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ABRASIVE BODIES AND METHODS OF MAKING SAME

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FIG. 1.

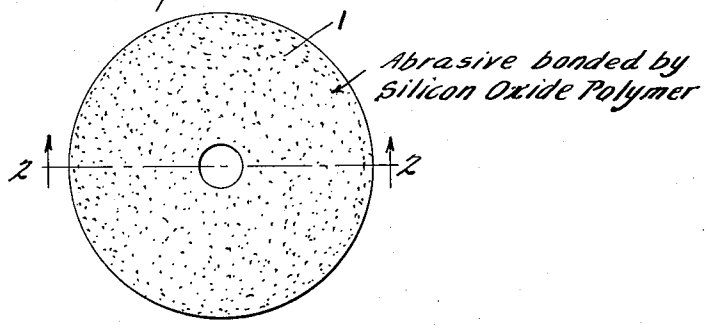


FIG. 2.

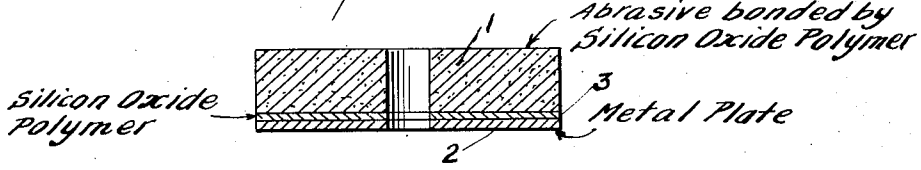
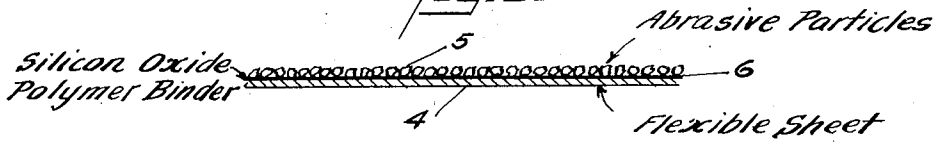


FIG. 3.



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ABRASIVE BODIES AND METHODS OF MAKING SAME

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10 Claims. (Cl. 51—298)

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This invention relates to abrasive bodies and methods of making the same and particularly to such abrasives which comprise abrasive grains bonded together into structures utilizable for abrasive purposes utilizing organo-silicon derivatives in the production of such bodies.

Abrasive bodies such as grinding wheels, stones, abrasive paper and cloth and flexible abrasive discs, have been made in the prior art with various types of binders and bonding agents. The characteristics of many of these prior art binders or bonding agents are unsatisfactory under some conditions in which it is desirable to utilize such abrasive bodies. The heat resistance of the binder, or the resistance of such binders to water, oil, or cooling fluids of various types used during wet grinding, have not been entirely satisfactory. Furthermore, with many of the prior art binders, there are limitations on control of the properties of the binders to suit them for utilization for these purposes.

Among the objects of the present invention is the production of abrasive bodies of any desired type, utilizing organo-silicon polymers or derivatives in the production of such abrasive bodies.

Further objects include the production of such bodies which shall have the desired properties including heat resistance, and resistance to cooling fluids utilized during drying operations making them eminently suitable for various grinding, abrading or polishing operations.

Still further objects and advantages will appear from the more detailed description set forth below, it being understood that this more detailed description is given by way of illustration and explanation only, and not by way of limitation, since various changes therein may be made by those skilled in the art without departing from the scope and spirit of the present invention.

In connection with that more detailed description, there is shown in the accompanying drawing, in

Figure 1, a front plan view of one form of grinding wheel; in

Figure 2, a section on the line 2—2 of Figure 1; and in

Figure 3, a section through a flexible sheet abrasive body produced in accordance with the present invention.

