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(54) **Abrasive articles.**

(57) An abrasive article comprising abrasive grains, a porous support material and a resin bond including a coupling agent for coating said abrasive grains and said support material, said resin bond being adhered to the grains and support material with the aid of said coupling agent, the coupling agent being compatible with the resin bond, said resin bond yielding little or no volatiles during its curing so as to effect the bonding and being cured under conditions to limit production of volatiles so as to maintain the amount of interchannel porosity to less than 14% of the total volume of the abrasive article, the porosity of the article being essentially determined by said support material, whereby the article has dimensional stability during cure and superior resistance to impregnation with water after being cured. The support material may include hollow bodies, such as microbubbles of glass or alumina or the like, and the support material is used in an amount that is carefully controlled to produce the desired porosity in the abrasive article. A wide range of controlled porosity levels in the respective grinding wheels produced may be accomplished resulting in the production of wheels having superior wet strength and dimensional stability.

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The invention relates to the production of resin bonded abrasive articles having a controlled porosity. More particularly a grinding wheel is described having a resin bond for supporting an abrasive mix that includes microspheres to produce the desired degree of non-interconnecting porosity in the resulting article.

Various spherical and/or hollow types of fillers for abrasive articles have been suggested in the prior art. U.S. 2,806,772 suggests the use of balloons of clay; U.S. 3,329,488 and U.S. 3,476,537 suggest the use of olivine, a porous mineral. Spherules filled with lubricant are taught in U.S. 3,502,453. Spacer material, including glass beads in a porous resin bond, is disclosed by U.S. 3,864,101 and a bead which can melt or shrivel up is taught in U.S. 3,925,034. Pore and hard form granules are utilized in U.S. 4,226,602.

None of the above patents recognizes the desirability of precisely controlling pore volume of the ultimate abrasive article through the confined internal space provided by the interior of the support material by incorporating such porous materials along with the abrasive grains in a non-porous bond thereby eliminating the interconnecting or interchannel voids between particles.

U.S. 3,041,156 teaches the use of hydrolyzed silane to treat the surface of the abrasive grains to be incorporated in a grinding wheel or the like, but no additional pore forming material is used in the abrasive product.

In U.S. 3,661,544 abrasive grains and friable particles such as glass microbubbles are formed into a premix by coating the particles with sufficient resin to form the bond for the abrasive article and the resin is then cured to a B stage. The pre-mix of coated particles, grain, and bond can be stored in this condition. Later the pre-mix may be compressed in a mold and heated to a thermosetting temperature range to cure the resin to a C stage.

The desirability of providing a simple mixture of an abrasive grain and a pore forming ingredient suitable for molding a wide range of products having related grinding characteristics that vary over a broad range has long been recognized in the abrasive art. However, the disparity in properties heretofore sought in many of the respective products has made it impossible to utilize one composition for an extensive range of abrasive content. For example, a mixture designed for a high abrasive content can not be molded with a bond designed for use to form a product having low abrasion content merely by allowing for a greater porosity volume in the mold because the resultant green product slumps during the curing step.

When an attempt is made to use a low abrasive content mixture suitable for molding soft grade high porosity products for the production of a dense closed pore product, swelling upon curing of the bond is likely to result with concomitant loss of volume and structure control.

Another aspect involved in the precise maintainance of the design porosity in a molded product is concerned with the production of a grinding wheel with the desired controlled porosity and one that has an improved wet strength for wet grinding operations.

Many products suitable for dry grinding operations deteriorate when cooled by water. On the other hand, if the grinding product is so dense and lacking porosity so as to prevent water penetration, it is also likely to be too hard acting and unsuitable for some wet grinding operations.

Prior art attempts to produce an abrasive mix that may be used to produce a variety of products that may be used interchangeably for producing wet or dry grinding abrasive products and having different porosity levels bonded with a single selected resin, have relied on the inclusion or exclusion of selected fillers such as lime, anhydrous calcium sulfate, activated alumina, molecular sieves, etc. Also, hollow spheres of clay, thermoplastic or glass beads have been employed.

