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3,458,300

ABRASIVE CLEANING COMPOSITIONS

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3 Claims

ABSTRACT OF THE DISCLOSURE

An abrasive cleaning composition for use in spray-cleaning systems is prepared from aluminum oxide, sodium metasilicate pentahydrate, a phosphate complex, and a wetting agent.

This invention relates to an abrasive cleaning compound. More particularly, it relates to an abrasive cleaning compound for use in spray-cleaning systems.

In many instances, the removal of corrosion products and the like from aluminum and aluminum alloy surfaces can be accomplished merely by immersing the article into a bath of an aqueous solution of a mineral acid and wetting agents. When the desired degree of cleaning has occurred, the articles are removed from the bath, rinsed, and then dried. In the case of aircraft, however, it is unwieldy and impractical to dip or immerse the same into baths. Accordingly, it is customary in the aircraft industry to brush or spray the cleaning solution on the aluminum surfaces to be cleaned. When the desired degree of cleaning has occurred, the solution is rinsed from the surface.

The aluminum cleaning solutions developed heretofore suffer from the deficiency of being corrosive to aluminum, magnesium and their alloys. There is a tendency more and more for aircraft to be constructed of both aluminum and magnesium parts. Consequently, the problem of corrosion of the aircraft surfaces is becoming quite serious.

Still another deficiency of the prior art aluminum cleaners resides in the fact that they are in the form of an aqueous solution. Elimination of water from the composition until the time of use results in savings in shipping and handling costs. Elimination of water does not, however, completely solve the problem since the strong acids used in the cleaning solutions are generally liquid at the usual temperature of shipping and storage.

Due to the inherent characteristic of aluminum to combine with oxygen, the exposed surfaces of most aluminum alloys rapidly develop an oxide scale, coating or film which manifest a dull and unattractive appearance. The film exhibits a great tenacity for the retention of grease, dirt and other forms of contamination which reduces still further the reflective characteristics of the original surface. Exterior skins of aircraft, for example, which are generally formed of aluminum or aluminum alloys, in operation become quite dull in appearance, and where a number of different alloys are used for the several parts and assemblies, the aircraft as a whole may present a varying patch-work of dull and unattractive shades of gray. It is customary, however, for aircraft manufacturers to require that the exterior skins present a uniform texture and appearance, and heretofore in practice, this usually has been accomplished by rubbing and buffing the surfaces of the skins by hand.

The present practice by the airlines is to use a water emulsion type cleaner for exhaust tracks and other heavily soiled areas, and a foam cleaner for lightly soiled, painted areas. With these cleaners a considerable amount of hand agitation with brushes and mops is required to satisfac-

torily remove the soil. This procedure allows a gradual build-up of soil which must be periodically removed by power buffing.

It is, therefore, a general object of this invention to provide the art with a dry aluminum cleaner. It is another object of the invention to develop aluminum cleaning compositions which are substantially noncorrosive to aluminum, aluminum alloy, magnesium and magnesium alloy surfaces. Still another object of this invention is to develop an aluminum cleaning composition in solid form that can be readily dissolved in water in a given proportion to give aqueous solutions that may be readily sprayed onto the surfaces to be cleaned.

We have found that a composition consisting essentially of from about 25 to 90 weight percent aluminum oxide having a particle size of from about 5 to 15 microns, from about 5 to 75 weight percent sodium metasilicate pentahydrate, from about 0.5 to 20 weight percent of phosphate complexes, and from about 0.5 to 20 weight percent wetting agents provides an excellent cleaning composition for use in spray-cleaning systems. All percentages herein are given in weight percent of the dry composition. The wide ranges of the ingredients allow the compositions of this invention to be adjusted to the difficulty of the soil being removed or to the type of surface being cleaned. Compositions of this invention are used in an aqueous solution for removal of soil in routine cleaning or for removing more complex surface soiling materials.