In accordance with the present invention, abrasive bodies are produced from any of the abrasive grains available by the utilization of organic silicon derivatives employed for the purpose of bonding such abrasive grains into a solid abrasive body of any desired form, or for bonding such abrasive grains to paper, textile, cloth, or other flexible sheet in the production of the flexible sheet type abrasives; or the organo-silicon derivatives may be utilized to coat the abrasive grains which are then bonded together by any of the desirable bonding agents available in the art or more desirably in accordance with the present invention by organic silicon polymers.

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The organic silicon derivatives which will be illustrated below, have markedly desirable properties for utilization in the production of abrasive bodies due to the fact that their properties can be controlled as desired to give characteristics of heat resistance, resistance to oils such as the hydrocarbon oils, kerosene, etc., resistance to caustic and other chemical action, resistance to water, etc. Furthermore, the properties of these organic silicon derivatives can be controlled to produce the desired degrees of flexibility, extensibility, compressibility, etc. to accommodate such materials when used as binders to flexion of the base on which the abrasive is carried, as for example, in the production of abrasive sheets. The organic silicon derivatives may be adjusted to withstand the high stresses and strains experienced in grinding operations as with grinding wheels and to prevent failures during wet grinding operations with such grinding wheels because of the action of cooling agents such as kerosene, oils or other hydrocarbons, etc. Furthermore, the organic silicon derivatives may be produced in any desired form from relatively mobile permanent liquids through flexible gel forms to hard brittle resins or hard flexible resinous materials. In their liquid form, or in solution, in solvents, they may be utilized for impregnation or wetting of the grains of abrasive followed by bonding of the grains either with other types of organic silicon derivatives or with other binders ordinarily employed in the production of abrasive bodies. They may thus be employed in monomeric form and subsequently converted into polymeric condition. These considerations exemplify the ready control of the properties of the organic silicon derivatives which lend them to utilization in the production of abrasive bodies.

Mixtures of organic silicon derivatives may be utilized in control of the properties of the desired bonding agents. Thus organic silicon derivatives convertible to a resilient state may be employed in combination with organic silicon derivatives that cure to hard resins in order to produce a blend of materials that cure to a bond of desired properties with the degree of resilience, hardness, etc. desired.

The solid abrasive bodies produced in accordance with this invention may be made from any type of abrasive grain desired, as for example, the varieties of alumina such as emery, corundum, dense fused alumina, porous white fused alumina, silicon carbide and other hard carbides, quartz, glass, diamonds, flint, garnet, Carborundum and in general both the natural abrasives and the artificial abrasive grains. The silicon containing abrasive grains such as Carborundum or other silicon carbides, flint, quartz, etc. are particularly useful with the organic silicon binders of the present invention. Further the binders of this invention are peculiarly adapted for utilization in the bonding of diamond grains since silicon derivatives may be produced which cure or harden at relatively low temperatures that preclude any disadvantageous effect due to oxidation of the diamond grains at higher temperatures. But whether utilized for binders with the relatively soft abrasives such as the siliceous abrasives, sandstones, quartz, tripoli, pumice and volcanic dusts, or the relatively hard abrasives such as corundum, diamond, garnet, silicon carbide, fused alumina, and other such hard abrasives commonly referred to as grits, the organic silicon derivatives are peculiarly adapted for utilization in the production of these abrasive bodies.

Any desirable methods for producing the solid bodies from the desired abrasive grains and chosen organic silicon derivatives may be employed. Thus in the production of grinding wheels or grinding stones, the abrasive grains may be mixed with a liquid organic silicon derivative or a solution of an organic silicon derivative in a desired solvent, the organic silicon derivative being one which is convertible as by heat or other treatment into a resinous polymeric derivative, and the mix then molded to the desired form including any desired metal top plate if this type of wheel is to be produced, the molding being done under pressure in the cold as by means of a hydraulic press, the mold then stripped and the green wheel baked in an oven for example, to produce the conversion of the silicon derivative into the resinous binder. Or if desired, the abrasive grains mixed with the polymerizable silicon derivative may be subjected directly to a hot pressing operation to produce the molded article. Or the abrasive grains may be wet with a non-polymerizable organic silicon derivative and the mix then incorporated with any desired binder preferably, however, an organic silicon derivative convertible into a resinous polymer, molded and heat treated or hot pressed directly by the methods set forth above.

