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71 Applicant: **Colgate-Palmolive Company**
300 Park Avenue
New York, N.Y. 10022(US)

72 Inventor: **Fahim, U. Ahmed**
46 Wetherhill Way
Dayton, New Jersey(US)
Inventor: **Buck, Charles E.**
3 Lockward Road
Caldwell, New Jersey(US)

74 Representative: **UEXKÜLL & STOLBERG**
Patentanwälte
Beselerstrasse 4
D-2000 Hamburg 52(DE)

54 **Thixotropic aqueous liquid automatic dishwashing detergent composition.**

57 Thixotropic aqueous liquid automatic dishwashing detergent composition with improved anti-filming and anti-spotting properties and method of using the detergent composition. The detergent composition comprises silica anti-filming agent, polyacrylate polymer anti-spotting agent, inorganic builder salts, chlorine bleach, bleach-stable detergent and a thixotropic thickener. The compositions provide reduced filming and spotting on dishware, glassware china and the like, particularly in hard water, and remain stable against phase separation.

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THIXOTROPIC AQUEOUS LIQUID AUTOMATIC DISHWASHING DETERGENT COMPOSITION

FIELD OF THE INVENTION

5 The present invention relates to a thixotropic aqueous liquid automatic dishwashing detergent composition with improved anti-filming and anti-spotting properties and method of using the detergent composition to clean dishware, glassware, china and the like. The dishwashing composition contains silica, as the anti-filming agent, polyacrylic acid or salt polymer anti-spotting agent, inorganic builder salts, chlorine bleach, bleach stable detergent and a thixotropic thickener.

10 The detergent dishwashing composition of the present invention reduces filming and spotting on dishware, glassware, china and the like, particularly in hard water, and remains stable against phase separation.

More specifically, the invention relates to the use of silica as an anti-filming agent and polyacrylic acid or salt polymer anti-spotting agent in thixotropic aqueous liquid dishwashing detergent compositions to reduce filming and spotting.

15 The detergent compositions do not require an added rinse aid, are stable in storage, do not settle and are readily redispersible and are pourable.

The present invention also relates to thixotropic aqueous suspension with improved physical stability. The invention relates to the use of long chain fatty acids, metal salts of fatty acids and clay as thixotropic agents for forming stable gel-like liquid suspensions suitable for use as liquid automatic dishwasher detergent compositions.

20 The present invention specifically relates to aqueous liquid automatic dishwashing detergent compositions having thixotropic properties, improved anti-filming and anti-spotting properties and improved physical stability properties, which are readily dispersible in the washing medium to provide effective cleaning of dishware, glassware, china and the like.

PRIOR ART

30 Commercially available household-machine dishwasher detergents provided in powder form have several disadvantages, e.g. non-uniform composition; costly operations necessary in their manufacture; tendency to cake in storage at high humidity, resulting in the formation of lumps which are difficult to disperse; dustiness, a source of particular irritation to users who suffer allergies; and tendency to cake in the dishwasher machine dispenser. Liquid forms of dishwashing compositions, however, generally cannot be used in automatic dishwashers due to high foam levels, unacceptably low viscosities and exceedingly high alkalinity.

35 In addition, the presently used formulated powder detergents frequently require a separate step of hand towel wiping and drying of the dishware, glassware, china and the like to avoid leaving undesirable traces of film of precipitated calcium and magnesium salts. The use of liquid detergent compositions present other problems. The builder salts settle in storage and are not readily redispersed. The compositions also frequently become thicker in storage and are not readily pourable.

40 Recent research and development activity has focused on the gel or "thixotropic" form of such compositions, however, such compositions have generally proven to be insufficiently viscous to remain "anchored" in the dispenser cup of the dishwasher, and moreover yield spotty residues on dishware, glassware, china and the like. Ideally, thixotropic cleaning compositions should be highly viscous in a quiescent state, Bingham plastic in nature, and have relatively high yield values. When subjected to shear stresses, however, such as being shaken in a container or squeezed through an orifice, they should quickly fluidize and, upon cessation of the applied shear stress, quickly revert to the high viscosity/Bingham plastic state. Stability is likewise of primary importance, i.e. there should be no significant evidence of phase separation or leaking after long standing.

45 For effective use, it is generally recommended that the automatic dishwashing detergent, hereinafter also designated ADD, contain (1) sodium tripolyphosphate (NaTPP) to soften or tie up hard-water minerals and to emulsify and/or peptize soil; (2) sodium silicate to supply the alkalinity necessary for effective detergency and to provide protection for fine china glaze and pattern; (3) sodium carbonate, generally

considered to be optional, to enhance alkalinity; (4) a chlorine-releasing agent to aid in the elimination of soil specks which lead to water spotting; and (5) defoamer/surfactant to reduce foam, thereby enhancing machine efficiency and supplying requisite detergency. See, for example, SDA Detergents in Depth, "Formulations Aspects of machine Dishwashing," Thomas Oberle (1974). Cleansers approximating to the
 5 afore-described compositions are mostly liquids or powders. Generally, such compositions omit hypochlorite bleach, since it tends to react with other chemically active ingredients, particularly surfactant, thereby degrading the suspending or thixotropic agent and impairing its effectiveness.

Thus, U.S. Patent No. 3,985,668 describes abrasive scouring cleaners of gel-like consistency containing (1) suspending agent, preferably the Smectite and attapulgite types of clay; (2) abrasive, e.g. silica sand or
 10 perlite; and (3) filler comprising light density powdered polymers, expanded perlite and the like, which has a bouyancy and thus stabilizing effect on the composition in addition to serving as a bulking agent, thereby replacing water otherwise available for undesired supernatant layer formation due to leaking and phase destabilization. The foregoing are the essential ingredients. Optional ingredients include hypochlorite bleach, bleach stable surfactant and buffer, e.g. silicates, carbonates, and monophosphates. Builders, such as
 15 NaTPP, can be included as further optional ingredients to supply or supplement building function not provided by the buffer, the amount of such builder not exceeding 5% of the total composition, according to the patent. Maintenance of the desired (greater than) pH 10 levels is achieved by the buffer/builder components. High pH is said to minimize decomposition of chlorine bleach and undesired interaction between surfactant and bleach. When present, NaTPP is limited to 5%, as stated. Foam killer is not
 20 disclosed.

