

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property  
Organization  
International Bureau



(43) International Publication Date  
23 June 2016 (23.06.2016)

(10) International Publication Number  
**WO 2016/100324 A1**

- (51) International Patent Classification:  
*C11D 1/83* (2006.01) *C11D 3/386* (2006.01)
- (21) International Application Number:  
PCT/US2015/065791
- (22) International Filing Date:  
15 December 2015 (15.12.2015)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:  
14198702.4 17 December 2014 (17.12.2014) EP
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- (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, BN, 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, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, 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, ST, 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, KM, ML, MR, NE, SN, TD, TG).
- Published:  
— with international search report (Art. 21(3))  
— with sequence listing part of description (Rule 5.2(a))



WO 2016/100324 A1

(54) Title: METHOD OF AUTOMATIC DISHWASHING

(57) Abstract: A method of cleaning a dishwashing load comprising dishware and tableware having bleachable stains in the presence of iron in a dishwasher, the method comprising the step of contacting the ware with a detergent composition comprising an iron chelant wherein the detergent composition is free or substantially free of bleach and preferably has a pH as measured in 1% weight aqueous solution at 25°C of from about 5 to about 7.5

## METHOD OF AUTOMATIC DISHWASHING

### TECHNICAL FIELD

The present invention is in the field of cleaning. It relates to a method of automatic dishwashing, in particular using a low pH automatic dishwashing detergent composition comprising an iron chelant. The method provides good removal of bleachable stains even in the absence or with very low levels of bleach.

### BACKGROUND OF THE INVENTION

10 The automatic dishwashing detergent formulator is continuously looking for ways to improve the performance and efficiency of automatic dishwashing. Items placed in a dishwasher to be washed are usually stained with different kinds of stains. Tea and coffee stains can be particularly difficult to remove and usually requires the use of high level of bleach, long programs and high temperature.

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The automatic dishwashing detergent formulator is not only looking for a detergent composition that provides good cleaning but it also looks for a composition that at the same time provides a good finishing, *i.e.*, leave the washed items free of filming and spotting. In addition, the composition should be environmentally friendly, provide care for the washed items and work in low-energy consumption programs, such as low temperature and short cycles.

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The objective of the present invention is to provide an alternative automatic dishwashing method capable of providing cleaning of bleachable stains, good finishing and good care and at the same time the method should be environmentally friendly and work in low-energy consumption programs.

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### SUMMARY OF THE INVENTION

The present invention provides a method of washing dishware and tableware, soiled with iron-containing soils, in a dishwasher in the presence of iron coming from soils on the soiled ware, using a low pH detergent composition comprising an iron chelant. The detergent composition used in the method of the invention is herein sometimes referred to as “the composition of the invention”. An automatic dishwashing program in a dishwasher typically comprises three or more cycles: a pre-wash cycle, a main-wash cycle and one or more rinse cycles. In the method of

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the invention the ware is contacted with the composition of the invention preferably during the main wash cycle.

The composition for use in the method of the invention is free or substantially free of bleach. By  
5 substantially free of bleach is herein meant that the composition preferably comprises less than about 10% bleach, more preferably less than 8%, more preferably from about 0.1 to about 5% bleach by weight of the composition.

Many of the soils found in dishware and tableware contain iron, such as tea, meat, fortified  
10 cereals, wholegrains, dark-green leafy vegetables, beans, lentils, *etc.* Without being bound by theory, it is believed that the iron ions present into the wash liquor (brought by soils, such as tea, beef, *etc.*, impurities in detergent components and/or water) act as a catalyst for the bleach to generate bleaching radicals. This effect is most pronounced when an iron chelant is used and it is believed this is the case because the iron chelant binds the iron to generate metal catalysts *in situ*  
15 that when combined with the bleach are able to drive excellent cleaning of bleachable stains. The generation of free radicals seem to be an auto-catalytic reaction, thus only a low level of iron is needed to highly improve the cleaning. This reaction does not need high temperature and it is very fast, thereby favouring the method of the invention for use in low temperature and short programs.

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The composition of the invention provides good cleaning of bleachable stains, even in the absence of bleach. Without being bound by theory, it is believed that the iron chelant also removes the heavy metals that form part of bleachable stains, thereby contributing to the loosening of the stain. The stain tends to detach itself from the ware. The cleaning can be  
25 further helped by the presence of a performance polymer, preferably a dispersant polymer that would help with the suspension of the stain. Under the low pH conditions provided by the compositions of the invention, when the heavy metals are taken from the bleachable stain, the stain can become more particulate in nature and the polymer can help with suspension of the stain. Preferred iron chelants for use herein have been found to be 1,2-dihydroxybenzene-3,5-  
30 disulfonic acid and hydroxypyridine N-Oxides, in particular hydroxypyridine N-Oxides and mixtures thereof. Conventional alkaline compositions use sodium percarbonate as bleach.

Sodium percarbonate is a source of hydrogen peroxide and it is not very effective at driving cleaning in short cycles, at lower temperatures and/or at lower pHs. That is not the case for the compositions of the invention, the removal of bleachable stains facilitated by iron chelant takes place at low temperature. Thus the composition of the invention is very well suited for use in  
5 low temperature programs.

It has also been found that small levels of bleach in the composition of the invention provide a level of bleaching much greater than expected. It has also been found that the bleaching occurs faster and at lower temperatures than using conventional alkaline detergents.

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The removal of bleachable stains provided by the compositions of the invention is further improved when the composition comprises a crystal growth inhibitor, in particular HEDP. It is also improved when the composition comprises a performance polymer, in particular an alkoxyated polyalkyleneimine.

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The performance provided by the method of the invention is further improved by anionic surfactant, preferably an alkyl ethoxy sulfate. When the composition comprises anionic surfactant, the use of a suds suppressor is preferred. The level of suds suppressor required is lower than the level required by an alkaline composition comprising the same level of anionic  
20 surfactant. The volume of foam generated by anionic surfactants in the low pH composition of the invention is smaller than the volume that would be found in an alkaline composition with the same level of anionic surfactant.

The use of amylase enzymes is preferred in the composition of the invention. A synergy in terms  
25 of cleaning seems to occur when the composition of the invention comprise anionic surfactant and amylase enzymes.

The composition is preferably “substantially builder-free”. For the purpose of this invention a “substantially builder-free composition” is a composition comprising less than 10%, preferably

less than 5%, more preferably less than 1% and especially less than 0.1% by weight of the composition of builder. Builders are cleaning actives widely used in automatic dishwashing detergents, in particular in alkaline compositions. Most, if not all, of the automatic dishwashing detergents available in the market are alkaline and comprise builders. Compounds that would act  
5 as builder under alkaline conditions would probably not be good builders under the low pH conditions of the composition of the invention. Builders can sequester calcium and other ions, from soils and from water greatly contributing to cleaning. The downside of using builders is that they can precipitate and give rise to filming and spotting on the washed items, especially under alkaline conditions. The formulation approach used in the method of the present invention  
10 overcomes the filming and spotting issues. The washed items, in particular, glass and metal items are left clear and shiny.

The composition of the invention has a “low pH”, by a low pH composition is herein meant a composition having a pH of from about 5 to about 7.5 as measured in 1% weight aqueous  
15 solution (distilled water) at 25°C. In addition to good cleaning and shine, this pH in combination with the low level of bleach is quite gentle on the washed items - it is not as aggressive as commonly used alkaline compositions comprising a high level of bleach and therefore keeps washed items such as glasses, patterned ware *etc.* looking newer for longer.

Preferably, the composition of the invention has a pH of from about 5 to about 6.9 as measured in  
20 1% weight aqueous solution (distilled water) at 25°C. This pH provides even better cleaning and shine at low temperature. This pH seems to be optimum in particular in terms of removal of bleachable stains such as tea and coffee.

The soils brought into the wash liquor during the automatic dishwashing process can greatly alter the pH of the wash liquor. In order to provide optimum cleaning the pH of the wash liquor  
25 should not vary too much. This is achieved with the composition of the present invention by the presence of a buffer that helps to keep the pH of the wash liquor within a desired range.

The composition of the invention comprises a buffer. By “buffer” is herein meant an agent that when present in a wash liquor is capable of maintaining the pH of the liquor within a narrow range. By a “narrow range” is herein meant that the pH changes by less than 2 pH units, more  
30 preferably by less than 1 pH unit.

Preferably the buffer comprises an organic acid, more preferably a carboxylic acid and more preferably the buffer is selected from a polycarboxylic acid, its salt and mixtures thereof.

Preferred amylases for use in the composition of the invention are low temperature amylases.

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Preferred compositions further comprise proteases. In particular proteases selected from the group consisting of:

- (i) a metalloprotease;
- (ii) a cysteine protease;
- 10 (iii) a neutral serine protease;
- (iv) an aspartate protease, and
- (v) mixtures thereof.

These proteases perform well in the low pH composition of the invention. Some of the proteases present in conventional alkaline detergents do not perform well at the pH of the composition of  
15 the invention. Also preferred are endoproteases, preferably those with an isoelectric point of from about 4 to about 9 and more preferably from about 4.5 to about 6.5. Compositions comprising proteases having these isoelectric points perform very well in the low pH compositions of the invention.

20 For the purpose of this invention a “low temperature program” is a program in which the maximum temperature of the water achieved in the main-wash cycle (herein referred to as main wash) is 50°C or less.

Preferably, the temperature of the main wash is 45°C or less, more preferably 40°C or less, more  
25 preferably 35°C or less. The temperature should preferably be higher than 5°C. Preferably, the length of the main wash should be 20 minutes or less, more preferably 15 minutes or less and more preferably 10 minutes or less. The length should preferably be more than 2 minutes, preferably 5 minutes or more.

The compositions of the invention are very suitable to be packed in unit-dose form. The compositions are so effective that only a low level needs to be used in the dishwasher to provide outstanding results thereby allowing for very compact packs. The pack of the invention, preferably in the form of a pouch has a weight of from about 5 to about 40 grams, more preferably from about 5 to about 25 grams, more preferably from about 7 to about 20 grams and especially from about 7 to about 15 grams. The pack of the invention comprises a water-soluble material enveloping the composition of the invention, preferably a polyvinyl alcohol film or resin. The packs can have a single compartment or a plurality of compartments.

10 According to a second aspect of the invention there is provided the use of an iron chelant in a low pH composition for the removal of bleachable stains, preferably tea and coffee stains, in automatic dishwashing in the presence of iron coming from a soiled load.

#### SUMMARY OF THE INVENTION

The present invention encompasses a method of washing dishware and tableware in a dishwasher in presence of iron using a low pH composition comprising an iron chelant. The method provides excellent cleaning of bleachable stains.

#### Detergent composition

The detergent composition of the invention can be in any physical form including solid, liquid, gel form. The composition of the invention is very well suited to be presented in unit-dose form, in particular in the form of a multi-compartment pack, more in particular a multi-compartment pack comprising compartment with compositions in different physical forms, for example a compartment comprising a composition in solid form and another compartment comprising a composition in liquid form. Due to the efficacy of the composition, the packs can be compact.

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The composition of the invention has a pH as measured in 1% weight aqueous solution at 25°C of from about 5 to about 7.5, preferably from about 5 to less than about 6.9 and more preferably from about 5 to about 6.5.

## Buffer

The benefits provided by the composition of the invention are linked to the low pH of the wash liquor. It is not sufficient to provide a composition presenting a low pH when dissolved in deionised water what is important is that the low pH of the composition is maintained during the duration of the wash.

In the process of dishwashing, the water and the different ions coming from the soils can destabilise the pH of the composition. In order to maintain the composition at low pH a buffering system capable of maintaining the low pH during the wash is needed. When the composition of the invention is added to water to create a wash liquor the buffer generates a buffering system. A buffering systems can be created either by using a mixture of an acid and its anion, such as a citrate salt and citric acid, or by using a mixture of the acid form (citric acid) with a source of alkalinity (such as a hydroxide, bicarbonate or carbonate salt) or by using the anion (sodium citrate) with a source of acidity (such as sodium bisulphate). Suitable buffering systems comprise mixtures of organic acids and their salts, such as citric acid and citrate.

Preferred buffers for use herein include a polycarboxylic acid, its salts and mixtures thereof, preferably citric acid, citrate and mixtures thereof.

Preferably the composition of the invention comprises from about 1% to about 60%, more preferably from about 10% to about 40% by weight of the composition of a buffer, preferably selected from citric acid, citrate and mixtures thereof.