While the compositions of the present invention are particularly applicable to the cleaning of aluminum aircraft components, it is to be understood that they have many other applications and may be used on such surfaces as aircraft gloss enamel, pigmented epoxy paint, plexiglass, neoprene and rubber. It is within the scope of the invention to use the compositions for routine maintenance cleaning and reconditioning of transportation equipment such as in auto washes, railroad equipment, marine equipment, trucks and trailers, particularly for unpainted surfaces thereon. The compositions may also be used for engine cleaning and carbon, rust and scale removal, and for metal polishing of copper kettles such as used in breweries and food processing plants.

The compositions of this invention may be made by merely mixing the ingredients together in any desired way. However, to prepare a uniform product it is preferred to add the dry powdered materials to the mixer one at a time while mixing. The liquid wetting agent is heated to about 150° F. and sprayed in a fine spray on the powdered materials while the mixer is operating. This procedure will provide a uniform, relatively lump-free product that is easily put into solution. The product is a white powder with a packed density of from about 8.0 pounds per gallon to about 13 pounds per gallon.

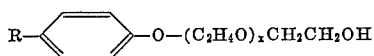
The aluminum oxide abrasive used in the compositions of this invention should have a particle size of from about 5 to 15 microns. It is preferred to use an aluminum oxide abrasive having particles in the 5 to 10 micron range so that at least less than 40% will remain on a 325 mesh sieve, U.S. Standard Sieve Series. Aluminum oxide is used because of its hardness and because it does not introduce foreign matter which could be the cause of localized corrosion.

The sodium metasilicate pentahydrate used in the compositions of this invention may be represented by the formula $\text{Na}_2\text{SiO}_5 \cdot 5\text{H}_2\text{O}$. It has a total Na_2O content of about 29.3%, with a 27.8% Na_2O active content and has a density of about 55 pounds per cubic foot.

The phosphate complexes that may be used within the scope of this invention include sodium tripolyphosphate, trisodium phosphate, the sodium pyrophosphates and the sodium hexametaphosphates. For economic reasons sodium tripolyphosphate is preferred.

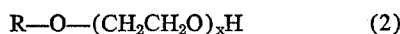
Any of a number of wetting agents may be used in the compositions of this invention. However, the wetting agents should not foam excessively since high foaming materials produce a cushioning effect which reduces oxide removal. It is also advantageous to use a wetting agent with anti-static properties to reduce deposition of the abrasive on the surface being cleaned.

One of the nonionic wetting agents that may be used in the compositions of this invention is the polyoxyethylene adducts of monoalkylated phenols, also generically known as alkyl phenol ethylene oxide condensates. The compounds may be represented by the formula:



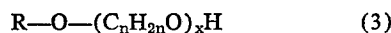
wherein R is an alkyl substituent having from about 6 to 20 carbon atoms and x has a value from about 5 to 30 such that the oxyethylene content is from about 25 to 85 weight percent of total compound. The preferred polyoxyethylene adducts of monoalkylated phenols have from about 8 to 12 carbon atoms in the alkyl substituent and an oxyethylene content from about 40 to 55 weight percent. The alkyl substituents include, for example, hexyl, heptyl, octyl, nonyl, decyl, dodecyl, pentadecyl and eicosyl. Typical alkylated phenols which can be condensed with ethylene oxide to prepare surface active agents of this type include hexylphenol, heptylphenol, octylphenol, nonylphenol and dodecylphenol.

Another type of nonionic wetting agent that may be used in the formulations of this invention is described as the N-alkoxy-polyethoxy-ethanols or ethylene oxide adducts of straight-chain primary alcohols. The hydrophobic alcohol portion of the surfactant may have carbon chains of from 6 to 20 carbon atoms. The primary alcohols to be ethoxylated may be natural or synthetic. They may be a single alcohol such as cetyl alcohol or they may be a blend of alcohols containing, for example, from 12 to 18 carbon atoms. Examples of alcohols that may be used include octyl alcohol, nonyl alcohol, decyl alcohol, dodecyl alcohol, tetradecyl alcohol, cetyl alcohol, lauryl alcohol, palmityl alcohol, stearyl alcohol, hydrogenated tallow alcohol and mixtures thereof. The ethoxylated straight-chain primary alcohols correspond to the formula:



wherein $\text{R}-\text{O}-$ is the hydrophobe and is the residue of an alcohol containing from 6 to 20 carbon atoms and x may be from 3 to 19 such that the ethylene oxide content is from about 35 to 85 weight percent of compound.

