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ABRASIVE ARTICLE AND METHOD OF MAKING THE SAME

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My present invention relates in general to the treatment of material, preferably in sheet form, and more particularly the treatment of material for the purpose of forming or attaining composite structures, of which well known forms of abrasives such as what is commonly known as sand-paper is an example.

Although I hereinafter disclose the practice of my invention in connection with abrasives such as sand-paper, it will be understood that my invention, or certain features thereof, have a wider field of utility.

Composite structures of the abrasive type such as sand-paper or emery cloth comprises generally, (*a*) a base of sheet material, which may be felted as in the case of paper or woven as in the case of cloth, (*b*) a more or less finely comminuted resistent material having abraiding properties, such as flint, garnet or corundum, and (*c*) a binder or adhesive which serves to bond the abrasive to the base.

The binders or adhesives heretofore employed have been generally of one of two general classes, (*a*) animal glue, of (*b*) vegetable oils and gums or the like.

These two classes of materials are open to certain objections when used for abrasive articles for certain purposes, viz, animal glue is hygroscopic and therefore cannot be successfully used in a water-abrading operation, nor has it thus far been successfully waterproofed as far as known to me, vegetable oils and gums require more or less elaborate treatment to render them satisfactory when used as bases for binders that are stable when used in a water-abrading operation, and both animal glue and vegetable oils and gums are more or less variable in quality and require careful checking and manipulation in order to produce continuous runs of material of an even quality.

The present invention contemplates the provision of a new abrasive article and a new method of making the same wherein there is employed certain resinous material, more particularly synthetic resins, of which certain phenol-aldehyde derivatives such as phenol-formaldehyde condensation products are examples, which viewed from certain aspects present features of novelty, and which can readily be controlled within certain predetermined and desired limits so that abrasive articles closely answering definite specifications can be more readily produced.

In its preferred form, the invention further contemplates the use of chemicals of known and quite definite characteristics whereby I am enabled to attain not only predetermined results as a result of the employment of my improved procedure, but am also enabled to attain certain results that have not been readily if at all obtainable for my purposes or for any purposes by prior procedure known to me.

Again, by synthetizing my improved binder I am enabled to avoid various objectionable features, such as loss of time, needless expense, and other factors due to variability in quality incident to variation in methods of preparation and the presence of impurities in unknown quantities in the cases of animal and vegetable products.

The principal objects of my present invention are the provision of an abrasive article having a binder which functions efficiently; the provision of an abrasive article having a binder characterized by the desired degree of flexibility; the provision of an abrasive article having a binder characterized by extensibility and compressibility to accommodate itself to flexion of the base without permanent distortion or deleterious disintegration; the provision of an abrasive article having a binder characterized by great tensile strength and resistance to shearing stresses; the provision of an abrasive article having a binder which is resistant to certain solvents, such as gasoline, met in certain abrading operations; the provision of an abrasive article having a binder of such a character that it can be manufactured rapidly; and moreover one which has characteristics permitting handling of the product expeditiously and especially one which allows such handling without impairment of the superficies of the material; the provision of an abrasive article having a binder which is advantageous in this that deterioration with

age is minimized; the provision of an abrasive article having a binder rendering available certain water or oil abrading operations; the provision of an abrasive article having a binder embodying proportions of basic materials and of modifying agents of predetermined characteristics; the provision of an improved moisture proof abrasive structure; and the provision generally of an improved process for the production of an abrasive article characterized by one or more of the features which are among the objects of the present invention, together with such other objects and further and additional benefits and advantages as may hereinafter appear or be pointed out.

In the employment of my present invention for the production of sand-paper and the like (which I cite for purposes of example) I use as the base such a sheet of material (which may be paper) as will conveniently serve the employment contemplated, and as the abrasive such comminuted material (which may be flint, garnet or corundum, of the desired size) as is similarly adapted to perform the function in view.

It is most desirable that the binder utilized have the functions and characteristics not only of great mechanical strength including toughness, resistance to tensile and shearing strains, and of great binding strength including adhesiveness and tenacity, but also that it be non-hygroscopic, moisture resistent, easily worked, made of materials easily obtainable in the market, inexpensive, facilely worked and applied, of known quality when manufactured, and where used with a base which is penetrable, penetrative of such base so as to form a strong union therewith, and furthermore that it be as resistent as may be to the solvents ordinarily met with in abrading operations as commonly carried out.

I have discovered that resinous materials are preferable not only to gums (which are more or less water soluble) but also to gum-resins and to hardened oils for certain purposes contemplated by me, and particularly synthetic resins as peculiarly adapted for my ends for a number of reasons including that their characteristics can not only be better controlled than is the case with natural products, but that batches having the desired characteristics can be readily reduplicated. I have found that various aldehyde-phenol materials are available, but phenol-formaldehyde products of condensation is preferred by me as a major constituent of the binder, that is as best attaining the desired ends, viewed from certain aspects.