## Builder

Preferably, the composition of the invention is substantially builder free, i.e. comprises less than about 10%, preferably less than about 5%, more preferably less than about 1% and especially less than about 0.1% of builder by weight of the composition. Builders are materials that sequester hardness ions, particularly calcium and/or magnesium. Strong calcium builders are species that are particularly effective at binding calcium and exhibit strong calcium binding constants, particularly at high pHs.



For the purposes of this patent a “builder” is a strong calcium builder. A strong calcium builder can consist of a builder that when present at 0.5mM in a solution containing 0.05mM of Fe(III) and 2.5mM of Ca(II) will selectively bind the calcium ahead of the iron at one or more of pHs 6.5 or 8 or 10.5. Specifically, the builder when present at 0.5mM in a solution containing 5 0.05mM of Fe(III) and 2.5mM of Ca(II) will bind less than 50%, preferably less than 25%, more preferably less than 15%, more preferably less than 10%, more preferably less than 5%, more preferably less than 2% and specially less than 1% of the Fe(III) at one or preferably more of pHs 6.5 or 8 as measured at 25°C. The builder will also preferably bind at least 0.25mM of the calcium, preferably at least 0.3mM, preferably at least 0.4mM, preferably at least 0.45mM, 10 preferably at least 0.49mM of calcium at one or more of pHs 6.5 or 8 or 10.5 as measured at 25°C.

The most preferred strong calcium builders are those that will bind calcium with a molar ratio (builder:calcium) of less than 2.5:1, preferably less than 2:1, preferably less than 1.5:1 and most 15 preferably as close as possible to 1:1, when equal quantities of calcium and builder are mixed at a concentration of 0.5mM at one or more of pHs 6.5 or 8 or 10.5 as measured at 25°C.

Examples of strong calcium builders include phosphate salts such as sodium triphosphate, amino acid-based builders such as amino acid based compounds, in particular MGDA (methyl-glycine-diacetic acid), and salts and derivatives thereof, GLDA (glutamic-N,N- diacetic acid) and 20 salts and derivatives thereof, IDS (iminodisuccinic acid) and salts and derivatives thereof, carboxy methyl inulin and salts and derivatives thereof and mixtures thereof.

Other builders include amino acid based compound or a succinate based compound. Other suitable builders are described in USP 6,426,229. In one aspect, suitable builders include; for example, aspartic acid-N-monoacetic acid (ASMA), aspartic acid- , -diacetic acid (ASDA), 25 aspartic acid-N- monopropionic acid (ASMP), iminodisuccinic acid (IDA), N- (2-sulfomethyl) aspartic acid (SMAS), N- (2-sulfoethyl) aspartic acid (SEAS), N- (2- sulfomethyl) glutamic acid (SMGL), N- (2- sulfoethyl) glutamic acid (SEGL), N- methyliminodiacetic acid (MID A), alpha-alanine-N,N-diacetic acid (alpha -ALDA), serine- , -diacetic acid (SEDA), isoserine-N,N-diacetic acid (ISDA), phenylalanine-N,N-diacetic acid (PHDA), anthranilic acid- N,N - diacetic acid 30 (ANDA), sulfanilic acid-N, N-diacetic acid (SLDA), taurine-N, N-diacetic acid (TUDA) and sulfomethyl-N,N-diacetic acid (SMDA) and alkali metal salts or ammonium salts thereof.

Polycarboxylic acids and their salts do not act as builders at the pH of the present invention and therefore are not to be considered as builder within the meaning of the invention. Polycarboxylic acids and their salts are considered a buffer within the meaning of the invention.

5 Iron chelant

The composition of the invention preferably comprises an iron chelant at a level of from about 0.1% to about 5%, preferably from about 0.2% to about 2%, more preferably from about 0.4% to about 1% by weight of the composition.

As commonly understood in the detergent field, chelation herein means the binding or  
10 complexation of a bi- or multi-dentate ligand. These ligands, which are often organic compounds, are called chelants, chelators, chelating agents, and/or sequestering agent. Chelating agents form multiple bonds with a single metal ion. Chelants form soluble, complex molecules with certain metal ions, inactivating the ions so that they cannot normally react with other elements or ions to produce precipitates or scale. The ligand forms a chelate complex with the substrate. The term is  
15 reserved for complexes in which the metal ion is bound to two or more atoms of the chelant.

The composition of the present invention is preferably substantially free of builders and preferably comprises an iron chelant. An iron chelant has a strong affinity (and high binding constant) for Fe(III).

20 It is to be understood that chelants are to be distinguished from builders. For example, chelants are exclusively organic and can bind to metals through their N,P,O coordination sites or mixtures thereof while builders can be organic or inorganic and, when organic, generally bind to metals through their O coordination sites. Moreover, the chelants typically bind to transition metals much more strongly than to calcium and magnesium; that is to say, the ratio of their transition  
25 metal binding constants to their calcium/magnesium binding constants is very high. By contrast, builders herein exhibit much less selectivity for transition metal binding, the above-defined ratio being generally lower.

The chelant in the composition of the invention is a selective strong iron chelant that will preferentially bind with iron (III) versus calcium in a typical wash environment where calcium  
30 will be present in excess versus the iron, by a ratio of at least 10:1, preferably greater than 20:1.

The iron chelant when present at 0.5mM in a solution containing 0.05mM of Fe(III) and 2.5mM of Ca(II) will fully bind at least 50%, preferably at least 75%, more preferably at least 85%, more preferably at least 90%, more preferably at least 95%, more preferably at least 98% and specially at least 99% of the Fe(III) at one or preferably more of pHs 6.5 or 8 as measured at 25°C. The amount of Fe(III) and Ca(II) bound by a builder or chelant is determined as explained herein below

#### Method for determining competitive binding

To determine the selective binding of a specific ligand to specific metal ions, such as iron(III) and calcium (II), the binding constants of the metal ion-ligand complex are obtained via reference tables if available, otherwise they are determined experimentally. A speciation modeling simulation can then be performed to quantitatively determine what metal ion-ligand complex will result under a specific set of conditions.

As used herein, the term “binding constant” is a measurement of the equilibrium state of binding, such as binding between a metal ion and a ligand to form a complex. The binding constant  $K_{bc}$  (25°C and an ionic strength (I) of 0.1 mol/L) is calculated using the following equation:

$$K_{bc} = [ML_x]/([M][L]^x)$$

where [L] is the concentration of ligand in mol/L, x is the number of ligands that bond to the metal, [M] is the concentration of metal ion in mol/L, and [ML<sub>x</sub>] is the concentration of the metal/ligand complex in mol/L.

Specific values of binding constants are obtained from the public database of the National Institute of Standards and Technology (“NIST”), R.M. Smith, and A.E. Martell, NIST Standard Reference Database 46, NIST Critically Selected Stability Constants of Metal Complexes: Version 8.0, May 2004, U.S. Department of Commerce, Technology Administration, NIST, Standard Reference Data Program, Gaithersburg, MD. If the binding constants for a specific ligand are not available in the database then they are measured experimentally.

Once the appropriate binding constants have been obtained, a speciation modeling simulation can be performed to quantitatively determine what metal ion-ligand complex will result under a specific set of conditions including ligand concentrations, metal ion concentrations, pH, temperature and ionic strength. For simulation purposes, NIST values at 25°C and an ionic strength (I) of 0.1 mol/L with sodium as the background electrolyte are used. If no value is listed in NIST the value is measured experimentally. PHREEQC from the US Geological Survey,

[http://wwwbrr.cr.usgs.gov/projects/GWC\\_coupled/phreeqc/](http://wwwbrr.cr.usgs.gov/projects/GWC_coupled/phreeqc/). PHREEQC is used for speciation modeling simulation.

Iron chelants include those selected from siderophores, catechols, enterobactin, hydroxamates  
5 and hydroxypyridinones or hydroxypyridine N-Oxides. Preferred chelants include anionic  
catechols, particularly catechol sulphonates, hydroxamates and hydroxypyridine N-Oxides.  
Preferred strong chelants include hydroxypyridine N-Oxide (HPNO), Octopirox, and/or Tiron  
(disodium 4,5-dihydroxy-1,3-benzenedisulfonate), with Tiron, HPNO and mixtures thereof as the  
10 most preferred for use in the composition of the invention. HPNO within the context of this  
invention can be substituted or unsubstituted. Numerous potential and actual resonance  
structures and tautomers can exist. It is to be understood that a particular structure includes all of  
the reasonable resonance structures and tautomers.

#### Bleach

The composition of the invention preferably comprises less than about 10% bleach, more  
15 preferably less than 8% and especially from about 1 to about 5% bleach by weight of the  
composition.

Inorganic and organic bleaches are suitable for use herein. Inorganic bleaches include perhydrate  
salts such as perborate, percarbonate, perphosphate, persulfate and persilicate salts. The inorganic  
20 perhydrate salts are normally the alkali metal salts. The inorganic perhydrate salt may be  
included as the crystalline solid without additional protection. Alternatively, the salt can be  
coated. Suitable coatings include sodium sulphate, sodium carbonate, sodium silicate and  
mixtures thereof. Said coatings can be applied as a mixture applied to the surface or sequentially  
in layers.

25

Alkali metal percarbonates, particularly sodium percarbonate is the preferred bleach for use  
herein. The percarbonate is most preferably incorporated into the products in a coated form  
which provides in-product stability.

Potassium peroxymonopersulfate is another inorganic perhydrate salt of utility herein.

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Typical organic bleaches are organic peroxyacids, especially diperoxydodecanedioic acid, diperoxytetradecanedioic acid, and diperoxyhexadecanedioic acid. Mono- and diperazelaic acid, mono- and diperbrassylic acid are also suitable herein. Diacyl and Tetraacylperoxides, for instance dibenzoyl peroxide and dilauroyl peroxide, are other organic peroxides that can be used  
5 in the context of this invention.

Further typical organic bleaches include the peroxyacids, particular examples being the alkylperoxy acids and the arylperoxy acids. Preferred representatives are (a) peroxybenzoic acid and its ring-substituted derivatives, such as alkylperoxybenzoic acids, but also peroxy- $\alpha$ -  
10 naphthoic acid and magnesium monoperoxphthalate, (b) the aliphatic or substituted aliphatic peroxy acids, such as peroxy lauric acid, peroxy stearic acid,  $\epsilon$ -phthalimidoperoxy caproic acid [phthaliminoperoxyhexanoic acid (PAP)], o-carboxybenzamidoperoxy caproic acid, N-nonenylamidoperadipic acid and N-nonenylamidopersuccinates, and (c) aliphatic and araliphatic peroxydicarboxylic acids, such as 1,12-diperoxy carboxylic acid, 1,9-diperoxy azelaic acid,  
15 diperoxy sebacic acid, diperoxy brassylic acid, the diperoxy phthalic acids, 2-decyldiperoxy butane-1,4-dioic acid, N,N-terephthaloyldi(6-aminopercaproic acid).

Preferably, the level of bleach in the composition of the invention is from about 0 to about 10%, more preferably from about 0.1 to about 5%, even more preferably from about 0.5 to about 3% by weight of the composition.

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#### Crystal growth inhibitor

Crystal growth inhibitors are materials that can bind to calcium carbonate crystals and prevent further growth of species such as aragonite and calcite.

25 Examples of effective crystal growth inhibitors include phosphonates, polyphosphonates, inulin derivatives and cyclic polycarboxylates.

Suitable crystal growth inhibitors may be selected from the group comprising HEDP (1-hydroxyethylidene 1,1-diphosphonic acid), carboxymethylinulin (CMI), tricarballylic acid and  
30 cyclic carboxylates. For the purposes of this invention the term carboxylate covers both the anionic form and the protonated carboxylic acid form.

Cyclic carboxylates contain at least two, preferably three or preferably at least four carboxylate groups and the cyclic structure is based on either a mono- or bi-cyclic alkane or a heterocycle. Suitable cyclic structures include cyclopropane, cyclobutane, cyclohexane or cyclopentane or cycloheptane, bicyclo-heptane or bicyclo-octane and/or tetrahydrofuran. One preferred crystal growth inhibitor is cyclopentane tetracarboxylate.

Cyclic carboxylates having at least 75%, preferably 100% of the carboxylate groups on the same side, or in the "cis" position of the 3D-structure of the cycle are preferred for use herein.