Another type of nonionic wetting agent derived from straight-chain primary alcohols may be generally represented by the formula:

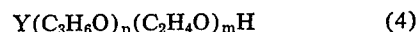


wherein $\text{R}-\text{O}-$ is the hydrophobe and is the residue of an alcohol containing from 6 to 20 carbon atoms, n is both 2 and 3 in a single molecule and x is the total number of oxyalkylene radicals in the molecule. The compounds represented by Formula 3 are prepared by (1) reacting mixtures of ethylene and propylene oxides with blends of straight-chain primary alcohols or (2) reacting ethylene oxide with blends of straight-chain primary alcohols and then capping the ethoxylated alcohols with propylene oxide. It follows, therefore, that the ethylene oxide and propylene oxide radicals may have either an ordered distribution or a random distribution in the molecule depending upon the method of synthesis. Examples of alcohols that may be used include octyl alcohol, nonyl alcohol, decyl alcohol, dodecyl alcohol, tetradecyl alcohol, cetyl alcohol, lauryl alcohol, pamityl alcohol, stearyl alcohol, hydrogenated tallow alcohol and mixtures thereof. These surface active agents may contain from about 35 to 90 weight percent ethylene oxide and from 10 to 25 weight percent propylene oxide based on total

molecular weight. The total molecular weight of these compounds is from about 300 to 800.

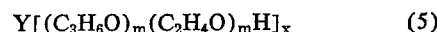
Other suitable water-soluble nonionic wetting agents include cogeneric mixtures of conjugated polyoxyalkylene compounds containing in their structure at least one hydrophobic oxyalkylene chain in which the oxygen/carbon atom ratio does not exceed about 0.33 and at least one hydrophilic oxyalkylene chain in which the oxygen/carbon atom ratio is not less than about 0.5. Propylene oxide, butylene oxide, amylene oxide and styrene oxide are illustrative of oxyalkylene compounds having an oxygen/carbon atom ratio not exceeding about 0.33; while ethylene oxide, butadiene dioxide and glycidol, as previously pointed out, are illustrative of oxyalkylene compounds having an oxygen/carbon atom ratio of at least about 0.5. Although the hydrophobic chain has an oxygen/carbon atom ratio not exceeding about 0.33, it is often advantageous to include in this chain a small amount of ethylene oxide, i.e., up to about 15 weight percent, and likewise in the hydrophilic chain which has an oxygen/carbon atom ratio not less than about 0.5, it is often advantageous to include a small amount of propylene oxide or butylene oxide, i.e., up to about 15 weight percent, and the oxygen/carbon atom ratios described herein and in the claims are not intended to preclude such mixtures.

Among the conjugated polyoxyalkylene compounds which can be used in the compositions of the invention are those which correspond to the formula:



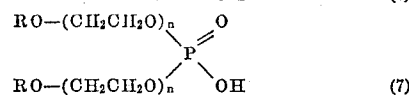
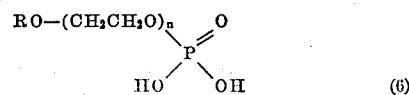
wherein Y is the residue of an organic compound having from about 1 to 6 carbon atoms and one reactive hydrogen atom, n has an average value of at least about 6.4 as determined by hydroxyl number and m has a value such that the oxyethylene portion constitutes about 10 to 90 weight percent of the molecule. Most of these surface active agents are more particularly described in U.S. Patent No. 2,677,700.

