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COATED ABRASIVE GRAINS AND THE METHOD OF COATING THE ABRASIVE GRAINS

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The present invention is directed to a new and improved polishing abrasive grain and to a method of producing same.

An object of the invention is to provide an abrasive grain of improved bonding properties.

Another object is to provide granules or abrasive grits with an unfused, unvitrified film or coating which presents a rough, irregular matted surface imparting greater tenacity to the adhesive bond between the granules or grits and the paper or cloth backing or support.

An additional object is to provide granules or abrasive grits uniformly coated with an inert or substantially inert material which is physically and/or chemically bonded to the surface of the grain by means of an unfused, unvitrified water resistant microscopic coating or film of a metallic metaphosphate.

A further object is to provide granules or abrasive grits with a water resistant film or coating bonding finely divided pigments or polishing powders to the surface of the abrasive material.

A still further object is to provide coated granules or abrasive grits affording strong capillary to liquid or mobile adhesives which when applied will adhere with greater tenacity and efficiency to the granule, thereby yielding a finished article of greater durability and strength and, therefore, greater utility as an abrasive.

Other objects and advantages of the present invention will be apparent to those skilled in the art as the description proceeds.

It is well known that abrasive grains are used for only a fraction of the time they might be efficiently employed in view of their toughness, hardness and sharpness. The reason for this is that abrasive grains as ordinarily produced are characterized by a smooth glassy surface to which adhesives do not adhere readily and consequently the abrasive grains are not retained in place long enough to achieve maximum efficiency in grinding. This fact is strikingly illustrated upon inspection of the refuse of grinding and polishing operations, which almost invariably contains a relatively high percentage of detached abrasive grains whose sharp edges are substantially unimpaired.

Heretofore, abrasive grains have been treated in various ways in an effort to increase their bonding properties and thereby improve the

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grinding efficiency of abrasive articles made therewith and while some measure of success has been achieved, the results have not been entirely satisfactory.

For example, one method which has been proposed involves etching the surface of the grains by means of acids or acid salts, but this method is objectionable because the above compounds have a selective action on the matrix of the grain in which the crystals are set and bring about a more rapid break-down of the grain during use.

Other methods of improving the adhesiveness of abrasive grains which have been advanced, comprise roughing the surface of the grain by attrition; providing the grains with a fused siliceous coating which presents rough edges and/or prominences extending outwardly from the surface of the grain; applying a ceramic material to the surface of the grains and heating to produce an unfused, unvitrified porous foraminous film; coating the grains with sodium silicate carrying various inert materials; treating the grains with an aqueous solution of the chlorides, nitrates or sulfates of iron or aluminum followed by heating to decompose these salts and thereby leave a residue thereof on the surface of the grain; and precoating the grains with resins of various types. However, these methods are subject to the disadvantage of being troublesome, time-consuming and expensive to carry out and in some instances fail to provide any substantial improvement in the adhesiveness of the abrasive grain.

We have discovered that the adhesion between abrasive grains and bonding materials is increased to a surprising degree by providing the surface of the grains with an insoluble or substantially insoluble metallic metaphosphate coating carrying finely divided inert or substantially inert material. This coating is applied as an aqueous solution of the corresponding mono-metallic orthophosphate containing the inert or substantially inert material, and then the coated grain is heated to a temperature sufficient to molecularly dehydrate the orthophosphate but below the temperature at which a substantial amount of fusion of the coating takes place. As a preferred alternative to this procedure, the aqueous solution of the mono-metallic orthophosphate is initially applied

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as a coating to the grain and then the inert material is adhesively bonded thereto by intimately and uniformly mixing the two materials together. After completing this operation, the resulting product is heated to a temperature sufficient to convert the orthophosphate into the corresponding metaphosphate.

The metallic salts useful for the above purpose are the water soluble mono-metallic orthophosphates which are convertible by heating into insoluble or substantially insoluble metaphosphates. These salts include mono-aluminum orthophosphate, mono-iron orthophosphate, mono-magnesium orthophosphate or a mixture of mono-sodium and mono-potassium orthophosphates in the proportions to yield upon molecular dehydration a composition consisting of substantially 80% sodium hexametaphosphate and 20% potassium metaphosphate. However, it should be clearly understood that the invention is not restricted thereto since any and all mono-metallic orthophosphates coming within the scope of the above definition are contemplated.

