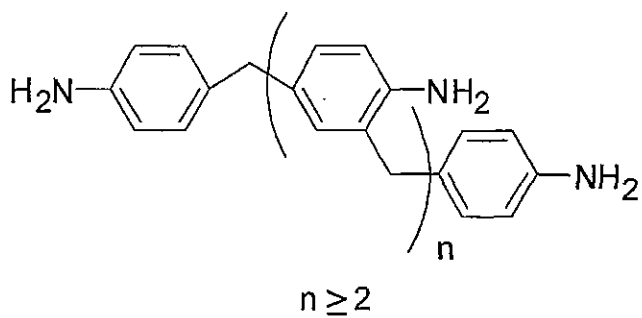
- 15 1. Ancamine DL-50 which is a mixture of 50%



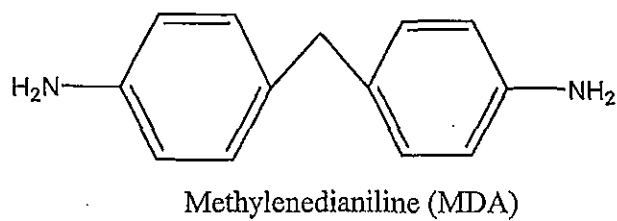
Methylenedianiline (MDA)

and 50% Polymethylene polyanilines

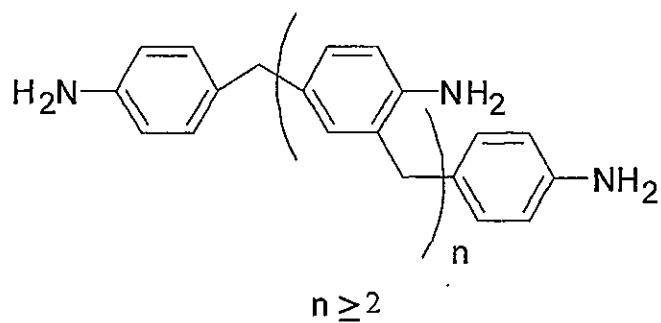
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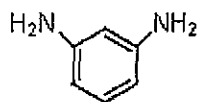
5 2. Ancamine 1482 which is a mixture of <36%



10 < 20% Polymethylene polyanilines



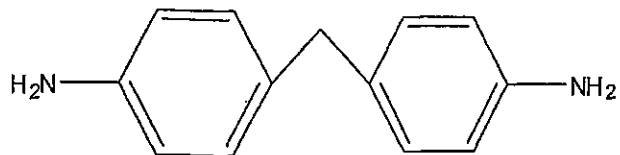
and 45% 1,3-phenylenediamine



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- 6 -

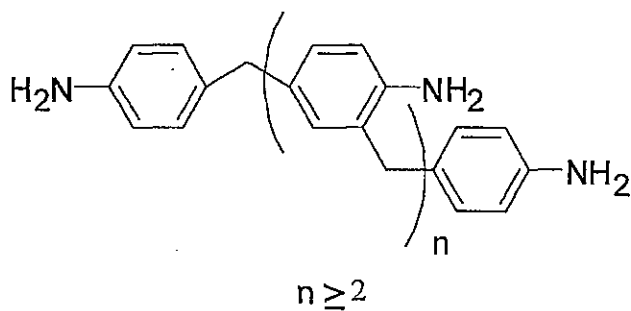
3. Ancamine Y which is a mixture of < 45%



Methylenedianiline (MDA)

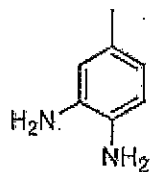
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< 30% Polymethylene polyanilines



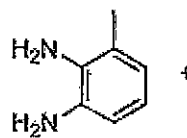
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<20% 3,4-diaminotoluene



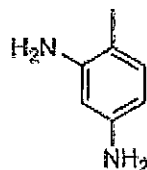
<15% 2,3-diaminotoluene

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<1% 2,4-diaminotoluene

- 7 -



In one embodiment the ratio of blocked polyurethane prepolymer to aromatic
5 amines is in a range of between about 6.5:1 and about 10.5:1. Preferably, the rate
ratio of blocked polyurethane prepolymer to aromatic amines is in a range of
between about 9.1:1 and about 10.1:1

Suitable components of the organic matrix are known to those of skill in the
art of surface-treating articles. Examples of suitable organic matrix components for
10 inclusion in surface-treating articles of the invention include phenoxy resin,
antioxidant, rheology modifier, and plasticizer. Typically, the ratio of organic matrix
to binder in a surface-treating article of the invention is in a range of between about
0.34:1 and about 0.43:1.

In one embodiment, this surface-treating article of the invention further
15 includes at least one lubricant. Examples of suitable lubricants include at least one
member of the group consisting of talc, kaolin, a metallic stearate and
tetrafluoroethylene (such as tetrafluoroethylene powder). Examples of suitable
metallic stearates include at least one member selected from the group consisting of
zinc stearate, calcium stearate and lithium stearate.