It is preferred that the two carboxylate groups, which are on the same side of the cycle are in directly neighbouring or "ortho" positions

10 Preferred crystal growth inhibitors include HEDP, tricarballylic acid, tetrahydrofuran tetracarboxylic acid (THFTCA) and cyclopentanetetracarboxylic acid (CPTCA). The THFTCA is preferably in the 2c,3t,4t,5c-configuration, and the CPTCA in the cis,cis,cis,cis-configuration.

The crystal growth inhibitors are present preferably in a quantity from about 0.01 to about 10 %, particularly from about 0.02 to about 5 % and in particular from 0.05 to 3 % by weight of the composition.

#### Performance polymer

Preferably the composition of the invention comprises from 0.1% to about 5%, preferably from about 0.2% to about 3% by weight of the composition of a performance polymer. Suitable polymers include alkoxyated polyalkyleneimines, polymeric polycarboxylates, including alkoxyated polycarboxylates, polymers of unsaturated monomeric acids, polyethylene glycols, styrene co-polymers, cellulose sulfate esters, carboxylated polysaccharides, amphiphilic graft copolymers and sulfonated polymers.

25 The performance polymers may be included to provide benefits in one or more of the areas of spotting and filming, dispersancy, cleaning and bleachable stain cleaning. The performance polymers which provide a dispersancy benefit can also be referred to as dispersing polymers.

A preferred performance polymer for use herein, in terms of cleaning of bleachable stains enhancing is an alkoxyated polyalkyleneimine.

30 Alkoxyated polyalkyleneimine

The alkoxyated polyalkyleneimine has a polyalkyleneimine backbone and alkoxy chains. Preferably the polyalkyleneimine is polyethyleneimine. Preferably, the alkoxyated polyalkyleneimine is not quaternized.

In a preferred alkoxyated polyalkyleneimine for use in the composition of the invention:

- 5 i) the polyalkyleneimine backbone represents from 0.5% to 40%, preferably from 1% to 30% and especially from 2% to 20% by weight of the alkoxyated polyalkyleneimine; and
- ii) the alkoxy chains represent from 60% to 99%, preferably from 50% to about 95%, more preferably from 60% to 90% by weight of the alkoxyated polyalkyleneimine.

Preferably, the alkoxy chains have an average of from about 1 to about 50, more preferably from about 2 to about 40, more preferably from about 3 to about 30 and especially from about 3 to about 20 and even more especially from about 4 to about 15 alkoxy units preferably ethoxy units. In other suitable polyalkyleneimine for use herein, the alkoxy chains have an average of from about 0 to 30, more preferably from about 1 to about 12, especially from about 1 to about 10 and even more especially from about 1 to about 8 propoxy units. Especially preferred are alkoxyated polyethyleneimines wherein the alkoxy chains comprise a combination of ethoxy and propoxy chains, in particular polyethyleneimines comprising chains of from 4 to 20 ethoxy units and from 0 to 6 propoxy units.

Preferably, the alkoxyated polyalkyleneimine is obtained from alkoxylation wherein the starting polyalkyleneimine has a weight-average molecular weight of from about 100 to about 60,000, preferably from about 200 to about 40,000, more preferably from about 300 to about 10,000 g/mol. A preferred example is 600 g/mol polyethyleneimine core ethoxylated to 20 EO groups per NH and is available from BASF.

Other suitable polyalkyleneimines for use herein includes compounds having the following general structure: bis((C<sub>2</sub>H<sub>5</sub>O)(C<sub>2</sub>H<sub>4</sub>O)<sub>n</sub>)(CH<sub>3</sub>)-N<sup>+</sup>-C<sub>x</sub>H<sub>2x</sub>-N<sup>+</sup>-(CH<sub>3</sub>)-bis((C<sub>2</sub>H<sub>5</sub>O)(C<sub>2</sub>H<sub>4</sub>O)<sub>n</sub>), wherein n = from 20 to 30, and x = from 3 to 8, or sulphated or sulphonated variants thereof.

#### Polycarboxylates

For example, a wide variety of modified or unmodified polyacrylates, polyacrylate/maleates, or polyacrylate/methacrylates are highly useful. It is believed, though it is not intended to be limited by theory, that these performance polymers are excellent dispersing agents and enhance overall detergent performance, particularly when used in combination with buffering agents, by crystal

growth inhibition, particulate soil release peptization, and antiredeposition. Examples of polymeric dispersing agents are found in U. S. Pat. No. 3,308,067 and EP 193,360.

Suitable polycarboxylate-based polymers include polycarboxylate polymers that may have average molecular weights of from about 500Da to about 500,000Da, or from about 5 1,000Da to about 100,000Da, or even from about 3,000Da to about 80,000Da. In one aspect, suitable polycarboxylates may be selected from the group comprising polymers comprising acrylic acid such as Sokalan PA30, PA20, PA15, PA10 and sokalan CP10 (BASF GmbH, Ludwigshafen, Germany), Acusol™ 45N, 480N, 460N and 820 (sold by Rohm and Haas, Philadelphia, Pennsylvania, USA) polyacrylic acids, such as Acusol™ 445 and Acusol™ 420 10 (sold by Rohm and Haas, Philadelphia, Pennsylvania, USA) acrylic/maleic co-polymers, such as Acusol™ 425N and acrylic/methacrylic copolymers. Several examples of such polymers are disclosed in WO 95/01416.

Alkoxyated polycarboxylates such as those prepared from polyacrylates are useful herein to and can provide additional grease suspension. Such materials are described in WO 91/08281 15 and PCT 90/01815. Chemically, these materials comprise polyacrylates having one ethoxy side-chain per every 7-8 acrylate units. The side-chains are ester-linked to the polyacrylate "backbone" to provide a "comb" polymer type structure. The molecular weight can vary, but may be in the range of about 2000 to about 50,000.

Dispersant polymers suitable for use herein are further illustrated by the film-forming polymers 20 described in U.S. Pat. No. 4,379,080 (Murphy), issued Apr. 5, 1983.

Other suitable dispersing polymers include those disclosed in U.S. Patent No. 3,308,067 issued March 7, 1967, to Diehl. Unsaturated monomeric acids that can be polymerized to form suitable dispersing polymers include acrylic acid, maleic acid (or maleic anhydride), fumaric acid, itaconic acid, aconitic acid, mesaconic acid, citraconic acid and methylenemalononic acid. The 25 presence of monomeric segments containing no carboxylate radicals such as methyl vinyl ether, styrene, ethylene, etc. is suitable provided that such segments do not constitute more than about 50% by weight of the dispersing polymer.

Co-polymers of acrylamide and acrylate having a molecular weight of from about 3,000 to about 100,000, preferably from about 4,000 to about 20,000, and an acrylamide content of less 30 than about 50%, preferably less than about 20%, by weight of the dispersing polymer can also be used. Most preferably, such dispersing polymer has a molecular weight of from about 4,000 to about 20,000 and an acrylamide content of from about 0% to about 15%, by weight of the polymer.



Yet other dispersing polymers useful herein include the cellulose sulfate esters such as cellulose acetate sulfate, cellulose sulfate, hydroxyethyl cellulose sulfate, methylcellulose sulfate, and hydroxypropylcellulose sulfate. Sodium cellulose sulfate is the most preferred polymer of this group.

5 Other suitable dispersing polymers are the carboxylated polysaccharides, particularly starches, celluloses and alginates, described in U.S. Pat. No. 3,723,322, Diehl, issued Mar. 27, 1973; the dextrin esters of polycarboxylic acids disclosed in U.S. Pat. No. 3,929,107, Thompson, issued Nov. 11, 1975; the hydroxyalkyl starch ethers, starch esters, oxidized starches, dextrans and starch hydrolysates described in  
10 U.S. Pat. No. 3,803,285, Jensen, issued Apr. 9, 1974; the carboxylated starches described in U.S. Pat. No. 3,629,121, Eldib, issued Dec. 21, 1971; and the dextrin starches described in U.S. Pat. No. 4,141,841, McDonald, issued Feb. 27, 1979.

Preferred cellulose-derived dispersant polymers are the carboxymethyl celluloses.

15 Yet another group of acceptable dispersing are the organic dispersing polymers, such as polyaspartates.

#### Amphiphilic graft co-polymers

Suitable amphiphilic graft co-polymer comprises (i) polyethylene glycol backbone; and (ii) and at least one pendant moiety selected from polyvinyl acetate, polyvinyl alcohol and mixtures thereof. In other examples, the amphiphilic graft copolymer is Sokalan HP22, supplied from BASF.

#### 20 Sulfonated polymers

Suitable sulfonated/carboxylated polymers described herein may have a weight average molecular weight of less than or equal to about 100,000 Da, preferably less than or equal to about 75,000 Da, more preferably less than or equal to about 50,000 Da, more preferably from about 3,000 Da to about 50,000, and specially from about 5,000 Da to about 45,000 Da.

25 Preferred carboxylic acid monomers include one or more of the following: acrylic acid, maleic acid, itaconic acid, methacrylic acid, or ethoxylate esters of acrylic acids, acrylic and methacrylic acids being more preferred. Preferred sulfonated monomers include one or more of the following: sodium (meth) allyl sulfonate, vinyl sulfonate, sodium phenyl (meth) allyl ether sulfonate, or 2-acrylamido-methyl propane sulfonic acid. Preferred non-ionic monomers include  
30 one or more of the following: methyl (meth) acrylate, ethyl (meth) acrylate, t-butyl (meth) acrylate, methyl (meth) acrylamide, ethyl (meth) acrylamide, t-butyl (meth) acrylamide, styrene, or  $\alpha$ -methyl styrene.

In the polymers, all or some of the carboxylic or sulfonic acid groups can be present in neutralized form, i.e. the acidic hydrogen atom of the carboxylic and/or sulfonic acid group in some or all acid groups can be replaced with metal ions, preferably alkali metal ions and in particular with sodium ions.

5 Preferred commercial available polymers include: Alcosperse 240, Aquatreat AR 540 and Aquatreat MPS supplied by Alco Chemical; Acumer 3100, Acumer 2000, Acusol 587G and Acusol 588G supplied by Rohm & Haas; Goodrich K-798, K-775 and K-797 supplied by BF Goodrich; and ACP 1042 supplied by ISP technologies Inc. Particularly preferred polymers are Acusol 587G and Acusol 588G supplied by Rohm & Haas, Versaflex Si™ (sold by Alco  
10 Chemical, Tennessee, USA) and those described in USP 5,308,532 and in WO 2005/090541.

Suitable styrene co-polymers may be selected from the group comprising, styrene co-polymers with acrylic acid and optionally sulphonate groups, having average molecular weights in the range 1,000 – 50,000, or even 2,000 – 10,000 such as those supplied by Alco Chemical Tennessee, USA, under the tradenames Alcosperse® 729 and 747.

15

#### Non-ionic surfactants

Suitable for use herein are non-ionic surfactants, they can acts as anti-redeposition agents. Traditionally, non-ionic surfactants have been used in automatic dishwashing for surface modification purposes in particular for sheeting to avoid filming and spotting and to improve  
20 shine. It has been found that in the compositions of the invention, where filming and spotting does not seem to be a problem, non-ionic surfactants can contribute to prevent redeposition of soils.

Preferably, the composition comprises a non-ionic surfactant or a non-ionic surfactant system having a phase inversion temperature, as measured at a concentration of 1% in distilled water,  
25 between 40 and 70°C, preferably between 45 and 65°C. By a “non-ionic surfactant system” is meant herein a mixture of two or more non-ionic surfactants. Preferred for use herein are non-ionic surfactant systems. They seem to have improved cleaning and finishing properties and stability in product than single non-ionic surfactants.

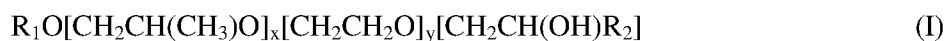
Phase inversion temperature is the temperature below which a surfactant, or a mixture  
30 thereof, partitions preferentially into the water phase as oil-swollen micelles and above which it

partitions preferentially into the oil phase as water swollen inverted micelles. Phase inversion temperature can be determined visually by identifying at which temperature cloudiness occurs.