The above mono-metallic orthophosphates, particularly mono-aluminum orthophosphate, are rather unique in that, notwithstanding the fact they are employed in the form of aqueous solutions of relatively high viscosity, they are characterized by their unusual ability to thoroughly and uniformly wet the surface of abrasive grains.

As to the inert material, any finely divided substances which are unreactive or substantially unreactive with the above mono-metallic orthophosphates at temperatures below the fusion point of the corresponding metaphosphate may be employed. Illustrative examples of such materials are red oxide of iron, chromic oxide, manganese dioxide, titanium oxide, Kentucky ball clay, boron carbide, silicon carbide, diamond dust, crushed firebrick, feldspars and the like, but of these red oxide of iron is preferred.

The particle size of the finely divided inert material may be varied widely so long as there is a substantial difference between it and the abrasive grain to be coated. In general, it is desirable to confine the inert material to a particle size which falls within the range of from 5 to 20 microns.

The improved grinding and polishing material prepared in accordance with the present invention is composed of a mass of granules, each of which comprises a core of abrasive materials such as fused aluminum oxide, silicon carbide, corundum, emery or garnet, and an insoluble or substantially insoluble metallic metaphosphate coating which adhesively binds one or more of the above inert or substantially inert materials to the surface of the grain. This coating, which is microscopic in thickness and is apparently physically and/or chemically bonded to the grain, presents an unfused, unvitrified, rough irregular matted surface, which, in contrast to the glass-like smooth surfaces of the untreated grain, enables the bonding material to grip the grains firmly and adhere tenaciously thereto, thus retaining the granules in service in an abrasive structure for a much longer period of time.

As an illustration of the preferred method of carrying out the present invention, reference is made to the following specific example.

EXAMPLE I

350 lbs. of #46 aluminum oxide abrasive grain and 1400 grams (3.08 lbs.) of an aqueous solution of mono-aluminum orthophosphate (sp. g.

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1.4 at 25° C.) were mixed together in a cement mixer for 15 minutes, whereupon 1590 grams (3.5 lbs.) of finely divided Fe_2O_3 was introduced and the mixing continued for 30 minutes. The resulting product was dried by heating and then calcined in a gas fired rotary calciner which was heated to a temperature of approximately 700° C.

The calcination step effected molecular dehydration of the mono-aluminum orthophosphate, thus converting this material into water insoluble aluminum metaphosphate which tenaciously bonded the Fe_2O_3 to the surface of the grain.

The coated product was characterized by a bright red color, an unfused, unvitrified, rough irregular matted surface and by the following screen analysis which compared favorably with the required screen test specifications for polishing grain.

Screens Used U. S. S. Series	Per Cent Coated Grain on Screen	Polishing Specifications
+30	-----	None
+40	14	0-15
+45	72	60-100
+50	13	0-40
+60	1	-----

In addition to the above properties, it was found that the coated grain had markedly improved adhesive properties as compared with untreated grain and that consequently grinding wheels prepared therewith using resin bonds displayed 17% greater efficiency than similar wheels prepared with uncoated grain.

EXAMPLE II

369 lbs. of #8 aluminum oxide abrasive grain and 2100 gms. (4.63 lbs.) of 1.35 gravity mono-aluminum orthophosphate solution were mixed together in a cement mixer for 10 minutes and then 1600 grams (3.53 lbs.) of finely divided Fe_2O_3 was added and the mixing continued for 10 more minutes. The product thus obtained was dried by heating for approximately 30 to 45 minutes and then passed through a gas fired rotary calciner which was maintained at a temperature of about 700° C. This operation brought about molecular dehydration of the mono-aluminum phosphate to the corresponding metaphosphate and thereby adhesively bonded the finely divided Fe_2O_3 to the surface of the grain.