Other conjugated polyoxyalkylene wetting agent which are most advantageously used in the compositions of the invention correspond to the formula:



wherein Y is the residue of an organic compound having from about 2 to 6 carbon atoms and containing x reactive hydrogen atoms in which x has a value of at least about 2, n has a value such that the molecular weight of the polyoxypropylene hydrophobic base is at least about 900 and m has a value such that the oxyethylene content of the molecule is from about 10 to 90 weight percent. Compounds falling within the scope of the definition for Y include, for example, propylene glycol, glycerine, pentaerythritol, trimethylolpropane, ethylenediamine, triethylenetetramine, triisopropanolamine, butylamine, and the like. Most of these compounds are more particularly described in U.S. Patent Nos. 2,674,619 and 2,979,528.

The preferred wetting agents for use in the compositions of this invention are mixtures of mono- and diesters of orthophosphoric acid made from nonionic surfactants of the ethylene oxide-adduct type and may be represented by the following structural formula:



where n is the average number of moles of ethylene oxide that have reacted with one mole of ROH (the hydrophobe) and n may be from about 3 to 20. R is a C_8 to C_{20} alkyl or alkylphenyl radical. This wetting agent is preferred since it is anionic and exhibits anti-static properties.

The complex phosphates, sodium metasilicate and wetting agents permit the removal of oil and dirt without interfering with the oxide film removal. Without these additives, the surface contamination cushions the impact to the point that the oxides are not removed. Also, without these additives, there is a tendency for the abrasive to deposit a film of aluminum oxide particles. This film can be easily wiped off but cannot be removed by rinsing after it has dried. The use of wetting agents in the formulation reduce this tendency to form a film. The film is avoided by flushing the treated surface with large volumes of water before the solution has dried.

In using the compositions of this invention, a slurry is made by placing the product in water. The wetting agent, phosphate complex and sodium metasilicate dissolve, leaving a suspension of fine aluminum oxide particles in the solution. Continuous mild agitation is necessary to keep the abrasive in suspension. The use concentration may be varied from about 0.1% to 40% by weight in water. The most effective use concentration range is from about 1% to about 10% by weight. The product should be used on a per gallon basis of from about 1 to 10 ounces per gallon of water.

Most effective use of the compositions of this invention can be accomplished by spraying them under high pressure. The system used should be capable of producing at least 1,000 p.s.i. and preferably up to 10,000 p.s.i. pressure from a high pressure pump and a delivering capacity of from about 0.75 to 3.5 gallons per minute through a suitable hose to a fan spray nozzle. Wear-resistant boron carbide or tungsten carbide spray nozzle tips are recommended. The high pressure pump may be equipped to supply more than one hose at a time. In operation, the spray nozzle tip may be held from about 3" to 24" from the surface being cleaned, with the exact distance depending upon the difficulty of removing the soil. The nozzle tip should be moved slowly with overlapping back and forth strokes across the area to be cleaned to assure a complete cleaning job.

For reconditioning and removal of heavy oxide film, the preferred composition consists essentially of from about 80 to 90% aluminum oxide having a particle size from about 5 to 10 microns such that at least less than 40% will remain on a 325 mesh sieve, U.S. Standard Sieve Series; from about 5 to 10% sodium metasilicate pentahydrate; from about 0.5 to 3% of a phosphate complex, preferably sodium tripolyphosphate; and from about 0.5 to 3% wetting agent, preferably a mixture of mono- and diesters of orthophosphoric acid made from nonionic surfactants of the ethylene oxide-adduct type as described above.

For routine cleaning jobs, it is preferred to use a composition consisting essentially of about 30 to 40% aluminum oxide having a particle size from about 5 to 10 microns such that at least less than 40% will remain on a 325 mesh sieve, U.S. Standard Sieve Series; from about 50 to 60% sodium metasilicate pentahydrate; from about 3 to 12% of a phosphate complex, preferably sodium tripolyphosphate; and from about 3 to 12% of a wetting agent, preferably a mixture of mono- and diesters of orthophosphoric acid made from nonionic surfactants of the ethylene oxide-adduct type as described above.

It is to be understood that these formulations are the preferred formulations but that the formulations may be varied within the broader ranges specified to meet the conditions of each cleaning job to be done.