Where the ultimate binding agent is not an organic silicon derivative, but is shellac, methacrylate or other resin, chloroprene, or other rubber whether synthetic or natural, etc., advantage is taken of the properties of the organic silicon derivatives in producing superior articles when so utilized. More desirably, however, the grains coated with the organic silicon derivative that need not necessarily be a polymerizable material, are bonded by resinous organic silicon polymers in accordance with the present invention.

Thus a wheel as shown in Figure 1 may be produced having a bonded abrasive portion 1, consisting of abrasive grains bonded by an organic silicon polymer in accordance with the present invention which may be utilized as such, or may include a metallic backing plate 2 to secure it to the abrasive body portion 1 by any desired adhesive layer 3, which adhesive layer may desirably be any satisfactory binder employed in the art for this purpose but more desirably in accordance with the present invention is a flexible organic silicon polymer.

The amount of binder employed will depend on the characteristics of the ultimate molded body desired and may, for example, vary from 25% to 75% of the final molded article although for most purposes, an amount of organic silicon derivative which will give a final product containing from 25 to 40% of organic silicon polymer to 75% to 60% of abrasive grains will be satisfactory for most purposes. The proportions employed depend on the characteristics of the particular organic silicon derivative utilized and the physical properties desired particularly from the standpoint of rigidity and elasticity, etc.

As a specific example of producing a molded grinding wheel, fused alumina grit was mixed with alkyl silicon hydroxides containing both methyl and butyl silicon hydroxides and molded 5 minutes at 175° C. under 5000 pounds per square inch pressure. The pressures employed may be varied and curing may be carried out even at atmospheric pressures, although pressures of several thousand pounds per square inch are preferred. So too the curing temperature employed may be varied and temperatures of for example from 100° C. or higher may be utilized.

In the production of abrasive paper and cloth or flexible abrasive discs, the desired sheet or backing may be first coated with the desired silicon derivative, abrasive grains distributed upon the liquid coated web in any conventional manner, and the abrasive coated web then subjected to heat treatment or any other treatment to convert the organic silicon derivative into the resinous polymer. If desired, a second coat of adhesives such as of an organic silicon derivative may be applied over the abrasive grains. The organic silicon derivatives utilized for this purpose may be liquid silicon derivatives which are convertible by heat or other treatment into resinous polymers, or the abrasive grains may first be coated with a non-polymerizable organic silicon derivative and applied to the flexible sheet material which has been treated with the polymerizable organic silicon derivative and subsequently subjected to treatment to produce the resinous polymer.

An article which may be produced in this way is illustrated in Figure 3 where the flexible sheet or backing 4 carries the abrasive particles 5, adherent to the sheet 4 by the organic silicon polymer 6.

The following example will illustrate the production of flexible abrasive sheets. A mixture of ethyl and butyl silicon hydroxides was dissolved in toluene and applied as a coating to paper, using an amount of coating to give about 2.5 pounds of silicon derivative per ream of paper sheets 9 x 11 inches. Fused alumina particles were electrostatically projected onto the adhesive coating and the coating dried sufficiently to set the grains firmly in position. A second application of the solution of organic silicon derivative was applied, and the abrasive coated paper dried to remove the solvent and finally heat treated first at 105° C. and then at 175° C. to produce a resinous polymer binding the grains to the flexible sheet.

The organic silicon derivatives of the present invention may be utilized either by themselves or in combination with other natural or synthetic

resins including phenol aldehyde resins, aniline aldehyde resins, acetone formaldehyde resins, alkyd resins, cumarone resins, vinyl resins, styrene resins, acrylate resins including polymeric esters of acrylic and methacrylic acids, diallyl maleate, allyl esters of polybasic acids, and the like.

