



(51) International Patent Classification:

C11D 1/02 (2006.01) *C11D 1/79* (2006.01)
A47L 15/00 (2006.01) *C11D 1/82* (2006.01)

(21) International Application Number:

PCT/IB2012/052518

(22) International Filing Date:

18 May 2012 (18.05.2012)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

61/519,341 20 May 2011 (20.05.2011) US

(71) Applicant (for all designated States except US): **ECOLAB USA INC.** [US/US]; 370 N. Wabasha Street, St. Paul, Minnesota 55102 (US).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **MONSRUD, Lee, J.** [US/US]; 7475 Cleadis Way, Inver Grove Heights, Minnesota 55076 (US). **RISCHMILLER, Michael, S.** [US/US]; 8669 Beverly Way, Inver Grove Heights, Minnesota 55076 (US). **MANSERGH, John** [US/US]; 7176 Hidden Valley Cove South, Cottage Grove, Minnesota 55016 (US). **OSTERBERG, Daniel** [US/US]; 1611 Mill St., White Bear Twp., Minnesota 55110 (US).

(74) Agent: **SORENSEN, Andrew, D.**; Ecolab USA Inc., 655 Lone Oak Drive, Eagan, Minnesota 55121 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— without international search report and to be republished upon receipt of that report (Rule 48.2(g))

(54) Title: NON-PHOSPHATE DETERGENTS AND NON-PHOSPHORIC ACIDS IN AN ALTERNATING ALKALI/ACID SYSTEM FOR WAREWASHING

(57) Abstract: A method of warewashing for the optimization of cleaning is obtained, excess detergent usage is minimized and further where deposit of film on ware is reduced in an alternating acidic and alkaline cleaning method. According to the invention, the type of acid and alkalinity used, or acid salt formed upon application of the acidic and alkaline washes is important to cleaning performance and phosphate or silicates should be avoided.



NON-PHOSPHATE DETERGENTS AND NON-PHOSPHORIC ACIDS IN AN ALTERNATING ALKALI/ACID SYSTEM FOR WAREWASHING

5 FIELD OF THE INVENTION

The invention is related to a method of warewashing, which includes a first alkaline step, a first acidic step, and an optional second alkaline step. The invention discloses critical parameters for the alkaline and acidic cleaners used which are necessary to optimize cleaning performance as the wash shifts from alkali to acidic
10 conditions. The method may be carried out in a variety of dish machines, including consumer and institutional dish machines.

BACKGROUND OF THE INVENTION

In recent years there has been an ever increasing trend towards safer and
15 sustainable detergent compositions. This has led to the development of alternative complexing agents, builders, threshold agents, corrosion inhibitors, and the like, which are used instead of predominantly phosphorus containing compounds. Phosphates can bind calcium and magnesium ions, provide alkalinity, act as threshold agents, and protect alkaline sensitive metals such as aluminum and
20 aluminum containing alloys.

Alkaline detergents, particularly those intended for institutional and commercial use, generally contain phosphates, nitrilotriacetic acid (NTA) or ethylenediaminetetraacetic acid (EDTA) as a sequestering agent to sequester metal ions associated with hard water such as calcium, magnesium and iron and also to
25 remove soils.

In particular, NTA, EDTA or polyphosphates such as sodium tripolyphosphate and their salts are used in detergents because of their ability to solubilize preexisting inorganic salts and/or soils. When calcium, magnesium salts precipitate, the crystals may attach to the surface being cleaned and cause
30 undesirable effects. For example, calcium carbonate precipitation on the surface of ware can negatively impact the aesthetic appearance of the ware, giving an unclean look. The ability of NTA, EDTA and polyphosphates to remove metal ions facilitates the detergency of the solution by preventing hardness precipitation,

assisting in soil removal and/or preventing soil redeposition during the wash process.

While effective, phosphates and NTA are subject to government regulations due to environmental and health concerns. Although EDTA is not currently
5 regulated, it is believed that government regulations may be implemented due to environmental persistence. There is therefore a need in the art for an alternative, and preferably environment friendly, cleaning composition that can reduce the content of phosphorus-containing compounds such as phosphates, phosphonates, phosphites, and acrylic phosphinate polymers, as well as persistent aminocarboxylates such as
10 NTA and EDTA.

It is an object of the invention to address at least one of the above problems and/or to offer detergent compositions with usage and/or environmental benefits.

SUMMARY OF THE INVENTION

15 Applicants have discovered that certain detergents and certain acids behave differently in a multiple step washing system that uses both alkali and acidic cleaning stages. Surprisingly, applicants have discovered that not only the pH of the cleaning agent is important, but the type of acid and alkali source is also important. Specifically, phosphate-containing detergents and phosphoric-acid containing acids
20 as well as silicates and other agents that may precipitate upon the changing pH conditions can cause the detergent controller in institutional machines to function improperly, it also results in excessive detergent usage. These precipitate forming components of detergent products also cause a negative film buildup on the dishware and have deleterious effects on cleaning performance.

25 The invention comprises methods for optimizing cleaning performance in a warewash process comprising at least a first alkaline step, a first acidic step, and an optional second alkaline step. The method includes the use of alkaline and acidic detergents that do not include components that may precipitate out as the wash conditions shift from basic to acidic. For example the use of phosphates or silicates
30 must be avoided in either the source of alkalinity, the acid source, the other functional and non functional components and even the wash water for any step in the process.

The method may include multiple additional alkaline and acidic steps. The method may also include pauses between steps as well as rinses. The method may be carried out using a variety of alkaline and acidic compositions, as long as none of the compositions include silicates or phosphates that may precipitate out. Finally,
5 the method may be carried out in a variety of dish machines, include consumer and institutional dish machines.

Additionally, the invention pertains to a method of cleaning articles in a dish machine using the steps of supplying a first alkaline detergent composition comprising a phosphate free and a silica free source of alkalinity and a water
10 conditioning agent, and optional functional ingredients, inserting the composition into a dispenser in a dish machine, forming a wash solution with the composition and water, contacting soil on an article in the dish machine with the wash solution, removing the soil, and rinsing the article. The invention next comprises an acidic detergent comprising a phosphate free and silica free acid and a surfactant and
15 optional additional functional ingredients. The invention pertains to a method of cleaning articles in dish machine using the steps of supplying an acidic detergent comprising an acid, inserting the composition into a dispenser in a dish machine, forming a wash solution with the composition and water, contacting soil on an article in a dish machine with the wash solution, removing the soil, and rinsing the
20 article. None of the components of the acidic or alkaline detergent comprises phosphates or silicates.

In a preferred embodiment the detergents are used in a dish machine while cycling an alkaline detergent with the acidic detergent. In some embodiments, the invention comprises a first alkaline rinse step wherein an alkaline composition is
25 brought into contact with a dish during an alkaline step of the cleaning process. The alkaline composition includes one or more alkaline carriers. Some non-limiting examples of suitable alkaline carriers include non phosphate based alkali components including: a hydroxide such as sodium hydroxide, or potassium hydroxide; an ethanolamine such as triethanolamine, diethanolamine, and
30 monoethanolamine; an alkali carbonate; and mixtures thereof. Any alkaline carrier is suitable as long as it does not include silicate or phosphate.

The alkaline composition may include additional ingredients. For example, the alkaline composition may include a water conditioning agent, an enzyme, an enzyme stabilizing system, a surfactant, a binding agent, an antimicrobial agent, a bleaching agent, a defoaming agent/foam inhibitor, an antiredeposition agent, a dye
5 or odorant, a carrier, a hydrotrope and mixtures thereof.

In some embodiments, the invention further comprises a first acidic step wherein an acidic composition is brought into contact with a dish during an acidic step in the cleaning process. The acidic composition includes one or more acids. The acids may be organic or non organic. Some non-limiting examples of suitable
10 acids include hydroxyacetic (glycolic) acid, citric acid, formic acid, acetic acid, propionic acid, butyric acid, valeric acid, caproic acid, gluconic acid, itaconic acid, urea sulfate, trichloroacetic acid, urea hydrochloride, and benzoic acid, oxalic acid, malonic acid, succinic acid, glutaric acid, maleic acid, fumaric acid, adipic acid, and terephthalic, sulfuric acid, sulfamic acid, methylsulfamic acid, hydrochloric acid,
15 hydrobromic acid, hydrofluoric acid, and nitric acid among others. Any acid may be used as long as it does not include silica or phosphorus.

The acidic composition may include additional ingredients. For example, the acidic composition may include an enzyme, an enzyme stabilizing system, a surfactant, a binding agent, an antimicrobial agent, a bleaching agent, a defoaming
20 agent/foam inhibitor, an antiredeposition agent, a dye or odorant, a carrier, and the like.

A method comprising at least a first alkaline step, a first acidic step, and a second alkaline step is disclosed. The method may include additional alkaline and acidic steps. The method may also include pauses between steps as well as rinses.
25 The method may be carried out using a variety of alkaline and acidic compositions. Finally, the method may be carried out in a variety of dish machines, include consumer and institutional dish machines.

These and other embodiments will be apparent to those of skill in the art and others in view of the following detailed description of some embodiments. It should
30 be understood, however, that this summary, and the detailed description illustrate only some examples of various embodiments, and are not intended to be limiting to

the invention as claimed.

DETAILED DESCRIPTION OF THE INVENTION

Definitions

5 For the following defined terms, these definitions shall be applied, unless a different definition is given in the claims or elsewhere in this specification.

All numeric values are herein assumed to be modified by the term "about," whether or not explicitly indicated. The term "about" generally refers to a range of numbers that one of skill in the art would consider equivalent to the recited value
10 (i.e., having the same function or result). In many instances, the term "about" may include numbers that are rounded to the nearest significant figure.

The recitation of numerical ranges by endpoints includes all numbers subsumed within that range (e.g. 1 to 5 includes 1, 1.5, 2, 2.75, 3, 3.80, 4 and 5).

As used in this specification and the appended claims, the singular forms "a",
15 "an", and "the" include plural referents unless the content clearly dictates otherwise. Thus, for example, reference to a composition containing "a compound" includes a mixture of two or more compounds. As used in this specification and the appended claims, the term "or" is generally employed in its sense including "and/or" unless the content clearly dictates otherwise.

20 As used herein, weight percent (wt-%), percent by weight, % by weight, and the like are synonyms that refer to the concentration of a substance as the weight of that substance divided by the total weight of the composition and multiplied by 100.

As used herein, the term "about" modifying the quantity of a component or ingredient in the compositions of the invention or employed in the methods of the
25 invention refers to variation in the numerical quantity that can occur, for example, through typical measuring and liquid handling procedures used for making concentrates or use solutions in the real world; through inadvertent error in these procedures; through differences in the manufacture, source, or purity of the ingredients employed to make the compositions or carry out the methods; and the
30 like. The term about also encompasses amounts that differ due to different equilibrium conditions for a composition resulting from a particular initial mixture.

Whether or not modified by the term "about," the claims include equivalents to the quantities.

"Cleaning" means to perform or aid in soil removal, bleaching, de-scaling, de-staining, microbial population reduction, rinsing, or combination thereof.

5 As used herein, the term "substantially free" refers to compositions completely lacking the component or having such a small amount of the component that the component does not affect the performance of the composition. The component may be present as an impurity or as a contaminant and shall be less than 0.5 wt.%. In another embodiment, the amount of the component is less than 0.1 wt-%
10 and in yet another embodiment, the amount of component is less than 0.01 wt.%.

As used herein, the term "ware" includes items such as eating and cooking utensils. As used herein, the term "warewashing" refers to washing, cleaning, or rinsing ware.

The term "actives" or "percent actives" or "percent by weight actives" or
15 "actives concentration" are used interchangeably herein and refers to the concentration of those ingredients involved in cleaning expressed as a percentage minus inert ingredients such as water or salts.

As used herein, the terms "phosphate -free" or "phosphorus-free" refers to a composition, mixture, or ingredients that do not contain phosphates including but
20 not limited to hypophosphite, organophosphorus compounds, phosphine, phosphine oxide, phosphinite, phosphonite, phosphite, phosphinate, phosphonate, polyphosphate, phosphorus oxoacids, and the like or to which the same have not been added. Should other phosphate containing compounds be present through contamination of a composition, mixture, ingredients, or even water used to from a
25 wash solution, the amount of the same shall be less than 0.5 wt.%. In a preferred embodiment, the amount of the same is less than 0.1 wt-% and in more preferred embodiment, the amount is less than 0.01 wt.%.

As used herein, the terms "silicate -free" or "silica-free" refers to a composition, mixture, or ingredients that do not contain silicates or a silica anion, or
30 to which the same have not been added. Should other silicate containing compounds be present through contamination of a composition, mixture, ingredients, or even water used in a wash solution, the amount of the same shall be less than 0.5 wt.%.

In a preferred embodiment, the amount of the same is less than 0.1 wt-% and in more preferred embodiment, the amount is less than 0.01 wt.%.

The term "substantially similar cleaning performance" refers generally to achievement by a substitute cleaning product or substitute cleaning system of
5 generally the same degree (or at least not a significantly lesser degree) of cleanliness or with generally the same expenditure (or at least not a significantly lesser expenditure) of effort, or both.

Methods of Use

10 The invention generally relates to improvement of cleaning performance in removing starchy soils and buildup from dishes using at least a first alkaline step, a first acidic step, and an optional second alkaline step. The methods are practiced in a phosphate and/or silicate free environment. Thus the source of alkalinity, the acid
15 solution or a wash solution must all be free of phosphates and silicates in order to improve performance of the system. Contrary to traditional though, the pH of the different cleaning agents, while important, is but one factor for optimizing cleaning performance. The source of the different ions used to generate the pH is perhaps more critical to optimizing performance. Thus the alternating alkaline and acidic
20 steps are performed without phosphate or silica agents.

The method may include more than a single alkaline and acidic step as long as the steps remain phosphorus and silica free. The additional alkaline and acidic steps preferably alternate to provide an alkaline-acidic-alkaline-acidic-- alkaline pattern. While it is understood that the method may include as many alkaline and
25 acidic steps as desired, the method preferably includes at least three steps, and not more than eight steps.

In another embodiment, the method may include pauses between the alkaline and acidic steps. For example, the method may proceed according to the following: first alkaline step, first pause, first acidic step, second pause, second alkaline step,
30 third pause, and so on. During a pause, no further cleaning agent is applied to the dish and the existing cleaning agent is allowed to stand on the dish for a period of time.

In yet another embodiment, the method may include rinses. For example, the method may proceed according to the following: first alkaline step, first acidic step, second alkaline step, rinse. Alternatively, the method may proceed according to the following: first alkaline step, first pause, first acidic step, second pause, second
5 alkaline step, third pause, rinse.

Finally, the method may include an optional prewash step prior to the first alkaline step.

The time for each step in the method may vary depending on the dish machine, for example if the dish machine is a consumer dish machine or an
10 institutional dish machine. The time required for a cleaning step in consumer dish machines is typically about 10 minutes to about 60 minutes. The time required for the cleaning cycle in a U.S. or Asian institutional dish machine is typically about 45 seconds to about 2 minutes, depending on the type of machine. Each method step preferably lasts from about 2 seconds to about 30 minutes.

15 The temperature of the cleaning solutions in each step may also vary depending on the dish machine, for example if the dish machine is a consumer dish machine or an institutional dish machine. The temperature of the cleaning solution in a consumer dish machine is typically about 110° F. (43° C.) to about 150° F. (66° C.) with a rinse up to about 160° F. (71° C.). The temperature of the cleaning
20 solution in a high temperature institutional dish machine in the U.S. is about typically about 150° F. (66° C.) to about 165° F. (74° C.) with a rinse from about 180° F. (82° C.) to about 195° F. (91° C.). The temperature in a low temperature institutional dish machine in the U.S. is typically about 120° F. (49° C.) to about 140° F. (60° C.). Low temperature dish machines usually include at least a seven minute
25 rinse with a sanitizing solution. The temperature in a high temperature institutional dish machine in Asia is typically from about 131° F. (55° C.) to about 136° F. (58° C.) with a final rinse at 180° F. (82° C.).