The phase inversion temperature of a non-ionic surfactant or system can be determined as follows: a solution containing 1% of the corresponding surfactant or mixture by weight of the solution in distilled water is prepared. The solution is stirred gently before phase inversion temperature analysis to ensure that the process occurs in chemical equilibrium. The phase inversion temperature is taken in a thermostable bath by immersing the solutions in 75 mm sealed glass test tube. To ensure the absence of leakage, the test tube is weighed before and after phase inversion temperature measurement. The temperature is gradually increased at a rate of less than 1°C per minute, until the temperature reaches a few degrees below the pre-estimated phase inversion temperature. Phase inversion temperature is determined visually at the first sign of turbidity.

Suitable nonionic surfactants include: i) ethoxylated non-ionic surfactants prepared by the reaction of a monohydroxy alkanol or alkyphenol with 6 to 20 carbon atoms with preferably at least 12 moles particularly preferred at least 16 moles, and still more preferred at least 20 moles of ethylene oxide per mole of alcohol or alkyphenol; ii) alcohol alkoxyated surfactants having a from 6 to 20 carbon atoms and at least one ethoxy and propoxy group. Preferred for use herein are mixtures of surfactants i) and ii).

Another suitable non-ionic surfactants are epoxy-capped poly(oxyalkylated) alcohols represented by the formula:

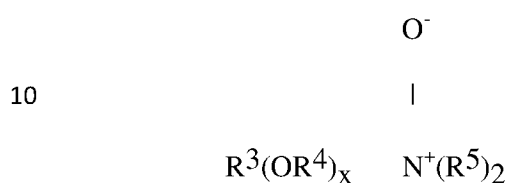


wherein  $R_1$  is a linear or branched, aliphatic hydrocarbon radical having from 4 to 18 carbon atoms;  $R_2$  is a linear or branched aliphatic hydrocarbon radical having from 2 to 26 carbon atoms;  $x$  is an integer having an average value of from 0.5 to 1.5, more preferably about 1; and  $y$  is an integer having a value of at least 15, more preferably at least 20.

Preferably, the surfactant of formula I has at least about 10 carbon atoms in the terminal epoxide unit  $[CH_2CH(OH)R_2]$ . Suitable surfactants of formula I are Olin Corporation's POLY-TERGENT® SLF-18B nonionic surfactants, as described, for example, in WO 94/22800, published October 13, 1994 by Olin Corporation.

Preferably non-ionic surfactants and/or system to use as anti-redeposition agents herein have a Draves wetting time of less than 360 seconds, preferably less than 200 seconds, more preferably less than 100 seconds and especially less than 60 seconds as measured by the Draves wetting method (standard method ISO 8022 using the following conditions; 3-g hook, 5-g cotton skein, 0.1% by weight aqueous solution at a temperature of 25°C).

Amine oxides surfactants are also useful in the present invention as anti-redeposition surfactants include linear and branched compounds having the formula:



wherein R<sup>3</sup> is selected from an alkyl, hydroxyalkyl, acylamidopropoyl and alkyl phenyl group, or mixtures thereof, containing from 8 to 26 carbon atoms, preferably 8 to 18 carbon atoms; R<sup>4</sup> is an alkylene or hydroxyalkylene group containing from 2 to 3 carbon atoms, preferably 2 carbon atoms, or mixtures thereof; x is from 0 to 5, preferably from 0 to 3; and each R<sup>5</sup> is an alkyl or hydroxyalkyl group containing from 1 to 3, preferably from 1 to 2 carbon atoms, or a polyethylene oxide group containing from 1 to 3, preferable 1, ethylene oxide groups. The R<sup>5</sup> groups can be attached to each other, e.g., through an oxygen or nitrogen atom, to form a ring structure.

These amine oxide surfactants in particular include C<sub>10</sub>-C<sub>18</sub> alkyl dimethyl amine oxides and C<sub>8</sub>-C<sub>18</sub> alkoxy ethyl dihydroxyethyl amine oxides. Examples of such materials include dimethyloctylamine oxide, diethyldecylamine oxide, bis-(2-hydroxyethyl)dodecylamine oxide, dimethyldodecylamine oxide, dipropyltetradecylamine oxide, methylethylhexadecylamine oxide, dodecylamidopropyl dimethylamine oxide, cetyl dimethylamine oxide, stearyl dimethylamine oxide, tallow dimethylamine oxide and dimethyl-2-hydroxyoctadecylamine oxide. Preferred are C<sub>10</sub>-C<sub>18</sub> alkyl dimethylamine oxide, and C<sub>10-18</sub> acylamido alkyl dimethylamine oxide.

Non-ionic surfactants may be present in amounts from 0 to 10%, preferably from 0.1% to 10%, and most preferably from 0.25% to 6% by weight of the composition.

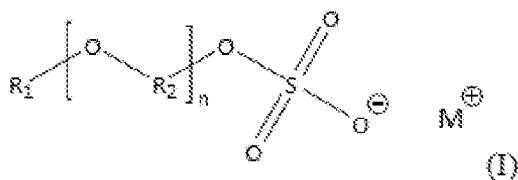
#### Anionic surfactant

- 5 Anionic surfactants include, but are not limited to, those surface-active compounds that contain an organic hydrophobic group containing generally 8 to 22 carbon atoms or generally 8 to 18 carbon atoms in their molecular structure and at least one water-solubilizing group preferably selected from sulfonate, sulfate, and carboxylate so as to form a water-soluble compound. Usually, the hydrophobic group will comprise a C8-C 22 alkyl, or acyl group. Such surfactants  
10 are employed in the form of water-soluble salts and the salt-forming cation usually is selected from sodium, potassium, ammonium, magnesium and mono-, di- or tri-alkanolammonium, with the sodium cation being the usual one chosen.

- The anionic surfactant can be a single surfactant or a mixture of anionic surfactants. Preferably  
15 the anionic surfactant comprises a sulphate surfactant, more preferably a sulphate surfactant selected from the group consisting of alkyl sulphate, alkyl alkoxy sulphate and mixtures thereof. Preferred alkyl alkoxy sulphates for use herein are alkyl ethoxy sulphates.

#### Alkyl ether sulphate (AES) surfactants

The alkyl ether sulphate surfactant has the general formula (I)



20

having an average alkoxylation degree (n) of from about 0.1 to about 8, 0.2 to about 5, even more preferably from about 0.3 to about 4, even more preferably from about 0.8 to about 3.5 and especially from about 1 to about 3.

- The alkoxy group (R<sub>2</sub>) could be selected from ethoxy, propoxy, butoxy or even higher  
25 alkoxy groups and mixtures thereof. Preferably, the alkoxy group is ethoxy. When the alkyl ether sulphate surfactant is a mixture of surfactants, the alkoxylation degree is the weight average

alkoxylation degree of all the components of the mixture (weight average alkoxylation degree). In the weight average alkoxylation degree calculation the weight of alkyl ether sulphate surfactant components not having alkoxyated groups should also be included.

Weight average alkoxylation degree  $n = (x_1 * \text{alkoxylation degree of surfactant 1} + x_2 * \text{alkoxylation degree of surfactant 2} + \dots) / (x_1 + x_2 + \dots)$

wherein  $x_1, x_2$ , are the weights in grams of each alkyl ether sulphate surfactant of the mixture and alkoxylation degree is the number of alkoxy groups in each alkyl ether sulphate surfactant.

The hydrophobic alkyl group ( $R_1$ ) can be linear or branched. Most suitable the alkyl ether sulphate surfactant to be used in the detergent of the present invention is a branched alkyl ether sulphate surfactant having a level of branching of from about 5% to about 40%, preferably from about 10% to about 35% and more preferably from about 20% to about 30%. Preferably, the branching group is an alkyl. Typically, the alkyl is selected from methyl, ethyl, propyl, butyl, pentyl, cyclic alkyl groups and mixtures thereof. Single or multiple alkyl branches could be present on the main hydrocarbyl chain of the starting alcohol(s) used to produce the alkyl ether sulphate surfactant used in the detergent of the invention.

The branched alkyl ether sulphate surfactant can be a single sulphate surfactant or a mixture of sulphate surfactants. In the case of a single sulphate surfactant the percentage of branching refers to the weight percentage of the hydrocarbyl chains that are branched in the original alcohol from which the sulphate surfactant is derived.

In the case of a sulphate surfactant mixture the percentage of branching is the weight average and it is defined according to the following formula:

Weight average of branching (%) =  $[(x_1 * \text{wt\% branched alcohol 1 in alcohol 1} + x_2 * \text{wt\% branched alcohol 2 in alcohol 2} + \dots) / (x_1 + x_2 + \dots)] * 100$

wherein  $x_1, x_2, \dots$  are the weight in grams of each alcohol in the total alcohol mixture of the alcohols which were used as starting material for the AES surfactant for the detergent of the invention. In the weight average branching degree calculation the weight of AES surfactant components not having branched groups should also be included.

Preferably the anionic surfactant of this invention is not purely based on a linear alcohol, but has some alcohol content that contains a degree of branching. Without wishing to be bound by theory

it is believed that branched surfactant drives stronger starch cleaning, particularly when used in combination with an  $\alpha$ -amylase, based on its surface packing.

Alkyl ether sulphates are commercially available with a variety of chain lengths, ethoxylation and branching degrees, examples are those based on Neodol alcohols ex the Shell company, Lial – Isalchem and Safol ex the Sasol company, natural alcohols ex The Procter & Gamble Chemicals company.

Preferably, the alkyl ether sulfate is present from about 0.05% to about 30%, preferably from about 0.1% to about 10%, more preferably from about 1% to about 6%, and most preferably from about 2% to about 5% by weight of the composition.

10

#### Suds suppressor

Suds suppressors suitable for use herein include an alkyl phosphate ester suds suppressor, a silicone suds suppressor, or combinations thereof. Suds suppressor technology and other defoaming agents useful herein are documented in "Defoaming, Theory and Industrial Applications," Ed., P.R. Garrett, Marcel Dekker, N.Y., 1973, incorporated herein by reference.

Suds suppressors are preferably included in the composition of the invention, especially when the composition comprises anionic surfactant. The suds suppressor is included in the composition at a level of from about 0.0001% to about 10%, preferably from about 0.001% to about 5%, more preferably from about 0.01% to about 1.5% and especially from about 0.01% to about 0.5%, by weight of the composition.

A preferred suds suppressor is a silicone based suds suppressor. Silicone suds suppressor technology and other defoaming agents useful herein are extensively documented in "Defoaming, Theory and Industrial Applications", Ed., P.R. Garrett, Marcel Dekker, N.Y., 1973, ISBN 0-8247-8770-6, incorporated herein by reference. See especially the chapters entitled "Foam control in Detergent Products" (Ferch et al) and "Surfactant Antifoams" (Blease et al). See also U.S. Patents 3,933,672 and 4,136,045. A preferred silicone based suds suppressors is polydimethylsiloxanes having trimethylsilyl, or alternate end blocking units as the silicone. These may be compounded with silica and/or with surface-active non-silicon components, as illustrated by a suds suppressor comprising 12% silicone/silica, 18% stearyl alcohol and 70% starch in granular form. A suitable commercial source of the silicone active compounds is Dow

30

Corning Corp. Silicone based suds suppressors are useful in that the silica works well to suppress the foam generated by the soils and surfactant

Another suitable silicone based suds suppressor comprises solid silica, a silicone fluid or a silicone resin. The silicone based suds suppressor can be in the form of a granule or a liquid.

- 5 Another silicone based suds suppressor comprises dimethylpolysiloxane, a hydrophilic polysiloxane compound having polyethylenoxy-propylenoxy group in the side chain, and a micro-powdery silica.

A phosphate ester suds suppressor may also be used. Suitable alkyl phosphate esters contain from 16-20 carbon atoms. Such phosphate ester suds suppressors may be monostearyl acid  
10 phosphate or monooleyl acid phosphate or salts thereof, preferably alkali metal salts.

Other suitable suds suppressors are calcium precipitating fatty acid soaps. However, it has been found to avoid the use of simple calcium-precipitating soaps as antifoams in the present composition as they tend to deposit on dishware. Indeed, fatty acid based soaps are not entirely free of such problems and the formulator will generally choose to minimize the content of  
15 potentially depositing antifoams in the instant composition.

#### Enzyme-related terminology

#### Nomenclature for amino acid modifications

In describing enzyme variants herein, the following nomenclature is used for ease of  
20 reference: Original amino acid(s):position(s):substituted amino acid(s).