In U.K. Patent Application GB 2,116,199A and GB 2,140,450A, both of which are assigned to Colgate-Palmolive, liquid ADD compositions are disclosed which have properties desirably characterizing thixotropic, gel-type structure and which include each of the various ingredients necessary for effective detergency with an automatic dishwasher. The normally gel-like aqueous automatic dishwasher detergent composition
 25 having thixotropic properties includes the following ingredients, on a weight basis:

- (a) 5 to 35% alkali metal tripolyphosphate;
- (b) 2.5 to 20% sodium silicate;
- (c) 0 to 9% alkali metal carbonate;
- (d) 0.1 to 5% chlorine bleach stable, water dispersible organic detergent active material;
- 30 (e) 0 to 5% chlorine bleach stable foam depressant;
- (f) chlorine bleach compound in an amount to provide about 0.2 to 4% of available chlorine;
- (g) thixotropic thickener in an amount sufficient to provide the composition with thixotropy index of about 2.5 to 10; and
- (h) sodium hydroxide, as necessary, to adjust pH.

35 ADD compositions so formulated are low-foaming; are readily soluble in the washing medium and most effective at pH values best conducive to improved cleaning performance, viz, pH 10.5-13.5. The compositions are normally of gel consistency, i.e. a highly viscous, opaque jelly-like material having Bingham plastic character and thus relatively high yield values. Accordingly, a definite shear force is necessary to initiate or
 40 increase flow, such as would obtain within the agitated dispenser cup of an energized automatic dishwasher. Under such conditions, the composition is quickly fluidized and easily dispersed. When the shear force is discontinued, the fluid composition quickly reverts to a high viscosity, Bingham plastic state closely approximating its prior consistency.

U.S. Patent 4,511,487 dated April 16, 1985 describes a low-foaming detergent paste for dishwashers.
 45 The composition is based on a mixture of finely divided hydrated sodium metasilicate, an active chlorine compound and a thickening agent which is a foliated silicate of the hectorite type. Small amount of nonionic tensides and alkali metal carbonates and/or hydroxides may be used.

A related copending application which is assigned to the common assignee is Serial No. 816,535, filed January 7, 1987 which is incorporated herein in its entirety by reference thereto. The copending application
 50 discloses thixotropic aqueous automatic dishwashing detergent composition which contains a long chain fatty acid as a thixotropic thickener agent.

Another related copending application which is also assigned to the common assignee is Serial No. 924,385 filed October 29, 1986 which is incorporated by reference. This copending application discloses an aqueous liquid thixotropic clay dishwashing detergent composition comprising a metal salt of a long chain
 55 fatty acid and a polyacrylic acid polymer or salt stabilizing agent.

ADVANTAGES OVER THE PRIOR ART

The thixotropic aqueous liquid detergent compositions of the present invention overcome many of the prior art problems associated with powder and liquid detergents. Because of the addition of a small effective amount of a silica anti-filming agent and polyacrylic acid polymer or salt anti-spotting agent to the composition an added rinse aid is not required and towel wiping and drying are not required to obtain dry sparkling clean dishes, glasses, cups and eating utensils. The thixotropic aqueous liquid detergent composition has the additional advantages of being stable, non-settling in storage and readily redispersible. The liquid compositions of the present invention are easily pourable, easily measured and easily put into the dishwashing machines.

An additional and unexpected advantage of adding the silica anti-filming agent to the detergent formulation is that the silica inhibits brown stain formation in the dishwashing machine. The brown stain is formed by the deposition in the dishwashing machine of iron and/or manganese oxides. The brown stain formation is a particularly serious problem in areas having hard water. The silica in the formulation acts on the iron and/or manganese in the wash water to prevent their deposition in the dishwashing machine as iron and/or manganese oxides.

OBJECTS OF THE PRESENT INVENTION

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It is an object of the present invention to provide a thixotropic aqueous liquid automatic dishwasher detergent composition that has improved anti-filming and anti-spotting properties.

It is another object of the invention to provide a thixotropic aqueous liquid detergent composition which is stable in storage, easily pourable and readily dispersible in the dishwashing water.

A further object of the invention is to provide a method of washing dishware, glassware, china and the like in an automatic dishwashing machine using a thixotropic aqueous liquid detergent composition in which a separate rinse aid is not added or needed.

A still further object of the invention is to provide a method of washing dishware, glassware, china and the like in an automatic washing machine using an aqueous liquid detergent composition by which method the dishware, glassware, china and the like are machine dried without leaving traces, film and spots.

It is a further object of this invention to provide stable aqueous thixotropic aqueous liquid compositions, especially automatic dishwasher detergent compositions, by incorporating in the aqueous suspension a small effective amount of a silica anti-filming agent and polyacrylic acid polymer or salt anti-spotting agent. There is also added a minor amount of a fatty acid, metal salt of a fatty acid and/or clay thixotropic thickener effective to inhibit the settling of the suspended particles and to prevent phase separation.

DETAILED DESCRIPTION OF THE INVENTION

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These and other objects of the invention which will become more readily understood from the following detailed description of the invention and preferred embodiments thereof are achieved by incorporating in an aqueous liquid detergent composition a small but effective amount of a silica anti-filming agent and polyacrylic acid polymer or salt anti-spotting agent. The physical stability of the composition is improved by the addition of a fatty acid, metal salt of a fatty acid and/or clay thixotropic thickener. More particularly, according to a preferred and specific embodiment of the invention, there is provided a normally gel-like automatic dishwasher detergent composition in which is incorporated from about 0.5 to 5% of a silica anti-filming agent and about 2 to 14% of a water soluble polyacrylic acid polymer or salt anti-spotting agent. The silica anti-filming agent has a particle size of about 0.1 to 10 microns. The water soluble polyacrylic acid or salt has a molecular weight of about 500 to 100,000. In a preferred embodiment of the invention there is added to the composition a sufficient amount of a long chain fatty acid or metal salt of a long chain fatty acid, or either of the foregoing in admixture with a clay thixotropic thickener to provide a thixotropic index of about 2.5 to 10 and to inhibit settling of the suspended particles, such as alkali metal builder salts, etc.

In accordance with this aspect, the present invention provided a normally gel-like aqueous liquid automatic dishwasher detergent composition having thixotropic properties which includes, on a weight basis:

- (a) 5 to 35% alkali metal triphosphate;

- (b) 2.5 to 40% sodium silicate;
- (c) 0.5 to 5% silica anti-filming agent;
- (d) 2 to 14% polyacrylic acid polymer or salt anti-spotting agent;
- (e) 0 to 9 % alkali metal carbonate;
- 5 (f) 0.1 to 5% chlorine bleach stable, water dispersible organic detergent active material;
- (g) 0 to 5% chlorine bleach stable foam depressant;
- (h) chlorine bleach compound in an amount to provide about 0.2 to 4% of available chlorine;
- (i) thixotropic thickener in an amount sufficient to provide a thixotropic index of about 2.5 to 10.
- (j) 0 to 8% sodium hydroxide; and
- 10 (k) balance water.

