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BINDER OF AN EPOXY RESIN, POLYAMIDE RESIN AND POLYESTER FOR FIBROUS ABRASIVE ARTICLES

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FIG 1

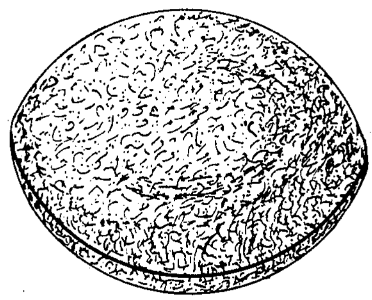
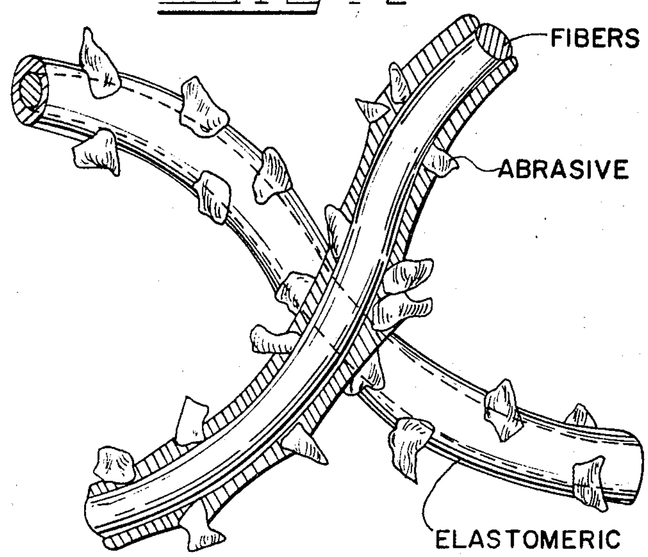


FIG 2



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BINDER OF AN EPOXY RESIN, POLYAMIDE RESIN AND POLYESTER FOR FIBROUS ABRASIVE ARTICLES

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ABSTRACT OF THE DISCLOSURE

Fibrous abrasive articles formed of a mass of non-woven fibers, preferably crimped or curled, the fibers being bonded at points where they cross and contact one another by means of a flexible binder which is a combination of an epoxy resin, polyamide and long chain polyester, the binder further serving to bond abrasive grain to the fibers.

This invention relates to an abrasive article and more particularly to fibrous abrasive articles and their method of manufacture.

Ever since the Stone Age when rocks and sand were used as abrasives, man has constantly sought new and better ways to polish and finish materials. In the thirteenth century, the Chinese ground sea shells and glued them to parchment with tree gums and this primitive tool was a forerunner of today's most commonly used polishing materials—coated abrasives.

Through the years various achievements have been made in the technology of coated abrasives—however, it is recognized that a highly technical refinement of the century's old process of gluing abrasive materials to a backing, just does not keep pace with the rapidly expanding finishing requirements of today's materials. Therefore, much research has been dircted to overcome the many factors that limit the life and performance of coated abrasives generally.

Although coated abrasives have been used for centuries, they have certain drawbacks which drastically limit their usefulness in industrial abrading and polishing techniques. For example, most coated abrasives do not readily conform to the surface being abraded or polished; especially whose surfaces with sharp or irregular contours. Moreover, the current method of grain coating limits the amount of total grain surface that can be utilized. With the grains imbedded in a continuous adhesive layer, only a portion of each grain is used before the sharp edges are worn away and the product must be discarded. Furthermore, loading and clogging further reduces product efficiency soon after the initial grinding and polishing techniques are started. Also, in some operations, excessive heat weakens the adhesive bond causing unused abrasive grains to shed and fall away.

From the above, it should be noted that the abrasive minerals themselves do not pose a problem. They can polish any surface, any material, to produce the desired result. The basic method by which they are held in place—the backing—prevents these abrasive minerals from doing their very best job. For years research has been working towards improving the abrasive carrier. Composition backings for improved flexibility and tougher and more heat-resistant resin bonds are but a few examples of these efforts. However, these advancements offer only a partial solution to the problem actually facing the coated abrasives industry.