According to this nomenclature, for instance the substitution of glutamic acid for glycine in position 195 is shown as G195E. A deletion of glycine in the same position is shown as G195\*, and insertion of an additional amino acid residue such as lysine is shown as G195GK.  
25 Where a specific enzyme contains a "deletion" in comparison with other enzyme and an insertion is made in such a position this is indicated as \*36D for insertion of an aspartic acid in position 36. Multiple mutations are separated by pluses, i.e.: S99G+V102N, representing mutations in positions 99 and 102 substituting serine and valine for glycine and asparagine, respectively. Where the amino acid in a position (*e.g.* 102) may be substituted by another amino acid selected  
30 from a group of amino acids, *e.g.* the group consisting of N and I, this will be indicated by V102N/I.



In all cases, the accepted IUPAC single letter or triple letter amino acid abbreviation is employed.

Where multiple mutations are employed they are shown with either using a "+" or a "/", so for instance either S126C + P127R + S128D or S126C/P127R/S128D would indicate the specific mutations shown are present in each of positions 126, 127 and 128.

#### Amino acid identity

The relatedness between two amino acid sequences is described by the parameter "identity". For purposes of the present invention, the alignment of two amino acid sequences is determined by using the Needle program from the EMBOSS package (<http://emboss.org>) version 2.8.0. The Needle program implements the global alignment algorithm described in Needleman, S. B. and Wunsch, C. D. (1970) J. Mol. Biol. 48, 443-453. The substitution matrix used is BLOSUM62, gap opening penalty is 10, and gap extension penalty is 0.5.

The degree of identity between an amino acid sequence of an enzyme used herein ("invention sequence") and a different amino acid sequence ("foreign sequence") is calculated as the number of exact matches in an alignment of the two sequences, divided by the length of the "invention sequence" or the length of the "foreign sequence", whichever is the shortest. The result is expressed in percent identity. An exact match occurs when the "invention sequence" and the "foreign sequence" have identical amino acid residues in the same positions of the overlap. The length of a sequence is the number of amino acid residues in the sequence.

#### Protease

Preferred proteases for use herein have an isoelectric point of from about 4 to about 9, preferably from about 4 to about 8, most preferably from about 4.5 to about 6.5. Proteases with this isoelectric point present good activity in the wash liquor provided by the composition of the invention. As used herein, the term "isoelectric point" refers to electrochemical properties of an enzyme such that the enzyme has a net charge of zero as calculated by the method described below.

Preferably the protease of the composition of the invention is an endoprotease, by "endoprotease" is herein understood a protease that breaks peptide bonds of non-terminal amino acids, in contrast with exoproteases that break peptide bonds from their end-pieces.

#### Isoelectric Point

The isoelectric point (referred to as IEP or pI) of an enzyme as used herein refers to the theoretical isoelectric point as measured according to the online pI tool available from ExPASy server at the following web address:

[http://web.expasy.org/compute\\_pi/](http://web.expasy.org/compute_pi/)

- 5 The method used on this site is described in the below reference:

Gasteiger E., Hoogland C., Gattiker A., Duvaud S., Wilkins M.R., Appel R.D., Bairoch A.; Protein Identification and Analysis Tools on the ExPASy Server;

(In) John M. Walker (ed): The Proteomics Protocols Handbook, Humana Press (2005).

- 10 Preferred proteases for use herein are selected from the group consisting of:

- (i) a metalloprotease;
- (ii) a cysteine protease;
- (iii) a neutral serine protease;
- (iv) an aspartate protease, and
- 15 (v) mixtures thereof.

Suitable proteases include those of animal, vegetable or microbial origin. Preferred proteases may be of microbial origin. The suitable proteases include chemically or genetically modified mutants of the aforementioned suitable proteases.

#### Metalloproteases

- 20 Metalloproteases can be derived from animals, plants, bacteria or fungi. Suitable metalloprotease can be selected from the group of neutral metalloproteases and *Myxobacter* metalloproteases. Suitable metalloproteases can include collagenases, hemorrhagic toxins from snake venoms and thermolysin from bacteria.

- Preferred thermolysin enzyme variants include an M4 peptidase, more preferably the thermolysin  
25 enzyme variant is a member of the PepSY~Peptidase\_M4~Peptidase\_M4\_C family.

Suitable metalloprotease variants can have at least 50% identity to the thermolysin set forth in SEQ ID NO: 1. In some embodiments, the thermolysin enzyme variant is from a genus selected from the group consisting of *Bacillus*, *Geobacillus*, *Alicyclobacillus*, *Lactobacillus*,

*Exiguobacterium, Brevibacillus, Paenibacillus, Herpetosiphon, Oceanobacillus, Shewanella, Clostridium, Staphylococcus, Flavobacterium, Stigmatella, Myxococcus, Vibrio, Methanosarcina, Chryseobacterium, Streptomyces, Kribbella, Janibacter, Nocardioidea, Xanthomonas, Micromonospora, Burkholderia, Dehalococcoides, Croceibacter, Kordia, Microscilla,*  
 5 *Thermoactinomyces, Chloroflexus, Listeria, Plesiocystis, Haliscomenobacter, Cytophaga, Hahella, Arthrobacter, Brachybacterium, Clavibacter, Microbacterium, Intrasporangium, Frankia, Meiothermus, Pseudomonas, Ricinus, Catenulispora, Anabaena, Nostoc, Halomonas, Chromohalobacter, Bordetella, Variovorax, Dickeya, Pectobacterium, Citrobacter, Enterobacter, Salmonella, Erwinia, Pantoea, Rahnella, Serratia, Geodermatophilus, Gemmata, Xenorhabdus,*  
 10 *Photorhabdus, Aspergillus, Neosartorya, Pyrenophora, Saccharopolyspora, Nectria, Gibberella, Metarhizium, Waddlia, Cyanotheca, Cellulphaga, Providencia, Bradyrhizobium, Agrobacterium, Mucilagibacter, Serratia, Sorangium, Streptosporangium, Renibacterium, Aeromonas, Reinekea, Chromobacterium, Moritella, Haliangium, Kangiella, Marinomonas, Vibrionales, Listonella, Salinivibrio, Photobacterium, Alteromonadales, Legionella,*  
 15 *Teredinibacter, Reinekea, Hydrogenivirga and Pseudoalteromonas.* In some embodiments, the thermolysin enzyme variant is from a genus selected from the group consisting of *Bacillus, Geobacillus, Alicyclobacillus, Lactobacillus, Exiguobacterium, Brevibacillus, Paenibacillus, Herpetosiphon, Oceanobacillus, Shewanella, Clostridium, Staphylococcus, Flavobacterium, Stigmatella, Myxococcus, Vibrio, Methanosarcina, Chryseobacterium, and Pseudoalteromonas.*  
 20 Preferably the thermolysin enzyme is from the genus *Bacillus*.

Preferred metalloproteases include thermolysin, matrix metalloproteinases and those metalloproteases derived from *Bacillus subtilis, Bacillus thermoproteolyticus, Geobacillus stearothermophilus* or *Geobacillus sp.*, or *Bacillus amyloliquefaciens*, as described in US PA 2008/0293610A1. A specially preferred metalloprotease belongs to the family EC3.4.24.27.

25 Further suitable metalloproteases are the thermolysin variants described in WO2014/71410. In one aspect the metalloprotease is a variant of a parent protease, said parent protease having at least 60%, or 80%, or 85% or 90% or 95% or 96% or 97% or 98% or 99% or even 100% identity to SEQ ID NO:1 including those with substitutions at one or more of the following sets of positions versus SEQ ID NO:1:

30 (a) 2, 26, 47, 53, 87, 91, 96, 108, 118, 154, 179, 197, 198, 199, 209, 211, 217, 219, 225, 232, 256, 257, 259, 261, 265, 267, 272, 276, 277, 286, 289, 290, 293, 295, 298, 299, 300, 301, 303, 305, 308, 311 and 316

- (b) 1, 4, 17, 25, 40, 45, 56, 58, 61, 74, 86, 97, 101, 109, 149, 150, 158, 159, 172, 181, 214, 216, 218, 221, 222, 224, 250, 253, 254, 258, 263, 264, 266, 268, 271, 273, 275, 278, 279, 280, 282, 283, 287, 288, 291, 297, 302, 304, 307 and 312;
- (c) 5, 9, 11, 19, 27, 31, 33, 37, 46, 64, 73, 76, 79, 80, 85, 89, 95, 98, 99, 107, 127, 129, 131, 137, 141, 145, 148, 151, 152, 155, 156, 160, 161, 164, 168, 171, 176, 180, 182, 187, 188, 205, 206, 207, 210, 212, 213, 220, 227, 234, 235, 236, 237, 242, 244, 246, 248, 249, 252, 255, 270, 274, 284, 294, 296, 306, 309, 310, 313, 314 and 315;
- (d) 3, 6, 7, 20, 23, 24, 44, 48, 50, 57, 63, 72, 75, 81, 92, 93, 94, 100, 102, 103, 104, 110, 117, 120, 134, 135, 136, 140, 144, 153, 173, 174, 175, 178, 183, 185, 189, 193, 201, 223, 230, 238, 239, 241, 247, 251, 260, 262, 269, and 285;
- (e) 17, 19, 24, 25, 31, 33, 40, 48, 73, 79, 80, 81, 85, 86, 89, 94, 109, 117, 140, 141, 150, 152, 153, 158, 159, 160, 161, 168, 171, 174, 175, 176, 178, 180, 181, 182, 183, 189, 205, 206, 207, 210, 212, 213, 214, 218, 223, 224, 227, 235, 236, 237, 238, 239, 241, 244, 246, 248, 249, 250, 251, 252, 253, 254, 255, 258, 259, 260, 261, 262, 266, 268, 269, 270, 271, 272, 273, 274, 276, 278, 279, 280, 282, 283, 294, 295, 296, 297, 300, 302, 306, 310 and 312;
- (f) 1, 2, 127, 128, 180, 181, 195, 196, 197, 198, 199, 211, 223, 224, 298, 299, 300, and 316  
all relative to SEQ ID NO:1.

In a further aspect the metalloprotease protease is a variant of a parent protease, said parent protease having at least 60%, or 80%, or 85% or 90% or 95% or 96% or 97% or 98% or 99% or even 100% identity to SEQ ID NO:1 including those with substitutions at one or more of the following sets of positions versus SEQ ID NO:1:

- (a) I001L, T002A, T002C, T002I, T002K, T002M, T004K, T004L, T004M, T004Y, Q017L, N037K, F040K, F040L, K045A, K045G, K045M, T049E, T049M, T049Y, L050P, S053C, S053L, A056M, A058E, A058L, Q061L, F063C, A064D, A064E, S065A, S065D, S065E, S065P, S065Y, V087C, V087K, V087L, V087M, V087N, V087Q, V087W, V087Y, N096K, N096L, N096Y, R101H, Q108L, Q108M, G109E, G109M, G109R, G109W, S118A, S118D, S118M, S118Q, S118R, S118T, S118V, Q128A, Q128L, Q128Y, I131L, I137L, T149N, G154A, G154H, G154K, G154M, G154Y, L155M, I164A, N181S, G196A, G196W, I197C, S198A, S198K, G199A, G199Y, A209C, A209M, H216A, Y217C, Y217L, T222K, N227A, I244L, Q246D, V256N, L263A, L263M, T272K, Q273N, Y274M, P277A, P277D, P277Y, L284A, L284M, L284Y, A286K, A286L, A286M, A286N, A286Y, A287C, A288L, A288M, V289A,

S291A, S291T, T293A, T293I, T293K, T293L, T293M, T293Y, L295A, L295K, L295M, L295W, Y296M, G297N, S298A, S298G, S298K, S298M, S298R, T299A, T299K, S300D, S300N, Q301K, E302A, V303A, V303P, V303Y, A304E, A304K, A304Y, S305A, S305K, S305M, V306L, V306T, A309C, F310M, D311A, D311K, D311L, D311M, D311V, D311W, D311Y, and A312C;