Among solvents that may be utilized in connection with the organic silicon derivatives are included hydrocarbon solvents such as aliphatic and aromatic compounds, namely, hexane, benzene, toluene, etc.; ethers such as dimethyl, diethyl, diisopropyl, dibutyl ethers or mixed ethers; esters such as ethyl, butyl or amyl acetates; alcohols, etc. The alcoholic solvents include both the aliphatic alcohols such as methanol, propanol, butanol, phenols such as phenol, cycloaromatic or alicyclic alcohols such as cyclohexanol, and the like; glycol ethers such as ethylene glycol mono-n-butyl ether, ketones such as acetone, methyl isopropyl ketone, etc. Where the stated solvents are not sufficient to produce the desired solution, mixtures of solvents may be employed.

The following will illustrate various organic silicon derivatives that may be utilized in producing the abrasive bodies as set forth above. Thus the organic silicon hydroxides and more particularly the alkyl silicon hydroxides and aryl silicon hydroxides may be used individually or in various mixtures as the bonding material. Examples of the production of such products will be set forth below. Mixtures of the alkyl silicon hydroxides and particularly silicon hydroxides containing different alkyl groups in the same molecule may be employed since by the utilization of mixed alkyl derivatives it is possible to modify the properties of a given alkyl silicon oxide resin in a desired direction to enhance its utility for particular purposes. Lower derivatives like the methyl derivatives produce hard brittle products while higher derivatives such as the butyl derivatives give products of increased flexibility. Thus mixed methyl-butyl silicon hydroxides may be employed in order to control the properties as desired or cetyl derivatives may be incorporated with the methyl derivatives to bring about an internal plasticization. Thus the control of flexibility or plasticity of any given alkyl derivative may be obtained by the presence of a different alkyl derivative enhancing the particular property desired. The use of alkyl derivatives containing at least three carbon atoms in the alkyl group is particularly important in thus modifying the desired characteristics of the compounds.

The alkyl silicon hydroxides may be produced either alone or in mixture by the use of corresponding alkyl magnesium halides reacted with silicon tetrachloride, followed by hydrolysis and dehydration. Or the alkyl silicon hydroxides may be prepared separately and then mixed in the desired proportions before dehydration.

The following example illustrates the production of a mixed methyl butyl derivative.

Example 1.—61.5 parts of methyl iodide was reacted in ether solution with 9.72 parts of magnesium. This solution was added gradually with rapid stirring to 45.3 parts of silicon tetrachloride in ether solution, and then refluxed 1½ hours. It was then hydrolyzed by pouring on ice and was washed repeatedly with water to free it from hydrochloric acid and magnesium salts. Most of the ether was evaporated at about 40 to 45° C. to give a concentrated material. 45.2 parts of normal butyl bromide was reacted in ether solution with 7.29 parts of magnesium. The solution was added to 51 parts of silicon tetrachloride, and then refluxed, hydrolyzed, washed and concentrated to a syrup containing butyl silicon hydroxides. Mixtures of the above methyl and butyl silicon hydroxides in various proportions were produced and the several mixtures gradually heated to 160° C. and kept at that temperature for 20 hours. The materials high in butyl cured to hard, brittle resins, while those high in methyl were somewhat rubbery.

Example 2.—16.6 parts of normal amyl bromide was mixed with 15.6 parts of methyl iodide and reacted in ether solution with 4.86 parts of magnesium. This solution was added slowly with stirring to 30.9 parts of silicon tetrachloride in ether solution. It was then refluxed 2 hours, hydrolyzed, washed, and concentrated as in the preceding example. The temperature was raised gradually to 105° C. and kept there 15 hours. It changed to a hard, brittle resin.

Example 3.—15.1 parts of normal butyl bromide was mixed with 12 parts of ethyl bromide and reacted in ether solution with 4.86 parts of magnesium. This solution was added slowly with stirring to 30.9 parts of silicon tetrachloride in ether solution. It was then refluxed 2 hours, hydrolyzed, washed and concentrated as in Example 3. It was heated gradually to 105° C. and kept there 15 hours and then heated at 175° C. for 14 hours. The material cured to a rubbery resin.