However, it has not heretofore been recognized that one mix having a standard composition could be used to produce a variety of abrasive products with a specifically prescribed porosity by making use of the method and composition here taught.

The present invention provides an abrasive mix composition that may be adapted for the production of a wide variety of grades when bonded with a standard bond. The composition comprises abrasive grains, support material which is hollow, such as microbubbles, and resin bond which evolves little or no volatile components during fluxing or cure. A great variety of abrasive articles can be produced each having a different porosity grade by relying almost exclusively on the selection of the proper size and quantity of the microbubble support material to provide the porosity desired.

By using the herein described procedures for treating both the abrasive grains and the support material, preferably glass microbubbles, with a coupling agent that is compatible with the resin bond to be used, inter-connected pores within the composition can be virtually eliminated. The resin bond material, with which the coupling agent is compatible and or even reactive, is cured to be essentially non-porous so that, unlike the prior art, the porosity of the final product is precisely determined by the selection of the quantity of microbubbles which produce the exact degree of internal pores desired.

In following this invention, it is possible to produce the wide variety of dimensionally stable molded articles making use of the single compositional system having a specified porosity and which also has a great resistance to deterioration by water. Thus, grinding wheels produced in following this teaching are particularly well suited for wet as well as dry grinding operations.

Grinding wheels, according to the invention, can be processed by cold or hot press molding methods and can be cured further over a wide range of temperatures without slumping and while remaining free standing in the curing oven, with a remarkable degree of dimensional stability.

The abrasive grain material adapted for use in the composition of this invention may be selected from any of the conventional particulate abrasive materials including alumino, silicon carbide, zirconia-alumina, corundum, garnet, diamond, and the like. The grit size may vary between 4 to at least 400 grit. The preferred range is from about 12 grit to about 220 grit. Whenever the terms grit size or mesh size is used, it refers to the U.S. Standard Sieve Series. For ease in mixing and handling it is preferred to have the same sizes for the abrasive grains and the support medium described below. The amount of abrasive grain may vary between from 60% to as little as 1 volume %.

The preferred composition of this invention includes abrasive grain, a crushable support medium, a coupling agent coated on the grain and support medium, a wetting agent, and a powdered polymeric bonding agent which fuses and coalesces or cures and/or cross links with little or no formation of gaseous or volatile by-products.

Support material for providing the designed degree of porosity is selected to be crushable within the range of pressures normally used for molding the abrasive article, but it must have sufficient mechanical strength to allow survival during normal mixing and handling procedures. Materials such as glass or phenolic resin microbubbles, granules or pumice, friable open or closed cell polymeric foams, such as urethane, phenolic, and multi-celled glass bubbles are suitable. Generally the desired characteristics demand the use of a material which is composed of a single or multiple celled material that is friable, compressible, and crushable. Glass bubbles are preferred.

The size of the material is preferably the same as, or coarser than, that of the abrasive grains with which it is mixed, but it may vary in size from 45 microns to 1/4" (6.35 mm) in diameter. Preferably the size range is from 12 mesh to 325 mesh and ideally between 12 to 80 mesh. For ease in handling and visually determining uniformity, it is desirable that the abrasive grains and the support material have generally the same size.

Finer hollow beads mixed with the abrasive grains tend to produce drier mixes which are somewhat more difficult to press. The support material is preferably added to the abrasive grains, followed by the coupling agent and then the wetting agent to which is then added the powdered bond. However, if it is added to the mix after the abrasive grains, bond powder and wetting agent have been blended, less crushing and shearing of the support material occurs.

The amount of support medium added can vary greatly and the volume % may range between 90% down to 1%. Typical abrasive articles have 25 to 50 volume % of the support media.

Multicelled glass bubbles are available from Pittsburgh-Corning Corporation in size -20/+40 mesh. Similar glass bubbles are available from Norton Company, generally in the size of through 20 mesh and on 40 mesh but this product is produced in a range down to an 80 mesh size. Single celled glass bubbles are manufactured by 3M Company that are smaller than a 150 mesh size.