Also related to this specific aspect, the invention provides a method for cleaning dishware in an automatic dishwashing machine with an aqueous wash bath containing an effective amount of the liquid automatic dishwasher detergent (LADD) composition as described above. According to this aspect of the invention, the LADD composition can be readily poured into the dispensing cup of the automatic dishwashing machine and will, within just a few seconds, promptly thicken to its normal gel-like or pasty state to remain securely within the dispensing cup until shear forces are again applied thereto, such as by the water spray from the dishwashing machine.

The invention will now be described in greater detail by way of specific embodiments thereof.

20 The LADD products of for example to prior disclosure in the aforementioned GB 2,116,199A and GB 2,140,450A exhibit rheological properties as evaluated by testing product viscosity as a function of shear rate. The compositions exhibited higher viscosity at a low shear rate and lower viscosity at a high shear rate, the data indicating efficient fluidization and gellation well within the shear rates extant within the standard dishwasher machine. In practical terms, this means improved pouring and processing characteristics as well as less leaking in the machine dispenser-cup, compared to prior liquid or gel ADD products. For applied shear rates corresponding to 3 to 30 rpm, viscosities (Brookfield) correspondingly ranged from about 10,000 to 30,000 cps to about 3,000 to 7,000 cps, as measured at room temperature by means of an LVT Brookfield viscometer after 3 minutes using a No. 4 spindle. A shear rate of 7.4 sec^{-1} corresponds to a spindle rpm of about 3. An approximate 10-fold increase in shear rate produces about a 3-to 9-fold reduction in viscosity. The compositions of the assignee's prior invention thus exhibit threshold fluidizations at lower shear rates and of significantly greater extent in terms of incremental increases in shear rate versus incremental decrease in viscosity. This property of the LADD products of the prior invention is summarized in terms of a thixotropic index (TI) which is the ratio of the apparent viscosity at 3 rpm and at 30 rpm. The prior compositions have a TI of from 2 to 10. The LADD compositions should exhibit substantial and quick return to prior quiescent state consistency when the shear force is discontinued.

In terms of apparent viscosity, it has been ascertained that so long as the viscosity at room temperature ($22 \pm 1^\circ \text{C}$) measured in a Brookfield Viscosimeter HATD, using a number 4 spindle at 20 rpm, is less than about 20,000 cps, the composition can be readily shaken so that a thixotropic composition can be easily "fluidized" or "liquefied" to allow the product to be dispensed through a conventional squeeze tube bottle or other convenient dispenser.

The present invention is based upon the surprising discovery that substantially improved anti-filming and anti-spotting properties can be obtained by adding to the thixotropic aqueous liquid detergent composition a small effective amount of a silica-filming agent and polyacrylic acid polymer or salt anti-spotting agent. The physical stability, i.e., resistance to phase separation, settling, etc. can be achieved by adding to the composition a small effective amount of a thixotropic thickener and stabilizing agent.

ANTI-FILMING AGENTS

50 The silica anti-filming agent materials that can be used are fumed or precipitated synthetic or natural silica. The silica may be amorphous or crystalline.

The silica material that is used may contain up to about 0.1 to 5% alumina ($\text{Al}_2 \text{O}_3$), usually up to about 0.5 to 3% and more usually about 1% alumina, based on the weight of silica.

55 A preferred silica material is Syloid 244 which is amorphous silica, has a particle size of about 4 microns and is provided by W.R. Grace Co. Other suitable silica material are Silox 15 also from W.R. Grace Co. which has a particle size of about 4 microns and Aerosil 200, from Daguessa, having a particle size of 5-6 microns.

Another preferred silica material is Huber Zeo 49 which is amorphous silica and is provided by J.M. Huber Corporation and contains about 1% alumina (Al₂O₃). The presence of as little as 1% Al₂O₃ is found to help reduce the hydrolysis and subsequent solubility of the silica in the highly alkaline automatic dishwashing detergent composition.

5 The particle size of the silica material that is used is important in achieving the desired anti-filming properties.

The silica particles that are used are finely divided and can have a particle size of about 0.10 to 10 microns, preferably 0.50 to 8 microns and more preferably about 1.0 to 5.0 microns. The silica particles of this size and in the amount used herein are not abrasive.

10 The finely divided silica material particles in the dishwashing wash act to coagulate proteinaceous particulate soils and keeps them in suspension and with the polyacrylic acid polymer or salt acts as an anti-redeposition and anti-spotting agent to prevent them from depositing on the clean glass and dishware.

The amount of silica anti-filming agent that can be used to achieve the desired improvement in filming and spotting will depend on the hardness of the water, detergent active compound, inorganic salts and other
15 ADD ingredients. The silica anti-filming agent is particularly effective in hard wash water of, for example, 300 ppm hardness or more.

The amount of silica anti-film agent that is used can be about 0.5 to 5%, preferably about 1 to 4% and more preferably about 1.5 to 3% by weight based on the weight of the entire composition.

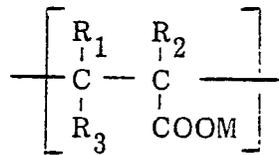
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POLYACRYLIC ACID POLYMERS AND SALTS THEREOF

The polyacrylic acid polymers and salts thereof anti-spotting agents that can be used are generally
25 commercially available and are briefly described as follows.

The polyacrylic acid polymers and salts thereof that can be used comprise water soluble low molecular weight polymers having the formula

30



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wherein the R₁, R₂ and R₃ can be the same or different and can be hydrogen, C₁-C₄ lower alkyl, or combinations thereof. The value of n is 5 to 1000, preferably, 10 to 500, and more preferably 20 to 100. M represents hydrogen, or an alkali metal such as sodium or potassium. The preferred substituent for M is sodium.

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The preferred R₁, R₂ and R₃ groups are hydrogen, methyl, ethyl and propyl. Preferred acrylic acid monomer is one where R₁ to R₃ are hydrogen, e.g. acrylic acid, or where R₁ and R₃ are hydrogen and R₂ is methyl, e.g. methyl acrylic acid monomer.