The coated grain was characterized by a bright red color and an unfused, unvitrified, rough irregular matted surface which substantially improved the bonding properties of the grain. In addition, the product was also characterized by having a coating which was substantially free of water soluble salts since no turbidity was produced when a sample of the coated grain was added to water and the resulting mixture vigorously agitated.

The following table further illustrates the various operating conditions and materials which have been successfully used in the preparation of coated abrasive grains having substantially improved bonding properties, it being understood that the phosphate solutions and inert materials were successively applied, and the coated product dried and calcined in substantially the manner indicated in the above examples.

Table I

Abrasive	Phosphate	Inert Material	Calcination Conditions	Properties of Product
100 grams of aluminum oxide abrasive grain #24 grit.	2 c. c. of an aqueous solution of Al (H ₂ PO ₄) ₃ (Sp. Gr. 1.35 at 25° C.).	1.5 grams of Kentucky Ball Clay.	Heated for 20 minutes at 550° C.	Dark gray colored granules having an unfused, unvitriified rough irregular matted surface. Granules did not produce turbidity when added to water.
100 grams of aluminum oxide abrasive grain #20 grit.	1 c. c. of an aqueous solution of Fe (H ₂ PO ₄) ₃ (Sp. Gr. 1.35 at 25° C.).	1.0 gram of Fe ₂ O ₃ .	Heated for 30 minutes at 550° C.	Bright red granules having a water resistant unfused, unvitriified, rough irregular matted surface.
Do.....	4 c. c. of 20% aqueous solution of Mg(H ₂ PO ₄) ₂do.....	Heated in muffle furnace to 700° C.	Do.
Do.....	2 c. c. of 30% aqueous solution of "Plastic Phosphate."do.....	Heated for 30 minutes at 550° C.	Do.
100 grams of silicon carbide abrasive grain.	1.5 c. c. of aqueous solution of Al(H ₂ PO ₄) ₃ (Sp. Gr. 1.35 at 25° C.).	1.5 grams of Fe ₂ O ₃do.....	Do.

It will be noted that in all instances the coated grain displayed an unfused, unvitriified rough irregular matted surface which was resistant to the action of water, thus indicating that the "Plastic Phosphate" had been rendered substantially water insoluble and also that the above orthophosphates had been molecularly dehydrated to the metaphosphate form.

The expression "Plastic Phosphate" used in the above table covers a mixture of 80% sodium hexametaphosphate and 20% potassium metaphosphate. It is distinguished from the other coating materials in that it need not be formed in situ but may be applied directly to the abrasive grain. However, it may be formed on the grain by employing equivalent amounts of the corresponding mixture of monosodium and monopotassium orthophosphates and then heating the latter to the metaphosphate forming temperature. Therefore, it is understood that the present invention covers both of these procedures.

The various conditions of operation will now be discussed in greater detail.

The present method of improving the bonding properties of abrasive grains has been applied to grains varying in particle size from 8 to 240 mesh, but it is to be understood that the invention is not restricted to this size range since particle size is not a critical variable provided the grain is substantially larger than the inert material to be bonded thereto.

The bonding material, that is, the "Plastic Phosphate" and the water soluble mono-metallic orthophosphate, is preferably employed in an amount just sufficient to coat all the particles of the abrasive grain with a thin film of the corresponding metaphosphate. This factor will vary with the phosphate, the thickness of the coating and the size of the grain. In general, however, from about 0.5% to about 5% by weight of the bonding phosphate is sufficient to give satisfactory grain coverage. Within the foregoing range, about 1.6% by weight is preferred.

The inert or substantially inert material to be adhesively bonded to the surface of the grain by the phosphate coating is preferably employed in an amount varying from about 0.5% to about 2% by weight, but larger or smaller amounts may also be used. In fact, in its broadest aspect, the invention contemplates omitting the inert material altogether, in which case the increased adhesiveness of the grain is derived from the metaphosphate coating.

With regard to the concentration of the solutions of "Plastic Phosphate" or mono-metallic orthophosphate, it is desirable to use solutions

having a specific gravity at 25° C. of from 1.2 to 1.7 and within this range a specific gravity of 1.35-1.5 is preferred.

The drying operation is generally carried out with agitation at 100° C. to 200° C., but higher or lower temperature may be used if desired.