In preparing the binder for use, the resin is used directly in the early stages of reaction, or in connection with a suitable vehicle which I prefer is of such a type as a mixture of alcohol and benzol, for reasons which I will duly proceed to explain.

In applying a resin directly in the early stages of the reaction or prepared with a vehicle such as the stated mixture of alcohol and benzol to one surface of a base of paper, for example, there is involved a penetration of the base by the vehicle carrying along with it particles of the resin, to a point which approximates the opposite surface of the sheet, but preferably falls short of actual exudation of such vehicle and of resin particles to any excessive extent on such opposite surface.

This penetration by the vehicle, particularly when coupled with the use of the character of resin pointed out above results in a moisture proofing of the material against the destructive absorption of moisture through the surface opposite to that to which the binder is applied, and further results in a coating and binding action being secured between the fibres or threads of the base which substantially retards and for all practical purposes entirely prevents the deleterious disintegration of the base at least throughout substantially the effective abrading life of the abrasive article, in addition to preventing access of moisture through the base to the plane of contact between the base and the main mass of the binding material, thus preventing the formation of blisters and rupture of the bond between such main mass and the base which is deleterious even though the bond tenaciously cling to the abrasive particles.

The efficient action of the binder may be enhanced in the manufacture of sand-paper if applied to the base by the means of pressure.

Various degrees of flexibility can be imparted to the binder by the addition of various modifying agents, or combinations thereof or by breaking the binders at intervals after the fabrication of the article has been completed in certain cases.

The substances I have discovered to be particularly adapted to this purpose include glycerol, starch, dextrine, and sugar on the one hand, and various proteins, castor oil and shellac on the other hand.

Sand-paper made in accordance with the disclosure of my present invention is characterized by the desired degree of flexibility without adverse deleterious effects, great resistance to water and moisture generally, and to various other solvents employed in the arts, and a bond of great mechanical strength which is capable of sustaining the grit even in the case of the coarser grits where the strains are relatively high.

The amount of binder to be applied to the base varies according to several variable factors. Among these are (*a*) the thickness of the base, (*b*) the fineness or coarseness of the grit or layer of abrasive particles to be

applied to the base, and (*c*) the contemplated use of the abrasive article. The amount of the binder applied can be regulated conveniently by the application of the binder to the base by means of squeeze rollers spaced for applying a coating or binder of predetermined thickness.

I have found in practice that the number of coats of the binder may also beneficially be varied according to (*a*) the thickness of the base, (*b*) the size of the grit, (*c*) the contemplated use of the abrasive article, and (*d*) whether the grit be incorporated in the binder before application of the binder to the base, or whether the grit be applied to the binder after such binder has been applied to the base.

I have also discovered that my improved binder may be suitably modified to permit its beneficial use as an auxiliary coating for waterproofing one or both sides of the base, and for applying an auxiliary coating to the grit carrying surface of the abrasive article.

I have further discovered that my improved binder when so suitably modified for use as an auxiliary waterproofing coating may be applied to the surface of the base which is opposite to the grit carrying surface either before or after the application of the bonding coat thereto, or contemporaneously therewith.

I have further discovered that by preheating the abrasive material before applying it to the bonding coat or commingling it therewith, a better bond than is otherwise to be had is attainable. I have found temperatures beneficial for such purposes to range about 150° F. to 175° F.

I have further discovered that the flexibility of the resultant article may be somewhat varied by heat treatment after the application of the binder and grit.

I have further discovered that by carrying out my improved process I am enabled to utilize resinous material without being under the necessity of employing oils in connection therewith, as have been heretofore employed in processes known to me.

While I have had the best results by following out the process hereinafter set forth, I have found it at times convenient and that tolerable results are attainable by the employment of certain synthetic resins obtainable on the market, when dissolved with suitable solvents and otherwise suitably modified, but the results thus had have not within my experience been comparable with those attained when the process is carried out ab initio in the making of the improved abrasive article without retracting any part of the process.

In carrying out my invention, in order that the resinous material may be a known quantity and of known quality I prefer to synthetize a phenol-aldehyde derivative, which may be a phenol-formaldehyde or phenol-furfurol condensation product, suitably modified and manipulated. I also contemplate the use of naphthol and an aldehyde and anthracene and an aldehyde. The treatment to which I subject these elements results in a composition in certain respects possessing novelty.

In producing the desired binder I have employed a number of alternative methods, each of which appears to have certain favorable characteristics and advantages.

One method which has given very good results will now be described in some detail as—

Method No. 1

In this method I employ a mixture of—

1 part commercial phenol (C_6H_5OH).