The temperature of the cleaning solutions is preferably from about 95° F. (35° C.) to about 176° F. (80° C.).

30

Compositions

The compositions of the invention may be either a concentrate or a diluted solution. The concentrate refers to the composition that is diluted to form the use solution. The concentrate is preferably a solid. The diluted solution refers to a
5 diluted form of the concentrate. It may be beneficial to form the composition as a concentrate and dilute it to a diluted solution on-site. The concentrate is often easier and less expensive to ship than the use solution. It may also be beneficial to provide a concentrate that is diluted in a dish machine to form the diluted solution during the cleaning process. For example, a composition may be formed as a solid and placed
10 in the dish machine dispenser as a solid and sprayed with water during the cleaning cycle to form a diluted solution. In a preferred embodiment, the compositions applied to the dish during cleaning are diluted solutions and not concentrates.

The compositions may be a liquid, thickened liquid, gelled liquid, paste, granular or pelletized solid material, solid block, cast solid block, powder, tablet, or
15 the like. Liquid compositions can typically be made by forming the ingredients in an aqueous liquid or aqueous liquid solvent system. Such systems are typically made by dissolving or suspending the active ingredients in water or in compatible solvent and then diluting the product to an appropriate concentration, either to form a concentrate or a use solution thereof. Gelled compositions can be made similarly
20 by dissolving or suspending the active ingredients in a compatible aqueous, aqueous liquid or mixed aqueous organic system including a gelling agent at an appropriate concentration. Solid particulate materials can be made by merely blending the dry solid ingredients in appropriate ratios or agglomerating the materials in appropriate agglomeration systems. Pelletized materials can be manufactured by compressing
25 the solid granular or agglomerated materials in appropriate pelletizing equipment to result in appropriately sized pelletized materials. Solid block and cast solid block materials can be made by introducing into a container either a prehardened block of material or a castable liquid that hardens into a solid block within a container.

The compositions may be provided in bulk or in unit dose. For example, the
30 compositions may be provided in a large solid block that may be used for many cleaning cycles. Alternatively, the compositions may be provided in unit dose form wherein a new composition is provided for each new cleaning cycle.

The compositions may be packaged in a variety of materials including a water soluble film, disposable plastic container, flexible bag, shrink wrap, and the like. Further, the compositions may be packaged in such a way as to allow for multiple forms of product in one package, for example, a liquid and a solid in one unit dose package.

The alkaline, acidic, and rinse compositions may be either provided or packaged separately or together. For example, the alkaline composition may be provided and packaged completely separate from the acidic composition. Alternatively, the alkaline, acidic, and rinse compositions may be provided together in one package. For example, the alkaline, acidic, and rinse compositions may be provided in a layered block or tablet wherein the first layer is the first alkaline composition, the second layer is the first acidic composition, the third layer is the second alkaline composition, and optionally, the fourth layer is the rinse composition. It is understood that this layered arrangement may be adjusted to provide for more alkaline and acidic steps as contemplated by the invention or to include additional rinses or no rinses. The individual layers preferably have different characteristics that allow them to dissolve at the appropriate time. For example, the individual layers may dissolve at different temperatures that correspond to different wash cycles; the layers may take a certain amount of time to dissolve so that they dissolve at the appropriate time during the wash cycle; or the layers may be divided by a physical barrier that allows them to dissolve at the appropriate time, such as a paraffin layer, a water soluble film, or a chemical coating.

In addition to providing the alkaline and acidic compositions in layers, the alkaline and acidic compositions may also be in separate domains. For example, the alkaline and acidic compositions may be in separate domains in a solid composition wherein each domain is dissolved by a separate spray when the particular composition is desired.

Alkaline Composition

The method of the present invention includes at least one alkaline step wherein an alkaline composition is brought into contact with a dish during the alkaline step of the cleaning process. The alkaline composition includes one or

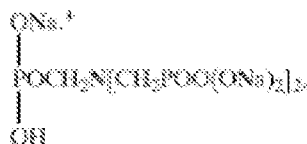
more phosphate and silica free alkaline carriers (i.e. source of alkalinity). Some non-limiting examples of suitable alkaline carriers include any that do not include silicates or phosphates. Examples include but are not limited to: a hydroxide such as sodium hydroxide, or potassium hydroxide; an ethanolamine such as triethanolamine, diethanolamine, and monoethanolamine; an alkali carbonate; and mixtures thereof. The alkaline carrier is preferably a hydroxide or a mixture of hydroxides, or an alkali carbonate. The alkaline carrier is preferably present in the diluted, ready to use, alkaline composition from about 125 ppm to about 5000 ppm, more preferably from about 250 ppm to about 3000 ppm and most preferably from about 500 ppm to about 2000 ppm. The alkaline composition preferably creates a diluted solution having a pH from about 7 to about 14, more preferably from about 9 to about 13, and most preferably from about 10 to about 12. The particular alkaline carrier selected is not as important as the resulting pH. Any alkaline carrier that achieves the desired pH may be used in the alkaline composition of the invention. The first alkaline cleaning step and the second alkaline cleaning step may use the same alkaline composition or different alkaline compositions.

The alkaline composition may include additional ingredients. For example, the alkaline composition may include a water conditioning agent, an enzyme, an enzyme stabilizing system, a surfactant, a binding agent, an antimicrobial agent, a bleaching agent, a defoaming agent/foam inhibitor, an antiredeposition agent, a dye or odorant, a carrier, a hydrotrope and mixtures thereof.

Water Conditioning Agent

The water conditioning agent can be referred to as a detergent builder and/or chelating agent and generally provides cleaning properties and chelating properties. Exemplary detergent builders include sodium sulphate, sodium chloride, starch, sugars, C₁-C₁₀ alkylene glycols such as propylene glycol, and the like. Exemplary chelating agents include citrates, GLDA, MGDA, phosphonates, and amino-acetates. Exemplary phosphonates include 1-hydroxyethane-1,1-diphosphonic acid, aminotrimethylene phosphonic acid, diethylenetriaminepenta(methylenephosphonic acid), 1-hydroxyethane-1,1-diphosphonic acid $\text{CH}_3\text{C}(\text{OH})[\text{PO}(\text{OH})_2]_2$,

aminotri(methylenephosphonic acid) $N[CH_2PO(OH)_2]_3$,
 aminotri(methylenephosphonate), sodium salt



- 5 2-hydroxyethyliminobis(methylenephosphonic acid) $HOCH_2CH_2N[CH_2PO(OH)_2]_2$,
 diethylenetriaminepenta(- -methylenephosphonic acid)
 $(HO)_2POCH_2N[CH_2CH_2N[CH_2PO(OH)_2]_2]_2$,
 diethylenetriaminepenta(methylenephosphonate)- , sodium salt $C_9H_{(28-x)}N_3Na_xO_5P_5$ ($x=7$), hexamethylenediamine(tetramethylenephosphonate),
 10 potassium salt $C_{10}H_{(28-x)}N_2K_xO_5P_4$ ($x=6$),
 bis(hexamethylene)triamine(pentamethylenephosphonic acid)
 $(HO)_2POCH_2N[(CH_2)_6N[CH_2PO(OH)_2]_2]_2$. Exemplary amino-acetates include
 aminocarboxylic acids such as N-hydroxyethyliminodiacetic acid, nitrilotriacetic
 acid (NTA), ethylenediaminetetraacetic acid (EDTA), N-hydroxyethyl-
 15 ethylenediaminetriacetic acid (HEDTA), and diethylenetriaminepentaacetic acid
 (DTPA).

Enzymes

- The present composition may include one or more enzymes, which can
 20 provide desirable activity for removal of protein-based, carbohydrate-based, or
 triglyceride-based soils from substrates such as flatware, cups and bowls, and pots
 and pans. Enzymes suitable for the inventive composition can act by degrading or
 altering one or more types of soil residues encountered on a surface thus removing
 the soil or making the soil more removable by a surfactant or other component of the
 25 cleaning composition. Both degradation and alteration of soil residues can improve
 detergency by reducing the physicochemical forces which bind the soil to the
 surface or textile being cleaned, i.e. the soil becomes more water soluble. For
 example, one or more proteases can cleave complex, macromolecular protein
 structures present in soil residues into simpler short chain molecules which are, of

themselves, more readily desorbed from surfaces, solubilized, or otherwise more easily removed by detergent solutions containing said proteases.

Suitable enzymes include a protease, an amylase, a lipase, a gluconase, a cellulase, a peroxidase, or a mixture thereof of any suitable origin, such as vegetable, animal, bacterial, fungal or yeast origin. Preferred selections are influenced by factors such as pH-activity and/or stability optima, thermostability, and stability to active detergents, builders and the like. In this respect bacterial or fungal enzymes are preferred, such as bacterial amylases and proteases, and fungal cellulases.

Preferably the enzyme is a protease, a lipase, an amylase, or a combination thereof.

A valuable reference on enzymes is "Industrial Enzymes," Scott, D., in Kirk-Othmer Encyclopedia of Chemical Technology, 3rd Edition, (editors Grayson, M. and Eckroth, D.) Vol. 9, pp. 173-224, John Wiley & Sons, New York, 1980.

Protease

A protease suitable for the present invention can be derived from a plant, an animal, or a microorganism. Preferably the protease is derived from a microorganism, such as a yeast, a mold, or a bacterium. Preferred proteases include serine proteases active at alkaline pH, preferably derived from a strain of *Bacillus* such as *Bacillus subtilis* or *Bacillus licheniformis*; these preferred proteases include native and recombinant subtilisins. The protease can be purified or a component of a microbial extract, and either wild type or variant (either chemical or recombinant). Examples of proteolytic enzymes which can be employed in the present invention include (with trade names) Savinase®; a protease derived from *Bacillus lentus* type, such as Maxacal®, Opticlean®, Durazym®, and Properase®; a protease derived from *Bacillus licheniformis*, such as Alcalase® and Maxatase®; and a protease derived from *Bacillus amyloliquefaciens*, such as Primase®. Preferred commercially available protease enzymes include those sold under the trade names Alcalase®, Savinase®, Primase®, Durazym®, or Esperase® by Novo Industries A/S (Denmark); those sold under the trade names Maxatase®, Maxacal®, or Maxapem® by Gist-Brocades (Netherlands); those sold under the trade names Purafect®, Purafect OX, and Properase by Genencor International; those sold under the trade names Opticlean® or Optimase® by Solvay Enzymes; and the like. A

mixture of such proteases can also be used. For example, Purafect® is a preferred alkaline protease (a subtilisin) for use in detergent compositions of this invention having application in lower temperature cleaning programs, from about 30° C. to about 65° C.; whereas, Esperase® is an alkaline protease of choice for higher
5 temperature deterative solutions, from about 50° C. to about 85° C. Suitable deterative proteases are described in patent publications including: GB 1,243,784, WO 9203529 A (enzyme/inhibitor system), WO 9318140 A, and WO 9425583 (recombinant trypsin-like protease) to Novo; WO 9510591 A, WO 9507791 (a protease having decreased adsorption and increased hydrolysis), WO 95/30010, WO
10 95/30011, WO 95/29979, to Procter & Gamble; WO 95/10615 (Bacillus amyloliquefaciens subtilisin) to Genencor International; EP 130,756 A (protease A); EP 303,761 A (protease B); and EP 130,756 A. A variant protease employed in the present stabilized enzyme cleaning compositions is preferably at least 80% homologous, preferably having at least 80% sequence identity, with the amino acid
15 sequences of the proteases in these references.

Naturally, mixtures of different proteolytic enzymes may be incorporated into this invention. While various specific enzymes have been described above, it is to be understood that any protease which can confer the desired proteolytic activity to the composition may be used and this embodiment of this invention is not limited
20 in any way by specific choice of proteolytic enzyme. While the actual amounts of protease can be varied to provide the desired activity, the protease is preferably present from about 0.1 wt. % to about 3 wt. % more preferably from about 1 wt. % to about 3 wt. %, and most preferably about 2 wt. % of commercially available enzyme. Typical commercially available enzymes include about 5-10% of active
25 enzyme protease.

Amylase

An amylase suitable for the stabilized enzyme cleaning composition of the present invention can be derived from a plant, an animal, or a microorganism.
30 Preferably the amylase is derived from a microorganism, such as a yeast, a mold, or a bacterium. Preferred amylases include those derived from a Bacillus, such as B. licheniformis, B. amyloliquefaciens, B. subtilis, or B. stearothermophilus. The

amylase can be purified or a component of a microbial extract, and either wild type or variant (either chemical or recombinant), preferably a variant that is more stable under washing or presoak conditions than a wild type amylase.

Examples of amylase enzymes that can be employed in the stabilized enzyme cleaning composition of the invention include those sold under the trade name Rapidase by Gist-Brocades® (Netherlands); those sold under the trade names Termamyl®, Fungamyl® or Duramyl® by Novo; Purastar STL or Purastar OXAM by Genencor; and the like. Preferred commercially available amylase enzymes include the stability enhanced variant amylase sold under the trade name Duramyl® by Novo. A mixture of amylases can also be used.

Amylases suitable for the present invention include: I-amylases described in WO 95/26397, PCT/DK96/00056, and GB 1,296,839 to Novo; and stability enhanced amylases described in J. Biol. Chem., 260(11):6518-6521 (1985); WO 9510603 A, WO 9509909 A and WO 9402597 to Novo; references disclosed in WO 9402597; and WO 9418314 to Genencor International. A variant I-amylase employed in the present stabilized enzyme cleaning compositions is preferably at least 80% homologous, preferably having at least 80% sequence identity, with the amino acid sequences of the proteins of these references.

Naturally, mixtures of different amylase enzymes can be incorporated into this invention. While various specific enzymes have been described above, it is to be understood that any amylase which can confer the desired amylase activity to the composition can be used and this embodiment of this invention is not limited in any way by specific choice of amylase enzyme. While the actual amount of amylases can be varied to provide the desired activity, the amylase is preferably present from about 0.1 wt. % to about 3 wt. %, more preferably from about 1 wt. % to about 3 wt. %, and most preferably about 2 wt. % of commercially wt. % available enzyme. Typical commercially available enzymes include about 0.25 to about 5% of active amylase.

Cellulases

A cellulase suitable for the present invention can be derived from a plant, an animal, or a microorganism. Preferably the cellulase is derived from a

microorganism, such as a fungus or a bacterium. Preferred cellulases include those derived from a fungus, such as *Humicola insolens*, *Humicola* strain DSM1800, or a cellulase 212-producing fungus belonging to the genus *Aeromonas* and those extracted from the hepatopancreas of a marine mollusk, *Dolabella Auricula* Solander.

5 The cellulase can be purified or a component of an extract, and either wild type or variant (either chemical or recombinant).

Examples of cellulase enzymes that can be employed in the stabilized enzyme cleaning composition of the invention include those sold under the trade names Carezyme® or Celluzyme® by Novo, or Cellulase by Genencor; and the like.

10 A mixture of cellulases can also be used. Suitable cellulases are described in patent documents including: U.S. Pat. No. 4,435,307, GB-A-2.075.028, GB-A-2.095.275, DE-OS-2.247.832, WO 9117243, and WO 9414951 A (stabilized cellulases) to Novo.

Naturally, mixtures of different cellulase enzymes can be incorporated into
15 this invention. While various specific enzymes have been described above, it is to be understood that any cellulase which can confer the desired cellulase activity to the composition can be used and this embodiment of this invention is not limited in any way by specific choice of cellulase enzyme. While the actual amount of cellulose can be varied to provide the desired activity, the cellulose is preferably
20 present from about 0.1 wt. % to about 3 wt. %, more preferably from about 1 wt. % to about 3 wt. %, and most preferably 2 wt. % of commercially available enzyme. Typical commercially available enzymes include about 5-10% active enzyme cellulase.