45

The degree of polymerization, i.e. the value of n, is generally determined by the limit compatible with the solubility of the polymer in water. The terminal or end groups of the polymer are not critical and can be H, OH, CH₃ or a low molecular weight hydrocarbon.

The polyacrylic acid polymers and salts thereof can have a molecular weight of 500 or 1,000 to 100,000, preferably 1,500 to 50,000 and especially preferably 2,000 to 10,000.

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Specific polyacrylic acid polymers which can be used include the Acrysol LMW acrylic acid polymers from Rohm and Haas, such as the Acrysol LMW-45N, a neutralized sodium salt, which has a molecular weight of about 4,500 and Acrysol LMW-20NX, a neutralized sodium salt, which has a molecular weight of about 2,000. Other polyacrylic acid polymers or salts thereof that can be used are: Alcosperse 149, molecular weight 2000, Alcosperse 123, molecular weight 4500, Alcosperse 107, molecular weight 3000, Alcosperse 124, molecular weight 2000, and Alcosperse 602N molecular weight 4500, all of which are available from Alco Chemical Corp. The low molecular weight acrylic acid polymers can, for example, have
55 a molecular weight of about 1,000 to 10,000. Another polyacrylic acid polymer that can be used is Alcosperse 110 (from Alco) which is a sodium salt of an organic polycarboxylate and which has a molecular weight of about 100,000.

The above polyacrylic acid polymers and salts thereof can be made using procedures known in the art,

see for example U.S. Patent 4,203,858.

The amount of polyacrylic acid polymer or salt builder that can be used to achieve the desired improvement in anti-filming and anti-spotting properties will depend on the hardness of the water, detergent active compound, inorganic salts and other ADD ingredients.

5 The polyacrylic acid or salt anti-spotting agent is particularly effective in reducing spotting in hard water of, for example, 300 ppm hardness or more.

Generally, the amounts of the polyacrylic acid polymer or salt anti-spotting agent that can be used are in the range of from about 2.0 to 14%, preferably from about 3.0 to 12%, especially preferably about 4 to 10%.

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THIXOTROPIC THICKENERS

15 The thixotropic thickeners or suspending agents that can be used in accordance with the present invention to provide the aqueous medium with thixotropic properties may be organic, for example, fatty acid or fatty acid polyvalent metal salts or inorganic colloid forming clay materials. The thixotropic thickeners should be stable to high alkalinity and stable to chlorine bleach compounds such as sodium hypochlorite. The preferred thixotropic thickeners comprise the fatty acids, the fatty acid polyvalent metal salts and the
20 inorganic, colloid-forming clays of smectite and/or attapulgite types. The amount of the thixotropic thickener used will depend on the particular thickener used, but sufficient thickener is added to the formulation to provide the composition with a thixotropy index of about 2.5 to 10.

The preferred fatty acid thixotropic thickeners are the higher aliphatic fatty monocarboxylic acids having from about 8 to about 22 carbon atoms, more preferably from about 10 to 20 carbon atoms, and especially
25 preferably from about 12 to 18 carbon atoms, inclusive of the carbon atom of the carboxyl group of the fatty acid. The aliphatic radical may be saturated or unsaturated and may be straight or branched. Straight chain saturated fatty acids are preferred. Mixtures of fatty acids may be used, such as those derived from natural sources, such as tallow fatty acid, coco fatty acid, soya fatty acid, etc., or from synthetic sources available from industrial manufacturing processes.

30 Thus, examples of the fatty acids which can be used as thickeners include, for example, decanoic acid, lauric acid, dodecanoic acid, palmitic acid, myristic acid, stearic acid, oleic acid, eicosanoic acid, tallow fatty acid, coco fatty acid, soya fatty acid and mixtures of these acids. Stearic acid and mixed fatty acids, e.g. coco fatty acid, are preferred.

The amount of the fatty acid thickener to achieve the desired values of thixotropy and physical stability
35 will depend on such factors as the nature of the fatty acid, detergent active compound, inorganic salts, especially TPP, other LADD ingredients, as well as the anticipated storage and shipping conditions.

Generally, however, amounts of the fatty acid thixotropic agent that can be used are in the range of from about 0.03 to 0.5%, preferably from about 0.03 to 0.2%, especially preferably from about 0.05 to 0.15%, provide the desired long term stability and absence of phase separation.

40 The polyvalent metal salts of the above fatty acids can also be used in the present invention as thixotropic thickener agents. Suitable metal salt thixotropic thickeners are disclosed in the prior application Serial No. 903,924 filed September 5, 1986 in the name of Drapier et al., which is incorporated herein in its entirety by reference thereto.

The preferred metals are the polyvalent metals such as magnesium, calcium, aluminum and zinc.

45 Generally, the metals may be present in the divalent to pentavalent state. Preferably, the metal salts are used in their higher oxidation states. Naturally, for LADD compositions, as well as any other applications where the invention composition will or may come into contact with articles used for the handling, storage or serving of food products or which otherwise may come into contact with or be consumed by people or animals, the metal salt should be selected by taking into consideration the toxicity of the metal. For this
50 purpose, the calcium and magnesium salts are especially highly preferred as generally safe food additives.

Many of these metal salts are commercially available. For example, the aluminum salts are available in the triacid form, e.g. aluminum stearate as aluminum tristearate, $\text{Al}(\text{C}_{17}\text{H}_{35}\text{COO})_3$. The monoacid salts, e.g. aluminum monostearate, $\text{Al}(\text{OH})_2(\text{C}_{17}\text{H}_{35}\text{COO})$ and diacid salts, e.g. aluminum distearate, $\text{Al}(\text{OH})\text{C}_{17}\text{H}_{35}\text{COO})_2$, and mixtures of two or three of the mono-, di- and tri-acid salts can be used for those
55 metals, e.g. Al, with valences of +3, and mixtures of the mono- and di-acid salts can be used for those metals, e.g. Zn, with valences of +2. It is more preferred that the diacids of the +2 valent metals and the triacids of the +3 valent metals, the tetraacids of the +4 metals, and the pentacids of the +5 valent metals, be used in predominant amounts. For example, at least 30%, preferably at least 50%, especially

preferably from 80 to 100% of the total metal salt should be in the highest possible oxidation state, i.e. each of the possible valence sites is occupied by a fatty acid residue.