A more complete understanding of the invention can be obtained by considering the following examples, which are not intended to be unduly limitative of the invention.

Example 1

The composition used in this example consisted of 89.0% aluminum oxide, 325 mesh, 9% sodium metasilicate pentahydrate, 1% sodium tripolyphosphate and 1% of a polyoxyethylated straight-chain primary alcohol sold by General Aniline and Film Corporation under the trade-

name of Antarox BL-330. This formulation was used for reconditioning and heavy duty cleaning.

Using this composition for oxide removal at a concentration of 8 ounces per gallon of water, the portions of the underwing surface and fuselage of a Boeing 720 aircraft were cleaned. The underwing surface and fuselage oxide soil was the result of the exhaust track from the jet engines depositing materials under the aircraft wings and on the fuselage surface. Using the above composition, the dark oxide film was removed leaving a clean surface having the characteristic metallic luster. The solution was applied at a line flow pressure of 8,000 to 10,000 p.s.i. and at a rate of 2.0 to 2.5 gallons per minute from a fan spray nozzle five inches wide, with the nozzle tip held 6 to 10 inches from the surface. Under these conditions, the surface was reconditioned in slow overlapping passes at a rate of about four square feet per minute on the heaviest black soil embedded under the wing of the Boeing 720 aircraft.

Example 2

The composition used in this example consisted of 34.0% aluminum oxide, 325 mesh, 54.0% sodium metasilicate pentahydrate, 6.0% sodium tripolyphosphate and 6.0% of a mixture of mono- and diesters of orthophosphoric acid made from nonionic surfactants of the ethylene oxide-adduct type sold under the tradename of Gafac RE-610. This formulation is used for routine and general maintenance cleaning. The composition for routine cleaning was used at a concentration of about two ounces per gallon. Asphalt soil as specified by specification MIL-C-22543 was applied to aluminum test panels. The solution of the cleaning composition was applied at a line flow pressure of from 5,000 to 8,000 p.s.i. and at a rate of from 2.5 to 3.2 gallons per minute from a fan spray nozzle, with the nozzle tip up to 18" from the surface. The surface was rapidly wetted down with the solution and allowed to soak for about five minutes. The surface was then sprayed in two overlapping passes of the fan spray so as to dislodge the soil. The surface was then thoroughly flushed with water. The asphalt soil was removed from the aluminum panels with no effect on the base metal. The test was repeated by applying asphalt soil to the painted surfaces on the test panels. Using the same conditions, the asphalt soil was removed from the test panels with no visible effect to the painted surfaces.

Example 3

In order to test the compositions of this invention on various surfaces, the following tests were performed.

(A) A 2% solution of the following composition was made:

Ingredients:	Percent
Aluminum oxide (325 mesh) -----	89.5
Sodium tripolyphosphate -----	1.0
Sodium metasilicate pentahydrate -----	9.0
Antarox BL-330 ¹ -----	0.5
	100.0

¹ Polyoxyethylated straight-chain alcohol wetting agent.

The 2% solution was in water at 65° F. and was sprayed on the surface of (1) aircraft gloss enamel, (2) pigmented epoxy paint, (3) plexiglass, (4) neoprene, and (5) rubber for 30 seconds at 1,000 p.s.i. working pressure with the fan spray 6" from the surface. The product was found to have no harmful effect on the surfaces of these materials.

(B) In order to test the abrasive effect of the compositions of this invention on various metal and alloy surfaces used in aircraft construction, the following procedure was used. A 2% solution in water of the above composition was made. The solution was sprayed on the surfaces of the metals and alloys indicated below for 30 seconds at 1,000 p.s.i. The weight loss and surface appearance results indicated below show that the composi-

tions of this invention have no visible effect and that the weight loss was held to a minimum on metal and alloy surfaces used in aircraft construction.