25 **Lipases**

A lipase suitable for the present invention can be derived from a plant, an animal, or a microorganism. Preferably the lipase is derived from a microorganism, such as a fungus or a bacterium. Preferred lipases include those derived from a *Pseudomonas*, such as *Pseudomonas stutzeri* ATCC 19.154, or from a *Humicola*,
30 such as *Humicola lanuginosa* (typically produced recombinantly in *Aspergillus oryzae*). The lipase can be purified or a component of an extract, and either wild type or variant (either chemical or recombinant).

Examples of lipase enzymes that can be employed in the stabilized enzyme cleaning composition of the invention include those sold under the trade names Lipase P "Amano" or "Amano-P" by Amano Pharmaceutical Co. Ltd., Nagoya, Japan or under the trade name Lipolase® by Novo, and the like. Other
5 commercially available lipases that can be employed in the present compositions include Amano-CES, lipases derived from *Chromobacter viscosum*, e.g. *Chromobacter viscosum* var. *lipolyticum* NRRLB 3673 from Toyo Jozo Co., Tagata, Japan; *Chromobacter viscosum* lipases from U.S. Biochemical Corp., U.S.A. and Disoynt Co., and lipases derived from *Pseudomonas gladioli* or from *Humicola*
10 *lanuginosa*.

A preferred lipase is sold under the trade name Lipolase® by Novo. Suitable lipases are described in patent documents including: WO 9414951 A (stabilized lipases) to Novo, WO 9205249, RD 94359044, GB 1,372,034, Japanese Patent Application 53,20487, laid open Feb. 24, 1978 to Amano Pharmaceutical Co. Ltd.,
15 and EP 341,947.

Naturally, mixtures of different lipase enzymes can be incorporated into this invention. While various specific enzymes have been described above, it is to be understood that any lipase which can confer the desired lipase activity to the composition can be used and this embodiment of this invention is not limited in any
20 way by specific choice of lipase enzyme. While the actual amount of lipase can be varied to provide the desired activity, the lipase is preferably present from about 0.1 wt. % to about 3 wt. % more preferably from about 1 wt. % to about 3 wt. %, and most preferably about 2 wt. % of commercially available enzyme. Typical commercially available enzymes include about 5-10% active enzyme lipase.

25

Additional Enzymes

Additional enzymes suitable for use in the present stabilized enzyme cleaning compositions include a cutinase, a peroxidase, a gluconase, and the like. Suitable cutinase enzymes are described in WO 8809367 A to Genencor. Known
30 peroxidases include horseradish peroxidase, ligninase, and haloperoxidases such as chloro- or bromo-peroxidase. Peroxidases suitable for stabilized enzyme cleaning compositions are disclosed in WO 89099813 A and WO 8909813 A to Novo.

Peroxidase enzymes can be used in combination with oxygen sources, e.g., percarbonate, perborate, hydrogen peroxide, and the like. Additional enzymes suitable for incorporation into the present stabilized enzyme cleaning composition are disclosed in WO 9307263 A and WO 9307260 A to Genencor International, WO
5 8908694 A to Novo, and U.S. Pat. No. 3,553,139 to McCarty et al., U.S. Pat. No. 4,101,457 to Place et al., U.S. Pat. No. 4,507,219 to Hughes and U.S. Pat. No. 4,261,868 to Hora et al.

An additional enzyme, such as a cutinase or peroxidase, suitable for the stabilized enzyme cleaning composition of the present invention can be derived from
10 a plant, an animal, or a microorganism. Preferably the enzyme is derived from a microorganism. The enzyme can be purified or a component of an extract, and either wild type or variant (either chemical or recombinant).

Naturally, mixtures of different additional enzymes can be incorporated into this invention. While various specific enzymes have been described above, it is to
15 be understood that any additional enzyme which can confer the desired enzyme activity to the composition can be used and this embodiment of this invention is not limited in any way by specific choice of enzyme. While the actual amount of additional enzyme, such as cutinase or peroxidase, can be varied to provide the desired activity, the enzyme is preferably from about 1 wt. % to about 3 wt. %, and
20 most preferably about 2 wt. % of commercially available enzyme. Typical commercially available enzymes include about 5-10% active enzyme.

Enzyme Stabilizing System

The composition can include an enzyme stabilizing system of a mixture of
25 carbonate and bicarbonate. The enzyme stabilizing system can also include other ingredients to stabilize certain enzymes or to enhance or maintain the effect of the mixture of carbonate and bicarbonate.

Stabilizing systems of certain cleaning compositions, for example medical or dental instrument or device stabilized enzyme cleaning compositions, may further
30 include from 0 to about 10%, preferably from about 0.01% to about 6% by weight, of chlorine bleach scavengers, added to prevent chlorine bleach species present in many water supplies from attacking and inactivating the enzymes, especially under

alkaline conditions. While chlorine levels in water may be small, typically in the range from about 0.5 ppm to about 1.75 ppm, the available chlorine in the total volume of water that comes in contact with the enzyme, for example during warewashing, can be relatively large; accordingly, enzyme stability to chlorine in-
5 use can be problematic. Since percarbonate or percarbonate, which have the ability to react with chlorine bleach, may be present in certain of the instant compositions in amounts accounted for separately from the stabilizing system, the use of additional stabilizers against chlorine, may, most generally, not be essential, though improved results may be obtainable from their use.

10 Suitable chlorine scavenger anions are widely known and readily available, and, if used, can be salts containing ammonium cations with sulfite, bisulfite, thiosulfite, thiosulfate, iodide, etc. Antioxidants such as carbamate, ascorbate, etc., organic amines such as ethylenediaminetetracetic acid (EDTA) or alkali metal salt thereof, monoethanolamine (MEA), and mixtures thereof can likewise be used.
15 Likewise, special enzyme inhibition systems can be incorporated such that different enzymes have maximum compatibility. Other conventional scavengers such as bisulfate, nitrate, chloride, sources of hydrogen peroxide such as sodium percarbonate tetrahydrate, sodium percarbonate monohydrate and sodium percarbonate, as well as phosphate, condensed phosphate, acetate, benzoate, citrate,
20 formate, lactate, malate, tartrate, salicylate, etc., and mixtures thereof can be used if desired.

 In general, since the chlorine scavenger function can be performed by ingredients separately listed under better recognized functions, there is no requirement to add a separate chlorine scavenger unless a compound performing that
25 function to the desired extent is absent from an enzyme-containing embodiment of the invention; even then, the scavenger is added only for optimum results. Moreover, the formulator will exercise a chemist's normal skill in avoiding the use of any enzyme scavenger or stabilizer that is unacceptably incompatible, as formulated, with other reactive ingredients. In relation to the use of ammonium salts, such salts
30 can be simply admixed with the stabilized enzyme cleaning composition but are prone to adsorb water and/or liberate ammonia during storage. Accordingly, such

materials, if present, are desirably protected in a particle such as that described in U.S. Pat. No. 4,652,392, Baginski et al.

Surfactant

5 The surfactant or surfactant mixture of the present invention can be selected from water soluble or water dispersible nonionic, semi-polar nonionic, anionic, cationic, amphoteric, or zwitterionic surface-active agents; or any combination thereof.

 A typical listing of the classes and species of surfactants useful herein
10 appears in U.S. Pat. No. 3,664,961 issued May 23, 1972, to Norris.

Nonionic Surfactants

 Nonionic surfactants useful in the invention are generally characterized by the presence of an organic hydrophobic group and an organic hydrophilic group and
15 are typically produced by the condensation of an organic aliphatic, alkyl aromatic or polyoxyalkylene hydrophobic compound with a hydrophilic alkaline oxide moiety which in common practice is ethylene oxide or a polyhydration product thereof, polyethylene glycol. Practically any hydrophobic compound having a hydroxyl, carboxyl, amino, or amido group with a reactive hydrogen atom can be condensed
20 with ethylene oxide, or its polyhydration adducts, or its mixtures with alkoxylenes such as propylene oxide to form a nonionic surface-active agent. The length of the hydrophilic polyoxyalkylene moiety which is condensed with any particular hydrophobic compound can be readily adjusted to yield a water dispersible or water soluble compound having the desired degree of balance between hydrophilic and
25 hydrophobic properties. Useful nonionic surfactants in the present invention include:

 1. Block polyoxypropylene-polyoxyethylene polymeric compounds based upon propylene glycol, ethylene glycol, glycerol, trimethylolpropane, and ethylenediamine as the initiator reactive hydrogen compound. Examples of polymeric compounds made from a sequential propoxylation and ethoxylation of
30 initiator are commercially available under the trade names Pluronic® and Tetronico manufactured by BASF Corp.

Pluronic® compounds are difunctional (two reactive hydrogens) compounds formed by condensing ethylene oxide with a hydrophobic base formed by the addition of propylene oxide to the two hydroxyl groups of propylene glycol. This hydrophobic portion of the molecule weighs from 1,000 to 4,000. Ethylene oxide is then added to sandwich this hydrophobe between hydrophilic groups, controlled by length to constitute from about 10% by weight to about 80% by weight of the final molecule.

Tetronic® compounds are tetra-functional block copolymers derived from the sequential addition of propylene oxide and ethylene oxide to ethylenediamine. The molecular weight of the propylene oxide hydrotype ranges from 500 to 7,000; and, the hydrophile, ethylene oxide, is added to constitute from 10% by weight to 80% by weight of the molecule.

2. Condensation products of one mole of alkyl phenol wherein the alkyl chain, of straight chain or branched chain configuration, or of single or dual alkyl constituent, contains from 8 to 18 carbon atoms with from 3 to 50 moles of ethylene oxide. The alkyl group can, for example, be represented by diisobutylene, di-amy, polymerized propylene, iso-octyl, nonyl, and di-nonyl. These surfactants can be polyethylene, polypropylene, and polybutylene oxide condensates of alkyl phenols. Examples of commercial compounds of this chemistry are available on the market under the trade names Igepal® manufactured by Rhone-Poulenc and Triton® manufactured by Union Carbide.

3. Condensation products of one mole of a saturated or unsaturated, straight or branched chain alcohol having from 6 to 24 carbon atoms with from 3 to 50 moles of ethylene oxide. The alcohol moiety can consist of mixtures of alcohols in the above delineated carbon range or it can consist of an alcohol having a specific number of carbon atoms within this range. Examples of like commercial surfactant are available under the trade names Neodol® manufactured by Shell Chemical Co. and Alfonic® manufactured by Vista Chemical Co.

4. Condensation products of one mole of saturated or unsaturated, straight or branched chain carboxylic acid having from 8 to 18 carbon atoms with from 6 to 50 moles of ethylene oxide. The acid moiety can consist of mixtures of acids in the above defined carbon atoms range or it can consist of an acid having a

specific number of carbon atoms within the range. Examples of commercial compounds of this chemistry are available on the market under the trade names Nopalcol® manufactured by Henkel Corporation and Lipopeg® manufactured by Lipo Chemicals, Inc.

5 In addition to ethoxylated carboxylic acids, commonly called polyethylene glycol esters, other alkanolic acid esters formed by reaction with glycerides, glycerin, and polyhydric (saccharide or sorbitan/sorbitol) alcohols have application in this invention. All of these ester moieties have one or more reactive hydrogen sites on their molecule which can undergo further acylation or ethylene oxide (alkoxide)
10 addition to control the hydrophilicity of these substances. Care must be exercised when adding these fatty ester or acylated carbohydrates to compositions of the present invention containing amylase and/or lipase enzymes because of potential incompatibility.

Examples of nonionic low foaming surfactants include:

15 5. Compounds from (1) which are modified, essentially reversed, by adding ethylene oxide to ethylene glycol to provide a hydrophile of designated molecular weight; and, then adding propylene oxide to obtain hydrophobic blocks on the outside (ends) of the molecule. The hydrophobic portion of the molecule weighs from 1,000 to 3,100 with the central hydrophile including 10% by weight to
20 80% by weight of the final molecule. These reverse Pluronics® are manufactured by BASF Corporation under the trade name Pluronic® R surfactants.

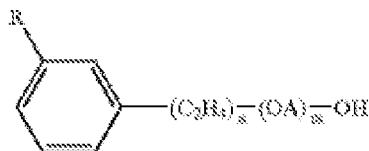
 Likewise, the Tetronic® R surfactants are produced by BASF Corporation by the sequential addition of ethylene oxide and propylene oxide to ethylenediamine. The hydrophobic portion of the molecule weighs from 2,100 to 6,700 with the
25 central hydrophile including 10% by weight to 80% by weight of the final molecule.

 6. Compounds from groups (1), (2), (3) and (4) which are modified by "capping" or "end blocking" the terminal hydroxy group or groups (of multi-functional moieties) to reduce foaming by reaction with a small hydrophobic molecule such as propylene oxide, butylene oxide, benzyl chloride; and, short chain
30 fatty acids, alcohols or alkyl halides containing from 1 to 5 carbon atoms; and mixtures thereof. Also included are reactants such as thionyl chloride which convert terminal hydroxy groups to a chloride group. Such modifications to the terminal

hydroxy group may lead to all-block, block-heteric, heteric-block or all-heteric nonionics.

Additional examples of effective low foaming nonionics include:

7. The alkylphenoxypolyethoxyalkanols of U.S. Pat. No. 2,903,486 issued Sep. 8, 1959 to Brown et al. and represented by the formula



in which R is an alkyl group of 8 to 9 carbon atoms, A is an alkylene chain of 3 to 4 carbon atoms, n is an integer of 7 to 16, and m is an integer of 1 to 10.

- 10 The polyalkylene glycol condensates of U.S. Pat. No. 3,048,548 issued Aug. 7, 1962 to Martin et al. having alternating hydrophilic oxyethylene chains and hydrophobic oxypropylene chains where the weight of the terminal hydrophobic chains, the weight of the middle hydrophobic unit and the weight of the linking hydrophilic units each represent about one-third of the condensate.

- 15 The defoaming nonionic surfactants disclosed in U.S. Pat. No. 3,382,178 issued May 7, 1968 to Lissant et al. having the general formula $Z[(\text{OR})_n\text{OH}]_z$ wherein Z is alkoxylatable material, R is a radical derived from an alkaline oxide which can be ethylene and propylene and n is an integer from, for example, 10 to 2,000 or more and z is an integer determined by the number of reactive
- 20 oxyalkylatable groups.

- The conjugated polyoxyalkylene compounds described in U.S. Pat. No. 2,677,700, issued May 4, 1954 to Jackson et al. corresponding to the formula $\text{Y}(\text{C}_3\text{H}_6\text{O})_n(\text{C}_2\text{H}_4\text{O})_m\text{H}$ wherein Y is the residue of organic compound having from 1 to 6 carbon atoms and one reactive hydrogen atom, n has an average value of at
- 25 least 6.4, as determined by hydroxyl number and m has a value such that the oxyethylene portion constitutes 10% to 90% by weight of the molecule.

The conjugated polyoxyalkylene compounds described in U.S. Pat. No. 2,674,619, issued Apr. 6, 1954 to Lundsted et al. having the formula $\text{Y}[(\text{C}_3\text{H}_6\text{O})_n(\text{C}_2\text{H}_4\text{O})_m\text{H}]_x$ wherein Y is the residue of an organic compound having

from 2 to 6 carbon atoms and containing x reactive hydrogen atoms in which x has a value of at least 2, n has a value such that the molecular weight of the polyoxypropylene hydrophobic base is at least 900 and m has value such that the oxyethylene content of the molecule is from 10% to 90% by weight. Compounds
 5 falling within the scope of the definition for Y include, for example, propylene glycol, glycerine, pentaerythritol, trimethylolpropane, ethylenediamine and the like. The oxypropylene chains optionally, but advantageously, contain small amounts of ethylene oxide and the oxyethylene chains also optionally, but advantageously, contain small amounts of propylene oxide.