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(b) T002Q, T004V, V007I, V009I, R01 IK, I020L, I020V, S025A, S025C, S025K, S025M, S025R, T026C, T026D, Y027C, Y027L, N037L, F040A, A044C, K045F, K045H, K045Q, K045Y, Y046C, R047D, R047E, R047G, R047L, R047M, R047Q, R047T, T049L, T049N, T049Q, T049V, S053A, S053N, S053V, A056E, Q061C, Q061I, A064T, S065L, S065T, S065W, A073F, A073L, A073M, A073W, H074C, H074F, H074M, H074N, H074Q, H074W, T080L, T080N, K085S, N086D, V087R, V087T, L091A, L091N, L091R, L091W, L091Y, S092L, Y093C, N096G, N096H, N096Q, N096R, N096S, N096W, N097E, N097M, A099R, A099S, R101C, R101L, R101S, S102N, S107G, Q108I, Q108K, Q108N, G109S, S118E, M120L, Q128I, Q128K, T129L, T129M, I131W, S134P, G136S, I137E, I137T, I137V, V140D, V148A, V148Q, T149D, T149S, T152G, G154C, G154N, L155I, N159S, N159Y, I164C, I168L, I171G, Y179F, A180S, G189A, Y193F, G196H, G196L, G196Y, I197F, S198M, S198N, S198R, S198W, S201A, A209G, A209I, A209K, A209P, A209R, A209Y, Y211E, Y211R, P214A, P214R, Y217A, Y217F, Y217M, Y217N, K219A, K219E, K219R, K219S, R220A, Y221A, Y221F, Y221G, Y221M, T222A, T222M, Q225C, Q225E, Q225K, Q225L, Q225S, I232L, I232R, I232S, I232T, I232V, I232Y, S234A, S234C, G235A, I236C, I244A, I244M, Q246C, V256S, G257K, G257R, I258A, I258C, I258K, I258Q, I258V, G259N, G259S, G259T, L263H, L263K, L263N, L263V, G264A, G264N, G264P, G264Q, G264S, G264T, K265N, I266C, I266M, I266T, I266V, F267A, F267C, F267H, F267I, F267K, F267L, F267M, F267T, F267Y, R269K, A270G, L271H, T272A, Q273E, Q273G, L275C, L275Q, L275S, L275T, T276A, T276L, T276V, T276Y, P277E, P277F, P277G, P277H, P277N, P277R, P277V, P277W, S279G, R285Y, A286C, A286Q, A286R, A286T, A288N, V289L, V289M, V289Y, Q290A, Q290H, Q290N, S291V, T293N, T293V, T293W, D294N, L295F, L295G, Y296W, G297D, S298E, S298N, S298P, T299N, S300A, S300G, S300T, Q301M, Q301S, Q301T, Q301V, E302D, E302Q, V303G, V303K, V303L, V303R, V303W, A304R, A304S, A304T, A304W, S305H, S305T, S305V, V306I, Q308A, Q308L, F310C, F310W, D311F, D311G, D311I, D311Q, D311S, D311T, V313C, G314Q, V315L, V315T, K316A, and K316M;

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(c) I001K, I001M, I001V, T002F, T002L, T002P, T002S, T002V, T002W, T002Y,  
T004E, S005D, S005N, S005P, T006C, RO11I, Q017I, Q017W, Q017Y, S025D, S025F,  
T026K, T026L, T026R, T026V, T026Y, Y027W, Q031A, Q031K, Q031V, N033S,  
N033T, N037D, N037Q, N037R, F040E, F040G, F040M, F040Q, F040S, F040Y,  
5 K045E, K045L, K045S, Y046L, R047A, R047C, R047H, R047K, R047N, T048E,  
T049A, T049D, T049F, T049H, T049I, T049S, S053F, S053H, S053I, S053M, S053Q,  
S053T, S053W, A056K, A056Q, A056V, A056W, Q061M, S065I, S065M, S065Q,  
S065V, D072F, H074E, H074L, Y076H, Y076L, Y076M, Y076Q, V079L, V079Q,  
V079T, T080I, Y081F, K085E, N086L, N086S, V087D, V087E, V087G, V087I, V087S,  
10 L091D, L091E, L091F, L091K, L091M, L091P, L091Q, L091S, Y093T, G095A,  
G095D, G095H, G095M, G095N, G095S, N096C, N096D, N096I, N096V, N097K,  
A098C, A098E, A098H, A098R, A099E, A099K, A099P, S107D, Q108C, Q108E,  
Q108F, Q108H, G127C, G127D, G127E, Q128C, Q128D, Q128E, Q128R, Q128S,  
T129I, T129R, S134A, I137P, A141S, T145A, T145C, T145E, T145G, T145M, T145N,  
15 T145Q, V148L, V148N, V148Y, T149M, T149V, Y151K, T152S, A153T, G154L,  
G154Q, G154S, G154T, L155C, Q158A, Q158K, Q158M, Q158N, N159R, N159W,  
S161A, S161N, S161P, S161T, I164L, I164N, I164S, I164T, I164V, I171C, I171E,  
I171F, I171L, I171S, F172G, F172L, F172M, F172Q, F172S, F172V, F172W, F172Y,  
G173A, G173C, T174C, V176L, V176N, N181L, G196D, G196E, G196T, I197D,  
20 I197K, I197L, I197T, I197V, I197W, I197Y, S198C, S198E, S198F, S198G, S198H,  
S198I, S198P, S198Q, S198T, S198V, G199C, G199E, G199F, G199H, G199Q, G199S,  
G199T, G199W, M205L, A209D, A209E, A209L, A209S, A209T, A209V, Y211A,  
Y211C, Y211D, Y211F, Y211G, Y211H, Y211I, Y211L, Y211N, Y211Q, Y211S,  
Y211T, D213N, D213S, P214C, P214G, P214K, P214S, H216C, H216E, H216S, H216T,  
25 Y217Q, Y217S, Y217T, Y217V, Y217W, S218K, S218L, S218Y, K219D, K219F,  
K219G, K219H, K219I, K219M, K219N, K219Q, K219T, R220K, R220V, Y221K,  
Y221N, Y221Q, Y221R, Y221S, Y221T, Y221V, T222C, T222D, T222L, T222Y,  
T224K, T224M, Q225D, Q225G, Q225H, Q225I, Q225P, Q225V, Q225W, I232C,  
I232E, I232F, I232K, I232M, I232N, I232Q, I232W, S234D, G235M, I236M, Y242C,  
30 Y242F, Y242N, Y242V, I244T, I244V, Q246E, Q246N, Q246T, G247A, G247S, T249K,  
T249M, T249N, H250A, H250C, G252K, G252Y, V253N, V253T, S254A, S254M,  
S254R, S254Y, V255L, V255P, V256L, V256T, G257C, G257D, G257E, G257L,  
G257N, G257P, G257Q, G257S, G257T, G257Y, I258E, I258L, I258M, I258N, G259A,  
G259C, G259E, G259F, G259H, G259L, G259M, G259W, D261A, D261N, L263C,

L263I, L263Q, L263T, K265A, K265C, K265D, K265M, K265P, K265Q, K265S,  
 I266A, I266F, I266L, I266S, F267E, F267G, F267N, F267S, F267V, F267W, Y268M,  
 Y268Q, Y268V, A270C, A270F, A270I, A270L, A270S, L271A, L271D, L271F, L271I,  
 T272E, T272L, T272V, T272W, Q273A, Q273H, Q273Y, Y274F, Y274H, L275I,  
 5 L275M, L275V, T276C, T276F, T276I, T276P, T276Q, T276W, P277Q, P277S, P277T,  
 T278G, S279A, S279D, S279I, S279L, S279M, S279N, S279Q, S279T, N280A, N280C,  
 N280D, N280E, S282K, S282N, L284V, L284W, R285K, A286D, A286E, A286F,  
 A286G, A286H, A286I, A286S, A287I, A287L, A287N, A287V, A287Y, A288C,  
 A288I, A288S, A288T, A288V, V289C, V289E, V289F, V289G, V289I, V289N, V289S,  
 10 V289W, Q290C, Q290D, Q290F, Q290G, Q290L, Q290W, S291E, T293C, T293E,  
 T293F, T293G, T293H, T293Q, T293S, L295C, L295I, L295N, Y296N, G297A,  
 G297M, G297R, G297Y, S298C, S298T, S298W, S298Y, T299C, T299F, T299L,  
 T299M, T299R, T299W, S300C, S300K, S300M, S300R, S300Y, Q301E, Q301H,  
 Q301P, Q301R, V303C, V303H, A304C, A304D, A304L, A304N, S305G, S305I,  
 15 S305L, S305N, S305W, S305Y, V306A, V306S, K307A, K307C, K307G, K307I,  
 K307M, K307N, K307Q, K307R, K307W, K307Y, Q308C, Q308D, Q308F, Q308G,  
 Q308I, Q308M, A309G, A309S, D311C, D311E, A312G, A312M, A312V, V313T,  
 G314A, G314E, G314H, G314M, G314S, G314W, V315A, V315C, V315I, V315M,  
 K316D, K316E, K316F, K316G, K316H, K316L, K316N, K316P, K316Q, K316R,  
 20 K316S, K316V, K316W and K316Y.

Further suitable metalloproteases are the NprE variants described in WO2007/044993,  
 WO2009/058661 and US 2014/0315775. In one aspect the protease is a variant of a parent  
 protease, said parent protease having at least 45%, or 60%, or 80%, or 85% or 90% or 95% or  
 25 96% or 97% or 98% or 99% or even 100% identity to SEQ ID NO:2 including those with  
 substitutions at one or more of the following sets of positions versus SEQ ID NO:2:

S23, Q45, T59, S66, S129, F130, M138, V190, S199, D220, K211, and G222,

Another suitable metalloprotease is a variant of a parent protease, said parent protease having at  
 least 60%, or 80%, or 85% or 90% or 95% or 96% or 97% or 98% or 99% or even 100% identity  
 30 to SEQ ID NO:2 including those with substitutions at one or more of the following sets of  
 positions versus SEQ ID NO:2:

Q45E, T59P, 566E, S129I, S129V, F130L, M138I, V190I, S199E, D220P, D220E, K211V, K214Q, G222C, M138L/D220P, F130L/D220P, S129I/D220P, V190I/D220P, M138L/V190I/D220P, S129I/V190I, S129V/V190I, S129V/D220P, S129I/F130L/D220P, T004V/S023N, T059K/S66Q/S129I, T059R/S66N/S129I, S129I/F130L/M138L/V190I/D220P  
5 and T059K/S66Q/S129V.

Especially preferred metalloproteases for use herein belong to EC classes EC 3.4.22 or EC3.4.24, more preferably they belong to EC classes EC3.4.22.2, EC3.4.24.28 or EC3.4.24.27. The most preferred metalloprotease for use herein belong to EC3.4.24.27.

10 Suitable commercially available metalloprotease enzymes include those sold under the trade names Neutrase® by Novozymes A/S (Denmark), the Corolase® range including Corolase® 2TS, Corolase® N, Corolase® L10, Corolase® LAP and Corolase® 7089 from AB Enzymes, Protex 14L and Protex 15L from DuPont (Palo Alto, California), those sold as thermolysin from Sigma and the Thermoase range (PC10F and C100) and thermolysin enzyme from Amano  
15 enzymes.

Cysteine proteases: Preferably the cysteine proteases of this invention are endoproteases, more preferably selected from bromelain, papain-like proteases and trypsin-like cysteine proteases. Other suitable cysteine proteases can be selected from the group of clostripain, streptopain and  
20 clostripain.

Neutral serine proteases: Preferably the serine proteases of this invention are endoproteases. Suitable examples include trypsin-type or chymotrypsin-type proteases, such as trypsin (*e.g.*, of porcine or bovine origin), including the *Fusarium* protease described in US5288627 and the chymotrypsin proteases derived from *Cellulomonas* described in US PA 2008/0063774A1.

25 Aspartate proteases: The aspartate proteases of this invention are preferably derived from bacteria or fungi. In one aspect the microbial aspartic proteases are selected from the group of (i) pepsin-like enzymes produced by *Aspergillus*, *Penicillium*, *Rhizopus*, and *Neurospora* and (ii) rennin-like enzymes produced by *Endothia* and *Mucor* spp.



Mixtures of proteases: In one aspect the protease can be a mixture of proteases, either a mix of the proteases mentioned above or a naturally occurring mixture. An example of a naturally occurring mixture is again derived from the latex of *Carica papaya* fruits.

- 5 The composition of the invention preferably comprises from 0.001 to 2%, more preferably from 0.003 to 1%, more preferably from 0.007 to 0.3% and especially from 0.01 to 0.1% by weight of the composition of active protease.

#### Amylase

- 10 Amylases for use herein are preferably low temperature amylases. Compositions comprising low temperature amylases allow for a more energy efficient dishwashing processes without compromising in cleaning.