Attempts have been made to overcome the problems associated with coated abrasives by utilizing fibrous webs, particularly nylon webs, which have abrasive grains

bonded thereto. The early fibrous webs which were impregnated with abrasive grains met with relatively little success, since there was a real difficulty in uniformly dispersing the grain throughout the web. Moreover, grain shedding was still a problem. The adhesives utilized in these prior products, principally the hard phenolic resins, did not always securely bond the abrasive mineral to the very fine fibers which are usually nylon, Dacron or animal fibers.

In the art of fibrous webbed abrasive structures, it has been generally recognized that the bonding of the abrasive mineral or grain to the fibers must be accomplished by the use of the harder, rigid resins such as the phenolic resins. It has been thought that such hard binder materials are necessary not only to adequately secure the grain to the fiber, but that substantial smearing would take place if anything but the resins were utilized. These harder, rigid resins do in fact reduce the tendency of the abrasive article to "smear" in use; however, the harder resins do have the very important drawback that they dramatically reduce the tensile strength of the fibrous webbed abrasive product. The softer rubbery-like resins or binder materials do increase the tensile strength of the abrasive article, but they do possess several drawbacks. First of all, the softer rubbery-like binders tend to smear in use and therefore abrasive articles using the softer binders when used, for example, in the polishing of stainless steel, are ordinarily used in conjunction with such lubricants as water and kerosene, which serve to cool and prevent heat build-up which would tend to further soften the binder and cause smearing. Moreover, tests have shown that these softer binders tend to break down when used in connection with hot detergent solutions.

A primary object, therefore, of this invention is to provide a fibrous abrasive article having increased tensile strength.

A further object of this invention is to provide a fibrous abrasive article in which the fibers are united at points of crossing and provided with a continuous resilient film which bonds abrasive particles to the fibers substantially throughout their length.

A further object is to provide in combination with a web of non-woven fibers interlaced randomly, a binder which unites abrasive grains to the fibers substantially throughout their length.

A still further object is to provide a fibrous abrasive article which will not smear and can be used in the absence of lubricants and is exceptionally resistant to the action of hot solutions of strong detergents and alkali.

Other specific objects and advantages will appear as this specification proceeds.

The invention is illustrated in one embodiment by the accompanying drawing in which:

FIG. 1 is a perspective view of an abrasive article embodying my invention; and FIG. 2, a greatly enlarged and part sectional view of a pair of fibers from the article shown in FIG. 1.

The articles shown in FIG. 1 is illustrative of many forms of abrasive articles which may utilize the present invention. The article illustrated is a pad or web formed in circular shape and consisting of a mass of relatively short fibers which are preferably crimped or curled and brought into interlaced non-woven relation, the fibers being united into an integrated pad by the use of a binder material at the points where the fibers are in crossing contact with each other. Bonded to the fibers also by the binder material are abrasive grains, as shown best in FIG. 2. The finished pad or web shown in FIG. 1 may be used as a floor scrubbing pad, manually or with machines, scouring pad, and for a variety of other purposes. Further, the web material may be formed and used with a backing as belts for the polishing and finishing of metals, wood, plastics, leather and the like.

The initial step in the forming of the abrasive article involves the formation of the open web in a layer of the desired thickness. This operation can be accomplished manually, but preferably is carried on mechanically on a garnett machine or other well-known fiber pad forming machine, such as, for example, a Curlator Rand-O-Webber. When using a garnett machine, it is preferred to use a Lapper (manufactured by Procter & Schwartz) in conjunction with the garnett machine to give additional randomness to the non-woven web. With such equipment, the length of the fibers employed should ordinarily be about ½ to 4 inches. We prefer to employ fibers of from 1½ to 2 inches. The fibers preferably should have a three-dimentional curvature impressed upon them by curling or crimping which may be accomplished by mechanical means or by chemical curling processes. The crimped or curled surface produces in the final product the necessary loft or openness of the web.

After the web has been formed as described above, we apply to the web a binder which will form a substantially continuous film along the fibers. Such a binder when sprayed or applied to the web of fibers is found to form a continuous film about the fibers, serving not only to unite the fibers, but to encase them throughout their length. This continuous film of binder about the fibers also provides the means for uniting the abrasive grain about and along the entire length of the fibers so as to form a protective armor or sheath about the fibers. Such abrasive materials may include all the well known or suitable abrasive materials such as for example, silicon carbide, aluminum oxide, garnett, flint, emery, and pumice in varying grit sizes. This protective armor or sheath about the fibers is especially important when natural fibers are used such as hog hair, cattle hair, horse hair and the like. Such natural fibers are not as tough as some of the synthetic fibers such as nylon and Dacron.