Conventional coupling agents known for treating abrasive grains and glass are certain silanes and titanates.

Silane treatment of abrasive grain is taught in U.S. 3,041,156 and those teachings are incorporated herein.

Many silanes are known to be suitable for this purpose and are available commercially. Two preferred silanes are amino propyl triethoxy silane and glycidoxypropyl trimethoxy silane. These are available from Union Carbide Corporation.

Another class of coupling agents are alkyl titanates such as tetra butyl titanate. Other titanate esters, both simple and complex, are also satisfactory and these titanates are commercially available.

The amount used should be sufficient to form at least a monomolecular layer over the surface of the material being coated.

The coupling agent can be applied in a conventional form or it may be dissolved in a compatible solvent or reactive liquid ingredient in order to insure a more rapid and thorough distribution of this agent over the abrasive and support material. Either liquid phenol-formaldehyde resol or epoxy resin may be used as such a liquid or carrier for example. This coupling agent may also be dissolved in other wetting agents in the proportion of about 0.25 wt. % of the selected silane based on the quantity of liquid wetting agent.

After a thorough blending, for example, of 25 vol % of A-187, a commercially available silane, in 75 vol % of Araldite 6004, a liquid epoxy resin, the abrasive mix is made in the usual way by adding the solution to a mixing pan containing abrasive grains and glass beads followed by the addition of more Araldite 6004 as desired and then by addition of the dry bonding materials.

It is essential that the resin bond material for incorporating in the mix of this invention be a liquid or powdered polymeric bonding agent which forms a strong bond by fusion and coalescence and/or which cures and/or cross-links by a mechanism which yields little or no gaseous or volatile by-products. Examples of the fusion type resins are polyvinylchloride, polycarbonate and ABS polymer. Examples of the cross-linking type resins are selected phenolic resins, epoxy resins, unsaturated polyester resins, and urethane polymers. It is preferable that a wetting agent be used with the abrasive mix, support material, and powdered bond; the bonding resin and wetting agent must be compatible with each other. The resin bond material can be present in the resulting abrasive products mix in as little as 5 vol. % and up to 90 volume %.

Conventional novolaks, with hexamethylenetetramine, can be operable in this invention. If such powders are initially low in water content very little volatile material such as water or ammonia is generated during a low temperature cure such as 160°C. Such materials can be used, even without lime as a scavenger, with liquid epoxy, liquid anhydride, furfural, or even low water content liquid resins as wetting agents. After the molded abrasive product geometry is well fixed with a partial cure, even higher bake temperatures can be used without encountering any deleterious slumping or swelling as the product cures.

The epoxy resin system is favored in higher bond content compositions because there is little risk of swelling.

Wetting agents for powdered resins in abrasive compositions are well known. While their use is not essential in the practice of this invention, they may be and preferably are employed. Preferably they are present in an amount of from 5 to 30 volume % of the total volume of the bonding resin used.

With powdered epoxy and phenoxy resins the following wetting agents are suggested: liquid epoxies, liquid anhydrides, furane resins, furfuryl alcohol, creosote oil, highly aromatic processings oils, low water content resoles, dioctyl phthalate, liquid novolak resins. These agents will also work for the PVC powder and the powdered phenolic novolaks with or without hexa. Furfural is also suitable for novolaks. For unsaturated alkyds (polyester resin powders), styrene and styrenated resin syrups are applicable wetting agents.

Other conventionally used additives for an abrasive mix, such as active and inactive fillers, may also be used in the formulation of the wheels of this invention.

Typical grinding wheels are made as here taught by introducing the abrasive grain and support material into a suitable container such as a vertical spindle mixer, Hobart, or similar type high shear mixer. The coupling agent may then be added and the batch mixed until the coupling agent is thoroughly coated onto the surfaces of the grains and particles of the support material. Alternatively the coupling agent may be dissolved in a wetting agent and the solution can be added to the batch for mixing with the grain and support material.