As used herein, “low temperature amylase” is an amylase that demonstrates at least 1.2, preferably at least 1.5 and more preferably at least 2 times the relative activity of the reference amylase at 25°C. As used herein, the “reference amylase” is the amylase of SEQ ID NO:3, commercially available under the tradename of TermamyI™ (Novozymes A/S). As used herein, “relative activity” is the fraction derived from dividing the activity of the enzyme at the temperature assayed versus its activity at its optimal temperature measured at a pH of 9.

- 20 Amylases for use herein can be derived from bacteria, fungi or plants. Suitable amylases ( $\alpha$  and/or  $\beta$ ) include those of bacterial or fungal origin. Chemically modified or protein engineered mutants are included. Amylases include, for example,  $\alpha$ -amylases obtained from *Bacillus*. Amylases of this invention preferably display some  $\alpha$ -amylase activity. Preferably said amylases belong to EC Class 3.2.1.1.

- Amylases for use herein, including chemically or genetically modified mutants (variants), are amylases possessing at least 80%, or 85%, or 90%, preferably 95%, more preferably 98%, even more preferably 99% and especially 100% identity, with those derived from *Bacillus Licheniformis*, *Bacillus amyloliquefaciens*, *Bacillus* sp. NCIB 12289, NCIB 12512, NCIB 12513, DSM 9375 (US 7,153,818) DSM 12368, DSMZ no. 12649, KSM AP1378 (WO 97/00324), KSM K36 or KSM K38 (EP 1,022,334).
- 30

Preferred amylases include:

(a) the variants of a parent amylase, said parent amylase having at least 60%, preferably 80%, more preferably 85%, more preferably 90%, more preferably 95%, more preferably 96%, more preferably 97%, more preferably 98%, more preferably 99% and specially 100% identity to SEQ ID NO:4. The variant amylase preferably further comprises one or more substitutions in the following positions versus SEQ ID NO: 4 of this patent:

9, 26, 30, 33, 82, 37, 106, 118, 128, 133, 149, 150, 160, 178, 182, 186, 193, 195, 202, 203, 214, 231, 256, 257, 258, 269, 270, 272, 283, 295, 296, 298, 299, 303, 304, 305, 311, 314, 315, 318, 319, 320, 323, 339, 345, 361, 378, 383, 419, 421, 437, 441, 444, 445, 446, 447, 450, 458, 461, 471, 482, 484 and preferably the variant amylase comprises the deletions of D183\* and G184\*.

Preferred amylases include those comprising substitutions at one or more of the following positions versus SEQ ID NO:4:

- i) one or more, preferably two or more, more preferably three or more substitutions in the following positions versus SEQ ID NO: 4: 9, 26, 149, 182, 186, 202, 257, 295, 299, 323, 339 and 345; and optionally with one or more, preferably four or more of the substitutions and/or deletions in the following positions: 118, 183, 184, 195, 320 and 458, which if present preferably comprise R118K, D183\*, G184\*, N195F, R320K and/or R458K.

Preferred amylases include variants of a parent amylase, said parent amylase having at least 60%, or 80%, or 85% or 90% or 95% or 96% or 97% or 98% or 99% or even 100% identity to SEQ ID NO:4, comprising the following sets of mutations versus SEQ ID NO:4:

- (i) M9L +, M323T;  
(ii) M9L + M202L/T/V/I + M323T;  
(iii) M9L + N195F + M202L/T/V/I + M323T;  
(iv) M9L + R118K + D183\* + G184\* + R320K + M323T + R458K;  
(v) M9L + R118K + D183\* + G184\* + M202L/T/V/I; R320K + M323T + R458K;  
(vi) M9L + G149A + G182T + G186A + M202L + T257I + Y295F + N299Y + M323T + A339S + E345R;  
(vii) M9L + G149A + G182T + G186A + M202I + T257I + Y295F + N299Y + M323T + A339S + E345R;  
(viii) M9L + R118K + G149A + G182T + D183\* + G184\* + G186A + M202L + T257I + Y295F + N299Y + R320K + M323T + A339S + E345R + R458K;  
(ix) M9L + R118K + G149A + G182T + D183\* + G184\* + G186A + M202I + T257I + Y295F + N299Y + R320K + M323T + A339S + E345R + R458K;

- (x) M9L + R118K + D183\* + D184\* + N195F + M202L + R320K + M323T + R458K;  
 (xi) M9L + R118K + D183\* + D184\* + N195F + M202T + R320K + M323T + R458K;  
 (xii) M9L + R118K + D183\* + D184\* + N195F + M202I + R320K + M323T + R458K;  
 (xiii) M9L + R118K + D183\* + D184\* + N195F + M202V + R320K + M323T + R458K;  
 5 (xiv) M9L + R118K + N150H + D183\* + D184\* + N195F + M202L + V214T + R320K +  
 M323T + R458K; or  
 (xv) M9L + R118K + D183\* + D184\* + N195F + M202L + V214T + R320K + M323T +  
 E345N + R458K.

10

Suitable amylases for use herein include those described in US 5,856,164 and WO99/23211, WO 96/23873, WO00/60060 and WO 06/002643.

b) variants exhibiting at least 90% identity with SEQ ID NO:5, especially variants comprising  
 15 deletions in the 183 and 184 positions and/or substitutions at one or more of the following  
 positions 93, 116, 118, 129, 133, 134, 140, 142, 146, 147, 149, 151, 152, 169, 174, 186, 189,  
 193, 195, 197, 198, 200, 203, 206, 210, 212, 213, 235, 243, 244, 260, 262, 284, 303, 304, 320,  
 338, 347, 359, 418, 431, 434, 439, 447, 458, 469, 476 and 477,

Preferred substitutions include E260A/D/C/Q/L/M/F/P/S/W/V/G/H/I/K/N/R/T/Y,  
 20 G304R/K/E/Q, W140Y/F, W189E/G/T, D134E, F262G/P, W284D/H/F/Y/R, W347H/F/Y,  
 W439R/G, G476E/Q/R/K, G477E/Q/K/M/R, N195F/Y, N197F/L, Y198N, Y200F, Y203F,  
 I206H/L/N/F/Y, H210Y, E212V/G, V213A, M116T, Q129L, G133E, E134Y, K142R, P146S,  
 G147E, G149R, N151R, Y152H, Q169E, N174R, A186R, Y243F, S244Q, G303V, R320N,  
 R359I, N418D and A447V.

25 Also preferred are and variants described in WO00/60060, WO2011/100410 and  
 WO2013/003659.

(c) variants exhibiting at least having at least 60%, preferably 80%, more preferably 85%,  
 more preferably 90%, more preferably 95%, more preferably 96%, more preferably 97%, more  
 preferably 98%, more preferably 99% and specially 100% identity to SEQ ID NO:6, the wild-  
 30 type enzyme from *Bacillus sp.707*, especially those comprising one or more of the following  
 mutations M202, M208, S255, R172, and/or M261. Preferably said amylase comprises one or  
 more of M202L, M202V, M202S, M202T, M202I, M202Q, M202W, S255N and/or R172Q.  
 Particularly preferred are those comprising the M202L or M202T mutations.

Other suitable amylases for use herein include amylases from *Bacillus stearothermophilus*, having SEQ ID NO: 6 in WO 02/010355 or variants thereof having 90% sequence identity. Preferred variants of *Bacillus stearothermophilus* are those having a deletion in positions 181 and 182 and a substitution in position 193. Other amylases which are suitable are hybrid alpha-amylase comprising residues 1 -33 of the alpha-amylase derived from *B. amyloliquefaciens* shown in SEQ ID NO: 6 of WO 2006/066594 and residues 36-483 of the *B. licheniformis* alpha-amylase shown in SEQ ID NO: 4 of WO 2006/066594 or variants having 90% sequence identity thereof. Preferred variants of this hybrid alpha-amylase are those having a substitution, a deletion or an insertion in one of more of the following positions: G48, T49, G107, H156, A181, N190, M197, I201, A209 and Q264. Most preferred variants of the hybrid alpha-amylase comprising residues 1 -33 of the alpha-amylase derived from *B. amyloliquefaciens* shown in SEQ ID NO: 6 of WO 2006/066594 and residues 36-483 of SEQ ID NO: 4 of WO 2006/066594 are those having the substitutions:

M197T;

H156Y+A181T+N190F+A209V+Q264S; or  
G48A+T49I+G107A+H156Y+A181T+N190F+I201 F+A209V+Q264S.

Further amylases which are suitable are amylases having SEQ ID NO: 6 in WO 99/019467 or variants thereof having 90% sequence identity to SEQ ID NO: 6. Preferred variants of SEQ ID NO: 6 are those having a substitution, a deletion or an insertion in one or more of the following positions: R181 , G182, H183, G184, N195, I206, E212, E216 and K269.

Particularly preferred amylases are those having deletion in positions R181 and G182, or positions H183 and G184.

Additional amylases which can be used are those having SEQ ID NO: 1 of WO 96/023873, SEQ ID NO: 3 of WO 96/023873, SEQ ID NO: 2 of WO 96/023873 or SEQ ID NO: 7 of WO 96/023873 or variants thereof having 90% sequence identity to SEQ ID NO: 1 , SEQ ID NO: 2, SEQ ID NO: 3 or SEQ ID NO: 7 of WO 96/023873. Preferred variants of SEQ ID NO: 1 of WO 96/023873, SEQ ID NO: 3 of WO 96/023873, SEQ ID NO: 2 of WO 96/023873 or SEQ ID NO: 7 of WO 96/023873 are those having a substitution, a deletion or an insertion in one or more of the following positions: 140, 181, 182, 183, 184, 195, 206, 212, 243, 260, 269, 304 and 476. More preferred variants are those having a deletion in positions 181 and 182 or positions 183 and 184. Most preferred amylase variants of SEQ ID NO: 1 of WO 96/023873, SEQ ID NO: 2 of WO 96/023873 or SEQ ID NO: 7 of WO 96/023873 are those having a deletion in positions 183 and 184 and a substitution in one or more of positions 140, 195, 206, 243, 260, 304 and 476.

Other amylases which can be used are amylases having SEQ ID NO: 2 of WO08/153815, SEQ ID NO: 10 in WO 01/66712 or variants thereof having 90% sequence identity to SEQ ID NO: 2 of WO 08/153815 or 90% sequence identity to SEQ ID NO: 10 in WO 01/66712. Preferred variants of SEQ ID NO: 10 in WO 01/66712 are those having a substitution, a deletion or an insertion in one of more of the following positions: 176, 177, 178, 179, 190, 201, 207, 211 and 264.

Further suitable amylases are amylases having SEQ ID NO: 2 of WO 09/061380 or variants having 90% sequence identity to SEQ ID NO: 2 thereof. Preferred variants of SEQ ID NO: 2 are those having a truncation of the C-terminus and/or a substitution, a deletion or an insertion in one of more of the following positions: Q87, Q98, S125, N128, T131, T165, K178, R180, S181, T182, G183, M201, F202, N225, S243, N272, N282, Y305, R309, D319, Q320, Q359, K444 and G475. More preferred variants of SEQ ID NO: 2 are those having the substitution in one of more of the following positions: Q87E/R, Q98R, S125A, N128C, T131 I, T165I, K178L, T182G, M201L, F202Y, N225E/R, N272E/R, S243Q/A/E/D, Y305R, R309A, Q320R, Q359E, K444E and G475K and/or deletion in position R180 and/or S181 or of T182 and/or G183. Most preferred amylase variants of SEQ ID NO: 2 are those having the substitutions:

N128C+K178L+T182G+Y305R+G475K;

N 128C+K178L+T182G+F202Y+Y305R+D319T+G475K;

S125A+N128C+K178L+T182G+Y305R+G475K; or

S125A+N128C+T131 I+T165I+K178L+T182G+Y305R+G475K wherein the variants are C-terminally truncated and optionally further comprises a substitution at position 243 and/or a deletion at position 180 and/or position 181 .

Other examples are amylase variants such as those described in WO2011/098531, WO2013/001078 and WO2013/001087.

Preferred commercially available amylases for use herein are STAINZYME®, STAINZYME PLUS®, STAINZYME ULTRA®, EVEREST® and NATALASE® (Novozymes A/S) and RAPIDASE, POWERASE® and the PREFERENZ S® series, including PREFERENZ S100® (DuPont).