10 Additional conjugated polyoxyalkylene surface-active agents which are advantageously used in the compositions of this invention correspond to the formula: $P[(C_3H_6O)_n(C_2H_4O)_mH]_x$ wherein P is the residue of an organic compound having from 8 to 18 carbon atoms and containing x reactive hydrogen atoms in which x has a value of 1 or 2, n has a value such that the molecular weight of the
 15 polyoxyethylene portion is at least 44 and m has a value such that the oxypropylene content of the molecule is from 10% to 90% by weight. In either case the oxypropylene chains may contain optionally, but advantageously, small amounts of ethylene oxide and the oxyethylene chains may contain also optionally, but advantageously, small amounts of propylene oxide.

20 8. Polyhydroxy fatty acid amide surfactants suitable for use in the present compositions include those having the structural formula R^2CONR^1Z in which: R^1 is H, C_1 - C_4 hydrocarbyl, 2-hydroxy ethyl, 2-hydroxy propyl, ethoxy, propoxy group, or a mixture thereof; R is a C_5 - C_{31} hydrocarbyl, which can be straight-chain; and Z is a polyhydroxyhydrocarbyl having a linear hydrocarbyl chain
 25 with at least 3 hydroxyls directly connected to the chain, or an alkoxyated derivative (preferably ethoxylated or propoxylated) thereof. Z can be derived from a reducing sugar in a reductive amination reaction; such as a glycityl moiety.

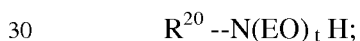
9. The alkyl ethoxylate condensation products of aliphatic alcohols with from 0 to 25 moles of ethylene oxide are suitable for use in the present compositions.
 30 The alkyl chain of the aliphatic alcohol can either be straight or branched, primary or secondary, and generally contains from 6 to 22 carbon atoms.

10. The ethoxylated C₆-C₁₈ fatty alcohols and C₆-C₁₈ mixed ethoxylated and propoxylated fatty alcohols are suitable surfactants for use in the present compositions, particularly those that are water soluble. Suitable ethoxylated fatty alcohols include the C₁₀-C₁₈ ethoxylated fatty alcohols with a degree of ethoxylation
 5 of from 3 to 50.

11. Suitable nonionic alkylpolysaccharide surfactants, particularly for use in the present compositions include those disclosed in U.S. Pat. No. 4,565,647, Llenado, issued Jan. 21, 1986. These surfactants include a hydrophobic group containing from 6 to 30 carbon atoms and a polysaccharide, e.g., a polyglycoside,
 10 hydrophilic group containing from 1.3 to 10 saccharide units. Any reducing saccharide containing 5 or 6 carbon atoms can be used, e.g., glucose, galactose and galactosyl moieties can be substituted for the glucosyl moieties. (Optionally the hydrophobic group is attached at the 2-, 3-, 4-, etc. positions thus giving a glucose or galactose as opposed to a glucoside or galactoside.) The intersaccharide bonds can
 15 be, e.g., between the one position of the additional saccharide units and the 2-, 3-, 4-, and/or 6-positions on the preceding saccharide units.

12. Fatty acid amide surfactants suitable for use in the present compositions include those having the formula: R⁶CON(R⁷)₂ in which R⁶ is an alkyl group containing from 7 to 21 carbon atoms and each R⁷ is independently hydrogen,
 20 C₁-C₄ alkyl, C₁-C₄ hydroxyalkyl, or --(C₂H₄O)_xH, where x is in the range of from 1 to 3.

13. A useful class of non-ionic surfactants includes the class defined as alkoxyated amines or, most particularly, alcohol alkoxyated/aminated/alkoxyated surfactants. These non-ionic surfactants may be at least in part represented by the
 25 general formulae:



in which R²⁰ is an alkyl, alkenyl or other aliphatic group, or an alkyl-aryl group of from 8 to 20, preferably 12 to 14 carbon atoms, EO is oxyethylene, PO is oxypropylene, s is 1 to 20, preferably 2-5, t is 1-10, preferably 2-5, and u is 1-10, preferably 2-5. Other variations on the scope of these compounds may be
 5 represented by the alternative formula:



in which R²⁰ is as defined above, v is 1 to 20 (e.g., 1, 2, 3, or 4 (preferably 2)), and w
 10 and z are independently 1-10, preferably 2-5.

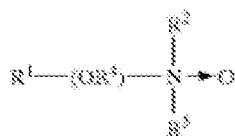
These compounds are represented commercially by a line of products sold by Huntsman Chemicals as nonionic surfactants. A preferred chemical of this class includes Surfonic™ PEA 25 Amine Alkoxylate.

The treatise Nonionic Surfactants, edited by Schick, M. J., Vol. 1 of the
 15 Surfactant Science Series, Marcel Dekker, Inc., New York, 1983 is an excellent reference on the wide variety of nonionic compounds generally employed in the practice of the present invention. A typical listing of nonionic classes, and species of these surfactants, is given in U.S. Pat. No. 3,929,678 issued to Laughlin and Heuring on Dec. 30, 1975. Further examples are given in "Surface Active Agents
 20 and Detergents" (Vol. I and II by Schwartz, Perry and Berch).

Semi-Polar Nonionic Surfactants

The semi-polar type of nonionic surface active agents is another class of nonionic surfactant useful in compositions of the present invention. Generally,
 25 semi-polar nonionics are high foamers and foam stabilizers, which can limit their application in CIP systems. However, within compositional embodiments of this invention designed for high foam cleaning methodology, semi-polar nonionics would have immediate utility. The semi-polar nonionic surfactants include the amine oxides, phosphine oxides, sulfoxides and their alkoxylated derivatives.

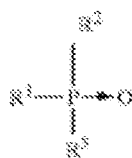
30 14. Amine oxides are tertiary amine oxides corresponding to the general formula:



wherein the arrow is a conventional representation of a semi-polar bond; and R^1 , R^2 , and R^3 may be aliphatic, aromatic, heterocyclic, alicyclic, or combinations thereof. Generally, for amine oxides of detergent interest, R^1 is an alkyl radical of from 8 to 24 carbon atoms; R^2 and R^3 are alkyl or hydroxyalkyl of 1-3 carbon atoms or a mixture thereof; R^2 and R^3 can be attached to each other, e.g. through an oxygen or nitrogen atom, to form a ring structure; R^4 is an alkaline or a hydroxyalkylene group containing 2 to 3 carbon atoms; and n ranges from 0 to 20.

Useful water soluble amine oxide surfactants are selected from the coconut or tallow alkyl di-(lower alkyl) amine oxides, specific examples of which are dodecyldimethylamine oxide, tridecyldimethylamine oxide, tetradecyldimethylamine oxide, pentadecyldimethylamine oxide, hexadecyldimethylamine oxide, heptadecyldimethylamine oxide, octadecyldimethylamine oxide, dodecyldipropylamine oxide, tetradecyldipropylamine oxide, hexadecyldipropylamine oxide, tetradecyldibutylamine oxide, octadecyldibutylamine oxide, bis(2-hydroxyethyl)dodecylamine oxide, bis(2-hydroxyethyl)-3-dodecoxy-1-hydroxypropylamine oxide, dimethyl-(2-hydroxydodecyl)amine oxide, 3,6,9-trioctadecyldimethylamine oxide and 3-dodecoxy-2-hydroxypropyl-di-(2-hydroxyethyl)amine oxide.

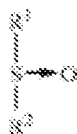
Useful semi-polar nonionic surfactants also include the water soluble phosphine oxides having the following structure:



wherein the arrow is a conventional representation of a semi-polar bond; and R^1 is an alkyl, alkenyl or hydroxyalkyl moiety ranging from 10 to 24 carbon atoms in chain length; and R^2 and R^3 are each alkyl moieties separately selected from alkyl or hydroxyalkyl groups containing 1 to 3 carbon atoms.

5 Examples of useful phosphine oxides include dimethyldecylphosphine oxide, dimethyltetradecylphosphine oxide, methylethyltetradecylphosphine oxide, dimethylhexadecylphosphine oxide, diethyl-2-hydroxyoctyldecylphosphine oxide, bis(2-hydroxyethyl)dodecylphosphine oxide, and bis(hydroxymethyl)tetradecylphosphine oxide.

10 Semi-polar nonionic surfactants useful herein also include the water soluble sulfoxide compounds which have the structure:



wherein the arrow is a conventional representation of a semi-polar bond; and, R^1 is an alkyl or hydroxyalkyl moiety of 8 to 28 carbon atoms, from 0 to 5 ether linkages
 15 and from 0 to 2 hydroxyl substituents; and $R_{sup.2}$ is an alkyl moiety consisting of alkyl and hydroxyalkyl groups having 1 to 3 carbon atoms.

Useful examples of these sulfoxides include dodecyl methyl sulfoxide; 3-hydroxy tridecyl methyl sulfoxide; 3-methoxy tridecyl methyl sulfoxide; and 3-hydroxy-4-dodecoxybutyl methyl sulfoxide.

20

Anionic Surfactants

Also useful in the present invention are surface active substances which are categorized as anionics because the charge on the hydrophobe is negative; or surfactants in which the hydrophobic section of the molecule carries no charge
 25 unless the pH is elevated to neutrality or above (e.g. carboxylic acids). Carboxylate, sulfonate, sulfate and phosphate are the polar (hydrophilic) solubilizing groups found in anionic surfactants. Of the cations (counter ions) associated with these polar groups, sodium, lithium and potassium impart water solubility; ammonium and

substituted ammonium ions provide both water and oil solubility; and, calcium, barium, and magnesium promote oil solubility.

As those skilled in the art understand, anionics are excellent detergent surfactants and are therefore favored additions to heavy duty detergent compositions.

5 Generally, however, anionics have high foam profiles which limit their use alone or at high concentration levels in cleaning systems such as CIP circuits that require strict foam control. Anionic surface active compounds are useful to impart special chemical or physical properties other than detergency within the composition. Anionics can be employed as gelling agents or as part of a gelling or thickening
10 system. Anionics are excellent solubilizers and can be used for hydrotropic effect and cloud point control.

The majority of large volume commercial anionic surfactants can be subdivided into five major chemical classes and additional sub-groups known to those of skill in the art and described in "Surfactant Encyclopedia," Cosmetics & Toiletries, Vol. 104 (2) 71-86 (1989). The first class includes acylamino acids (and
15 salts), such as acylglutamates, acyl peptides, sarcosinates (e.g. N-acyl sarcosinates), taurates (e.g. N-acyl taurates and fatty acid amides of methyl tauride), and the like. The second class includes carboxylic acids (and salts), such as alkanoic acids (and alkanoates), ester carboxylic acids (e.g. alkyl succinates), ether carboxylic acids, and
20 the like. The third class includes sulfonic acids (and salts), such as isethionates (e.g. acyl isethionates), alkylaryl sulfonates, alkyl sulfonates, sulfosuccinates (e.g. monoesters and diesters of sulfosuccinate), and the like. The fifth class includes sulfuric acid esters (and salts), such as alkyl ether sulfates, alkyl sulfates, and the like.

25 Anionic sulfate surfactants suitable for use in the present compositions include the linear and branched primary and secondary alkyl sulfates, alkyl ethoxysulfates, fatty oleyl glycerol sulfates, alkyl phenol ethylene oxide ether sulfates, the C₅-C₁₇ acyl-N--(C₁-C₄ alkyl) and --N--(C₁-C₂ hydroxyalkyl)glucamine sulfates, and sulfates of alkylpolysaccharides such as the sulfates of
30 alkylpolyglucoside (the nonionic nonsulfated compounds being described herein).

Examples of suitable synthetic, water soluble anionic detergent compounds include the ammonium and substituted ammonium (such as mono-, di- and

triethanolamine) and alkali metal (such as sodium, lithium and potassium) salts of the alkyl mononuclear aromatic sulfonates such as the alkyl benzene sulfonates containing from 5 to 18 carbon atoms in the alkyl group in a straight or branched chain, e.g., the salts of alkyl benzene sulfonates or of alkyl toluene, xylene, cumene
5 and phenol sulfonates; alkyl naphthalene sulfonate, diamyl naphthalene sulfonate, and dinonyl naphthalene sulfonate and alkoxyated derivatives.

Anionic carboxylate surfactants suitable for use in the present compositions include the alkyl ethoxy carboxylates, the alkyl polyethoxy polycarboxylate surfactants and the soaps (e.g. alkyl carboxyls). Secondary soap surfactants (e.g.
10 alkyl carboxyl surfactants) useful in the present compositions include those which contain a carboxyl unit connected to a secondary carbon. The secondary carbon can be in a ring structure, e.g. as in p-octyl benzoic acid, or as in alkyl-substituted cyclohexyl carboxylates. The secondary soap surfactants typically contain no ether linkages, no ester linkages and no hydroxyl groups. Further, they typically lack
15 nitrogen atoms in the head-group (amphiphilic portion). Suitable secondary soap surfactants typically contain 11-13 total carbon atoms, although more carbons atoms (e.g., up to 16) can be present.

Other anionic detergents suitable for use in the present compositions include olefin sulfonates, such as long chain alkene sulfonates, long chain hydroxyalkane
20 sulfonates or mixtures of alkenesulfonates and hydroxyalkane-sulfonates. Also included are the alkyl sulfates, alkyl poly(ethyleneoxy)ether sulfates and aromatic poly(ethyleneoxy)sulfates such as the sulfates or condensation products of ethylene oxide and nonyl phenol (usually having 1 to 6 oxyethylene groups per molecule). Resin acids and hydrogenated resin acids are also suitable, such as rosin,
25 hydrogenated rosin, and resin acids and hydrogenated resin acids present in or derived from tallow oil.

The particular salts will be suitably selected depending upon the particular formulation and the needs therein.

Further examples of suitable anionic surfactants are given in "Surface Active
30 Agents and Detergents" (Vol. I and II by Schwartz, Perry and Berch). A variety of such surfactants are also generally disclosed in U.S. Pat. No. 3,929,678, issued Dec. 30, 1975 to Laughlin, et al. at Column 23, line 58 through Column 29, line 23.

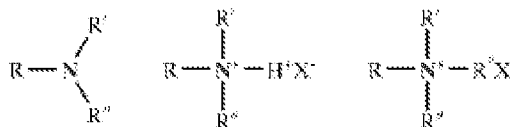
Cationic Surfactants

Surface active substances are classified as cationic if the charge on the
5 hydrotrope portion of the molecule is positive. Surfactants in which the hydrotrope
carries no charge unless the pH is lowered close to neutrality or lower, but which are
then cationic (e.g. alkyl amines), are also included in this group. In theory, cationic
surfactants may be synthesized from any combination of elements containing an
"onium" structure $R_nX^+Y^-$ and could include compounds other than nitrogen
10 (ammonium) such as phosphorus (phosphonium) and sulfur (sulfonium). In practice,
the cationic surfactant field is dominated by nitrogen containing compounds,
probably because synthetic routes to nitrogenous cationics are simple and
straightforward and give high yields of product, which can make them less
expensive.

15 Cationic surfactants preferably include, more preferably refer to, compounds
containing at least one long carbon chain hydrophobic group and at least one
positively charged nitrogen. The long carbon chain group may be attached directly
to the nitrogen atom by simple substitution; or more preferably indirectly by a
bridging functional group or groups in so-called interrupted alkylamines and amido
20 amines. Such functional groups can make the molecule more hydrophilic and/or
more water dispersible, more easily water solubilized by co-surfactant mixtures,
and/or water soluble. For increased water solubility, additional primary, secondary
or tertiary amino groups can be introduced or the amino nitrogen can be quaternized
with low molecular weight alkyl groups. Further, the nitrogen can be a part of
25 branched or straight chain moiety of varying degrees of unsaturation or of a
saturated or unsaturated heterocyclic ring. In addition, cationic surfactants may
contain complex linkages having more than one cationic nitrogen atom.

The surfactant compounds classified as amine oxides, amphoterics and
zwitterions are themselves typically cationic in near neutral to acidic pH solutions
30 and can overlap surfactant classifications. Polyoxyethylated cationic surfactants
generally behave like nonionic surfactants in alkaline solution and like cationic
surfactants in acidic solution.