The metal salts, as mentioned above, are generally commercially available but can be easily produced by, for example, saponification of a fatty acid, e.g. animal fat, stearic acid, etc., or the corresponding fatty acid ester, followed by treatment with an hydroxide or oxide of the polyvalent metal, for example, in the case of aluminum salt, with alum, alumina, etc.

Calcium stearate, i.e. calcium distearate, magnesium stearate, i.e. magnesium distearate, aluminum stearate, i.e. aluminium tristearate, and zinc stearate, i.e. zinc distearate, are the preferred polyvalent fatty acid salt stabilizers. Mixed fatty acid metal salts, such as the naturally occurring acids, e.g. coco acid, as well as mixed fatty acids resulting from the commercial manufacturing process are also advantageously used as an inexpensive but effective source of the long chain fatty acid.

The amount of the fatty acid salt stabilizers to achieve the desired enhancement of physical stability will depend on such factors as the nature of the fatty acid salt, the nature and amount of the thixotropic agent, detergent active compound, inorganic salts, especially TPP, other LADD ingredients, as well as the anticipated storage and shipping conditions.

Generally, however, amounts of the polyvalent metal fatty acid salt stabilizing agents in the range of from about 0.02 to 1%, preferably from about 0.06 to 0.8%, especially preferably from about 0.08 to 0.4% , provide the long term stability and absence of phase separation upon standing or during transport at both low and elevated temperatures as are required for a commercially acceptable product.

There may also be used in the present invention the conventional inorganic thixotropic clay thickeners. The clay thickeners may be used in small amounts in combination with the fatty acid thickeners or in combination with fatty acid polyvalent metal salt thickeners. The clay thickeners, however, may be used by themselves as the thixotropic thickeners.

The preferred clay thickeners comprise the inorganic, colloid forming clays of smectite and/or attapulgite types.

Smectite clays include montmorillonite (bentonite), hectorite, attapulgite, smectite, saponite, and the like. Montmorillonite clays are preferred and are available under tradenames such as Thixogel (Registered Trademark) No. 1 and Gelwhite (Registered Trademark) GP, H, etc., from Georgia Kaolin Company; and Eccagum (Registered Trademark) GP, H, etc., from Luthern Clay Products. Attapulgite clays include the materials commercially available under the tradename Attagel (Registered Trademark), i.e. Attagel 40, Attagel 50 and Attagel 150 from Engelhard Minerals and Chemicals Corporation. Mixtures of smectite and attapulgite types in weight ratios of 4:1 to 1:5 are also useful herein. Thickening or suspending agents of the foregoing types are well known in the art, being described, for example, in U.S. Patent No. 3,985,668 referred to above. Abrasives or polishing agents should be avoided in the LADD compositions as they may mar the surface of fine dishware, crystal and the like.

When used in combination with the fatty acids or the fatty acid polyvalent metal salts, the clay thixotropic thickeners are used in amounts of 0.1 to 3%, preferably 0.1 to 2.5% and more preferably in amounts of 0.1 to 2%.

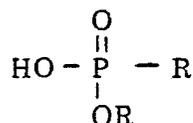
When the clay thixotropic thickeners are used alone as the thixotropic thickener agent they can be used in amounts of about 1.5 to 8%, preferably 2 to 5% by weight of the formulation.

Generally, LADD effectiveness is directly related to (a) available chlorine levels; (b) alkalinity; (c) solubility in washing medium; and (d) foam inhibition. It is preferred herein that the pH of the LADD composition be at least about 9.5, more preferably from about 10.5 to 13.5 and most preferably at least about 11.5. At the relatively lower pH values, the LADD product is too viscous, i.e. solid-like, and this not readily fluidized under the shear-force levels created within the dispenser cup under normal machine operating conditions. Addition of NaOH is thus often needed to increase the pH to within the above ranges, and to increase flowability properties. The presence of carbonate is also often needed herein, since it acts as a buffer helping to maintain the desired pH level. Excess carbonate is to be avoided, however, since it may cause the formation of needle-like crystals of carbonate, thereby impairing the stability, thixotropy and/or detergency of the LADD product, as well as impairing the dispensibility of the product from, for example, squeeze tube bottles. Caustic soda (NaOH) serves the further function of neutralizing the phosphoric or phosphonic acid ester foam depressant when present. About 0.5 to 3 wt% of NaOH and about 2 to 9 wt% of sodium carbonate in the LADD composition are typical, although it should be noted that sufficient alkalinity may be provided by the NATPP and sodium silicate.

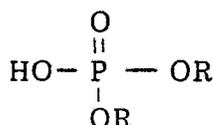
The NaTPP may be employed in the LADD composition in a range of about 8 to 35 wt%, preferably about 20 to 30 wt%, and should preferably be free of heavy metal which tends to decompose or inactivate the preferred sodium hypochlorite and other chlorine bleach compounds. The NaTPP may be anhydrous or hydrated, including the stable hexahydrate with a degree of hydration of 6 corresponding to about 18% by

weight of water or more. Actually, in view of the stability of the hexahydrate, the presence of some water of hydration is highly effective, serving it is thought to form seeds of the stable hexahydrate which expedites hydration and solubilization of the remaining NaTPP particles. If only the hexahydrate is used, the detergent product may be too liquid. Conversely, if only the anhydrous NaTPP is used, the product may, in some cases, be too thick and, therefore, unsuitable. Especially preferred LADD compositions are obtained, for example, when using a 0.5:1 to 2:1 weight ratio of anhydrous to hexahydrated NaTPP, values of about 1:1 being particularly preferred.

Foam inhibition is important to increase dishwasher machine efficiency and minimize destabilizing effects which might occur due to the presence of excess foam within the washer during use. Foam may be sufficiently reduced by suitable selection of the type and/or amount of detergent active material, the main foam-producing component. The degree of foam is also somewhat dependent on the hardness of the wash water in the machine whereby suitable adjustment of the proportions of NaTPP which has a water softening effect may aid in providing the desired degree of foam inhibition. However, it is generally preferred to include a chlorine bleach stable foam depressant or inhibitor. Particularly effective are the alkyl phosphonic acid esters of the formula



available for example from BASF-Wyandotte (PCUK-PAE), and especially the alkyl acid phosphate esters for the formula



available, for example, from Hooker (SAP) and Knapsack (LPKn-158), in which one or both R groups in each type of ester may represent independently a C₁₂₋₂₀ alkyl group. Mixtures of the two types, or any other chlorine bleach stable types, or mixtures of mono- and di-esters of the same type, may be employed. Especially preferred is a mixture of mono- and di-C₁₅₋₁₈ alkyl acid phosphate esters such as monostearyl/distearyl acid phosphates 1.2:1 (Knapsack). When employed, proportions of 0.01 to 5 wt%, preferably 0.1 to 5 wt%, especially about 0.1 to 0.5 wt%, of foam depressant in the composition is typical, the weight ratio of detergent active component to foam depressant generally ranging from about 10:1 to 1:1 and preferably about 4:1 to 1:1. Other defoamers which may be used include, for example, the known silicones.