The mixed-alkyl combinations thus produced may include different alkyl groups attached to the same silicon atom, or mixtures of different alkyl silicon oxide derivatives, or both. These novel silicons have thermal stability greater than the usual coating and bonding agents. They may be applied by dissolving them in appropriate solvents as set forth above and while they are in soluble form, and may then be polymerized in situ. As pointed out, the hard brittle polymers may be plasticized by the addition of suitable plasticizing agents or by silicon oxide resins of lower softening point.

The relative ratios of the alkyl groups to each other and to the silicon atom in these compounds may vary. In the production of curable combinations, the average of alkyl groups per silicon atom should desirably be between the limits of 0.5 to 2.0 alkyl groups per silicon atom and where curing is desired, the particular proportions selected particularly with respect to different alkyl groups in the mixed-alkyl silicon derivatives should be chosen to produce the desired properties as set forth herein.

The above examples illustrate the production of mixed-alkyl silicon hydroxides and their utilization in the production of resins and these materials either individual alkyl silicon hydroxides or mixed hydroxides prepared in the manner set forth above may be used as bonding agents in the production of solid abrasive bodies as set forth above. However, a wide variety of other types of silicon derivatives may be utilized. Thus copolymerization products may be produced from a silica derivative, reacted with an organic substituted silicon derivative, so that copolymerization products are produced in which relatively inexpensive materials such as esters of orthosilicic acid, or an acyl silicon may be utilized in the production of stable, coherent resinous products having high heat stability, good color and chemical resistance. Generally the reaction products of this type may be produced from a silica deriva-

tive selected from the group consisting of organic orthosilicates, silicon tetro-acylates, and silicon halides, with an organic substituted silicon derivative selected from the group consisting of organic orthosiliconates, organic silicon hydroxides, organic silicon acylates, and organic silicon halides, the organic groups in such stated compounds desirably being selected from aliphatic and carbocyclic radicals. The organic silicon derivatives may carry substituent groups therefor, such as alkyl, alphyl, aryl, alkynyl, alkenyl, aralkyl, alkanyl, olefinyl, non-aromatic carbocyclic, and the like, and one or more of such groups may be present in mixed derivatives utilized in producing products in accordance with these derivatives. The reactants may be monosilicon derivatives, or polysilicon derivatives, such as silicon tetrachloride, disilicon hexa-acetate, disilicon hexa-chloride, hexa ethyl disiliconate and the like. The silica derivatives may be esters such as methyl orthosilicate, ethyl orthosilicate, butyl orthosilicate, phenyl orthosilicate and the like, or acylates such as silicon tetraformate, silicon tetroacetate, silicon tetrabutyrate, and the like.

Thus mixtures of alkyl silicon chlorides and silicon tetrachloride may be hydrolyzed to produce cohydrolytic products which may be dehydrated to a clear resin. Or mixtures such as alkyl alkoxy silicon and ethyl orthosilicate may be hydrolyzed together and subsequently heated to give clear hard resins.

The following examples will illustrate the production of different types of such derivatives.

Example 4.—One mole of ethyl orthosilicate and 2 moles of water were mixed together and sufficient alcohol added to give a clear solution. The solution was refluxed for 3 hours. A somewhat viscous product containing some silica was produced. This was mixed in equal volume proportions with n-butyl silicon trihydroxide. Such solutions and mixtures may be utilized in producing the solid abrasive bodies in accordance with the present invention. The stated derivative of this example when heated to 140° C. gives a hard, clear resin.

Example 5.—2 parts of an alkyl silicon hydroxide, made from 0.5 mole ethyl bromide, 0.75 mole n-butyl bromide and 1 mole of silicon tetrachloride followed by hydrolysis, were mixed with 1 part of ethyl orthosilicate and 3 parts of acetic anhydride. The solution was heated to boiling. It thickened rapidly and on being cast set to a white gel which became a transparent, hard resin on heating up to 130° C. to eliminate acetic anhydride and ethyl acetate which had formed.