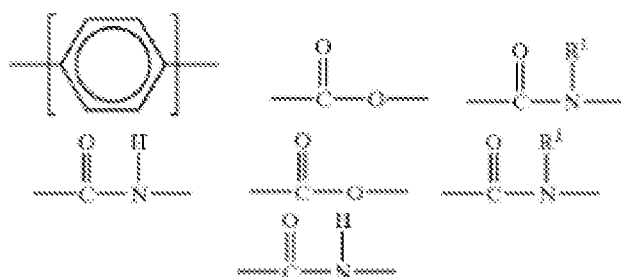
The simplest cationic amines, amine salts and quaternary ammonium compounds can be schematically drawn thus:



in which, R represents a long alkyl chain, R', R'', and R''' may be either long alkyl
 5 chains or smaller alkyl or aryl groups or hydrogen and X represents an anion. The
 amine salts and quaternary ammonium compounds are preferred for practical use in
 this invention due to their high degree of water solubility.

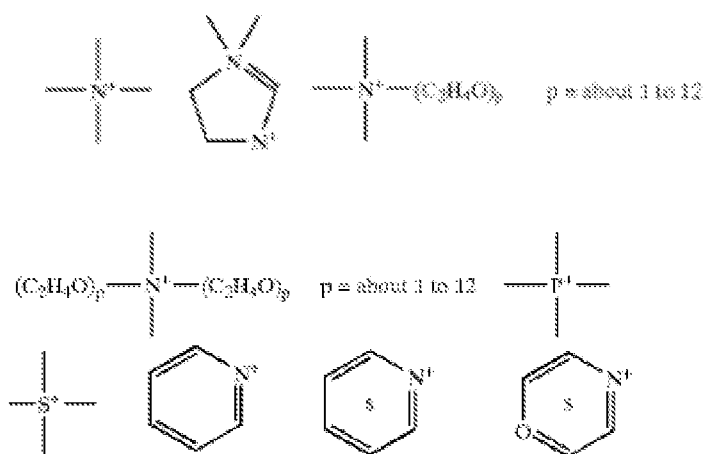
The majority of large volume commercial cationic surfactants can be
 subdivided into four major classes and additional sub-groups known to those of skill
 10 in the art and described in "Surfactant Encyclopedia," Cosmetics & Toiletries, Vol.
 104 (2) 86-96 (1989). The first class includes alkylamines and their salts. The
 second class includes alkyl imidazolines. The third class includes ethoxylated
 amines. The fourth class includes quaternaries, such as
 alkylbenzyltrimethylammonium salts, alkyl benzene salts, heterocyclic ammonium
 15 salts, tetra alkylammonium salts, and the like. Cationic surfactants are known to
 have a variety of properties that can be beneficial in the present compositions.
 These desirable properties can include detergency in compositions of or below
 neutral pH, antimicrobial efficacy, thickening or gelling in cooperation with other
 agents, and the like.

20 Cationic surfactants useful in the compositions of the present invention
 include those having the formula $\text{R}_m^1\text{R}_x^2\text{YLZ}$ wherein each R^1 is an organic group
 containing a straight or branched alkyl or alkenyl group optionally substituted with
 up to three phenyl or hydroxy groups and optionally interrupted by up to four of the
 following structures:



or an isomer or mixture of these structures, and which contains from 8 to 22 carbon atoms. The R^1 groups can additionally contain up to 12 ethoxy groups. m is a number from 1 to 3. Preferably, no more than one R^1 group in a molecule has 16 or more carbon atoms when m is 2, or more than 12 carbon atoms when m is 3. Each R^2 is an alkyl or hydroxyalkyl group containing from 1 to 4 carbon atoms or a benzyl group with no more than one R^2 in a molecule being benzyl, and x is a number from 0 to 11, preferably from 0 to 6. The remainder of any carbon atom positions on the Y group is filled by hydrogens.

Y can be a group including, but not limited to:



or a mixture thereof.

Preferably, L is 1 or 2, with the Y groups being separated by a moiety selected from R^1 and R^2 analogs (preferably alkylene or alkenylene) having from 1 to 22 carbon atoms and two free carbon single bonds when L is 2. Z is a water soluble anion, such as sulfate, methylsulfate, hydroxide, or nitrate anion, particularly

preferred being sulfate or methyl sulfate anions, in a number to give electrical neutrality of the cationic component.

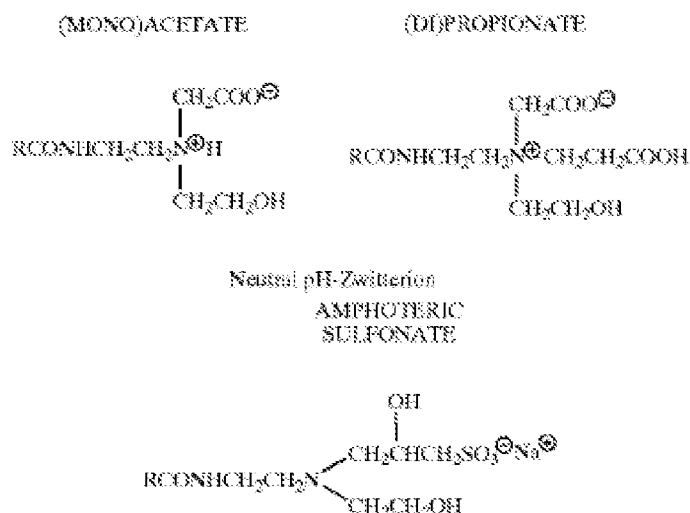
Amphoteric Surfactants

5 Amphoteric, or ampholytic, surfactants contain both a basic and an acidic hydrophilic group and an organic hydrophobic group. These ionic entities may be any of the anionic or cationic groups described herein for other types of surfactants. A basic nitrogen and an acidic carboxylate group are the typical functional groups employed as the basic and acidic hydrophilic groups. In a few surfactants, sulfonate, 10 sulfate, phosphonate or phosphate provide the negative charge.

Amphoteric surfactants can be broadly described as derivatives of aliphatic secondary and tertiary amines, in which the aliphatic radical may be straight chain or branched and wherein one of the aliphatic substituents contains from 8 to 18 carbon atoms and one contains an anionic water solubilizing group, e.g., carboxy, sulfo, 15 sulfato, phosphato, or phosphono. Amphoteric surfactants are subdivided into two major classes known to those of skill in the art and described in "Surfactant Encyclopedia," Cosmetics & Toiletries, Vol. 104 (2) 69-71 (1989). The first class includes acyl/dialkyl ethylenediamine derivatives (e.g. 2-alkyl hydroxyethyl imidazoline derivatives) and their salts. The second class includes N-alkylamino 20 acids and their salts. Some amphoteric surfactants can be envisioned as fitting into both classes.

Amphoteric surfactants can be synthesized by methods known to those of skill in the art. For example, 2-alkyl hydroxyethyl imidazoline is synthesized by condensation and ring closure of a long chain carboxylic acid (or a derivative) with 25 dialkyl ethylenediamine. Commercial amphoteric surfactants are derivatized by subsequent hydrolysis and ring-opening of the imidazoline ring by alkylation--for example with ethyl acetate. During alkylation, one or two carboxy-alkyl groups react to form a tertiary amine and an ether linkage with differing alkylating agents yielding different tertiary amines.

30 Long chain imidazole derivatives having application in the present invention generally have the general formula:



wherein R is an acyclic hydrophobic group containing from 8 to 18 carbon atoms and M is a cation to neutralize the charge of the anion, generally sodium.

Commercially prominent imidazoline-derived amphoteries that can be employed in the present compositions include for example: Cocoamphopropionate, Cocoamphocarboxy-propionate, Cocoamphoglycinate, Cocoamphocarboxy-glycinate, Cocoamphopropyl-sulfonate, and Cocoamphocarboxy-propionic acid. Preferred amphocarboxylic acids are produced from fatty imidazolines in which the dicarboxylic acid functionality of the amphodicarboxylic acid is diacetic acid and/or dipropionic acid.

The carboxymethylated compounds (glycinates) described herein above frequently are called betaines. Betaines are a special class of amphoteric discussed herein below in the section entitled, Zwitterion Surfactants.

Long chain N-alkylamino acids are readily prepared by reacting RNH₂, in which R.dbd.C₈-C₁₈ straight or branched chain alkyl, fatty amines with halogenated carboxylic acids. Alkylation of the primary amino groups of an amino acid leads to secondary and tertiary amines. Alkyl substituents may have additional amino groups that provide more than one reactive nitrogen center. Most commercial N-alkylamine acids are alkyl derivatives of beta-alanine or beta-N(2-carboxyethyl) alanine. Examples of commercial N-alkylamino acid ampholytes having application in this invention include alkyl beta-amino dipropionates, RN(C₂H₄COOM)₂ and

RNHC₂H₄COOM. In these, R is preferably an acyclic hydrophobic group containing from 8 to 18 carbon atoms, and M is a cation to neutralize the charge of the anion.

Preferred amphoteric surfactants include those derived from coconut products such as coconut oil or coconut fatty acid. The more preferred of these coconut derived surfactants include as part of their structure an ethylenediamine moiety, an alkanolamide moiety, an amino acid moiety, preferably glycine, or a combination thereof; and an aliphatic substituent of from 8 to 18 (preferably 12) carbon atoms. Such a surfactant can also be considered an alkyl amphodicarboxylic acid. Disodium cocoampho dipropionate is one most preferred amphoteric surfactant and is commercially available under the tradename Miranol.TM. FBS from Rhodia Inc., Cranbury, N.J. Another most preferred coconut derived amphoteric surfactant with the chemical name disodium cocoampho diacetate is sold under the tradename Miranol C2M-SF Conc., also from Rhodia Inc., Cranbury, N.J.

A typical listing of amphoteric classes, and species of these surfactants, is given in U.S. Pat. No. 3,929,678 issued to Laughlin and Heuring on Dec. 30, 1975. Further examples are given in "Surface Active Agents and Detergents" (Vol. I and II by Schwartz, Perry and Berch).

Zwitterionic Surfactants

Zwitterionic surfactants can be thought of as a subset of the amphoteric surfactants. Zwitterionic surfactants can be broadly described as derivatives of secondary and tertiary amines, derivatives of heterocyclic secondary and tertiary amines, or derivatives of quaternary ammonium, quaternary phosphonium or tertiary sulfonium compounds. Typically, a zwitterionic surfactant includes a positive charged quaternary ammonium or, in some cases, a sulfonium or phosphonium ion, a negative charged carboxyl group, and an alkyl group. Zwitterionics generally contain cationic and anionic groups which ionize to a nearly equal degree in the isoelectric region of the molecule and which can develop strong "inner-salt" attraction between positive-negative charge centers. Examples of such zwitterionic synthetic surfactants include derivatives of aliphatic quaternary ammonium, phosphonium, and sulfonium compounds, in which the aliphatic radicals can be

straight chain or branched, and wherein one of the aliphatic substituents contains from 8 to 18 carbon atoms and one contains an anionic water solubilizing group, e.g., carboxy, sulfonate, sulfate, phosphate, or phosphonate. Betaine and sultaine surfactants are exemplary zwitterionic surfactants for use herein.

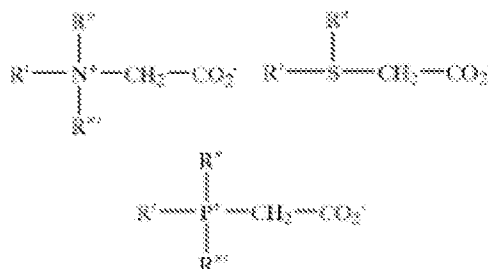
5 A general formula for these compounds is:



wherein R¹ contains an alkyl, alkenyl, or hydroxyalkyl radical of from 8 to 18 carbon atoms having from 0 to 10 ethylene oxide moieties and from 0 to 1 glyceryl moiety; Y is selected from the group consisting of nitrogen, phosphorus, and sulfur
10 atoms; R² is an alkyl or monohydroxy alkyl group containing 1 to 3 carbon atoms; x is 1 when Y is a sulfur atom and 2 when Y is a nitrogen or phosphorus atom, R³ is an alkylene or hydroxy alkylene or hydroxy alkylene of from 1 to 4 carbon atoms and Z is a radical selected from the group consisting of carboxylate, sulfonate, sulfate, phosphonate, and phosphate groups.

15 Examples of zwitterionic surfactants having the structures listed above include: 4-[N,N-di(2-hydroxyethyl)-N-octadecylammonio]-butane-1-carboxylate; 5-[S-3-hydroxypropyl-S-hexadecylsulfonio]-3-hydroxypentane-1-sulfate; 3-[P,P-diethyl-P-3,6,9-trioxatetracosanephosphonio]-2-hydroxypropane-1-phosphate; 3-[N,N-dipropyl-N-3-dodecoxy-2-hydroxypropyl-ammonio]-propane-1-phosphonate;
20 3-(N,N-dimethyl-N-hexadecylammonio)-propane-1-sulfonate; 3-(N,N-dimethyl-N-hexadecylammonio)-2-hydroxy-propane-1-sulfonate; 4-[N,N-di(2(2-hydroxyethyl)-N(2-hydroxydodecyl)ammonio)-butane-1-carboxylate; 3-[S-ethyl-S-(3-dodecoxy-2-hydroxypropyl)sulfonio]-propane-1-phosphate; 3-[P,P-dimethyl-P-dodecylphosphonio]-propane-1-phosphonate; and S [N,N-di(3-hydroxypropyl)-N-
25 hexadecylammonio]-2-hydroxy-pentane-1-sulfate. The alkyl groups contained in said detergent surfactants can be straight or branched and saturated or unsaturated.

The zwitterionic surfactant suitable for use in the present compositions includes a betaine of the general structure:



These surfactant betaines typically do not exhibit strong cationic or anionic characters at pH extremes nor do they show reduced water solubility in their isoelectric range. Unlike "external" quaternary ammonium salts, betaines are compatible with anionics. Examples of suitable betaines include coconut acylamidopropyldimethyl betaine; hexadecyl dimethyl betaine; C₁₂₋₁₄ acylamidopropylbetaine; C₈₋₁₄ acylamidohexyldiethyl betaine; 4-C₁₄₋₁₆ acylmethyramidodiethylammonio-1-carboxybutane; C₁₆₋₁₈ acylamidodimethylbetaine; C₁₂₋₁₆ acylamidopentanedithylbetaine; and C₁₂₋₁₆ acylmethyramidodimethylbetaine.

Surfactants useful in the present invention include those compounds having the formula (R(R¹)₂N⁺.sup.+R²SO³⁻), in which R is a C₆-C₁₈ hydrocarbyl group, each R¹ is typically independently C₁-C₃ alkyl, e.g. methyl, and R² is a C₁-C₆ hydrocarbyl group, e.g. a C₁-C₃ alkylene or hydroxyalkylene group.

A typical listing of zwitterionic classes, and species of these surfactants, is given in U.S. Pat. No. 3,929,678 issued to Laughlin and Heuring on Dec. 30, 1975. Further examples are given in "Surface Active Agents and Detergents" (Vol. I and II by Schwartz, Perry and Berch).

20 Foam Inhibitors

A foam inhibitor may be included for reducing the stability of any foam that is formed. Examples of foam inhibitors include fatty amides, hydrocarbon waxes, fatty acids, fatty esters, fatty alcohols, fatty acid soaps, ethoxylates, mineral oils, polyethylene glycol esters, polyoxyethylene-polyoxypropylene block copolymers.

A discussion of foam inhibitors may be found, for example, in U.S. Pat. No. 3,048,548 to Martin et al., U.S. Pat. No. 3,334,147 to Brunelle et al., and U.S. Pat.

No. 3,442,242 to Rue et al., the disclosures of which are incorporated by reference herein. The composition preferably includes from about 0.0001 wt. % to about 5 wt. % and more preferably from about 0.01 wt. % to about 3 wt. % of the foam inhibitor.