Subsequently the powdered resin bond is added. If desired, a dampening agent is added to the coated material in the mixer and after thorough blending of all the ingredients the composition is pressed to shape in a suitable mold. The amount of abrasive mix material used in filling the mold is such that the planned porosity of the pressed shape exclusive of the porous support material is less than 14% and generally 0 to 5%. It is preferred that the planned porosity for some products be made to approach zero %, but zero porosity may not be preferred for very high bond content compositions because of spring back that is inherent in the use of finely powdered resin bond materials. Higher porosity levels are known to produce less spring back.

The pressing or molding of the wheel shape can be either cold or hot. For the cold pressing operation sufficient pressure to achieve the targeted 0-14% porosity is up to about 12 tons/in$^2$ (1,700 kg/cm$^2$) and preferably below about 5 tons/in$^2$ (703 kg/cm$^2$). For hot pressing, the pressure is up to about 2.5 tons/in$^2$ (351.5 kg/cm$^2$).

The hot pressing temperatures are on the order of 160-165°C. and hot pressed articles may be post baked, as is conventional, at temperatures up to about 210°C. Cold pressed wheels can be cured in the usual manner at a temperature of approximately 175°C. and after cure are trued to the desired size to insure proper geometry.

The invention is further illustrated by the following examples in which all parts and percentages are by weight unless otherwise indicated. The non-limiting examples are designed to teach those skilled in the art how to practice the invention.

Coupling agents and resin bond products used in the examples below, are:

A-187, a silane from Union Carbide (gamma-glycidoxy propyl trimethoxy silane);

Araldite 6004, 6010, liquid epoxy resins sold by Ciba-Geigy, a bis phenol-A epoxy;

A-1100 and A-1102 silane, gamma-amino propyl triethoxy silanes sold by Union Carbide;

EMI-24, a 2-ethyl-4-methyl imidazole catalyst sold by Fike Chemical Company;

37-624, a liquid anhydride sold by the Reichold Chemicals, Inc.;

Varcum 6404, and Varcum 6407, solid epoxy resins.

Example 1

The following amounts of the ingredients listed below were used for the abrasive wheel mix.

| ITEM | NAME | AMOUNT (in lbs) | (in kg) |
|---|---|---|---|
| A | 57 Alundum, 60 grit aluminum oxide abrasive | 13.23 | (6.001) |
| B | Multicellular glass nodules 20-40 mesh (Norton Company) | 1.24 | (0.5625) |
| C | A-187 silane 25% vol. dissolved in 75% vol. Araldite 6004 | 0.08 | (0.0363) |
| D | Solution of 0.65 lbs. (0.29 kg) Araldite 6004 and 0.03 lbs. (0.01 kg) EMI-24 | 0.68 | (0.3084) |
| E | Varcum 6404 powdered epoxy resin planned porosity 0% | 2.84 | (1.288) |

Items A and B were placed in a vertical spindle mixer to which Item C was added. The materials were thoroughly mixed in order to coat the particles A and B with the silane solution C. Next the wetting agent D and EMI-24 were added and thoroughly blended for uniform coating of the particles. Finally Item E, the epoxy bond resin, was added and mixed until the mixture appeared to have a uniform distribution. The final mixture was screened through a 10 mesh screen to remove any coarse particles. A second quantity of wheel mix was prepared in the same way and the two mixed for a total of about 36 pounds (16 kg). An 8-3/16" (208 mm) O.D. mold with a 1" (25.4 mm) arbor was loaded with 3.87 lbs. (1.76 kg) of the above abrasive mixture. The mix was leveled with a straight edge after which it was cold pressed to a thickness of 1-1/8" (28.6 mm). Thirty tons of pressing pressure was required on the mold. Subsequently the green wheel was stripped from the mold. The procedure was repeated to form seven more wheels to give a total of eight wheels. Each wheel was prepared for bake by wrapping the periphery of the wheel with a strip of paper held in place with a piece of pressure sensitive tape. The wheel was placed on an oven batt and the center hole of each wheel was filled with quartz granules.