Example 6.—An ether solution of 4 parts of ethyl silicon trichloride was mixed with 1 part of silicon tetrachloride. The mixture was hydrolyzed by pouring on cracked ice. There was no evidence of precipitated silica. The ether may be separated and the product used for bonding purposes as set forth herein. At 120° C. heating for several hours, a clear hard resin is obtained.

A similar mixture made by mixing 3 parts of ethyl silicon trichloride with 1 part of silicon tetrachloride was hydrolyzed in the same manner and also on baking gives a clear resin.

The following examples and considerations illustrate the utilization of organic silicon derivatives in combination with resins such as urea formaldehyde resins. Urea formaldehyde type resins such as urea formaldehyde resins per se or resins produced from urea derivatives such as dicyandiamide, guanidine, alkyl urea or ureas, thiourea or alkyl thioureas, biguanide, phenyl urea and the like, are compatible with the organic silicon derivatives in limited proportions and may be utilized in combination therewith for the bonds for the production of solid abrasive bodies. The organo-siliconols utilized in these combinations may be those produced as set forth above. Organo-silicon acylates having the general formula $R_xSi(OH)_y(OR'')_z$, where R is an organic group as specified above and R'' is an acyl group, x is a positive number less than 4, either an integer or fractional, $y+z$ is equal to $4-x$ and z is not zero. More particularly, such acylates may have the formula $R_xSi(OR'')_{4-x}$, where R, R'' and x have the values set forth immediately above.

The siliconols and acylates have restricted compatibility with urea resins and where clear products are desired should not be utilized in amounts of more than 5 to 10% to produce the desired compatibility. However, the organic alkoxy silicons, particularly the alkyl alkoxy silicons, such as the alkyl alkane siliconates including ethyl alkane siliconate, have excellent compatibility in amounts up to 50%. Such organo-alkoxy silicons may be represented by the general formula $R_xSi(OH)_y(OR')_z$, where R and R' are the same or different radicals selected from the groups indicated above in connection for the corresponding substituents in the siliconols, x is less than 4, $y+z$ is equal to $4-x$, and z is not zero, x being either an integer or fraction. More particularly such alkoxy silicons will have the formula $R_xSi(OR')_{4-x}$, where R, R' and x have the values set forth immediately above in the general formulation of the alkoxy silicons. The following examples illustrate formulations where urea resins are utilized in combination with the organic silicon derivatives.

Example 7.—Three parts of dimethylol urea were mixed with 40 parts of n-butanol and 0.3 part of an amyl silicon hydroxide obtained from the hydrolysis of the reaction product of one mole of n-amyl bromide and one mole of silicon tetrachloride in the presence of magnesium. Another mixture was made using 0.16 part of the above n-amyl silicon hydroxide. These formulations represent lacquer compositions containing 10% and 5% respectively of the silicon hydroxide. On removal of water and excess butanol, clear products are obtained which may be baked at 140° C. for 1 hour, to give hard final polymers. These lacquer solutions may be illustrated as set forth above in the production of solid abrasive bodies employed either to wet the grains of the abrasive body or as the bonding agents in the production of flexible types of abrasive paper, etc.

Example 8.—Three parts of dimethylol urea and 1 part (25% based on non-volatiles) of ethyl ethane orthosiliconate ($C_2H_5Si(OC_2H_5)_3$) prepared by the action of ethyl magnesium bromide on ethyl orthosilicate were mixed with 40 parts of n-butanol and 10 parts of ethylene glycol mono-n-butyl ether. One-tenth parts of o-phosphoric acid was added and the excess butyl alcohol and water removed by distillation. A clear lacquer is produced which may be utilized as set forth above in the production of solid abrasive bodies. Baked at 140° C. for 1 hour it produces a clear hard product.