Although any chlorine bleach compound may be employed in the compositions of this invention, such as dichloro-isocyanurate, dichloro-dimethyl hydantoin, or chlorinated TSP, alkali metal, e.g. potassium, lithium, magnesium and especially sodium hypochlorite is preferred. The composition should contain sufficient chlorine bleach compound to provide about 0.2 to 4.0% by weight of available chlorine, as determined, for example, by acidification of 100 parts of the composition with excess of hydrochloric acid. A solution containing about 0.2 to 4.0% by weight of sodium hypochlorite contains or provides roughly the same percentage of available chlorine. A solution containing about 0.8 to 1.6% by weight sodium hypochlorite contains about 0.8 to 1.6% by weight of available chlorine and is especially preferred. For example, sodium hypochlorite (NaOCl) solution of from about 11 to about 13% available chlorine in amounts of about 3 to 20%, preferably about 7 to 12%, can be advantageously used.

The sodium silicate, which provides alkalinity and protection of hand surfaces, such as fine china glaze and pattern, is employed in an amount ranging from about 2.5 to 40 wt%, preferably about 10 to 35 wt%, in the composition. The sodium silicate also protects the internal washing machine parts from corrosion. At the higher levels specified herein for example at levels greater than about 10 wt% the sodium silicate also provides increased antispotting action. The sodium silicate is generally added in the form of an aqueous solution, preferably having an Na₂O:SiO₂ ratio of about 1:2.2 to 1:2.8, for example, 1:2.4. Most of the other components of the composition, especially NaOH, sodium hypochlorite and foam depressant may also be added in the form of an aqueous dispersion or solution.

Detergent active material useful herein must be stable in the presence of chlorine bleach, especially

hypochlorite bleach, and those of the organic anionic, amine oxide, phosphine oxide, sulphoxide or betaine water dispersible surfactant types are preferred, the first mentioned anionics being most preferred. They are used in amounts ranging from about 0.1 to 5% preferably about 0.3 to 2.0%. Particularly preferred surfactants herein are the linear or branched alkali metal mono- and/or di-(C₈₋₁₄) alkyl diphenyl oxide mono and/or disulphonates, commercially available for example as DOWFAX (Registered Trademark) 3B-2 and DOWFAX 2A-1.

In addition, the surfactant should be compatible with the other ingredients of the composition. Other suitable surfactants include the primary alkylsulphates, alkylsulphonates, alkylaryl-sulphonates and sec.-alkylsulphates. Examples include sodium C₁₀₋₁₈ alkylsulphates such as sodium dodecylsulphate and sodium tallow alcohol sulphate; sodium C₁₀₋₁₈ alkanesulphonates such as sodium hexadecyl-1-sulphonate and sodium C₁₂₋₁₈ alkylbenzenesulphonates such as sodium dodecylbenzenesulphonates. The corresponding potassium salts may also be employed.

As other suitable surfactants or detergents, the amine oxide surfactants are typically of the structure R₂R¹NO, in which each R represents a lower alkyl group, for instance, methyl, and R¹ represents a long chain alkyl group having from 8 to 22 carbon atoms, for instance a lauryl, myristyl, palmityl or cetyl group. Instead of an amine oxide, a corresponding surfactant phosphine oxide R₂R¹PO or sulphoxide RR¹SO can be employed. Betaine surfactants are typically of the structure R₂R¹N - R²COO⁻, in which each R represents a lower alkylene group having from 1 to 5 carbon atoms. Specific examples of these surfactants are lauryl-dimethylamine oxide, myristyldimethylamine oxide, the corresponding phosphine oxides and sulphoxides, and the corresponding betaines, including dodecyldimethylammonium acetate, tetradecyldiethylammonium pentanoate, hexadecyl-dimethylammonium hexanoate and the like. For biodegradability, the alkyl groups in these surfactants should be linear, and such compounds are preferred.

Surfactants of the foregoing type, all well known in the art, are described, for example, in U.S. Patents 3,985,668 and 4,271,030.

The amount of water contained in these compositions should, of course, be neither so high as to produce unduly low viscosity and fluidity, nor so low as to produce unduly high viscosity and low flowability, thixotropic properties in either case being diminished or destroyed. Such amount is readily determined by routine experimentation in any particular instance, generally ranging from about 25 to 75 wt%, preferably about 50 to 65 wt%. The water should also be preferably deionized or softened. These amounts of water in the composition include the water added as parts of the liquid solutions of other ingredients, but do not include bound water, for example that in NaTPP hexahydrate.

Other conventional ingredients may be included in these compositions in small amounts, generally less than about 3 wt%, such as perfume, hydrotropic agents such as the sodium benzene, toluene, xylene and cumene sulphonates, preservatives, dyestuffs and pigments and the like, all of course being stable to chlorine bleach compound and high alkalinity (properties of all the components). Especially preferred for coloring are the chlorinated phthalocyanines and polysulphides of aluminosilicate which provide, respectively, pleasing green and blue tints.

The liquid ADD compositions of this invention are readily employed in known manner for washing dishes, glasses, cups, eating utensils and the like in an automatic dishwasher, provided with a suitable detergent dispenser, in an aqueous wash bath containing an effective amount of the composition.

In a preferred embodiment of the invention the aqueous liquid dishwashing detergent composition is formulated using the below named ingredients.

Component	Weight Percent
Alkali Metal Tripolyphosphate	10-25
Sodium Silicate (47.5%)	15-40
Silica Anti-filming Agent	1-4
Polyacrylic Acid Polymer or Salt Anti-spotting Agent	3-12
Alkali Metal Carbonate (anhydrous)	2-8
Chlorine Bleach Stable, Water Dispersible Organic Detergent Active Material	0.5-3
Chlorine Bleach Stable Foam Depressant	0.10-3
Sodium Hypochlorite Bleach Compound	0.2-4
Fatty Acid Thixotropic Thickener	0.03-0.5
Sodium Hydroxide (50%)	2-6
Balance Water	

The thixotropic aqueous liquid automatic dishwashing detergent compositions of the present invention can contain conventional dishwashing detergent composition additives. The formulations can be prepared with commercially available solid powder builders, and/or the ingredients can be mixed and the formulations ground to a desired particle size.