The calcination step is carried out at a temperature sufficient to molecularly dehydrate the mono-metallic orthophosphate to metaphosphate but below that temperature at which a substantial amount of fusion of the metaphosphate takes place. Since the limits of the temperature range vary with the mono-metallic orthophosphate selected and moreover since this information is either available in the literature or is readily ascertainable by one skilled in the art, no attempt will be made to more specifically define the calcination temperature range. In general, however, a temperature of about 550° C. is preferred.

With reference to the use of "Plastic Phosphate," it is essential to calcine the coating, whether directly applied to the abrasive grain or formed in situ, so as to convert the metaphosphates into a substantially water insoluble form. This is preferably accomplished by heating the coated product for about 30 minutes at a temperature of about 550° C.

Where "inert material" is referred to in the claims, it is to be understood that this expression likewise covers substantially inert materials such as iron oxide, chromium oxide, manganese oxide and equivalent materials.

While we have described our invention in detail, it should be understood that many changes may be made therein without departing from spirit of same.

What we claim is:

1. Abrasive grain coated with a substantially water insoluble, unfused, unvitriified film which bonds finely divided inert materials to the surface of the grain, said film consisting essentially of a material selected from the group consisting of aluminum metaphosphate, ferric metaphosphate, magnesium metaphosphate and "Plastic Phosphate."

2. Aluminum oxide abrasive grain coated with a substantially water insoluble, unfused, unvitriified film which bonds finely divided inert materials to the surface of the grain, said film consisting essentially of a material selected from the group consisting of aluminum metaphosphate, ferric metaphosphate, magnesium metaphosphate and "Plastic Phosphate."

3. Silicon carbide abrasive grain coated with a substantially water insoluble, unfused, unvitriified film which bonds finely divided inert materials

to the surface of the grain, said film consisting essentially of a material selected from the group consisting of aluminum metaphosphate, ferric metaphosphate, magnesium metaphosphate and "Plastic Phosphate."

4. Aluminum oxide abrasive grain coated with a substantially water insoluble, unfused, unvitrified film which bonds from 0.5% to 2% by weight of finely divided inert materials to the surface of the grain, said film consisting essentially of a material selected from the group consisting of aluminum metaphosphate, ferric metaphosphate, magnesium metaphosphate and "Plastic Phosphate."

5. Aluminum oxide abrasive grain coated with a substantially water insoluble, unfused, unvitrified film which bonds from 0.5% to 2% by weight of finely divided ferric oxide to the surface of the grain, said film consisting essentially of a material selected from the group consisting of aluminum metaphosphate, ferric metaphosphate, magnesium metaphosphate and "Plastic Phosphate."

6. Aluminum oxide abrasive grain coated with a substantially water insoluble, unfused, unvitrified film which bonds from 0.5% to 2% by weight of finely divided clay to the surface of the grain, said film consisting essentially of a material selected from the group consisting of aluminum metaphosphate, ferric metaphosphate, magnesium metaphosphate and "Plastic Phosphate."

7. Aluminum oxide abrasive grain coated with a substantially water insoluble, unfused, unvitrified film which bonds about 1% by weight of finely divided inert materials to the surface of the grain, said film consisting essentially of a material selected from the group consisting of aluminum metaphosphate, ferric metaphosphate, magnesium metaphosphate and "Plastic Phosphate."

8. Aluminum oxide abrasive grain coated with a substantially water insoluble, unfused, unvitrified film which bonds about 1.5% by weight of finely divided ferric oxide to the surface of the grain, said film consisting essentially of aluminum metaphosphate.

9. Aluminum oxide abrasive grain coated with a substantially water insoluble, unfused, unvitrified film which bonds about 1% by weight of finely divided ferric oxide to the surface of the grain, said film consisting essentially of aluminum metaphosphate.

10. Aluminum oxide abrasive grain coated with a substantially water insoluble, unfused, unvitrified film which bonds about 1.5% by weight of finely divided clay to the surface of the grain, said film consisting essentially of aluminum metaphosphate.