While organo-siliconols, organo-alkoxy silicons, and organo-silicon acylates are particularly emphasized above for inclusion in the compositions for producing blends with urea-formaldehyde type resins, it is not intended that the organo-silicon derivatives must be utilized in exclusion of each other, but mixtures of two or

more of the various types of organo-silicon derivatives utilized in the same composition, using two or more siliconols, alkoxy silicons, or acylates in the same composition, or mixtures of one type of organo-silicon derivatives with those of another can be employed.

Further illustrating the possibility of the utilization of blends of the organo-siliconols with other types of synthetic resins, the following illustrates the utilization of melamine aldehyde type resins in conjunction with the siliconols. Thus the organic silicon derivatives may be compounded with amino ring compounds selected from the group consisting of amino triazines, polyamino triazines, amino triazols, polyamino triazols, amino diazines, polyamino diazines, amino diazols, polyamino diazols, and mixtures thereof. The amino ring compounds and particularly the amino triazine aldehyde resins, specifically melamine-formaldehyde resins, are compatible in all proportions with the organo silicon resins and yield products of improved characteristics as to color retention, heat resistance, chemical resistance, etc. The melamine type resins may be utilized with alkyl silicon hydroxides, alkyl silicon acylates, and alkyl alkoxy silicons. The organic silicon derivatives may generally be represented by the formula $(R)_x—Si—(OR_1)_{4-x}$, where x is an integer or fraction less than four, and where R is an alkyl, aryl, alkaryl, alphyl, olefinyl, alkenyl, alkynyl, aralkenyl, cycloaryl, and the like, and R_1 may be any of the above stated groups as well as hydrogen, and also $R_2CO—$ where R_2 may be any of the above stated groups as well as hydrogen. These organo-silicon derivatives include for example, methyl silicon hydroxides, ethyl silicon hydroxides, propyl silicon hydroxides, butyl silicon hydroxides, amyl silicon hydroxides, mixed alkyl silicon hydroxides, methyl methane orthosiliconate, ethyl methane orthosiliconate, ethyl ethane orthosiliconate, ethyl propane orthosiliconate, ethyl butane orthosiliconates, ethyl pentane or orthosiliconate, ethyl silicon acetates, methyl silicon acetates, butyl silicon acetates, ethyl silicon propionates, phenyl silicon benzoates, and the like, as well as mixed organic silicons, such as the alkyl silicon derivatives referred to, and also the organo-silicon derivatives derived from disilicon hexahalides, silicon oxyhalides, polysilicon polyhalides, and the like. The amino ring compounds are illustrated by aminotriazines such as melamine, ammeline, melam, melon and the like, or mixtures of aminotriazines, or polyaminotriazines, or aminotriazoles, polyaminotriazoles, aminodiazines, polyaminodiazines, aminodiazoles, polyaminodiazoles, and such amine containing ring compounds may be utilized either as individual compounds, or in various mixtures thereof, either between themselves, or in mixture with other compounds, such as a urea compound including urea and its derivatives such as thiourea, biuret, dicyandiamide, guanidine, biguanide and the like.

The compositions may be utilized by blending the desired constituents by means of a solvent, the compositions being employed subsequently for bonding agents either retaining the solvent therein, or after removal of the solvent following the blending operation. Thus solutions may be produced and utilized for treatment of the abrasive grains as set forth above, or in the treatment of flexible sheets to which the abrasives are to be bonded. Or they may be utilized in the preparation of molding compositions to produce molded bodies of the abrasive grains as set forth above. The following examples will illustrate the production of these combinations with melamine type resins.

Example 9.—Three parts of n-amyl silicon hydroxide prepared by the hydroylsis of the reaction product obtained from amyl bromide and silicon tetrachloride in a molecular ratio of 1:1 reacted in the presence of magnesium and then hydrolyzed, was mixed with 10 parts of a melamine-formaldehyde solution produced as set forth below. Fifty parts of n-amyl alcohol was added and the mixture heated. Forty parts of n-amyl alcohol and some water were taken off through a column in 1 hour of distillation. A clear lacquer solution is produced which may be utilized as set forth above and when baked at 140° C. yields a clear, hard product.