5 The invention may be put into practice in various ways and a number of specific embodiments will be described to illustrate the invention with reference to the accompanying examples.

All amounts and proportions referred to herein are percent by weight of the composition unless otherwise indicated.

10 The present invention is further illustrated by the following examples.

Example 1

15 A thixotropic aqueous liquid automatic dishwashing detergent composition is formulated from the following ingredients in the amounts specified.

<u>Component</u>	<u>Weight Percent</u>
Deionized Water	24.05
Knapsack LPKN-158 Foam Depressant ⁽¹⁾	0.16
Sodium Hydroxide (50%)	5.00
Sodium Carbonate (anhydrous)	5.00
Sodium Tripolyphosphate (anhydrous)	20.00
Silica Anti-filming Agent ⁽²⁾	2.5
Sodium Polyacrylate Polymer Anti-spotting Agent ⁽³⁾ (A.I.)	8.00
Stearic Acid Thixotropic Thickener	0.10
Dowfax 3B-2 Surfactant ⁽⁴⁾	0.80
Sodium Hypochlorite (11%)	9.10
Sodium Silicate (1.2.23 - 47%)	25.29
	<u>100.00</u>

(1) Mixture of mono and distearyl (C₁₆-C₁₈) alkyl esters of phosphoric acid, mole ratio 1:1.3.

(2) Silica Syloid 244 has a particle size of about 4 microns and is available from W.R. Grace Co.

(3) Alcosperse 149, about 2000 mw, available as a 40% solution.

(4) Na mono- and didecyl diphenyl ether disulfonate (45% solution).

20 The stearic acid is melted, and the ingredients are added to the water generally in the order listed and gently stirred until a homogeneous mixture is obtained. The formulation is tested by washing glassware and dishware at a temperature of 130° F in hard water (300 ppm hardness) in an automatic dishwashing machine and the clean and dried dishes are found to have no apparent film and no apparent spots.

45 Example 2

A thixotropic formulation is prepared containing the following ingredients.

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Component	Weight Percent
Deionized Water	27.64
Knapsack LPKN-158 Foam Depressant	0.16
Sodium Hydroxide (50%)	5.00
Sodium Carbonate (Anhydrous)	5.00
Sodium Tripolyphosphate (Anhydrous)	20.00
Silica (Syloid 244) Anti-filming Agent	2.00
Sodium Polyacrylate Polymer ⁽¹⁾ (A.I.)	5.00
Stearic Acid Thixotropic Thickener	0.10
Dowfax 3B-2 Surfactant	0.80
Sodium Hypochlorite (11%)	9.00
Sodium Silicate (1/2.23 - 47%)	25.30
	<u>100.00</u>

(1) LMW-45N, about 4500 MW, available as a 45% solution.

20 The stearic acid is melted, and the ingredients are added to the water generally in the order listed and gently stirred until a homogeneous mixture is obtained. The fomulation is tested by washing glassware at 130 ° F in hard water (300 ppm hardness).

The above formulation is tested in a Kenmore automatic dishwasher using the procedure described in ASTM D 3566-79, except that only four cleaning cycles were used. The filming and spotting are evaluated according to the following scales.

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Film Rating Scale

- 30 1. Best, no apparent film
- 2. Filming slight, becoming apparent
- 3. Noticeable film, increasing
- 4. Continued increase of significant film
- 5. Filming becoming excessive
- 6. Filming high, excessive buildup
- 35 7. Continued increase of excessive film.

Spot Rating Scale

- 40 A. Best - no spots
- B. Very few spots apparent
- C. Distinct Spots
- D. Significant coverage approximately 50%.

45 The results obtained in the fourth cycle were Spot A and Film 1-2.

Example 2

50 A thixotropic aqueous liquid automatic dishwashing detergent compositions are formulated from the following ingredients in the amounts specified.

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Component	Weight Percent
Deionized Water	27.64
Knapsack LPKN-158 Foam Depressant	0.16
Sodium Hydroxide (50%)	5.00
Sodium Carbonate (Anhydrous)	5.00
Sodium Silicate (1/2.35 - 43.5%)	25.30
Sodium Tripolyphosphate (Anhydrous)	20.00
Silica Anti-filming Agent ⁽¹⁾	2.00
Sodium Polyacrylate Anti-spotting Agent ⁽²⁾ (A.I.)	5.00
Dowfax 3B-2 Surfactant ⁽³⁾	0.80
Stearic Acid Thixotropic Thickener ⁽⁴⁾	0.10
Sodium Hypochlorite (11%)	9.00
	<u>100.00</u>

(1) Silica (Huber Zeo 49) contains about 1% alumina (AL₂O₃) and has a particle size of about 9 microns.

(2) LMW 45 N, about 4500 MW, available as a 45% solution of active ingredient.

(3) Na mono and didecyl diphenyl ether disulfonate (45% solution).

(4) Emersol 132 available from Emery Company.

The stearic acid is melted, and the ingredients are added to the water generally in the order listed and stirred until a homogeneous mixture is obtained. The formulation is tested by washing glassware at 130 ° F in hard water (300 ppm hardness).

The formulation is tested in a Kenmore automatic dishwasher using the procedure described in ASTM D 3566-79, except that only four cleaning cycles were used. The spotting and filming are evaluated as in Example 2. The results obtained in the fourth cycle were Spot A and Film 2.

Example 4

A thixotropic aqueous liquid automatic dishwashing detergent composition is formulated from the following ingredients in the amounts specified.

Component	Weight Percent
Deionized Water	32.79
Aluminum Stearate Thixotropic Thickener	0.25
Clay (Pharmagel H) Thixotropic Thickener	1.25
Sodium Silicate (1/2.4 - 47.5%)	17.73
Sodium Tripolyphosphate (anhydrous)	12.00
Sodium Tripolyphosphate (hexahydrate)	12.00
Silica Anti-filming Agent	2.00
Sodium Polyacrylate Anti-spotting Agent (MW 4500)	6.00
Sodium Carbonate (anhydrous)	5.00
Sodium Hypochlorite (11%)	7.61
Dowfax 3B-2 Surfactant	0.80
Foam Depressant ⁽¹⁾	0.16
Sodium Hydroxide (50%)	2.40
Graphitol Green	0.01
	<u>100.00</u>

(1) 1:1 mixture of LPKN-158 and PCUK-PAE.