20 The amount of lubricant in the binder of the surface-treating article of the
invention generally is in a range of between about 7% and about 12% by weight of
the binder. More specifically, the range can be between about 10 % and about 11%.

In another embodiment, the invention is a method for forming a surface-
treating article. The method includes combining a blocked polyurethane prepolymer
25 and a mixture of aromatic amines, where the aromatic amines contain
polymethylene polyaniline having a functionality greater than 4, to thereby form the
binder precursor. The blocked polyurethane prepolymer and aromatic amines
suitable for use in the method are the same as those described above.

The aromatic amines come as mixture of pure MDA and polymethylene polyanilines. An industrial mixer equipped with high shear blade is used to prepare the mixture of the blocked polyurethane prepolymer and aromatic amines. The sequence of addition is shown in the formulation from top to bottom. The high shear
5 blade has a diameter of 16" and rotates at 150 – 200 RPM. Sufficient time is provided to ensure the final mixture is homogeneous.

The ratios of blocked polyurethane prepolymer and aromatic amines are in the range discussed above, as is the ratio of binder precursor to organic matrix.

The binder precursor is combined with the organic matrix by a suitable
10 method, such as by adding to the binder precursor in the sequence as shown in the formulation under agitation.

The binder precursor is combined with suitable abrasive particles to form a curable abrasive slurry. Examples of suitable particles include silicone carbide, alumina oxide, ceramic abrasives, abrasive agglomerates of grit size between ANSI
15 60 and ANSI800. The weight ratio of abrasive particles to binder precursor ranges from 1.5:1 to 2.5:1.

In another embodiment, the method is directed to an abraded work piece employing a surface-treating article as described above.

The surface-treating article can be a unitized abrasive wheel. In one
20 embodiment, the unified wheel discs is formed from non-woven abrasive sheets comprising a lofty fiber web bound by a polymer prebond followed by a curable abrasive slurry comprising a binder precursor and abrasive particles. The nonwoven abrasive sheets are stacked, unitized and cured under pressure at an elevated temperature, such as a temperature in a range of between about 90°C and about
25 130°C, to form a slab. Specific embodiments of elevated temperature include exposure to a temperature of 126.7°C for 2 hours, or 98.9°C for 15 hours. Unified wheel discs are then cut from the slab along with a centered hole for fitting onto the abrasive tool.

The surface-treating article can also be a convolute wheel. In one
30 embodiment, the convolute wheels are be formed from a non-woven abrasive sheet comprising a lofty fiber web bound by a polymer prebond followed by a curable

- 9 -

abrasive slurry comprising a binder precursor and abrasive particles. The sheet is attached to a hollow core and spirally wound around the core to form a rolled cylinder. The core is bound via curing at elevated temperature, as described above, and convolute discs are cut from the edge of the bound cylinder.

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EXEMPLIFICATION

Example 1

A non-woven substrate consist of crimped Nylon staples of 15 denier is prepared on an air-laid web formation line, such as that sold by DOA (Dr. Otto Angleitner, Ges.m.b.H. & Co.KG, Austria.), at the weight of about 124.4 gsm (grams per square meter). The non-woven substrate is sprayed with acrylic latex on both sides at a total dry weight of 44.4 gsm. The substrate is than passed through an oven to cure the acrylic binder for about 2.4 minutes at 290°F. The non-woven substrate is then cut into square sheets of 43.2 x 43.2 cm.

15 The binder precursor and abrasive slurry is prepared as described above and has a viscosity of 2,500 – 3,000 cps at 25°C. The solvent of MIBK can be used to adjust the abrasive slurry viscosity.

A two-roll coater is used to impregnate the non-woven substrate with the abrasive slurry by passing the square sheet through the coater nip. The coater nip pressure is adjusted thus the abrasive slurry application is about 197 gsm.

20 The coated sheets are stacked on top of each other in between two metal plates. The numbers of sheets is determined by the final product density. The stack is then placed in an oven at 126.7°C for 2 hours and 98.9°C for 15 hours to complete the curing of the binder precursor, thus forming a cured slab. The cured slab is then cut into unified wheel discs having a centered hole.

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Example 2

A non-woven substrate consist of crimped Nylon staples of defined denier is prepared on an air-laid web formation line such that sold by as DOA (Dr. Otto Angleitner, Ges.m.b.H. & Co.KG, Austria) at the defined weight. The non-woven

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- 10 -

substrate is sprayed with acrylic latex on both sides. The substrate is then passed through an oven to cure the acrylic binder for about 2.4 minutes at 290°F. The non-woven substrate is then rolled into jumbos of 100 yards in length approximately.