The melamine-formaldehyde resin employed may be produced as follows. A melamine-formaldehyde resin solution and amyl alcohol was made by mixing 63 parts of melamine, 203 parts of 37% formaldehyde solution, 250 parts of n-amyl alcohol and 100 parts of methanol. The solution was refluxed for 3 hours, then the water and methanol distilled off. More amyl alcohol was added and the final solution made up to 31% solids.

Example 10.—One part of n-amyl silicon hydroxide produced as set forth in Example 9 above, was mixed with 38 parts of a 50% solution of melamine-urea-formaldehyde resin. The latter solution was made by mixing 12.6 parts melamine, 6 parts urea, 57 parts 37% formaldehyde solution (pH=7) and 100 parts of 1-butanol. The solution was refluxed together then some of the water distilled off. The solution was rendered slightly acid and the remainder of the water and some butanol were distilled off. Fresh butanol was added and the solution concentrated to 50% solids. The mixture of amyl silicon hydroxide and melamine-urea-formaldehyde resin solution was diluted with 50 parts of 1-butanol and heated under a column. Forty parts of butanol was removed by distillation. A clear lacquer was thus produced which may be utilized in accordance with the present invention and on baking at 140° C. yields a clear, hard product.

Having thus set forth our invention, we claim:

1. An abrasive article comprising abrasive grains bonded by a resinous condensation product of an organic derivative of ortho silicic acid in which an average of ½ to 2 hydroxyl groups per molecule of ortho silicic acid have been replaced by monovalent hydrocarbon radicals.

2. An abrasive article comprising abrasive grains bonded by a resinous condensation product of an organic derivative of ortho silicic acid in which an average of ½ to 1½ hydroxyl groups per molecule of ortho silicic acid have been replaced by phenyl and methyl groups.

3. An abrasive article comprising abrasive grains bonded by a resinous condensation product of an organic derivative of ortho silicic acid in which an average of ½ to 1½ hydroxyl groups per molecule of ortho silicic acid have been replaced by ethyl groups.

4. An abrasive article comprising abrasive grains bonded by a resinous condensation product of an organic derivative of ortho silicic acid in which an average of about 1 to 2 hydroxyl groups per molecule of ortho silicic acid have been replaced by alkyl and aryl radicals.

5. An abrasive article comprising abrasive

grains bonded by a resinous condensation product of an organic derivative of ortho silicic acid in which an average of about 1 to 2 hydroxyl groups per molecule of ortho silicic acid have been replaced by phenyl and methyl groups.

6. An abrasive article comprising abrasive grains bonded by a resinous organo-silicon oxide polymer in which the organo groups are alkyl and the average of alkyl groups per silicon atom is from 1 to 2.

7. An abrasive article comprising abrasive grains bonded by a resinous condensation product of an organic derivative of ortho silicic acid in which an average of about 1 to 2 hydroxyl groups per molecule of ortho silicic acid have been replaced by methyl groups.

8. An abrasive article comprising abrasive grains bonded by a resinous condensation product of an organic derivative of ortho silicic acid in which an average of about 1 to 2 hydroxyl groups per molecule of ortho silicic acid have been replaced by ethyl groups.

9. A solid abrasive body comprising abrasive grains bonded by a resinous condensation product of an organic silicon derivative having the formula $R_xSi(OR')_{4-x}$, wherein R is a monovalent hydrocarbon group, x is an average of ½ to 2, and R' is selected from the group consisting of hydrogen, monovalent hydrocarbon groups, and acyl radicals.

10. In the method of making abrasive articles,

the steps of bonding a quantity of abrasive grain with a resinous condensation product of an organic silicon derivative having the formula $R_xSi(OR')_{4-x}$, wherein R is a monovalent hydrocarbon group, x is an average of ½ to 2, and R' is selected from the group consisting of hydrogen, monovalent hydrocarbon groups, and acyl radicals, said organic silicon derivative being convertible by heat into a resilient conversion product.

FREDERICK A. HESSEL.
JOHN B. RUST.

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