1 part 40% commercial formaldehyde (CH_2O).

$\frac{1}{10}$ part zinc chloride ($ZnCl_2$).

This mixture is placed in a flask fitted with a reflex condenser. It is heated with a low flame or by an oil bath. The heating is continued at a slow boil until the first appearance of a line of demarcation between the resinous matter (bottom layer) and the water (top layer). To catch this point in the early stages it is necessary to stop boiling to take observations. It is essential that the reaction should be stopped in the early stages to secure the desired fluidity. If the chemicals employed are substantially pure, the resinous matter at this stage is white in color and of the consistency of soft pitch. When it is proposed to use this resinous matter as a primary bonding coat for sand-paper the temperature is preferably maintained at about 100° F. to 150° F. in order to keep the viscosity as low as practicable and as is desirable in order that the material may flow freely. It will thus be seen that I produce by the foregoing method, a new composition of matter having certain characteristics rendering it particularly useful as a waterproof stable bond for sandpaper and the like, these desirable characteristics not being possessed by the composition prior to my treatment thereof nor in its final stage without my treatment. It may now be applied to the backing or base of the abrasive article, in the customary manner, a set of squeeze rolls spaced apart a predetermined degree being employed to determine the thickness of the coating of binder applied to the base. It should be borne in mind that the point at which the reaction is stopped affects the viscosity of the binder and hence the amount applied to the base at a given spacing of the rolls. It is also to be recognized that the relatively coarser grits require a greater thickness of bonding coating than the relatively finer grits and, therefore, that it is desirable to use a more viscous and consequently heavier coating for the

coarser grits. In the case of the finer grits I find it expedient at times to employ a mixture Q. S. of alcohol (either CH_3OH or C_2H_5OH) and benzol (C_6H_6) or other solvents or mixtures such as acetone ($(CH_3)_2CO$) an amyl-acetate ($C_5H_{11}OCOCH_3$) for further reducing the viscosity of the resinous material.

If the grit has not been incorporated in the resinous material prior to the application thereof to the bases (as can be done especially in the case of the relatively finer grits) the grit is then applied to the base which has been coated with the resinous binder. In order to enhance the adhesion between the binder and the grit, the grit is preferably preheated to between 150° F. and 175° F. as hereinabove suggested.

In case the back of the base has not been theretofore waterproofed, or if the relative thickness of the paper renders it desirable to compensate for any starving of the bond between the binder and the base which might occur through the penetration of the binder into the base beyond a desired extent, or if the relatively larger size of the grit render such a step desirable in order to compensate for any deficiency in the bonding coat, an auxiliary coat or coats may now be applied, either to the back of the sheet opposite to the grit bearing surface or to such grit bearing surface, or to both.

The abrasive article thus produced is next cured by the application of heat which may conveniently be about 140° F. to 180° F. for a period of time, the duration of which depends on the degree of heat employed and the end point desired. I have used air heated to 165° F. for fifteen hours effectively. A certain degree of curing is necessary in order that the sheet of abrasive material may be insoluble to water. The final reaction may be further carried out by raising the temperature with consequent hardening of the article and increasing its resistance to solvents such as gasoline, alcohol, acetone, ethyl ether, etc.

A certain degree of flexibility is desirable. In the case of the relatively coarser grits, the degree of flexibility desired may be relatively little if any. In the case of the relatively finer grits a relatively high degree of flexibility may be desirable.

I have discovered in practice that the degree of flexibility may be varied somewhat by the heat treatment, that is the length and temperature thereof.

I have also found that especially in the case of the finer grits in order to gain in flexibility it may be desirable to add one or more of the modifying elements such as glycerol, etc., hereinabove mentioned, to the mixture first herein referred to under the caption "Method No. 1". The amount to be added is a matter depending upon certain variable factors, viz, the thickness of the bonding coat and the size of the grit, but the amount ranges too according to the particular modifying agent used. In the case of glycerol, for example, I have found that 20 parts by weight gives good results.

For the $ZnCl_2$ above referred to in connection with "Method No. 1", other catalytic agents may be substituted. Aluminum chloride ($AlCl_3$) and tartaric acid ($C_4H_6O_6$) are examples of these.

As an alternative to Method No. 1 (supra) I have also had good results with what I shall refer to as—

Method No. 2

In this method I employ a mixture of—
1 part phenol, (commercial).
1 part formaldehyde (commercial 40%).
1/20 part ammonia (NH_3 7%, H_2O 93%).
In this method I proceed as above outlined.

In both Method No. 1 and Method No. 2 the reaction is retarded in its early stages so that the resulting resin may be properly manipulated in the coating process. This is effected by discontinuing the heat, and, if necessary, washing the resinous material with water and partly neutralizing the catalyst employed, by suitable reagents which are well-known.

