Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).
BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

[0001] The present invention relates to the field of cleaning. In particular, the invention relates to methods of cleaning an object employing alternating pressure.

DESCRIPTION OF THE RELATED ART

[0002] Laundering is in general performed by agitating the fabrics in a detergent solution for a certain period of time followed by rinsing the fabrics in water. Laundering may be carried out using an automatic washing machine or it may be done by hand. Modern detergents are complex compositions comprising a number of components such as; surfactants, builders, bleaches, polymers, enzymes etc. just to mention a few, and are usually formulated as a powder or a liquid.

[0003] Several modifications of the laundering process and detergent compositions have been suggested to increase cleaning performance or to reduce water and/or energy consumption. EP0086935 describes a method of washing soiled textile goods where foam is created and blown on the textile. The benefit of the method is that it can be performed using small amounts of detergent and water. GB2340846 describes a method of washing items comprising; placing items in a vessel, introducing a washing liquid thereto, reducing pressure within the vessel and thereby causing gas/vapor to bubble through the liquid. The purpose of reducing the pressure is to create bubbling of gas/vapor to agitate the items as an alternative to mechanical agitation. The reduction in pressure is furthermore used to cause boiling of the washing liquid thereby avoiding that items being exposed to temperatures needed to boil said liquid at atmospheric pressure. EP0677577 describes a method of cleaning textiles by using foam whereby the foam or foam residues on the textiles subsequently being substantially removed by application of vacuum. EP0765932 describes a method of cleaning and conditioning textile fabrics by applying foam comprising a fabric softening clay and subsequently removing foam residues by vacuum. WO 94/12621A and US2585464 A disclose a further prior art.

[0004] Use of foam for laundering is known, however presence of high levels of foam in conventional washing processes is not desirable due to the difficulties in removing foam during rinse. Thus, there is still a need for developing new washing processes in which foam that are utilized in laundering may be controlled.

SUMMARY OF THE INVENTION

[0005] It is an object of the present invention to provide a method for cleaning an object which unlike conventional methods is grounded on the use of alternating pressure in combination with a foam composition.

[0006] The invention relates to a method according to claim 1.

BRIEF DESCRIPTION OF THE FIGURES

[0007] Figure 1 shows wash performance of WAP compared to beaker wash and a standard fine wash. Figure 2 shows wash performance of WAP compared to wash at constant pressure. Figure 3 shows the effect of WAP rinse compared to that of beaker rinse on wash performance. Figure 4 shows the effect of WAP rinse compared to that of beaker rinse on the amount of residual LAS in the rinse solution. Figure 5 shows a schematic drawing of a WAP device. Figure 6 shows a picture of the WAP device used.

Definitions

[0008] AP: The term "AP" as used herein means alternating pressure. WAP: The terms "WAP" or "WAP wash" as used herein means washing with alternating pressure. WAP rinse: The term "WAP rinse" as used herein means rinsing with alternating pressure. Wash performance: The term "wash performance" as used herein means the delta remission measured at 440 nm of the swatch, where delta remission is the remission measured at 440 nm of a washed swatch minus the
remission measured at 440 nm of an unwashed swatch.

**Plateau border.** The term "plateau border" as used herein means the transition zone formed when bubbles/films meet. Except for free-floating bubbles, films have to be supported by frames, bulk surfaces or other films. The transition zone separating these from the film proper, always containing some bulk liquid, is called a plateau border.

**DETAILED DESCRIPTION OF THE INVENTION**

[0009] In conventional laundering, the soiled textile is immersed in a detergent solution and subjected to mechanical action, followed by repeated rinsing with water, and drying. The detergent solution generally includes surfactants and enzymes. The detergent is typically formulated with a view to avoid foaming.

[0010] The invention is based on the observation that when an enzyme enriched foam are added to the fabric/textile and micro-mechanical action is applied by means of alternating pressure surprisingly increased wash performance is obtained compared to conventional wash. Alternating pressure may furthermore be utilized during rinsing whereby an improved rinsing is obtained.

[0011] Water consumption is reduced for washing as well as for rinsing because the alternating pressure principles may be used to speed up the dilution and exchange of wash active ingredients and soil to the suds and the rinse water.

[0012] The invention may furthermore result in reduced energy and resource consumption compared to that of conventional washing processes because the macro-mechanical action (turning the drum) is avoided, and heating can either be eliminated or reduced due to the combined action of enzyme and alternating pressure.

[0013] This have the consequence that the laundering according to the invention may be performed on a shorter time achieving same result as would have taken longer time using a conventional laundering process.

[0014] In some aspects the invention relates to a method for cleaning an object comprising the steps: (a) placing the object to be cleaned in an alternating pressure resistant container; (b) applying to the object a foam composition comprising at least one foaming agent, at least one enzyme and a dissolved gas; (c) cleaning the object with the foam composition by applying alternating pressure to the container; and (d) rinsing the object.

**The foam composition**

[0015] The foam composition comprises at least one foaming agent, at least one enzyme and a dissolved gas. It is typically an aqueous foam composition. It is preferred that the foam composition is particular adapted to use in the method according to the invention.

**Foaming agents**

[0016] The at least one foaming agent may in principle be any such known foaming agent capable of forming stable foam, such as high foaming surfactants selected among: non-ionic surfactants; anionic surfactants; cationic surfactants; ampholytic surfactants; zwitterionic surfactants; semi-polar surfactants; or any combinations thereof. The kind and concentration of surfactants may be chosen with a view to good foam formation and compatibility with the at least one enzyme. The surfactants are typically present at a level of from 0.1% to 60% by weight; from 0.1% to 30%; from 0.1% to 20%; from 0.1% to 10%; from 0.1% to 5%; from 0.1% to 1% by weight.