5 The non-woven substrate can be used directly to produce the convolute logs or can go to an additional process to become a pre-size before it is used for making convolute logs.

10 In the pre-size process, the non-woven substrate is impregnated with a binder precursor by dip and squeeze process in a two-roll coater. The impregnated substrate is then coated with grain in both sides using a gravity hopper. After the grain coat, a phenolic resin based spray coating is applied to secure the grain into the substrate. It is then passed through an oven to cure the polyurethane and phenolic resins for about 15 minutes at 300°F.

15 A two-roll coater is used to impregnate the non-woven substrate or pre-size with the polyurethane abrasive slurry by passing the non-woven or pre-size substrate through the coater nip. The coater nip pressure is adjusted to comply with the predefined abrasive slurry application for the specific material. The coated substrate is then wound spirally on the machine to form the convolute logs of various diameters and densities. The convolute log density can be varied by adjusting the amount of material wound into the log. The convolute is then placed in an oven at 20 126.7°C for 2 hours and 98.9°C for 15 hours to complete the cure of the binder precursor.

Smear Testing

Smear Test 1 Procedure

A disc of 7.62 cm in diameter is mounted on a portable air grinder that
5 rotates at 18,000 rpm, available from Dynabrade, model 52257. The surface speed
at the perimeter of the discs is 71.8 meters per second. A metal work piece of
Stainless Steel or Titanium of thickness between 0.1 and 0.25 inches are secured on
a workbench with a clamping device. The surface area of the work piece should be
large enough to allow for a grinding path of at least 7 inches in length. Prior to the
10 smear test the discs are conditioned by grinding approximately 60 seconds on the
work piece with a back and forth movement. The grinding force will be in the range
of 4 to 6 lbf, emulating normal hand grinding. Use a clean area on the metal work
piece, free from any smear residues left from previous test, and grind in one spot for
10 seconds. Make strokes of 3 to 5 inches in length with a slightly higher pressure
15 and fast moves right after the grinding starts. At least 5 strokes are performed in
different areas of the metal. Smear is reported if any residues of disc material are
transferred to the work piece in the form of a dark color material film.

Smear Test 2 Procedure

20 For discs of 15.24 cm in diameter a Baldor bench grinder is used, with the
disc rotating at 3,600 rpm. The surface speed at the perimeter of the discs is 28.7
meters per second. In this case the work piece is brought towards the rotating disc.
Similar to the Smear Test 1 procedure, the disc will be dressed by grinding a piece
of metal work piece for 60 seconds. A clean area in the work piece is selected and
25 grinded for 10 seconds in one area. Fast strokes of 3 to 5 inches in length are made,
with constant pressure after the smear test starts. At least 5 strokes are performed,
and smearing is then reported.

EQUIVALENTS

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

CLAIMS

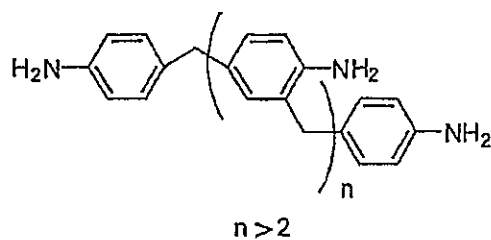
WHAT IS CLAIMED IS:

1. A surface-treating article comprising an organic matrix substantially engulfed by a binder, the binder including a reaction product of a blocked polyurethane prepolymer and a mixture of aromatic amines, wherein the aromatic amines include polymethylene polyanilines having a functionality equal to or greater than 4.

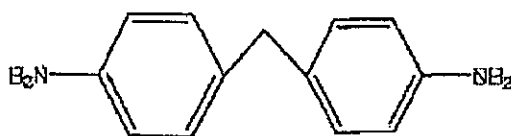
2. The surface-treating article of Claim 1, wherein the weight ratio of blocked polyurethane prepolymer to aromatic amines is in a range of between about 6.5:1 and about 10.5:1.

3. The surface-treating article of Claim 2, wherein the blocked polyurethane prepolymer includes at least one member of the group consisting of methyl ethyl ketoxime, toluene diisocyanate or methylene diisocyanate, poly butyl glycol ether, polyester polyol, or polycaprolactone.

4. The surface-treating article of Claim 3, wherein the polymethylene polyaniline includes at least one compound having the formula:



5. The surface-treating article of Claim 4, wherein the aromatic amine includes at least one compound selected from the formula:



6. The surface-treating article of Claim 5 wherein the surface-treating article includes at least one organic matrix selected from the group consisting of phenoxy resin, rheology modifier, plasticizer, and antioxidant.

7. The surface-treating article of Claim 6, further including at least one lubricant of the group consisting of talc, kaolin, a metallic stearate and tetrafluoroethylene powder.

8. The surface-treating article of Claim 7, wherein the metallic stearate is at least one member selected from the group consisting of zinc stearate, calcium stearate and lithium stearate.