11. Aluminum oxide abrasive grain coated with a substantially water insoluble, unfused, unvitrified film which bonds about 1.4% by weight of finely divided ferric oxide to the surface of the grain, said film consisting essentially of ferric metaphosphate.

12. Aluminum oxide abrasive grain coated with a substantially water insoluble, unfused, unvitrified film which bonds about 1% by weight of finely divided ferric oxide to the surface of the grain, said film consisting essentially of magnesium metaphosphate.

13. Aluminum oxide abrasive grain coated with a substantially water insoluble, unfused, unvitrified film which bonds about 1% by weight of finely divided ferric oxide to the surface of the

grain, said film consisting essentially of "Plastic Phosphate."

14. Silicon carbide abrasive grain coated with a substantially water insoluble, unfused, unvitrified film which bonds about 1.5% by weight of finely divided ferric oxide to the surface of the grain, said film consisting essentially of aluminum metaphosphate.

15. The method of improving the bonding properties of abrasive grains, which comprises coating them with a material consisting essentially of a solution of a mono-metallic orthophosphate carrying finely divided inert material and then heating the coated grain to a temperature sufficient to molecularly dehydrate said orthophosphate to metaphosphate but below the temperature at which substantial fusion of the metaphosphate takes place, said mono-metallic orthophosphate being selected from the group consisting of mono-aluminum orthophosphate, mono-iron orthophosphate, mono-magnesium orthophosphate and a mixture of mono-potassium and mono-sodium orthophosphates in amounts equivalent to "Plastic Phosphate."

16. The method of improving the bonding properties of aluminum oxide abrasive grains, which comprises coating said grains with a material consisting essentially of a solution of a mono-metallic ortho-phosphate, applying finely divided ferric oxide to the coated grains and heating the resulting product to a temperature sufficient to molecularly dehydrate said orthophosphate to metaphosphate but below the temperature at which substantial fusion of the metaphosphate takes place, said mono-metallic orthophosphate being selected from the group consisting of mono-aluminum orthophosphate, mono-iron orthophosphate, mono-magnesium orthophosphate and a mixture of mono-potassium and mono-sodium orthophosphates in amounts equivalent to "Plastic Phosphate."

17. The method of improving the bonding properties of aluminum oxide abrasive grains, which comprises coating said grains with a material consisting essentially of a solution of mono-aluminum orthophosphate, applying finely divided ferric oxide to the coated grains and heating the resulting product to a temperature sufficient to molecularly dehydrate said orthophosphate to metaphosphate but below the temperature at which substantial fusion of the metaphosphate takes place.

18. The method of improving the bonding properties of aluminum oxide abrasive grains, which comprises coating said grains with a material consisting essentially of a solution of mono-iron orthophosphate, applying finely divided ferric oxide to the coated grains and heating the resulting product to a temperature sufficient to molecularly dehydrate said orthophosphate to metaphosphate but below the temperature at which substantial fusion of the metaphosphate takes place.

19. The method of improving the bonding properties of aluminum oxide abrasive grains, which comprises coating said grains with a material consisting essentially of a solution of mono-magnesium orthophosphate, applying finely divided ferric oxide to the coated grains and heating the resulting product to a temperature sufficient to molecularly dehydrate said orthophosphate to metaphosphate but below the temperature at which substantial fusion of the metaphosphate takes place.

20. The method defined in claim 16 wherein the

aqueous solution of mono-metallic orthophosphate has a specific gravity of 1.2 to 1.7 at 25° C.

21. The method defined in claim 16 wherein the aqueous solution of mono-metallic orthophosphate has a specific gravity of 1.35 to 1.50 at 25° C.

22. The method defined in claim 16 wherein an aqueous solution of mono-aluminum orthophosphate having a specific gravity of about 1.4 at 25° C. is employed.

23. The method of improving the bonding properties of silicon carbide abrasive grains, which comprises coating said grains with an aqueous solution of mono-aluminum orthophosphate having a specific gravity of 1.35 at 25° C., applying finely divided ferric oxide to the coated grains and heating the resulting product to a temperature sufficient to molecularly dehydrate said orthophosphate to metaphosphate but below the temperature at which substantial fusion of the metaphosphate takes place.

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