5

Antiredeposition Agents

The composition may also include an antiredeposition agent capable of facilitating sustained suspension of soils in a cleaning solution and preventing the removed soils from being redeposited onto the substrate being cleaned. Examples of
10 suitable antiredeposition agents include fatty acid amides, complex phosphate esters, styrene maleic anhydride copolymers, and cellulosic derivatives such as hydroxyethyl cellulose, hydroxypropyl cellulose, and the like. The composition preferably includes from about 0.5 wt. % to about 10 wt. % and more preferably from about 1 wt. % to about 5 wt. % of an antiredeposition agent.

15

Binding Agent

The composition may optionally include a binding agent to bind the detergent composition together to provide a solid detergent composition. The binding agent may be formed by mixing alkali metal carbonate, alkali metal
20 bicarbonate, and water. The binding agent may also be urea or polyethylene glycol.

Bleaching Agent

Bleaching agents for use in inventive formulations for lightening or whitening a substrate, include bleaching compounds capable of liberating an active
25 halogen species, such as Cl_2 , Br_2 , --OCI-- and/or --OBr-- , under conditions typically encountered during the cleansing process. Suitable bleaching agents for use in the present cleaning compositions include, for example, chlorine-containing compounds such as a chlorine, a hypochlorite, chloramine. Preferred halogen-releasing compounds include the alkali metal dichloroisocyanurates, chlorinated trisodium
30 phosphate, the alkali metal hypochlorites, monochloramine and dichloramine, and the like. Encapsulated bleaching sources may also be used to enhance the stability of the bleaching source in the composition (see, for example, U.S. Pat. Nos.

4,618,914 and 4,830,773, the disclosure of which is incorporated by reference herein). A bleaching agent may also be a peroxygen or active oxygen source such as hydrogen peroxide, perborates, sodium carbonate peroxyhydrate, phosphate peroxyhydrates, potassium permonosulfate, and sodium perborate mono and
5 tetrahydrate, with and without activators such as tetraacetylene diamine, and the like. A cleaning composition may include a minor but effective amount of a bleaching agent, preferably about 0.1 -10 wt. %, preferably about 1-6 wt. %.

Dye or Odorant

10 Various dyes, odorants including perfumes, and other aesthetic enhancing agents may also be included in the composition. Dyes may be included to alter the appearance of the composition, as for example, Direct Blue 86 (Miles), Fastsol Blue (Mobay Chemical Corp.), Acid Orange 7 (American Cyanamid), Basic Violet
15 10 (Sandoz), Acid Yellow 23 (GAF), Acid Yellow 17 (Sigma Chemical), Sap Green (Keyston Analine and Chemical), Metanil Yellow (Keyston Analine and Chemical), Acid Blue 9 (Hilton Davis), Sandolan Blue/Acid Blue 182 (Sandoz), Hisol Fast Red (Capitol Color and Chemical), Fluorescein (Capitol Color and Chemical), Acid
20 Green 25 (Ciba-Geigy), and the like. Fragrances or perfumes that may be included in the compositions include, for example, terpenoids such as citronellol, aldehydes such as amyl cinnamaldehyde, a jasmine such as CIS-jasmine or jasmal, vanillin, and the like.

Hydrotrope

25 The compositions of the invention may optionally include a hydrotrope, coupling agent, or solubilizer that aides in compositional stability, and aqueous formulation. Functionally speaking, the suitable couplers which can be employed are non-toxic and retain the active ingredients in aqueous solution throughout the temperature range and concentration to which a concentrate or any use solution is exposed.

30 Any hydrotrope coupler may be used provided it does not react with the other components of the composition or negatively affect the performance properties of the composition. Representative classes of hydrotropic coupling agents or

solubilizers which can be employed include anionic surfactants such as alkyl sulfates and alkane sulfonates, linear alkyl benzene or naphthalene sulfonates, secondary alkane sulfonates, alkyl ether sulfates or sulfonates, alkyl phosphates or phosphonates, dialkyl sulfosuccinic acid esters, sugar esters (e.g., sorbitan esters),
5 amine oxides (mono-, di-, or tri-alkyl) and C₈-C₁₀ alkyl glucosides. Preferred coupling agents for use in the present invention include n-octanesulfonate, available as NAS 8D from Ecolab Inc., n-octyl dimethylamine oxide, and the commonly available aromatic sulfonates such as the alkyl benzene sulfonates (e.g. xylene sulfonates) or naphthalene sulfonates, aryl or alkaryl phosphate esters or their
10 alkoxyated analogues having 1 to about 40 ethylene, propylene or butylene oxide units or mixtures thereof. Other preferred hydrotropes include nonionic surfactants of C₆-C₂₄ alcohol alkoxyates (alkoxyate means ethoxyates, propoxyates, butoxyates, and co-or-terpolymer mixtures thereof) (preferably C₆-C₁₄ alcohol alkoxyates) having 1 to about 15 alkylene oxide groups (preferably about 4 to about
15 10 alkylene oxide groups); C₆-C₂₄ alkylphenol alkoxyates (preferably C₈-C₁₀ alkylphenol alkoxyates) having 1 to about 15 alkylene oxide groups (preferably about 4 to about 10 alkylene oxide groups); C₆-C₂₄ alkylpolyglycosides (preferably C₆-C₂₀ alkylpolyglycosides) having 1 to about 15 glycoside groups (preferably about 4 to about 10 glycoside groups); C₆-C₂₄ fatty acid ester ethoxyates, propoxyates or
20 glycerides; and C₄-C₁₂ mono or dialkanolamides.

Carrier

The composition may optionally include a carrier or solvent. The carrier may be water or other solvent such as an alcohol or polyol. Low molecular weight
25 primary or secondary alcohols exemplified by methanol, ethanol, propanol, and isopropanol are suitable. Monohydric alcohols are preferred for solubilizing surfactant, but polyols such as those containing from about 2 to about 6 carbon atoms and from about 2 to about 6 hydroxy groups (e.g. propylene glycol, ethylene glycol, glycerine, and 1,2-propanediol) can also be used.

30

Acidic Detergent Composition

The method of the present invention includes at least one acidic step wherein an acidic composition is brought into contact with a dish during the acidic step of the cleaning process. The acidic composition includes one or more acids which do not
5 include phosphates or silicates. Both organic and inorganic acids have been found to be generally useful in the present composition. Examples of suitable organic acids include hydroxyacetic (glycolic) acid, citric acid, formic acid, acetic acid, propionic acid, butyric acid, valeric acid, caproic acid, gluconic acid, itaconic acid, trichloroacetic acid, urea hydrochloride, and benzoic acid, among others. Organic
10 dicarboxylic acids such as oxalic acid, malonic acid, succinic acid, glutaric acid, maleic acid, fumaric acid, adipic acid, and terephthalic acid among others are also useful in accordance with the invention. Any combination of these organic acids may also be used intermixed or with other organic acids which allow adequate formation of the composition of the invention.

15 Inorganic acids useful in accordance with the invention include sulfuric acid, sulfamic acid, methylsulfamic acid, hydrochloric acid, hydrobromic acid, hydrofluoric acid, and nitric acid among others. These acids may also be used in combination with other inorganic acids or with those organic acids mentioned above. An acid generator may also be used in the composition to form a suitable acid. For
20 example, suitable generators include potassium fluoride, sodium fluoride, lithium fluoride, ammonium fluoride, ammonium bifluoride, etc.

In one embodiment, if an organic acid is selected as the acid, the acid component of the composition may comprise up to about 99.5 wt. % (active acid) of the final detergent composition. For example, the acid preferably comprises in the
25 range of from about 50 to about 99.5 wt. % of the total detergent composition, more preferably in the range of from about 75 to about 97 wt. % of the total detergent composition, and most preferably in the range of from about 90 to about 95 wt. % of the total detergent composition. In another embodiment, if an inorganic or mineral acid is selected as the acid, the acid component of the composition may comprise in
30 the range from about 1 to about 85 wt. % (active acid) of the total detergent composition, more preferably in the range of from about 5 to about 75 wt. % of the total detergent composition, and most preferably in the range of from about 10 to

about 75 wt. % of the total detergent composition. In another embodiment, the acid component may comprise up to 100 wt. % of the final detergent composition.

The acid is preferably present in the diluted, ready to use, acidic composition from about 0.01 wt. % to about 1 wt. %, more preferably from about 0.25 wt. % to about 0.5 wt. % and most preferably from about 0.05 wt. % to about 0.05 wt. %. The acidic composition preferably creates a diluted solution having a pH from about 0 to about 7, more preferably from about 1 to about 5, and most preferably from about 2 to about 4. The particular acid selected is not as important as the resulting pH. Any acid that achieves the desired pH may be used in the acidic composition of the invention.

The acidic composition may include additional ingredients. For example, the acidic composition may include an anticorrosion agent, a water conditioning agent, a surfactant, an enzyme, an enzyme stabilizing system, a foam inhibitor/defoaming agents, an anti-etch agent, a bleaching agent, a dye or odorant, an antimicrobial agent, a hydrotrope, a binding agent, a carrier and mixtures thereof. The water conditioning agent, enzyme, enzyme stabilizing system, surfactant, bleaching agent, dye or odorant, antimicrobial agent, hydrotrope, antiredeposition agent, binding agent, and carrier may be selected from any those compositions previously described herein.

Surfactant

The acidic warewashing composition can include at least one cleaning agent comprising a surfactant or surfactant system as described herein and supra. A variety of surfactants can be used in a warewashing composition, such as anionic, nonionic, cationic, and zwitterionic surfactants. It should be understood that surfactants are an optional component of the warewashing composition and can be excluded from the concentrate. The warewashing composition, when provided as a concentrate, can include the cleaning agent in a range of between about 0.5 wt. % and about 20 wt. %, between about 0.5 wt. % and about 15 wt. %, between about 1.5 wt. % and about 15 wt. %, between about 1 wt. % and about 10 wt. %, and between about 2 wt. % and about 5 wt. %. Additional exemplary ranges of surfactant in a

concentrate include about 0.5 wt. % to about 5 wt. %, and about 1 wt. % to about 3 wt. %.

Exemplary surfactants that can be used are commercially available from a number of sources. For a discussion of surfactants, see Kirk-Othmer, Encyclopedia
5 of Chemical Technology, Third Edition, volume 8, pages 900-912. When the warewashing composition includes a cleaning agent, the cleaning agent can be provided in an amount effective to provide a desired level of cleaning.

Anionic surfactants useful in the warewashing composition includes, for example, carboxylates such as alkylcarboxylates (carboxylic acid salts) and
10 polyalkoxycarboxylates, alcohol ethoxylate carboxylates, nonylphenol ethoxylate carboxylates, and the like; sulfonates such as alkylsulfonates, alkylbenzenesulfonates, alkylarylsulfonates, sulfonated fatty acid esters, and the like; sulfates such as sulfated alcohols, sulfated alcohol ethoxylates, sulfated alkylphenols, alkylsulfates, sulfosuccinates, alkylether sulfates, and the like; and phosphate esters
15 such as alkylphosphate esters, and the like. Exemplary anionic surfactants include sodium alkylarylsulfonate, alpha-olefinsulfonate, and fatty alcohol sulfates.

Nonionic surfactants useful in the warewashing composition include, for example, those having a polyalkylene oxide polymer as a portion of the surfactant molecule. Such nonionic surfactants include, for example, chlorine-, benzyl-,
20 methyl-, ethyl-, propyl-, butyl- and other like alkyl-capped polyethylene glycol ethers of fatty alcohols; polyalkylene oxide free nonionics such as alkyl polyglycosides; sorbitan and sucrose esters and their ethoxylates; alkoxylated ethylene diamine; alcohol alkoxylates such as alcohol ethoxylate propoxylates, alcohol propoxylates, alcohol propoxylate ethoxylate propoxylates, alcohol
25 ethoxylate butoxylates, and the like; nonylphenol ethoxylate, polyoxyethylene glycol ethers and the like; carboxylic acid esters such as glycerol esters, polyoxyethylene esters, ethoxylated and glycol esters of fatty acids, and the like; carboxylic amides such as diethanolamine condensates, monoalkanolamine condensates, polyoxyethylene fatty acid amides, and the like; and polyalkylene
30 oxide block copolymers including an ethylene oxide/propylene oxide block copolymer such as those commercially available under the trademark PLURONIC®

(BASF-Wyandotte), and the like; and other like nonionic compounds. Silicone surfactants such as the ABIL® B8852 can also be used.

Cationic surfactants that can be used in the warewashing composition include amines such as primary, secondary and tertiary monoamines with C₁₋₈ alkyl
5 or alkenyl chains, ethoxylated alkylamines, alkoxylates of ethylenediamine, imidazoles such as a 1-(2-hydroxyethyl)-2-imidazoline, a 2-alkyl-1-(2-hydroxyethyl)-2-imidazoline, and the like; and quaternary ammonium salts, as for example, alkylquaternary ammonium chloride surfactants such as n-alkyl(C₁₂-C₁₈)dimethylbenzyl ammonium chloride, n-tetradecyldimethylbenzylammonium
10 chloride monohydrate, a naphthylene-substituted quaternary ammonium chloride such as dimethyl-1-naphthylmethylammonium chloride, and the like. The cationic surfactant can be used to provide sanitizing properties.

Zwitterionic surfactants that can be used in the warewashing composition include betaines, imidazolines, and propinates. Because the warewashing
15 composition is intended to be used in an automatic dishwashing or warewashing machine, the surfactants selected, if any surfactant is used, can be those that provide an acceptable level of foaming when used inside a dishwashing or warewashing machine. It should be understood that warewashing compositions for use in automatic dishwashing or warewashing machines are generally considered to be
20 low-foaming compositions.

The surfactant can be selected to provide low foaming properties. One would understand that low foaming surfactants that provide the desired level of
detergent activity are advantageous in an environment such as a dishwashing machine where the presence of large amounts of foaming can be problematic. In
25 addition to selecting low foaming surfactants, one would understand that defoaming agents can be utilized to reduce the generation of foam. Accordingly, surfactants that are considered low foaming surfactants as well as other surfactants can be used in the warewashing composition and the level of foaming can be controlled by the addition of a defoaming agent.

30

Additional Functional Ingredients

Other active ingredients may optionally be used to improve the effectiveness of the detergent. Some non-limiting examples of such additional functional ingredients can include: anticorrosion agents, wetting agents, water conditioning
5 agents, enzymes, foam inhibitors, antiredeposition agents, anti-etch agents, antimicrobial agents and other ingredients useful in imparting a desired characteristic or functionality in the detergent composition as described supra, and hereinafter. The following describes some examples of such ingredients.

10 Anticorrosion Agents

The composition may optionally include an anticorrosion agent. Anticorrosion agents provide compositions that help to prevent chemical attack, oxidation, discoloration, and pitting on dish machines and dishware surfaces. Preferred anticorrosion agents which can be used according to the invention include
15 copper sulfate, triazoles, triazines, sorbitan esters, fluconate, borates, organic amines, sorbitan esters, carboxylic acid derivatives, sarcosinates, phosphate esters, zinc, nitrates, chromium, molybdate containing components, and borate containing components. Exemplary phosphates or phosphonic acids are available under the name Dequest (i.e., Dequest 2000, Dequest 2006, Dequest 2010, Dequest 2016,
20 Dequest 2054, Dequest 2060, and Dequest 2066) from Solutia, Inc. of St. Louis, Mo. Exemplary triazoles are available under the name Cobratec (i.e., Cobratec 100, Cobratec TT-50-S, and Cobratec 99) from PMC Specialties Group, Inc. of Cincinnati, Ohio. Exemplary organic amines include aliphatic amines, aromatic amines, monoamines, diamines, triamines, polyamines, and their salts. Exemplary
25 amines are available under the names Amp (i.e. Amp-95) from Angus Chemical Company of Buffalo Grove, Ill.; WGS (i.e., WGS-50) from Jacam Chemicals, LLC of Sterling, Kans.; Duomeen (i.e., Duomeen O and Duomeen C) from Akzo Nobel Chemicals, Inc. of Chicago, Ill.; DeThox amine (C Series and T Series) from DeForest Enterprises, Inc. of Boca Raton, Fla.; Deriphath series from Henkel Corp. of
30 Ambler, Pa.; and Maxhib (AC Series) from Chemax, Inc. of Greenville, S.C. Exemplary sorbitan esters are available under the name Calgene (LA-series) from Calgene Chemical Inc. of Skokie, Ill. Exemplary carboxylic acid derivatives are

available under the name Recor (i.e., Recor 12) from Ciba-Geigy Corp. of Tarrytown, N.Y. Exemplary sarcosinates are available under the names Hamposyl from Hampshire Chemical Corp. of Lexington, Mass.; and Sarkosyl from Ciba-Geigy Corp. of Tarrytown, N.Y.