9. The surface-treating article of Claim 8, wherein the amount of lubricant in the binder is in a range of between about 7% and about 10% by weight of the binder.

10. The surface-treating article of Claim 1, wherein the surface-treating article is a unitized abrasive wheel or a convolute wheel.

11. The surface-treating article of claim 10, wherein organic matrix of the surface-treating article includes non-woven abrasive sheets comprising a lofty fiber web bound by the binder.

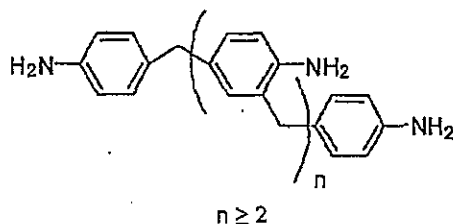
12. A method of forming a surface-treating article comprising the steps of:

- a) combining a blocked polyurethane prepolymer and a mixture of aromatic amines, wherein the aromatic amines include at least one polymethylene polyaniline, and at least one aromatic amine having functionality equal to or greater than 4, to thereby form a binder precursor;
- b) combining the binder precursor with an organic matrix;
- c) combining the binder precursor and organic matrix with abrasive particles; and
- d) curing the binder precursor to thereby form the surface-treating article.

13. The method of Claim 12, wherein the weight ratio of blocked polyurethane prepolymer to aromatic amines is in a range of between about 9:1 and about 10:1.

14. The method of Claim 13, wherein the blocked polyurethane prepolymer includes at least one member of the group consisting of methyl ethyl ketoxime, toluene diisocyanate and butyl glycol ether.

15. The method of Claim 14, wherein the polymethylene polyaniline includes at least one compound having the formula:



16. The method of Claim 15, wherein the aromatic amine includes at least one compound selected from the formula:



17. The method of Claim 16, further including at least one lubricant of the group consisting of talc, kaolin, a metallic stearate and tetrafluoroethylene.

18. The method of Claim 17, wherein the metallic stearate is at least one member selected from the group consisting of zinc stearate, calcium stearate and lithium stearate.

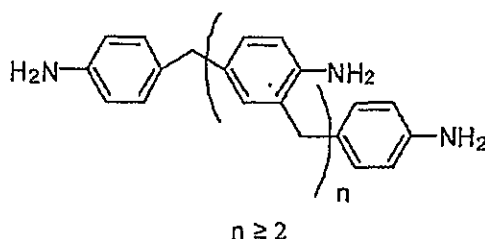
19. The method of Claim 18, wherein the amount of lubricant in the binder is in a range of between about 7% and about 10% by weight of the binder.

20. A method of abrading a workpiece, comprising the step of applying to the workpiece a surface-treating article that includes an organic matrix substantially engulfed by a binder formed from a reaction product of a blocked polyurethane prepolymer and a mixture of aromatic amines, wherein the aromatic amines include at least one polymethylene polyaniline, and at least one aromatic amine having a functionality equal to or greater than 4.

21. The method of Claim 20, wherein the weight ratio of blocked polyurethane prepolymer to aromatic amines is in a range of between about 9:1 and about 10:1.

22. The method of Claim 21, wherein the blocked polyurethane prepolymer includes at least one member of the group consisting of methyl ethyl ketoxime, toluene diisocyanate and butyl glycol ether.

23. The method of Claim 22, wherein the polymethylene polyaniline includes at least one compound having the formula:



24. The method of Claim 23, wherein the aromatic amine includes at least one compound selected from the formula:



25. The method of Claim 24, further including at least one lubricant of the group consisting of talc, kaolin, a metallic stearate and tetrafluoroethylene.

26. The method of Claim 25, wherein the metallic stearate is at least one member selected from the group consisting of zinc stearate, calcium stearate and lithium stearate.

27. The method of Claim 26, wherein the amount of lubricant in the binder is in a range of between about 7% and about 10% by weight of the binder.

28. The method of Claim 12, wherein the organic matrix includes one or more non-woven abrasive sheets comprising a lofty fiber web bound by the binder.

29. The method of claim 28, wherein the lofty fiber web of the abrasive sheets are bound by a polymer prebond followed by bonding with the binder, and wherein the nonwoven abrasive sheets are stacked, unitized and cured under pressure at a temperature in a range of between about 90°C and about 130°C, to form a slab, and wherein the slab is cut into unified wheel discs having a centered hole.

30. The method of claim 28, wherein the lofty fiber web of the abrasive sheet is bound by a polymer prebond followed by bonding with the binder, and wherein the abrasive sheet is attached to a hollow core and spirally wound around the core to form a rolled cylinder, and wherein the core is bound via curing at a temperature in a range of between about 90°C and about 130°C, and convolute discs are cut from an edge of the bound cylinder.