The ingredients are mixed in a conventional manner or are mixed following the procedure of the

copending commonly assigned application Serial No. 903,924 filed September 5, 1986 which is incorporated herein in its entirety by reference thereto.

The formulation is tested by washing glassware at 130° F in hard water (300 ppm hardness) in an automatic dishwashing machine. The cleaned and dried glassware are found to have no apparent film and no apparent spots.

The thixotropic aqueous liquid automatic dishwashing detergent compositions of the present invention provide improved film and spot properties. The invention is not to be limited by the above disclosure and Examples which are given as illustrations only. The invention is to be interpreted in accordance with the below claims.

Claims

1. A gel-like thixotropic aqueous liquid automatic dishwashing detergent composition comprising water, at least one ingredient selected from the group consisting of organic detergent, bleach, detergent builder, sequestering agent, foam inhibitors, and mixtures thereof, from about 0.5 to 5% of a silica anti-filming agent and about 2 to 14% of a polyacrylic acid polymer or salt anti-spotting agent, and a sufficient amount of a thixotropic thickener to provide a thixotropic index of about 2.5 to 10.

2. The composition of claim 1 wherein the silica anti-filming is in an amount of about 1 to 4% and the polyacrylic acid polymer or salt anti-spotting agent is in an amount of about 3 to 12%.

3. A thixotropic aqueous liquid automatic dishwasher composition comprising approximately by weight:

(a) 5 to 35% detergent builder;

(b) 2.5 to 40% sodium silicate;

(c) 0.5 to 5% of silica anti-filming agent having a particle size of about 0.1 to 10 microns;

(d) 2 to 14% polyacrylic acid polymer or salt anti-spotting agent having a molecular weight of 1000 to 100,000;

(e) 0 to 9% alkali metal carbonate;

(f) 0.1 to 5% chlorine bleach stable, water-dispersible organic detergent active material;

(g) 0 to 5% chlorine bleach stable foam depressant;

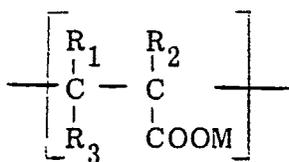
(h) chlorine bleach compound in an amount to provide about 0.2 to 4% of available chlorine;

(i) a sufficient amount of a thixotropic thickener to provide a thixotropic index of about 2.5 to 10.

(j) 0 to 8% of sodium hydroxide;

(k) balance water.

4. The composition of claim 3 wherein the polyacrylic acid polymer or salt anti-spotting agent has the formula



wherein R₁, R₂ and R₃ can be the same or different and can be hydrogen, C₁-C₄ lower alkyl, M represents hydrogen, or an alkali metal, n = 5 to 1000 and the polymer has a molecular weight of 1000 to 100,000.

5. The composition of claim 3 wherein the thixotropic thickener comprises a long chain fatty acid in an amount of about 0.03 to 0.5%.

6. The composition of claim 3 wherein the thixotropic thickener comprises a polyvalent metal salt of a long chain fatty acid in an amount of about 0.02 to 1.0%.

7. The composition of claim 5 additionally comprising a clay thixotropic thickener in an amount of about 0.1 to 3.0%.

8. The composition of claim 6 additionally comprising a clay thixotropic thickener in an amount of about 0.1 to 3.0%.

9. The composition of claim 3 wherein the silica anti-filming agent has a particle size of about 0.5 to 8.0 microns.

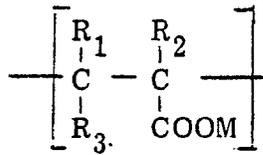
10. A thixotropic aqueous liquid automatic dishwasher composition comprising approximately by weight:

(a) 5 to 35% alkali metal tripolyphosphate;

- (b) 2.5 to 40% sodium silicate;
 (c) 1 to 4% silica anti-filming agent having a particle size of about 0.5 to 8.0 microns;
 (d) 3 to 12% polyacrylic acid polymer or salt anti-spotting agent;
 (e) 0 to 9% alkali metal carbonate;
 5 (f) 0.1 to 5% chlorine bleach stable, water dispersible organic detergent active material;
 (g) 0 to 5% chlorine bleach stable foam depressant;
 (h) chlorine bleach compound in an amount to provide about 0.2 to 4% of available chlorine;
 (i) a sufficient amount of a thixotropic thickener to provide a thixotropic index of about 2.5 to 10.
 (j) 0 to 8% of sodium hydroxide;
 10 (k) balance water.

11. The composition of claim 10 wherein the polyacrylic acid polymer or salt anti-spotting agents has the formula

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wherein R_1 and R_3 are hydrogen, and R_2 is hydrogen or methyl, M represents hydrogen, sodium or potassium, $n = 10$ to 500 and the polymer has a molecular weight of 1500 to 50,000.

25 12. The composition of claim 10 wherein the polyacrylic acid polymer or salt has a molecular weight of about 2000.

13. The composition of claim 10 wherein the polyacrylic acid polymer or salt has a molecular weight of about 4500.

14. The composition of claim 10 wherein the silica anti-filming agent contains about 0.1 to 5% of alumina, based on weight of silica.

30 15. The composition of claim 10 wherein the silica has a particle size of about 1 to 5 microns.

16. The composition of claim 10 wherein the thixotropic thickener comprises a long chain fatty acid having C_{16} to C_{20} carbon atoms in an amount of about 0.03 to 0.20%.

17. The composition of claim 10 wherein the thixotropic thickener comprises a polyvalent metal salt of a long chain fatty acid having C_{16} to C_{20} carbon atoms in an amount of about 0.06 to 0.8%.

35 18. The composition of claim 17 wherein the polyvalent metal is one of aluminum, calcium, zinc and magnesium.

19. The composition of claim 16 additionally comprising a clay thixotropic thickener in an amount of about 0.1 to 2.5%.

40 20. The composition of claim 17 additionally comprising a clay thixotropic thickener in an amount of about 0.1 to 2.5%.

21. A method for cleaning soiled glassware and dishware in an automatic dishwashing machine which comprises contacting the soiled dishware in an automatic dishwashing machine in an aqueous washbath having dispersed therein an effective amount of the composition of claim 3.

45 22. A method for cleaning soiled dishware in an automatic dishwashing machine which comprises contacting the soiled glassware and dishware in an automatic dishwashing machine in an aqueous washbath having dispersed therein an effective amount of the composition of claim 10.

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