Where the washing is deemed to have removed a considerable portion of the formaldehyde, a small quantity of paraformaldehyde ($(CH_2O)_3$) may be added to the resinous mass before it is utilized. This addition of paraformaldehyde will evolve sufficient formaldehyde gas when subjected to final heating to carry the resinous mass to the end point desired.

Another alternative to Method No. 1 and Method No. 2 with which I have had comparable but less satisfactory results I shall refer to as

Method No. 3

In this method I employ a mixture of—
1 part of commercial synthetic resin, and of a well known and readily obtainable type known to the trade as bakelite resin "A"
1 to 3 parts dissolved in a solvent such as a combination of alcohol and benzol for the primary bonding coat, and
1 part of said commercial resin "A" and
2 to 4 parts of the solvent such as a mixture of alcohol and benzol for the auxiliary coats.

The alcohol and benzol mixture may be varied according to the conditions met in practice, but ordinarily I find that a mixture of equal parts of alcohol and benzol give quite satisfactory service.

I have discovered that in curing the product the best results are attained by controlling temperature between 140° F. and 180° F.

Having thus described my invention and illustrated its use what I claim as new and desire to secure by Letters Patent is:

1. The new article of manufacture, flexible

sandpaper, which includes a backing, a grit or layer of abrasive particles, and a bond for uniting the grit to the backing including a synthetic resinous condensation product which is solidified to a flexible and waterproof state.

2. The new article of manufacture in the nature of sandpaper, which includes a backing, a grit or layer of abrasive particles, and a bond interposed between the grit and said backing for uniting a grit thereto and including an oil modified synthetic resinous condensation product which is solidified to combine with said backing to form a flexible and waterproof article.

3. The new article of manufacture, flexible sandpaper, which includes a backing, a grit or layer of abrasive particles, and a bond for uniting the grit to the backing including a synthetic resinous condensation product which is solidified to a flexible and waterproof state by the application of heat thereto.

4. The new article of manufacture in the nature of sandpaper, which includes a backing, a grit or layer of abrasive particles, and a waterproof, stable adhesive bond for uniting the grit to the backing, said bond including a resinous condensation product of a phenol and aldehyde and a solvent therefor which serves as a vehicle therefor to penetrate the sheet and to solidify to a flexible and tenacious state rendering the article substantially insoluble in the presence of moisture and friction.

5. The new article of manufacture in the nature of sandpaper which includes a grit or layer of abrasive particles and a waterproof stable adhesive bond therefor including a resin which is flexible and insoluble in the presence of water and friction when solidified, the grit being in a heated state when joined with the adhesive bond to cause the latter to flow more intimately into contact with the particles of grit.

6. The process of forming a flexible waterproof abrasive article which comprises condensing an aldehyde and a phenol in the presence of a catalyst at low temperatures to produce an adhesive product, applying such products together with an abrasive grit to a suitable backing, and heating said product whereby to form an abrasive device which is flexible when solidified and insoluble in the presence of moisture and friction.

7. The process of forming a waterproof flexible abrasive article, which comprises applying to a suitable backing an adhesive coating including the initial reaction product of a phenol and an aldehyde in the presence of a catalyst, embedding an abrasive grit, or layer in said adhesive coating, and setting such adhesive whereby to form an abrasive device which is flexible when solidified and insoluble in the presence of moisture and friction.

8. The process of forming a waterproof flexible abrasive article, which comprises applying to a suitable backing an adhesive coating including the initial reaction product of a phenol and an aldehyde in the presence of a catalyst at temperatures between approximately 100° F. to 150° F. embedding an abrasive grit or layer in said adhesive coating, and setting such adhesive whereby to form an abrasive device which is flexible when solidified and insoluble in the presence of moisture and friction.

9. The process of forming a waterproof flexible abrasive article, which comprises forming an adhesive material including the initial reaction product of a phenol and an aldehyde in the presence of a catalyst, adding a solvent for such a product, applying the adhesive material to a backing to penetrate the same, separating the solvent therefrom, and embedding an abrasive grit or layer in said adhesive, and setting said adhesive whereby to form an abrasive device which is flexible when solidified and insoluble in the presence of moisture and friction.

10. The process of forming a waterproof flexible abrasive article, which comprises applying to a suitable backing an adhesive coating including the initial reaction product of a phenol and an aldehyde in the presence of a catalyst, heating an abrasive grit and applying the same while hot to said coating to cause an intimate association of said coating and said grit, and setting such adhesive whereby to produce an abrasive device which is flexible when solidified and insoluble in the presence of moisture and friction.

In testimony whereof I have hereunto signed my name.

RICHARD PAUL CARLTON.