Examples of other amylases include amylases having SEQ ID NO: 2 in WO 95/10603 or variants having 90% sequence identity to SEQ ID NO: 3 thereof. Preferred variants are described in WO 94/02597, WO 94/18314, WO 97/43424 and SEQ ID NO: 4 of WO 99/019467, such as variants with substitutions in one or more of the following positions: 15, 23, 105, 106, 124, 128,

133, 154, 156, 178, 179, 181, 188, 190, 197, 201, 202, 207, 208, 209, 211, 243, 264, 304, 305, 391, 408, and 444.

Examples of such commercially available amylases are TERMAMYL ULTRA® and DURAMYL®.

- 5 If the amylase is derived from the wild-types of *Bacillus Licheniformis* or *Bacillus Amyloliquefaciens*, it is an engineered variant thereof comprising at least one mutation designed to impart performance optionally with superior stability. The amylase is preferably not BAN®.

The composition of the invention preferably comprises from 0.001 to 2%, more preferably from  
10 0.003 to 1%, more preferably from 0.007 to 0.3% and especially from 0.01 to 0.1% by weight of the composition of active amylase.

#### Other enzymes

Preferably the composition of the invention further comprises one or more enzymes selected from the group consisting of an  $\alpha$ -amylase, a  $\beta$ -amylase, a pullulanase, a protease, a lipase, a  
15 cellulase, an oxidase, a phospholipase, a perhydrolase, a xylanase, a pectate lyase, a pectinase, a galacturanase, a hemicellulase, a xyloglucanase, a mannanase and a mixture thereof.

Suitable enzymes include X-Pect®, Mannaway®, Lipex®, Lipoclean®, Whitezyme®, Carezyme®, Celluzyme®, Carezyme Premium®, Celluclean® from Novozymes A/S and Purastar® and PrimaGreen® from DuPont.

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The composition of the invention preferably comprises from 0.001 to 2%, more preferably from 0.003 to 1%, more preferably from 0.007 to 0.3% and especially from 0.01 to 0.1% by weight of the composition of active amylase.

#### Unit dose form

25 The composition of the invention is suitable to be presented in unit-dose form. Products in unit dose form include tablets, capsules, sachets, pouches, injection moulded containers, etc. Preferred for use herein are tablets and detergents wrapped with a water-soluble film (including wrapped tablets, capsules, sachets, pouches) and injection moulded containers. Preferably the water-soluble film is a polyvinyl alcohol, preferably comprising a bittering agent. The detergent  
30 composition of the invention is preferably in the form of a water-soluble multi-compartment pack.

Preferred packs comprise at least two side-by-side compartments superposed onto another compartment. This disposition contributes to the compactness, robustness and strength of the pack and additionally, it minimises the amount of water-soluble packing material required. It only requires three pieces of material to form three compartments. The robustness of the pack allows also for the use of very thin films (less than 150 micron, preferably less than 100 micron) without compromising the physical integrity of the pack. The pack is also very easy to use because the compartments do not need to be folded to be used in machine dispensers of fixed geometry. At least two of the compartments of the pack contain two different compositions. By “different compositions” herein is meant compositions that differ in at least one ingredient.

Preferably, at least one of the compartments contains a solid composition, preferably in powder form and another compartment an aqueous liquid composition, the compositions are preferably in a solid to liquid weight ratio of from about 20:1 to about 1:20, more preferably from about 18:1 to about 2:1 and even more preferably from about 15:1 to about 5:1. This kind of pack is very versatile because it can accommodate compositions having a broad spectrum of values of solid:liquid ratio. Particularly preferred have been found to be pouches having a high solid:liquid ratio because many of the detergent ingredients are most suitable for use in solid form, preferably in powder form. The ratio solid:liquid defined herein refers to the relationship between the weight of all the solid compositions and the weight of all the liquid compositions in the pack.

Preferably the two side-by-side compartments contain liquid compositions, which can be the same but preferably are different and another compartment contains a solid composition, preferably in powder form, more preferably a densified powder. The solid composition contributes to the strength and robustness of the pack.

For dispenser fit reasons the unit dose form products herein preferably have a square or rectangular base and a height of from about 1 to about 5 cm, more preferably from about 1 to about 4 cm. Preferably the weight of the solid composition is from about 5 to about 20 grams, more preferably from about 10 to about 15 grams and the total weight of the liquid compositions is from about 0.5 to about 5 grams, more preferably from about 1.5 to about 4 grams.

In preferred embodiments, at least two of the films which form different compartments have different solubility, under the same conditions, releasing the content of the compositions which they partially or totally envelope at different times.

5 Controlled release of the ingredients of a multi-compartment pouch can be achieved by modifying the thickness of the film and/or the solubility of the film material. The solubility of the film material can be delayed by for example cross-linking the film as described in WO 02/102,955 at pages 17 and 18. Other water-soluble films designed for rinse release are described in US 4,765,916 and US 4,972,017. Waxy coating (see WO 95/29982) of films can  
10 help with rinse release. pH controlled release means are described in WO 04/111178, in particular amino-acetylated polysaccharide having selective degree of acetylation. Other means of obtaining delayed release by multi-compartment pouches with different compartments, where the compartments are made of films having different solubility are taught in WO 02/08380.

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Alternatively the dissolution of the liquid compartments can be delayed by modification of the liquid that is contained within the film. Use of anionic surfactants, particularly anionic surfactant mixtures that pass through a highly structured phase (such as hexagonal or lamellar) upon addition of water retards the dissolution of the surfactant containing compartment. In one aspect  
20 of this invention, one or more compartments comprise anionic surfactant and their release is delayed versus other compartments.

#### Auto-dosing delivery device

The compositions of the invention are extremely useful for dosing elements to be used in an auto-dosing device. The dosing elements comprising the composition of the present invention can be  
25 placed into a delivery cartridge as that described in WO 2007/052004 and WO 2007/0833141. The dosing elements can have an elongated shape and set into an array forming a delivery cartridge which is the refill for an auto-dosing dispensing device as described in case WO 2007/051989. The delivery cartridge is to be placed in an auto-dosing delivery device, such as  
30 that described in WO 2008/053191.

#### Example



The generation of radicals using a composition having a low pH, an iron chelant and substantially free of bleach (Composition 1) was assessed by immersing methylene blue dye on a paper test strip in three different solutions.

Solution		Observations
A	Deionised water	No discolouration
B	Composition 1	No discolouration
C	Composition 1 + Tea	Spots of discolouration

- 5 As it can be seen from the chart below, when the paper test strip was immersed in an aqueous solution comprising Composition 1, the test strip did not show any sign of discoloration, indicating that no bleaching took place. When a test strip was immersed in an aqueous solution containing Composition 1 and tea discolouration was observed, indicating that bleaching was occurring. This discolouration grew over time.

10

#### Abbreviations used in the Example

In the example, the abbreviated component identifications have the following meanings:

Suds suppressor	:	GP-4314 powdered antifoam supplied by Dow Corning
Lutensol FP 620	:	Ethoxylated polyethyleneimine. Molecular weight 600. 20 ethoxy groups. Supplied by BASF.
Neodol C11E9	:	Non-ionic surfactant available from Shell
Plurafac L224	:	Low foaming non-ionic surfactant supplied by BASF
Lutensol TO7	:	Non-ionic surfactant supplied by BASF
NaHEDP	:	Sodium salt of 1- hydroxyethylidene -1, 1-diphosphonic acid
Ultimase	:	Protease supplied by DuPont
Stainzyme Plus®	:	Amylase supplied by Novozymes
AES	:	Sodium C <sub>12-14</sub> alkyl ethoxy 3 sulfate
DPG	:	Dipropylene glycol

#### Composition 1

Solid composition	grams
Suds suppressor	0.5
Lutensol FP 620	0.4

2-Pyridinol 1 oxide	0.4
NaHEDP	0.5
Citric Acid	1
Stainzyme Plus® (14.4mg/g)	0.25
Ultimase	0.06
Sodium Percarbonate	0.5
Sodium Citrate	4.5
Liquid composition	grams
Lutensol TO7	0.51
DPG	0.23
Amine Oxide	0.16
Plurafac LF 224	0.61
AES	1.8
Neodol C11E9	0.05
Glycerine	0.08
Dye	0.07

The dimensions and values disclosed herein are not to be understood as being strictly limited to the exact numerical values recited. Instead, unless otherwise specified, each such dimension is intended to mean both the recited value and a functionally equivalent range surrounding that value. For example, a dimension disclosed as “40 mm” is intended to mean “about 40 mm”.

## CLAIMS

What is claimed is :

1. A method of cleaning a dishwashing load comprising dishware and tableware having bleachable stains in the presence of iron in a dishwasher, the method comprising the step of contacting the ware with a detergent composition comprising an iron chelant wherein the detergent composition is free or substantially free of bleach and preferably has a pH as measured in 1% weight aqueous solution at 25°C of from about 5 to about 7.5.
2. A method according to claim 1 wherein the iron chelant is selected from the group consisting of siderophores, catechols, catechol sulfonates, enterobactin, hydroxamates, hydroxypyridinones (or hydroxypyridine N-Oxides) and mixtures thereof, preferably the iron chelant comprises a hydroxypyridine N-Oxide.
3. A method according to any of the preceding claims wherein the composition comprises a crystal growth inhibitor, preferably HEDP.
4. A method according to any of the preceding claims wherein the composition comprises a cleaning polymer, preferably an alkoxyated polyalkyleneimine.
5. A method according to any of the preceding claims wherein the composition comprises an anionic surfactant preferably the anionic surfactant comprising an alkyl ethoxy sulfate.
6. A method according to any of the preceding claims wherein the composition has a pH as measured in 1% weight aqueous solution at 25°C of from about 5 to about 6.9.
7. A method according to any of the preceding claims wherein the composition is substantially builder-free.
8. A method according to any of the preceding claims wherein the composition comprises a buffer, preferably comprising a polycarboxylic acid, its salt or a mixture thereof.
9. A method according to any of the preceding claims wherein the composition comprises low temperature amylase.

10. A method according to any of the preceding claims wherein the composition comprises a protease selected from the group consisting of:
- (i) a metalloprotease;
  - (ii) a cysteine protease;
  - (iii) a neutral serine protease;
  - (iv) an aspartate protease, and
  - (v) mixtures thereof.
11. A method according to any of the preceding claims wherein the temperature of the main wash is less than about 50°C.
12. A method according to any of the preceding claims wherein the length of the main wash is less than 15 minutes.
13. Use use of an iron chelant in a low pH composition for the removal of bleachable stains in automatic dishwashing in the presence of iron.

**INTERNATIONAL SEARCH REPORT**

International application No  
PCT/US2015/065791

A. CLASSIFICATION OF SUBJECT MATTER  
INV. C11D1/83 C11D3/386  
ADD.  
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED  
Minimum documentation searched (classification system followed by classification symbols)  
C11D  
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2012/110564 A1 (NOVOZYMES AS [DK]; OESTERGAARD PETER RAHBEK [DK]; FRIIS ESBEN PETER [D] 23 August 2012 (2012-08-23) page 19, line 19 page 34, line 9 - page 36, line 2 page 18, line 18 - line 21; claims; examples	1-13
Y	US 6 835 703 B1 (CHO SUK H [US] ET AL) 28 December 2004 (2004-12-28) column 4, line 23 - line 43; claims; examples	1-13
Y	US 2013/045910 A1 (MIRACLE GREGORY SCOT [US] ET AL) 21 February 2013 (2013-02-21) paragraphs [0005], [0023], [0032]; claims; examples	1-13
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Further documents are listed in the continuation of Box C.

See patent family annex.

\* Special categories of cited documents :

<p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&amp;" document member of the same patent family</p>
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Date of the actual completion of the international search <b>5 February 2016</b>	Date of mailing of the international search report <b>15/02/2016</b>
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer <b>Vernier, Frédéric</b>

## INTERNATIONAL SEARCH REPORT

International application No  
PCT/US2015/065791

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	US 6 492 316 B1 (HERBOTS IVAN MAURICE ALFONS JA [BE] ET AL) 10 December 2002 (2002-12-10) claims; examples 19-22 -----	1-13
A	US 2014/251385 A1 (KELLY-MURRAY KRISTIN MARIE [US] ET AL) 11 September 2014 (2014-09-11) paragraphs [0004], [0013], [0018], [0021], [0047]; claims; examples -----	1-13

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2015/065791

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