5 The composition optionally includes an anticorrosion agent for providing enhanced luster to the metallic portions of a dish machine. When an anticorrosion agent is incorporated into the composition, it is preferably included in an amount of between about 0.05 wt. % and about 5 wt. %, between about 0.5 wt. % and about 4 wt. % and between about 1 wt. % and about 3 wt. %.

10

Wetting Agents

 The compositions may include a wetting agent which can raise the surface activity of the composition of the invention. The wetting agent may be selected from the list of surfactants previously described. Preferred wetting agents include
15 Triton CF 100 available from Dow Chemical, Abil 8852 available from Goldschmidt, and SLF-18-45 available from BASF. The wetting agent is preferably present from about 0.1 wt. % to about 10 wt. %, more preferably from about 0.5 wt. % to 5 wt. %, and most preferably from about 1 wt. % to about 2 wt. %.

Anti-Etch Agents

 The composition may also include an anti-etch agent capable of preventing etching in glass. Examples of suitable anti-etch agents include adding metal ions to the composition such as zinc, zinc chloride, zinc gluconate, aluminum, and beryllium. The composition preferably includes from about 0.1 wt. % to about 10
25 wt. %, more preferably from about 0.5 wt. % to about 7 wt. %, and most preferably from about 1 wt. % to about 5 wt. % of an anti-etch agent.

Antimicrobial Agent

 The compositions may optionally include an antimicrobial agent or
30 preservative. Antimicrobial agents are chemical compositions that can be used in the composition to prevent microbial contamination and deterioration of commercial products material systems, surfaces, etc. Generally, these materials fall in specific

classes including phenolics, halogen compounds, quaternary ammonium compounds, metal derivatives, amines, alkanol amines, nitro derivatives, analides, organosulfur and sulfur-nitrogen compounds and miscellaneous compounds. The given antimicrobial agent depending on chemical composition and concentration may

5 simply limit further proliferation of numbers of the microbe or may destroy all or a substantial proportion of the microbial population. The terms "microbes" and "microorganisms" typically refer primarily to bacteria and fungus microorganisms. In use, the antimicrobial agents are formed into the final product that when diluted and dispensed using an aqueous stream forms an aqueous disinfectant or sanitizer

10 composition that can be contacted with a variety of surfaces resulting in prevention of growth or the killing of a substantial proportion of the microbial population. Common antimicrobial agents that may be used include phenolic antimicrobials such as pentachlorophenol, orthophenylphenol; halogen containing antibacterial agents that may be used include sodium trichloroisocyanurate, sodium

15 dichloroisocyanurate (anhydrous or dihydrate), iodine-poly(vinylpyrrolidin-onen) complexes, bromine compounds such as 2-bromo-2-nitropropane-1,3-diol; quaternary antimicrobial agents such as benzalconium chloride, cetylpyridiniumchloride; amines and nitro containing antimicrobial compositions such as hexahydro-1,3,5-tris(2-hydroxyethyl)-s-triazine, dithiocarbamates such as

20 sodium dimethyldithiocarbamate, and a variety of other materials known in the art for their microbial properties. Antimicrobial agents may be encapsulated to improve stability and/or to reduce reactivity with other materials in the detergent composition. When an antimicrobial agent or preservative is incorporated into the composition, it is preferably included in an amount of between about 0.01 wt. % to about 5 wt. %,

25 between about 0.01 wt. % to about 2 wt. %, and between about 0.1 wt. % to about 1.0 wt. %.

Rinse

The method may optionally include a rinse step. The rinse step may take

30 place at any time during the cleaning process and at more than one time during the cleaning process. The method preferably includes one rinse at the end of the cleaning process.

The rinse composition may comprise a formulated rinse aid composition containing a wetting or sheeting agent combined with other optional ingredients. The rinse aid components is a water soluble or dispersible low foaming organic material capable of reducing the surface tension of the rinse water to promote

5 sheeting action and to prevent spotting or streaking caused by beaded water after rinsing is complete in warewashing processes. Such sheeting agents are typically organic surfactant like materials having a characteristic cloud point. The cloud point of the surfactant rinse or sheeting agent is defined as the temperature at which a 1 wt. % aqueous solution of the surfactant turns cloudy when warmed. Since there are

10 two general types of rinse cycles in commercial warewashing machines, a first type generally considered a sanitizing rinse cycle uses rinse water at a temperature of about 180° F., about 80°C or higher. A second type of non-sanitizing machines uses a lower temperature non-sanitizing rinse, typically at a temperature of about 125° F., about 50°C or higher. Surfactants useful in these applications are aqueous rinses

15 having a cloud point greater than the available hot service water. Accordingly, the lowest useful cloud point measured for the surfactants of the invention is approximately 40°C. The cloud point can also be 60° C. or higher, 70° C or higher, 80° C or higher, etc., depending on the use locus hot water temperature and the temperature and type of rinse cycle. Preferred sheeting agents, typically comprise a

20 polyether compound prepared from ethylene oxide, propylene oxide, or a mixture in a homopolymer or block or heteric copolymer structure. Such polyether compounds are known as polyalkylene oxide polymers, polyoxyalkylene polymers or polyalkylene glycol polymers. Such sheeting agents require a region of relative hydrophobicity and a region of relative hydrophilicity to provide surfactant

25 properties to the molecule. Such sheeting agents have a molecular weight in the range of about 500 to 15,000. Certain types of (PO)(EO) polymeric rinse aids have been found to be useful containing at least one block of poly(PO) and at least one block of poly(EO) in the polymer molecule. Additional blocks of poly(EO), poly PO or random polymerized regions can be formed in the molecule. Particularly

30 useful polyoxypropylene polyoxyethylene block copolymers are those comprising a center block of polyoxypropylene units and blocks of polyoxyethylene units to each side of the center block. Such polymers have the formula shown below:



wherein n is an integer of 20 to 60, each end is independently an integer of 10 to 130.

Another useful block copolymer are block copolymers having a center block of
5 polyoxyethylene units and blocks of polyoxypropylene to each side of the center
block.

Such copolymers have the formula:



10

wherein m is an integer of 15 to 175 and each end are independently integers of
about 10 to 30. The solid functional materials of the invention can often use a
hydrotrope to aid in maintaining the solubility of sheeting or wetting agents.

Hydrotropes can be used to modify the aqueous solution creating increased

15 solubility for the organic material. Preferred hydrotropes are low molecular weight
aromatic sulfonate materials such as xylene sulfonates and dialkyldiphenyl oxide
sulfonate materials. Bleaching agents for use in inventive formulations for
lightening or whitening a substrate, include bleaching compounds capable of
liberating an active halogen species, such as Cl_2 , Br_2 , $--OCl--$ and/or $--OBr--$, under
20 conditions typically encountered during the cleansing process. Suitable bleaching
agents for use in the present cleaning compositions include, for example, chlorine-
containing compounds such as a chlorine, a hypochlorite, chloramine. Preferred
halogen-releasing compounds include the alkali metal dichloroisocyanurates,
chlorinated trisodium phosphate, the alkali metal hypochlorites, monochloramine
25 and dichloroamine, and the like. Encapsulated chlorine sources may also be used to
enhance the stability of the chlorine source in the composition (see, for example,
U.S. Pat. Nos. 4,618,914 and 4,830,773, the disclosure of which is incorporated by
reference herein). A bleaching agent may also be a peroxygen or active oxygen
source such as hydrogen peroxide, perborates, sodium carbonate peroxyhydrate,
30 phosphate peroxyhydrates, potassium permonosulfate, and sodium perborate mono
and tetrahydrate, with and without activators such as tetraacetylene diamine,
and the like.

Method of Manufacturing the Composition

The compositions of the present invention may include liquid products, thickened liquid products, gelled liquid products, paste, granular and pelletized solid compositions powders, solid block compositions, cast solid block compositions, 5 extruded solid block composition and others. Liquid compositions can typically be made by forming the ingredients in an aqueous liquid or aqueous liquid solvent system. Such systems are typically made by dissolving or suspending the active ingredients in water or in compatible solvent and then diluting the product to an appropriate concentration, either to form a concentrate or a use solution thereof. 10 Gelled compositions can be made similarly by dissolving or suspending the active ingredients in a compatible aqueous, aqueous liquid or mixed aqueous organic system including a gelling agent at an appropriate concentration. Solid particulate materials can be made by merely blending the dry solid ingredients in appropriate ratios or agglomerating the materials in appropriate agglomeration systems. 15 Pelletized materials can be manufactured by compressing the solid granular or agglomerated materials in appropriate pelletizing equipment to result in appropriately sized pelletized materials. Solid block and cast solid block materials can be made by introducing into a container either a prehardened block of material or a castable liquid that hardens into a solid block within a container. Preferred 20 containers include disposable plastic containers or water soluble film containers. Other suitable packaging for the composition includes flexible bags, packets, shrink wrap, and water soluble film such as polyvinyl alcohol.

25 Dish Machines

The method of the invention may be carried out in any consumer or institutional dish machine. Some non-limiting examples of dish machines' include door machines or hood machines, conveyor machines, undercounter machines, glasswashers, flight machines, pot and pan machines, utensil washers, and consumer 30 dish machines. The dish machines may be either single tank or multi-tank machines. In a preferred embodiment, the dish machine is made out of acid resistant material,

especially when the portions of the dish machine that contact the acidic composition do not also contact the alkaline composition.

A door dish machine, also called a hood dish machine, refers to a commercial dish machine wherein the soiled dishes are placed on a rack and the rack
5 is then moved into the dish machine. Door dish machines clean one or two racks at a time. In such machines, the rack is stationary and the wash and rinse arms move. A door machine includes two sets arms, a set of wash arms and a rinse arm, or a set of rinse arms.

Door machines may be a high temperature or low temperature machine. In a
10 high temperature machine the dishes are sanitized by hot water. In a low temperature machine the dishes are sanitized by the chemical sanitizer. The door machine may either be a recirculation machine or a dump and fill machine. In a recirculation machine, the detergent solution is reused, or "recirculated" between wash cycles. The concentration of the detergent solution is adjusted between wash
15 cycles so that an adequate concentration is maintained. In a dump and fill machine, the wash solution is not reused between wash cycles. New detergent solution is added before the next wash cycle. Some non-limiting examples of door machines include the Ecolab Omega HT, the Hobart AM-14, the Ecolab ES-2000, the Hobart LT-1, the CMA EVA-200, American Dish Service L-3DW and HT-25, the
20 Autochlor A5, the Champion D-HB, and the Jackson Tempstar.

The method of the invention may be used in conjunction with any of the door machines described above. When the method of the invention is used in a door machine, the door machine may need to be modified to accommodate the acidic step. The door machine may be modified in one of several ways. In one embodiment, the
25 acidic composition may be applied to the dishes using the rinse spray arm of the door machine. In this embodiment, the rinse spray arm is connected to a reservoir for the acidic composition. The acidic composition may be applied using the original nozzles of the rinse arm. Alternatively, additional nozzles may be added to the rinse arm for the acidic composition. In another embodiment, an additional rinse
30 arm may be added to the door machine for the acidic composition. In yet another embodiment, spray nozzles may be installed in the door machine for the acidic

composition. In a preferred embodiment, the nozzles are installed inside the door machine in such a way as to provide full coverage to the dish rack.

The above specification provides a basis for understanding the broad meets and bounds of the invention. The following examples and test data provide an

5 understanding of certain specific embodiments of the invention. The examples are not meant to limit the scope of the invention that has been set forth in the foregoing description. Variations within the concepts of the invention are apparent to those skilled in the art.

10

EXAMPLES

The general method involves alternating the pH chemistry applied to the dishware in a dishmachine. This is done by applying an alkalinity source like sodium hydroxide or sodium carbonate followed by applying an acidic source like
15 citric acid. It was surprisingly found that the acid and base react with each other in peculiar ways that were not anticipated. It was expected that the acid and the base neutralize each other, but the other ingredients in the detergent(specifically phosphate) were also found to react with the acid. Without being bound by a specific theory, it is believed that, upon neutralization with acid, the phosphate in the
20 dishmachine wash tank forms a precipitate thus lowering the conductivity of the wash tank solution which, in turn, causes the detergent controller to erringly feed more detergent.

A number of detergent formulations and acid formulations are possible for this invention. However, whenever a detergent containing phosphate is used, we
25 surprisingly found that the overall system resulted in an excess detergent usage. The same result was found when an acid containing phosphoric acid was used in the system.

The preferred alkaline detergent composition would thus not contain phosphate and the preferred acid composition would thus not contain phosphoric
30 acid, or variations thereof.

EXAMPLES

100 Cycle Warewash Test Procedure:

5 **ONE HUNDRED-CYCLE FILM EVALUATION FOR**
 INSTITUTIONAL WAREWASH DETERGENTS

PURPOSE:

 To provide a generic method for evaluating glass and plastic film
10 accumulation in an institutional warewash machine. This procedure is used to
 evaluate test formulations, Ecolab products, and competitive products.

PRINCIPLE:

15 Test glasses are washed in an institutional warewash machine with a
 predetermined concentration of detergent. All of the glasses are left untreated and
 examined for film accumulation.

APPARATUS AND MATERIALS:

- 20
1. Institutional machine hooked up to the appropriate water supply
 2. Raburn glass rack
 3. Libbey heat resistant glass tumblers, 10 oz.
 4. Cambro Newport plastic tumblers
 - 25 5. Sufficient detergent to complete the test
 6. Titrator and reagents to titrate alkalinity
 7. Water hardness test kit

PREPARATION:

- 30
1. Clean 6 glasses according to above procedure.
 2. Fill the dishmachine with the appropriate water. Test the water for hardness.
 Record the value. Turn on tank heaters.

3. Turn on the dishmachine and run wash/rinse cycles through the machine until a wash temperature of 150-160°F and rinse temperature of 175-190°F is reached.
4. Set controller to dispense appropriate amount of detergent into the wash tank.
5. Titrate to verify detergent concentration.
5. Place 6 clean glasses diagonally and four plastic tumblers off-diagonally in the Raburn rack (see figure below for arrangement) and place the rack inside the dishmachine. G=glass tumblers, P=plastic tumbler and place the rack inside the dishmachine.

10

					G
				G	
			G		
		G			
	G			P	
G					

6. Begin 100 cycle test
7. At the beginning of each wash cycle, the appropriate amount of detergent is automatically dispensed into the warewash machine to maintain the initial detergent concentration. Detergent concentration is controlled by conductivity.

15

PROCEDURE:

1. Begin 100 cycle test
- 20 2. After the completion of each cycle, the machine is appropriately dosed (automatically) to maintain the initial concentration.
3. Let the glasses and tumblers dry overnight. Grade all glasses for film accumulation using Image Analysis. (a number around 15000 indicates a perfectly clean glass. Any number lower than 40000 is visually acceptable for scale control performance.)
- 25

Light box evaluation of 100 cycle glasses:

The light box test standardizes the evaluation of the glasses run in the 100 cycle test using an analytical method. The light box test is based on the use of an optical system including a photographic camera, a light box, a light source, and a
5 light meter. The system is controlled by a computer program (Spot Advance and Image Pro Plus).