Material	Weight loss mg./in. ²	Appearance
AZ31B-F magnesium alloy ¹	0.16	Satin finish.
2024 bare aluminum ²	0.10	Do.
7075 Alclad aluminum ³	0.01	Do.
7075 bare aluminum ⁴	0.01	Do.
1010 steel ⁵	0.05	Do.
Cadmium plated steel.....	0.50	Do.

¹ See page 1069, Metals Handbook, American Society for Metals, 8th Edition for composition.

² See page 917, Metals Handbook, American Society for Metals, 8th Edition for composition.

³ See page 917, Metals Handbook, American Society for Metals, 8th Edition for composition.

⁴ See page 917, Metals Handbook, American Society for Metals, 8th Edition for composition.

⁵ See page 62, Metals Handbook, American Society for Metals, 8th Edition for composition.

(C) In order to test for corrosive conditions, the following materials were subjected to a seven-day immersion test at 100° F. in a 2% solution of the composition listed in part (A) above. The following results were obtained:

Material	Weight change (mg./in. ²)	Surface Effect
AZ31B-F magnesium alloy ¹	+0.09	Brown adherent Ctg.
2024 bare aluminum ²	-0.003	None.
2024 Alclad aluminum ³	-0.002	Do.
7075 Alclad Aluminum ³	-0.143	Do.
Cadmium plated steel.....	+0.58	Loose coating.
1010 steel ⁵	-0.003	None.

^{1 2 3 5} See footnotes above.

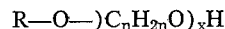
⁴ See page 917, Metals Handbook, American Society for Metals, 8th edition, for composition.

Thus, it is seen that the compositions of this invention are relatively free from corrosive effects.

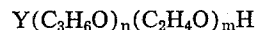
What we claim is:

1. A composition of matter adapted for cleaning metallic surfaces consisting essentially of from about 25 to 90% aluminum oxide having a particle size of from about 5 to 15 microns, from about 5 to 75% sodium metasilicate pentahydrate, from about 0.5 to 20% of a phosphate complex selected from the group consisting essentially of (1) sodium tripolyphosphate, (2) trisodium phosphate, (3) sodium pyrophosphate, and (4) sodium hexametaphosphate, and from about 0.5 to 20% of a wetting agent selected from the group consisting essentially of (1) polyoxyethylated straight-chain alcohols, (2) a mixture of monoester and diesters of orthophosphoric acid made from nonionic surfactants of the ethylene oxide-adduct type, (3) polyoxyethylene adducts of mono-

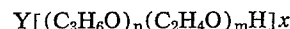
alkylated phenols, (4) compounds corresponding to the formula:



where R—O— is the hydrophobe residue of a C₆ to C₂₀ alcohol, *n* is both 2 and 3 in the same molecule and *x* is an integer such that the total molecular weight is from about 300 to 800, (5) compounds corresponding to the formula:



where Y is the residue of an organic compound having from 1 to 6 carbon atoms and one reactive hydrogen atom, *n* has an average value of at least 6.4 as determined by hydroxy number, and *m* has a value such that the oxyethylene portion constitutes about 10 to 90 weight percent of the molecule, and (6) compounds corresponding to the formula:



where Y is the residue of an organic compound having from about 2 to 6 carbon atoms and containing *x* reactive hydrogen atoms in which *x* has a value of at least about 2, *n* has a value such that the molecular weight of the polyoxypropylene hydrophobic base is at least 900, and *m* has a value such that the oxyethylene content of the molecule is from about 10 to 90 weight percent, based on 100 weight percent for the total composition.

2. The composition of claim 1 wherein said aluminum oxide is from about 80 to 90%, said sodium metasilicate pentahydrate is from about 5 to 10%, said phosphate complex is from about 0.5 to 3%, and said wetting agent is from about 0.5 to 3%.

3. The composition of claim 1 wherein said aluminum oxide is from about 25 to 40%, said sodium metasilicate is from about 50 to 60%, said phosphate complex is from about 3 to 12%, and said wetting agent is from about 3 to 12%.

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DONALD J. ARNOLD, Primary Examiner

U.S. Cl. X.R.

51—309; 106—3, 14