The binder and abrasive grains may be applied in a number of ways. In one method, a binder slurry can be formulated with a dispersion of the abrasive grain in the slurry. The slurry containing the grain can then be applied to the fibrous web, either by spraying, dipping, or roller coating. In another method, the grain and binder can be applied in separate operations, the grain being applied by gravity, rolling in, or by electrostatic deposition. If desired, a second coating or binder can be applied for better reinforcing, and this also may be accomplished by spraying, roller coating, or dipping. Thereafter, the binder and abrasive-coated fibrous web may be dried and cured at appropriate temperatures depending upon the nature of the binder material employed.

In another procedure, the non-woven fibrous web may be sprayed, dipped, or roller coated with binder on one side and abrasive material applied thereto by gravity or electrostatic methods, and the pad may then be turned over and the spraying or other means of application employed to finish the other side, and the abrasive grains then applied. If desired, a top size coat of binder may then be applied to both sides of the abrasive article.

After the non-woven fibrous web has been coated with binder and abrasive material, it may then be processed to cause the binder to bond the fibers together and to firmly unite the grain to the fibers. Temperatures employed in the curing process may be in the range of about 325 to 375° F. for a period up to about ten minutes, depending upon the binder material employed.

The binder employed in our invention can be identified as one having a Knoop hardness number of 6 or less, preferably having a Knoop hardness number of about 1 or 2 and even less. This binder is soft and flexible in nature and has sufficient plasticity to enable it to form the continuous film about the fibers, since it is desired that the film extend longitudinally of the fibers for supporting the abrasive particles along their length, particularly along the fiber portions which are open and extend between the joints or bonded cross portions of the fibers. This binder material is considerably softer than the binders heretofore used in fibrous abrasive products which are substantially hard and rigid. We have discovered that the deficiencies associated with the soft vulcanized rubber elastomers or the harder and more rigid resins may be overcome through the use of epoxy resins which have been chemically modified by certain polyesters and polyamides. Such binders, according to the Knoop hardness test are just as soft or even softer than the soft vulcanized rubber elastomers. These chemically modified epoxy resins when used as the binder material for our abrasive articles will not smear even when used, for example, in the polishing of stainless steel. In such an operation, no lubricants are required. Moreover, tests have shown that the tensile strength of a fibrous abrasive product prepared according to this invention using the modified epoxy resins as binders, has a tensile strength which is at least 50% greater than that obtained with the harder and more rigid binders. Moreover, the life expectancy of abrasive products using these binders is also far greater.

These modified epoxy resin binders can be described as the combination of an epoxy resin, polyester and polyamide.

The epoxy resins employed in the present invention are the reaction product of epichlorohydrin with a dihydric phenol. Because of its ready availability, bisphenol A [bis(4-hydroxyphenyl)dimethylmethane] is preferred. The reaction is carried out in the presence of a caustic such as sodium hydroxide with the epichlorohydrin being employed in excess. The epoxy resins suitable for use in this invention may be characterized as having an epoxide equivalent of from 170 to 200; a viscosity at 25° C. in centipoises of from 3,000 to 20,000; an average molecular weight of about twice the epoxide equivalent and are usually in a liquid condition at room temperature.

The polyamide component of the binder can be characterized as the condensation polymer of dimerized (and trimerized) vegetable oils, unsaturated fatty acids, and aryl or alkyl polyamines. The polyamides are amber colored thermoplastic resins with molecular weights ranging from about 3,000 to about 10,000 and melting points ranging up to about 190° C. The polyamides having lower molecular weights, up to about 6,000, and lower melting points are used in this binder. We also prefer to use the polyamides in which a higher amine such as DETA is used in preference to ethylenediamine. We also prefer to use the polyamides having higher amine values such as those having amine values ranging from about 290–450, with those polyamides having amine values ranging from 350–400 giving excellent results. The polyamides used can be further identified as having a viscosity (Gardner-Holdt) or from about 200–1,000 cps. at 25° C. Versamid 140 (available from General Mills) and D.E.H. 14 (available from Dow Chemical Co.) are two examples of polyamides which perform exceptionally well in the binder composition.