To evaluate the glasses, each glass is placed on the light box resting on its side and the intensity of the light source is adjusted to a predetermined value using a light meter. The conditions of the 100 cycle test are entered into the computer. A
10 picture of the glass is taken with the camera and saved on the computer for analysis by the program. The picture was analyzed using the upper half of the glass in order to avoid the gradient of darkness on the film from the top of the glass to the bottom of the glass, based on the shape of the glass.

Generally, a lower light box rating indicates that more light is able to pass
15 through the glass. Thus, the lower the glass rating, the more effective the composition is at preventing scale on the surface on the glass. Light box evaluation of a clean, unused glass has a light box score of approximately 12,000 which corresponds to a score of 72,000 for the sum of the six glasses.

Light box evaluation of a clean, unused plastic tumbler has a light box of
20 approximately 25,000.

The minimum obtainable score for 6 glasses and one plastic tumbler is approximately 97,000.

Example 1 Comparison of Different Acids: Shows how phosphoric acid
25 causes higher detergent consumption and higher film(CaPO_4) compared to four other acids.

Example 2 Detergent Consumption Data: Shows how Solid Power
containing tripolyphosphate causes more detergent usage compared to Solid Power
30 LP(containing no phosphate). Two different acids were used.

Example 3 and 4 Analytical and Physical Chemistry Report show the elemental makeup of the glassware film using two different acids for 100 cycle tests. The film found when using phosphoric acid was identified as a calcium phosphate film. The film when using MSA acid was identified as a calcium carbonate film.

5

EXAMPLE 1

SUMMARY

The first experiments involved testing in-line alkaline detergents in conjunction with straight phosphoric acid as the acid source for the acid rinse step. Both of the in-line detergents contained tripolyphosphate. The detergent/acid combinations performed relatively good in short-term cleaning performance tests, but when we conducted longer term(100 cycle) tests it was found that the detergent usage was unexpectedly high.

When we later tested the non-phosphate containing detergents under the same conditions, we did not observe nearly as much detergent consumption. Furthermore, upon conducting side-by-side 100 cycle tests, we observed a white film buildup on the glasses and on the dishmachine whenever the phosphoric-containing acid or the phosphate-containing detergent was used. When we investigated the film composition, we concluded that it was a calcium phosphate film. The phosphate component of the film was identified by an analytical laboratory(EDS analysis) and was further supported with the fizz test (the film did not fizz when concentrated acid was dripped onto the film). Phosphate films do not fizz whereas the more common carbonate films do indeed fizz in the fizz test. In less formal experiments we observed significantly less filming on the glass and the dish machine when using Solid Power LP (phosphate free) in conjunction with phosphoric acid as compared to in-line Solid Power with phosphoric acid.

METHODS

Four different formulations were prepared and run according to the 100 cycle film evaluation for warewash detergents in and institutional warewash machine according to the table below.

COMPARISON OF DIFFERENT ACIDS

Detergent	SP Tripoly	SP Tripoly	SP Tripoly	SP Tripoly	SP Tripoly
Acid	Lime-A-Way	Phos Acid	MSA	Sodium Bisulfate	Sulfamic Acid
Initial	3366.84	2845.8	2079.7	1625.37	1185.9
100 Cycle	2885.62	2301.29	1670.28	1264.56	793.16
Detergent Used	481.22	544.51	409.42	360.81	392.74
Odor	None	None	None	None	None
pH	2	2	2	2	2
mL/cycle	2.5	2.5	1.3 top		3.5
			1 bottom		
	Film	Bad film	Film	Film	Film

As can be seen, when sodium bisulfate, methane sulfonic acid, or sulfamic acid were used there was less film and detergent used was decreased from 544.51 to 360.81.

EXAMPLE 2
Detergent Consumption Data

Next Solid Power containing tripolyphosphate was tested against Solid Power LP (phosphate free) with two different acids. The tripolyphosphate detergent caused greater detergent usage than the phosphate free detergent. Results are shown in the table below.

Table 2

Detergent	Consumption Data		
14 drops	Solid Power Tripoly formula		
	Acid	Weight Loss	
Initial	3428.66		
Cycle 5	3398.75	29.91	
Cycle 10	3373.1	25.65	
Cycle 15	3342.14	30.96	
Cycle 20	3309.49	32.65	
	Total	119.17	6.0 g/cycle

Comparison of Different Acids

Detergent	SP Tripoly			SP Tripoly	
Acid	Lime-A-Way			Phos Acid	
Initial	3366.84			2845.8	
100 Cycle	2885.62			2301.29	
Detergent	481.22	4.8 g/cycle		544.51	5.4 g/cycle
Used					
Odor	None			None	
pH	2			2	
mL/cycle	2.5			2.5	
Film				Bad Film	

Comparison of Different Detergents/Acids

Detergent	SP LP			SP LP	
Acid	Lime-A-Way			Phos Acid	
Initial	2581.31			2312.88	
20	2520.74			2246.52	
Cycles					
Detergent	60.57	3.0 g/cycle		66.36	3.3
Used					
Odor	None				
pH	2.02			1.8	
mL/cycle	1,8			2.06	

- 5 As can be seen when the SP LP phosphate detergent followed by an acid rinse with either phosphoric acid or Lime-a-way was conducted. There was up to 4 or 5 times less detergent used than when tripolyphosphate detergent was used, (481.22 and 544.51 to 60.57 and 66.36 respectively).

EXAMPLE 3**Elementary makeup of glassware film**

Tables 3 and 4 show the Analytical and physical chemistry report of the
 5 elementary make-up to glassware film with two different acids. The film found
 when using phosphoric acid was identified as calcium phosphate film. The film left
 behind when using, methane sulfonic acid was calcium carbonate film.

PHOSPHORIC ACID FILM

Sample #	Sample Name	EDS Results (in wt %)				
		Calcium	Carbon	Magnesium	Oxygen	Phosphorus
100729003-001(1)	Glass	26.07	23.64	2.28	34.44	13.57

Note ND = Not detected

Comments for Sample 100729003-001(1) and Test EDS Deposit

15 Comments for Sample 100729003-001(1) and Test FTIR:

Sample 'Glass' was analyzed by ATR-FTIR (Attenuated Total Reflectance-Fourier Transform Infrared spectroscopy) to identify organic compounds

FTIR SAMPLE PREPARATION

20 (x) The sample was scraped from the outside of the glass and was analyzed as provided with no further sample preparation

FTIR ANALYSIS RESULTS

25 (x) The spectrum was consistent with carbonate and morganic. The sample looks to be a phosphate species, most likely calcium phosphate. The sample is not calcium sulfate as indicated. No sulfur is indicated on the EDS spectrum.

30

MSA FILM

EDS Results (in wt %)	
Sample #	100806038-001(1)
Sample Name	MSA Film
Aluminum	0.18
Calcium	8.04
Carbon	37.14
Magnesium	3.86
Oxygen	44.55
Phosphorus	5.65
Silicon	0.19
Sodium	0.40

Note ND = Not detected

Comments for Sample 100806038-001(1) and Test EDS Deposit

- 5 Comments for Sample 100806038-001(1) and Test FTIR:

Sample 'MSA film' was analyzed by ATR-FTIR (Attenuated Total Reflectance-Fourier Transform Infrared spectroscopy) to identify organic compounds

- 10 FTIR SAMPLE PREPARATION

(x) The sample was analyzed as provided with no further sample preparation

FTIR ANALYSIS RESULTS

(x) The spectrum was consistent with carbonate and morganic.

15

EXAMPLE 4

**Solid Power – 100 Cycle Text X-Stream Clean Electrolux
1000ppm 17gpg – With Acid Rinse**

5

Product name & Code Data:	Solid Power	Glass	Film Score	Light box Mean
# drops measured:	1000ppm	1	2.00	15317.22
Conductivity (ohms):		2	2.50	24297.88
Sump pH:		3	2.00	14661.58
Hardness (grains):	17	4	2.00	16819.85
Machine Type:	Electrolux WG65	5	1.50	12945.17
Group / Set Pt. controller		6	4.00	56138.38
Comments:	Xstream Clean Cycle with Phos. Acid Rinse	Plastic	3	
		6 Glass Average:	2.33	23197
		6 Glass Std. Dev.:	0.88	16618
		4 Glass Average:	2.00	16931
		4 Glass Std. Dev.	0.41	5051

**Solid Power – 100 Cycle Test X-Stream Clean Electrolux
1000ppm 17Gpg – Without Acid Rinse**

10

Product name & Code Data:	Solid Power	Glass	Film Score	Light box Mean
# drops measured:	1000ppm	1	5.00	65535.00
Conductivity (ohms):		2	5.00	65535.00
Sump pH:		3	5.00	65535.00
Hardness (grains):	17	4	5.00	65535.00
Machine Type:	Electrolux WG65	5	5.00	63930.63
Group / Set Pt. controller		6	5.00	65535.00
Comments:	Xstream Clean Cycle with NO acid rinse	Plastic	5	
		6 Glass Average:	5.00	65268
		6 Glass Std. Dev.:	0.00	855
		4 Glass Average:	5.00	85134
		4 Glass Std. Dev.	0.00	802

- 100 cycle tests were run on the Electrolux WG65 "X-Stream clean" machine using inline, Tripoly-containing Solid Power at 1000ppm. We tested the standard X-Stream Clean 90 second cycle with phosphoric acid in the intermediate acid rinse and saw very good results. The same conditions but with no phosphoric acid in the intermediate acid rinse gave very filmy results. Solid Power in a normal wash cycle (below) gave okay results, which shows there is a benefit to using the phosphoric acid in the intermediate rinse step.

**Solid Power – 100 Cycle Test X-Stream Clean Electrolux
1000 ppm 17 gpg – Without Acid Rinse**

Product name & Code Data:	Solid Power	Glass	Film Score	Light box Mean
# drops measured:		1	4.50	65535.00
Conductivity (ohms):		2	2.00	13567.00
Sump pH:		3	3.00	15871.00
Hardness (grains):	17	4	3.00	16063.00
Machine Type:	Electrolux WG65	5	2.00	13951.00
Group / Set Pt. controller		6	6.00	47295.00
Comments:	Normal cycle with NO acid rinse	Plastic	4.5	
		6 Glass Average:	3.25	28714
		6 Glass Std. Dev.:	1.25	22241
		4 Glass Average:	2.50	14863
		4 Glass Std. Dev.	0.58	1287

X-Stream Clean

14 drops	Solid Power Tripoly formula		Normal Cycle – No extra rinse			
	No Acid	Weight Loss	Acid	Weight Loss		Weight Loss
Initial	3516.26		3428.66		1407.01	
Cycle 5	3500.08	16.18	3398.75	29.91	1390.51	16.5
Cycle 10	3476.48	23.6	3373.1	25.65	1374.24	16.27
Cycle 15	3457.28	19.2	3342.14	30.96	1357.32	16.92
Cycle 20	3428.69	28.59	3309.49	32.65	1341.27	16.05
Total		87.57		119.17		65.74

	Lime-A-Way	Phos Acid	MSA	Sodium Bisulfate	Sulfamic Acid	SPLP with LimeAW ay
Initial	3366.84	2845.8	2079.7	1625.37	1185.9	
100 Cycle	2885.62	2301.29	1670.28	1264.56	793.16	
Detergent Used	481.22	544.51	409.42	360.81	392.74	
Odor	None	None	None	None	None	None
pH	2	2	2	2	2.2	2.3
mL/cycle	2.5	2.5	1.3 top 1 bottom		3.5	Less film

When running the 100 cycles with phosphoric acid in the rinse, we observed a white/blue film that was consistent to what we typically see in the high phosphate detergents. Samples of the film were taken and analyzed by Analytical and found to be mostly a calcium phosphate film. This film was not present in tests where no

5 phosphoric acid was used or in tests where other acids were used.

WHAT IS CLAIMED IS:

1. A method of cleaning an article in a dish machine comprising:
 - (a) applying to the article a first alkaline cleaning agent, wherein said agent does
5 not include phosphate or silicate;
 - (b) applying to the article a first acidic cleaning agent, wherein said agent does not include phosphoric acid; and further wherein said cleaning is improved over the cleaning of phosphate and/or silicate comprising agents.
- 10 2. The method of claim 1 further comprising the step of:
 - (c) applying to the article at least one additional phosphate and/or silicate free cleaning agent, wherein the additional cleaning agent is selected from the group consisting of a second alkaline cleaning agent and a second acidic cleaning agent.
- 15 3. The method of claim 1, wherein the additional cleaning agent is a second alkaline cleaning agent.
4. The method of claim 1, wherein the first alkaline cleaning agent and the
20 second alkaline cleaning agent are the same.
5. The method of claim 1, wherein the first alkaline cleaning agent contains at least one alkaline carrier that is phosphate and/or silicate free.
- 25 6. The method of claim 5, wherein the alkaline carrier is selected from the group consisting of sodium hydroxide, potassium hydroxide, alkali carbonate, or mixtures thereof.
7. The method of claim 6, wherein the first alkaline cleaning agent further
30 comprises an additional functional ingredient that is phosphate and/or silicate free.

8. The method of claim 7, wherein the additional functional ingredient is selected from the group consisting of a water conditioning agent, an enzyme, an enzyme stabilizing system, a surfactant, a binding agent, an antimicrobial agent, a bleaching agent, a defoaming agent, a foam inhibitor, an antiredeposition agent, a dye, an odorant, a carrier, a hydrotrope, and mixtures thereof.
9. The method of claim 1, wherein the first acidic cleaning agent contains at least one acid other than phosphoric acid.
10. The method of claim 1, wherein the pH of the first acidic cleaning agent is from about 0 to about 7.
11. The method of claim 9, wherein the acid is selected from the group consisting of mineral acids and organic acids.
12. The method of claim 11, wherein the acid is selected from the group consisting of hydroxyacetic acid, citric acid, formic acid, acetic acid, propionic acid, butyric acid, valeric acid, caproic acid, gluconic acid, itaconic acid, trichloroacetic acid, urea hydrochloride, benzoic acid, oxalic acid, malonic acid, urea sulfate, succinic acid, glutaric acid, maleic acid, fumaric acid, adipic acid, terephthalic acid, sulfuric acid, sulfamic acid, methylsulfamic acid, hydrochloric acid, hydrobromic acid, hydrofluoric acid, nitric acid, and mixtures thereof.
13. The method of claim 14, wherein the acidic cleaning agent further comprises an additional phosphate and/or silicate free functional ingredient.
14. The method of claim 13, wherein the additional functional ingredient is selected from the group consisting of a water conditioning agent, a surfactant, an enzyme, an enzyme stabilizing system, a foam inhibitor, a defoaming agent, an anti-etch agent, a bleaching agent, a dye, an odorant, an antimicrobial agent, a hydrotrope, a binding agent, a carrier, and mixtures thereof.

15. A method of reducing film buildup in a warewash system that comprises an alkaline and an acidic detergent wash step comprising:
- (a) applying to an article a first alkaline cleaning agent, wherein said agent does not include phosphate or silicate;
 - 5 (b) applying to the article a first acidic cleaning agent, wherein said agent does not include phosphoric acid so that a precipitate film is not deposited on said article by the alternating alkaline and acidic environments.
16. The method of claim 15 further comprising the step of:
- 10 (c) applying to the article at least one additional phosphate and/or silicate free cleaning agent, wherein the additional cleaning agent is selected from the group consisting of a second alkaline cleaning agent and a second acidic cleaning agent.
17. The method of claim 15, wherein the method takes place in an institutional dish machine.
18. The method of claim 17, wherein at least a portion of the institutional dish machine is composed of acid-resistant material.
19. The method of claim 15, wherein the method takes place in a consumer dish machine.
20. A method of reducing detergent usage in an alkaline and acidic alternating cleaning system in an institutional dish machine that uses conductance measurements to deliver detergent comprising:
- (a) applying to an article a first alkaline cleaning agent, wherein said agent does not include phosphate or silicate;
 - 25 (b) applying to the article a first acidic cleaning agent, wherein said agent does not include phosphoric acid so that excess detergent consumption is
 - 30 minimized and phosphate or silica precipitate is eliminated.