All the wheels were placed in an electrically heated convection oven. The oven temperature was made to rise gradually to a temperature of 175°C. and the wheels were baked at this temperature for 15 hours. Then the oven containing the wheels was allowed to cool to room temperature gradually. The fired wheels were found to have an average thickness of only 1.2% thinner than before the bake, showing the remarkable ability of this compositional system to retain molded dimensions during cure.

Target sp gr 1.83
Actual sp gr 1.87

The wheels were trued and tested as follows:

Three of the wheels were speed tested to destruction dry and three were centrifugally burst after a 10 day immersion in water.

The average dry burst strength was 23,921 sfpm 7291.1 m/min. and the average wet burst strength was 22,214 sfpm (6770.8 m/min.)

sfpm = surface feet per minute.

These data show the remarkable wet strength retention of the inventive wheels.

## Example 2

For comparative purposes, this example which is not illustrative of the invention shows that conventional high "planned in" porosity outside of the limited porosity range of the invention, with similar composition and curing steps reduces the desired properties of the wheels. The designed porosity of these wheels was 30%.

The following amounts of the ingredients listed below were employed:

| ITEM | NAME | AMOUNT (in lbs.) | (in kg) |
|---|---|---|---|
| A | 38 Alundum 80 grit aluminum oxide abrasive | 9.47 | (4.30) |
| B | Multicellular glass nodules | 0.18 | (0.08) |
| C | A-1102 silane and phenolformaldehyde resole, 1,000cP, 9% $H_2O$ | .04 | (0.02) |
| D | .0011 lb. (0.50 g) EMI 24 in 0.22 lb (99.7 g) Araldite 6004 | .23 | (0.10) |
| E | V-6411 resin (a 50/50 blend of an epoxy and a one step solid phenolic resole | 2.12 | (4.67) |

The procedure of Example 1 was followed for preparation of the total mount of mix needed and for the molding of these wheels.

To the same mold as in Example 1, 3.58 lbs. (1.62 kg) of the above mix was added and pressed to a thickness of 1-1/8" (28.6 mm). The baking procedure of Example 1 was followed.

The baked wheel had a thickness of about 5% less than the molded green wheel. This indicates that there is insufficient structural support for this composition with a 30% planned in porosity.

Target sp gr 1.70
Actual sp gr 1.85

Three wheels were burst centrifugally dry and three wheels were centrifugally burst after a 10 day soak in water.

Average dry burst 20,385 sfpm (6,213.3 m/min.)
Average wet burst 14,102 sfpm (4,298.3 m/min.)

The following is another example of the invention:

Example 3

| ITEM | NAME | AMOUNT (in lbs.) | (in kg) |
|---|---|---|---|
| A | 32 Alundum 50 grit aluminum oxide abrasive | 18.38 | (8.34) |
| B | 60 mesh multicellular glass nodules (Norton Company) | 1.72 | (0.78) |
| C | 25 vol.% of A-187 silane and 75 vol. % Araldite 6004 liquid epoxy resin | .08 | (0.04) |
| D | 0.92 lbs. (0.42 kg) Araldite 6004 and 0.08 lb. (0.01 kg) EMI 24 catalyst | .95 | (0.43) |
| E | Powdered Varcum 6404 resin | 3.95 | (1.79) |

The procedure of Example 1 was followed in preparing the mix. An amount of 18.44 lbs. (8.36 kg) of the above mixture was loaded into a 24-5/16" (617 mm) mold containing an 11-7/8" (302 mm) arbor and compressed to a thickness of 0.852" (21.6 mm). The wheel was prepared and baked as in Example 1. On cooling the thickness of the fired wheel was found to be 0.849" (21.6), or 0.3% thinner than the green wheel. The wheel was designed to have a target sp gr of 1.83 and the fired, or actual, sp gr was 1.84.