The polyamide component serves to cure the epoxy resin and to flexibilize the resin. Depending upon the amount of polyester, the weight ratio of polyamide to epoxy resin in the binder of this invention is ordinarily from about 0.5/1 to about 1/1.

The polyesters useful in the binder composition are the long chain polyesters having chain lengths of at least 14 members. The chains may be terminated either with carboxy or alcoholic hydroxyl groups depending on the ratio of reactants employed in the synthesis. Excellent results have been obtained with a polyester identified as PL–5 available from General Resin Corporation and comprising the reaction product of approximately 3 mols of phthalic acid, 7 mols of adipic acid and 12 mols of dipropylene glycol. The weight ratio of polyester to epoxy resin is about 0.25/1 to about 1/1.

In preparing the binder, the epoxy resin, polyamide and polyester are mixed together and thinned with a suitable solvent for ease in applying the binder to the fibrous web. The solvent is volatile; methylene chloride has proved to be an excellent solvent for this purpose.

Specific examples further illustrating and describing this invention are as follows:

Example I

Crimped nylon fibers of lengths of about 1½ inches (15 denier) were formed into a web on a Rand-O-Webber machine. The web weighed about 3.0–3.6 ounces and was ¼" thick. One side of the web was sprayed with about 15–20 ounces per square yard of a binder slurry and including abrasive grain, the binder having the following composition:

	Parts
Epi-Rez 510—An epoxy resin having a viscosity from 10,000 to 16,000 cps., a specific gravity of 1.15–1.17 at 25° C., an epoxide equivalent of from 185–200, being the reaction product of 2 mols of epichlorohydrin with 1 mol of bisphenol A and available from Jones Dabney	100
DEH-14—A polyamide curing agent and flexibilizer having an amine value of 350–400; a viscosity of 200–600 cps. at 75° C. (Gardner-Holdt) and available from Dow Chemical Company	100
PL-5—A completely polymerized long chain polyester being the reaction of approximately 3 mols of phthalic acid with 7 mols of adipic acid and 12 mols of dipropylene glycol. It has an acid value of 28–32 and is available from General Resin Corporation	75
Silicon carbide (No. 500 mesh)	310
Methylene chloride (solvent)	120

The above binder slurry penetrated approximately 75% of the web. Following spraying, the web was run through a forced air drying oven at 325° F. for approximately 5 minutes to set the binder. The partially coated web was then turned over and sprayer on the opposite side with the same formulation as set forth above, again in the amount of 15 to 20 ounces per square yard. The coated product was cured at about 375° F. for a period of approximately 7 minutes.

The cured binder material utilized in this Example III had a Knoop hardness number of approximately 0.67.

Example II

The abrasive article prepared in Example I was found to give extremely uniform abrasion and finishing. A series of tests were run to study the comparative wearing qualities of a floor stripping pad produced in accordance with Example I and a pad which is commercially available from the 3M Company under the trademark "Scotchbrite". For identification purposes, the pad produced in accordance with Example I was identified as Sample No. 1, the "Scotchbrite" pad was identified as Sample No. 2.

According to the test procedure, 5 strips (24 inches long x ¾ inches wide) of a safety walk material (available from the 3M Company) were positioned parallel, 9 inches apart, on an asphalt tile floor. A floor scrubbing machine was reciprocated across the safety walk strips, using water and a normal floor stripping detergent. The floor scrubbing machine was reciprocated across the safety walk strips for one minute intervals. At each one minute interval, the stripping pads were examined for wearing qualities. The test results were as follows.

Sample No. 1

Specimen:	Result
1.	Eight minutes, stripping pad exhibited slight tearing.
2.	Nine minutes, stripping pad exhibited slight tearing.
3.	Eleven minutes, stripping pad exhibited appreciable tearing.

Sample No. 2

Specimen:	Result
1.	Seven minutes, stripping pad exhibited appreciable tearing.
2.	Six minutes, stripping pad exhibited considerable tearing.
3.	Six minutes, stripping pad exhibited considerable tearing.