The elastic modulus of the fired wheel was found to be 9.2 and SBP (Sandblast Penetration) (2/25) was 1.26 - 1.29.

A smaller wheel, 4" x 0.77" x 7/8" (102 mm x 20 mm x 22 mm) was cut out from this large wheel. The small wheel was tested in grinding AISI 52100 steel with a Rockwell C scale hardness of 60 on an experimental grinding machine. In comparison with other wheels, including vitrified bonded wheels, the wheel of this invention was shown to grind more durably with slower wetting and less wheel wear, but without any burn in comparison with the vitrified wheel.

Example 4

| ITEM | NAME | AMOUNT |
|---|---|---|
| A | 57 Alundum 80 grit aluminum oxide abrasive | 14.57 lbs. (6.61 kg) |
| B | 36 grit multicellular glass bubbles (Pittsburgh-Corning) | 0.97 lbs. (0.44 kg) |
| C | A-187 silane, 25 vol. % and 75% Araldite 6004 | 37.5 cc |
| D | Araldite 6004 | 0.28 lbs. (0.13 kg) |
| E | Varcum 6404 | 1.18 lbs. (0.54 kg) |

The wheels to be made were designed to have a volume of 48% abrasive grits, 16% volume of bond, and 36% volume of glass beads.

The mix was prepared and eight wheels were pressed both as described in Example 1. All wheels were individually molded in an 8-3/16" (208 mm) mold with a 1" (25.4 mm) arbor to a targeted thickness of 1.28" (32.5 mm) with a paper disc on top and bottom of each wheel. The molded wheels were stacked four high and the holes filled with quartz. Each stack was then given a double paper wrap which was fixed with pressure sensitive tape. The wheel stacks were baked as described in Example 1.

Each wheel was found to weigh 5.33 lbs. (2.42 kg) and after firing showed a 0.39" (9.9 mm) increase in thickness. A typical wheel from this batch was selected for analysis of certain data. The sp gr before firing was 2.21 and after being cured was found to be 2.19, the SBP (2/25) was 2.57 and the elastic modulus was 14.

The dry burst speed of 3 wheels averaged 23,426 surface feet per minute (7140.2) and the average wet burst strength for 3 other wheels was 21,180 surface feet per minute (6455.7 m/min.)

Examples 5-7

Items A-E are as defined in Example 4, but were mixed in the following proportions. Several mixes were made to produce the needed total.

| ITEM | 5 | | 6 | | 7 | |
|---|---|---|---|---|---|---|
| A | 13.47 lbs. | (6.11 kg) | 13.23 lbs. | (6.001 kg) | 11.90 lbs. | (5.40 kg) |
| B | 0.93 lbs. | (0.42 kg) | 0.96 lbs. | (0.44 kg) | 0.94 lbs. | (0.43 kg) |
| C | 35.3 cc | | 35.4 cc | | 33.0 cc | |
| D | 0.31 lbs. | (0.14 kg) | 0.35 lbs. | (0.16 kg) | 0.41 lbs. | (0.19 kg) |
| E | 1.28 lbs. | (0.58 kg) | 1.28 lbs. | (0.58 kg) | 1.73 lbs. | (0.78 kg) |
| TOTAL | 16 lbs. | (7.25 kg) | 16 lbs. | (7.25 kg) | 16 lbs. | (7.25 kg) |
| VOL. % A | 46 | | 44 | | 40 | |
| VOL. % B | 36 | | 36 | | 36 | |
| VOL. % E | 18 | | 20 | | 24 | |
| Planned Porosity | 0 | | 0 | | 0 | |

The wheels were molded and cured as described above in Example 4 and the following data were recorded.

| Example | Wt. of each wheel (in lbs.) | (in kg) | % Thickness change after firing | sp gr target | sp gr actual |
|---|---|---|---|---|---|
| 5 | 5.19 | (2.35) | +0.14 | 2.16 | 2.14 |
| 6 | 5.06 | (2.30) | +0.00 | 2.10 | 2.08 |
| 7 | 4.79 | (2.17) | -0.98 | 1.99 | 1.99 |