Example III

A series of tests were run to determine by comparative means the tensile strength of an abrasive pad prepared in accordance with the teachings of this invention and a pad commercially available from the 3M Company under the trademark "Scotchbrite". One (1) by five (5) inch samples were cut from an abrasive pad made according to Exhibit I and from a pad commercially from the 3M Company under the trademark "Scotchbrite". Each of the samples were placed in a Scott Tensile Tester operated at 11 feet per minute with no counterbalance weight. The tensile strength was measured across the width and length of the samples. The following results were obtained.

Sample:	Tensile strength, pounds
Article of Ex. I (width)	14–16
"Scotchbrite" (width)	8–10
Article of Ex. I (length)	17–23
"Scotchbrite" (length)	8–12

Example IV

The following polyesters may be substituted for the polyester PL-5 set forth in Ex. I:

(a)

	Mols
Propylene glycol	13.4
Phthalic anhydride	6.0
Adipic acid	3.0
Lauric acid	1.0

(b)

Propylene glycol	14.0
Glycerine	1.0
Iso-phthalic acid	3.0
Adipic acid	7.0

(c)

Ethylene glycol	10.0
Glycerine	3.0
Soya oil	1.0
Phthalic acid	8.0

While in the foregoing description specific details have been set out for the purpose of illustrating the embodiments of the invention, it will be understood that such details may be varied widely by those skilled in the art without departing from the spirit of our invention.

We claim:

1. An abrasive article having a web of non-woven fibers interlaced randomly and in crossing contact with each other and a resilient binder material bonding said fibers together at points where they cross and contact one another to form an integrated web, said binder comprising:

(a) an epoxy resin having an epoxide equivalent of from 170 to 200, and a viscosity at 25° C. in centipoises of from 3,000 to 20,000;

(b) a polyamide thermoplastic resin having a molecular weight of from 3,000 to 6,000, an amine value of from about 290 to 450, and a viscosity at 25° C. in centipoises of from 200 to 1,000, the weight ratio of said polyamide to said epoxy resin being about 0.5/1 to about 1/1; and

(c) a long chain saturated polyester having chain lengths of at least 14 members, said polyester comprising the reaction of a glycol selected from the group consisting of propylene glycol, dipropylene glycol, ethylene glycol, diethylene glycol and mixtures thereof with a reactant selected from the group consisting of phthalic acid, adipic acid, isophthalic acid, phthalic anhydride and mixtures thereof, and wherein the ratio of said polyester to said epoxy resin is about .25/1 to about 1/1;

and abrasive grains bonded to said fibers by means of said binder material.

2. The abrasive article of claim **1** wherein said resilient binder has a Knoop hardness value of 6 or less and wherein said binder forms a substantially continuous film about said fibers and bonding said fibers at points of crossing to form an integrated web.

3. The abrasive article of claim **1** wherein said resilient binder has a Knoop hardness value of less than 6 and comprises:

(a) an epoxy resin having an epoxide equivalent of from 185 to 200, and a viscosity at 25° C. in centipoises of from 10,000 to 16,000;

(b) a polyamide thermoplastic resin having a molecular weight of from 3,000 to 6,000, an amine value of from about 350 to 400, and a viscosity at 25° C. in centipoises of from 200 to 600, the weight ratio of said polyamide to said epoxy resin being about 0.5/1 to about 1/1; and

(c) a long chain saturated polyester having chain lengths of at least 14 members, said polyester comprising the reaction of a glycol selected from the group consisting of propylene glycol, dipropylene glycol, ethylene glycol, diethylene glycol and mixtures thereof with a reactant selected from the group consisting of phthalic acid, adipic acid, isophthalic acid, phthalic anhydride and mixtures thereof, and wherein the ratio of said polyester to said epoxy resin is about .75/1 to about 1/1.

4. The abrasive article of claim **3** wherein said fibers are nylon.

5. The abrasive article of claim **3** wherein said long chain polyester is the reaction product of about 3 moles of phthalic acid, 7 moles of adipic acid and 12 moles of dipropylene glycol and wherein the ratio of polyamide to epoxy resin is about 1/1 and the ratio of polyester to epoxy resin is about .75/1.

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