The physical data from the selected typical wheels were:

| Example | SBP 2/25 | Elastic modules | Centrifugal burst speed SFPM dry | wet | (m/min.) dry | wet |
|---|---|---|---|---|---|---|
| 5 | 2.64 | 13 | 23,156 | 21,180 | 7058 | 6456 |
| 6 | 2.34 | 13 | 23,420 | 21,886 | 7138 | 6671 |
| 7 | 2.00 | 12 | 23,509 | 21,858 | 7166 | 6662 |

The centrifugal burst speed data recorded above, for both dry and wet wheels, is the average of three wheels.

From an inspection of the description and examples set forth above, it is seen that a composition is provided that has universal applicability to the fabrication of abrasive articles with a more exact control of porosity. By making use of the porous support medium together with abrasive grains in a substantially non-porous resin bond, a very precise designed degree of porosity can be built into the cured product. The ability to control the degree of porosity in the final product makes possible the production of grinding wheels, for example, having improved grinding characteristics related to the structure of the specified wheel. The improved grinding ability of such wheels flows in part from the use of the non-porous bond which for wet grinding operations provides a wheel having an increased resistance to bursting forces where the wheel is rapidly rotated.

The molding procedures applied to the composition described having porous support material makes the production of articles with a very exact degree of porosity possible. When a crushable porous support material is mixed with the abrasive grain, the volume quantities of the grain and support material, together with the bond resin, can be selected to produce a desired porosity in the cured non-porous resin bonded product. Since the pores are built into the article as it is being fabricated, precise control of the volume or degree of porosity is possible. In one aspect of the invention the porous support material can be supplied in the mix in a slight excess, and when the green wheel shape, for example, is being pressed in a mold, the slight excess of support material can be crushed to provide a wheel that fills the mold to 100% of its designed volume with an exact volume of pores resulting from the inclusion of the remaining uncrushed porous support material in the mixture.

It will be noted that while a porous abrasive article can be made with the disclosed composition and method, it should be observed that the only pores in the mass of the wheel are closed pores as distinguished from open and interconnected pores that usually result upon the curing of the conventional type of resin bonded abrasive products. It is the elimination of the interconnecting channels within the body of the product that is, in part, responsible for the improved wet strength of the herein described product. Also it is believed that the coupling agent that is applied over the surfaces of the grains and particles of the support material, provides for optimum bonding between these surfaces and the non-porous bonding mass whereby a stronger cured porous product is made.

# CLAIMS

1. An abrasive article comprising abrasive grains, a porous support material and a resin bond including a coupling agent for coating said abrasive grains and said support material, said resin bond being adhered to the grains and support material with the aid of said coupling agent, the coupling agent being compatible with the resin bond, said resin bond yielding little or no volatiles during its curing so as to effect the bonding and being cured under conditions to limit production of volatiles so as to maintain the amount of interchannel porosity to less than 14% of the total volume of the abrasive article, the porosity of the article being essentially determined by said support material, whereby the article has dimensional stability during cure and superior resistance to impregnation with water after being cured.

2. An article according to claim 1, wherein the coupling agent is a silane.

3. An article according to claim 1 or 2, in which the support material comprises glass microbubbles, said microbubbles preferably being of 12 to 325 mesh.

4. An article according to any one of the preceding claims, wherein the interchannel porosity volume is less than 5% of the total volume of the abrasive article.

5. An abrasive article according to any one of the preceding claims, wherein the resin bond comprises a phenolic resin, an epoxy resin, or a phenoxy resin.

6. An article according to any one of the preceding claims, which includes a wetting agent for introducing the coupling agent into the wheel composition.

7. A process for a cured resin bonded abrasive article according to claim 6, which comprises:

I. admixing the abrasive grains and particles of the porous support material with the coupling agent to coat the support material and grains for strong adherence to a resin bond;

II. mixing the liquid wetting agent with the coated grains;