[0017] The foam composition will usually contain from about 0.1% to about 40%; from 0.1% to 30%; from 0.1% to 20%; from 0.1% to 10%; from 0.1% to 5%; from 0.1% to 1% by weight.

[0018] The foam composition will usually contain from about 0.1% to about 40%; from 0.1% to 30%; from 0.1% to 20%; from 0.1% to 10%; from 0.1% to 5%; from 0.1% to 1% by weight of an anionic surfactant such as linear alkylbenzenesulfonate, alpha-olefinsulfonate, alkyl sulfate (fatty alcohol sulfate), alcohol ethoxysulfate, secondary alkanesulfonate, alpha-sulfo fatty acid methyl ester, alkyl- or alkenylsuccinonic acid or soap.

[0019] It is preferred that the foaming agent is selected among anionic surfactants. Preferred examples of foaming agents include Eucerin and sodium linear C12 alky benzene sulphonate (LAS).

[0020] In some embodiments the invention relates to a method, wherein the at least one foaming agent is selected from: non-ionic, anionic surfactants; cationic surfactants; ampholytic surfactants; zwitterionic surfactants; semi-polar surfactants; or any combinations thereof.

[0021] In some embodiments the invention relates to a method, wherein the anionic surfactant is selected from: linear alkylbenzenesulfonate; alpha-olefin sulfonate; alkyl sulfonate (fatty alcohol sulfonate); alcohol ethoxy sulfonate; secondary alkanesulfonate; alpha-sulfo fatty acid methyl ester; alkyl- or alkenyl succinonic acid or soap, or any combination thereof.

[0022] In some embodiments the invention relates to a method, wherein the concentration of the foaming agent is
0.1%-60% w/w relative to the soiled object.

Enzymes

[0023] The at least one enzyme comprised in the foam composition according to some embodiments of the invention may in principle be any enzyme known to have an effect on soiled objects such as fabrics/textiles. Such enzymes may e.g. be enzymes traditionally used in laundering, having optimal activity in the neutral to alkaline range, or enzymes having optimal activity in the acidic to neutral range, and may include at least one enzyme selected from the group containing: amylases; arabinases; carboxyglucosidases; cellulases; cutinases; galactanases; haloperoxidases; hydrolases; laccases; lipases; mannanases; oxidases; oxidoreductases; pectinases; peroxidases; proteases; xylanases. The at least one enzyme comprised in the foam composition, and accordingly the method according to some embodiments of the invention, are described in further details below:

Amylase: Any amylase (α and/or β) may in principle be used. Suitable amylases include those of bacterial or fungal origin. Chemically or genetically modified mutants are included. Amylases include, for example, α-amylases obtained from a special strain of *B. licheniformis*, described in more detail in GB 1,296,839. Commercially available amylases are Duramyl™, Termamyl™, Fungamyl™ and BAN™ (Novozymes A/S) and Rapidase™ and Maxamyl P™ (Genencor).

Cellulase: Any cellulase may in principle be used. Suitable cellulases include those of bacterial or fungal origin. Chemically or genetically modified mutants are included. Suitable cellulases are disclosed in US 4,435,307, which discloses fungal cellulases produced from *Humicola insolens*. Especially suitable cellulases are the cellulases having colour care benefits. Examples of such cellulases are cellulases described in EP0495257. Commercially available cellulases include Celluzyme™ produced by a strain of *Humicola insolens* (Novozymes A/S), and KAC-500(B)™ (Kao Corporation).

Lipases: Suitable lipases include those of bacterial or fungal origin. Chemically or genetically modified mutants are included. Examples of useful lipases include a *Humicola lanuginosa* lipase, e.g., as described in EP 258 068 and EP 305 216, a *Rhizomucor miehei* lipase, e.g., as described in EP 238 023, a *Candida* lipase, such as a *C. antarctica* lipase, e.g., the *C. antarctica* lipase A or B described in EP 214 761, a *Pseudomonas* lipase such as a *P. alcaligenes* and *P. pseudoalcaligenes* lipase, e.g., as described in EP0218272, a *P. cepacia* lipase, e.g., as described in EP0331376, a *P. stutzeri* lipase, e.g., as disclosed in GB 1,372,034, a *P. fluorescens* lipase, a *Bacillus* lipase, e.g., a *B. subtilis* lipase (Dartois et al., (1993), Biochemica et Biophysica acta 1131, 253-260), a *B. stearothermophilus* lipase (JP 64/744992) and a *B. pumilus* lipase (WO 91/16422). Furthermore, a number of cloned lipases may be useful, including the *Penicillium camemberti* lipase described by Yamaguchi et al. (1991) Gene vol.103, p.61-67, the *Geotrichum candidum* lipase (Schimada, Y. et al. (1989) J. Biochem. Viol.106, p.383-388), and various *Rhizopus* lipases such as a *R. delemar* lipase (Hass, M.J et al. (1991) Gene vol.109, p.117-113), a *R. niveus* lipase (Kugimiya et al. (1992) Biosci. Biotech. Biochem. Vol.56, p.716-719) and a R. oryzae lipase.

[0024] Other types of lipolytic enzymes such as cutinases may also be useful, e.g., a cutinase derived from *Pseudomonas mendocina* as described in WO 88/09367, or a cutinase derived from *Fusarium solani pisi* (e.g. described in WO 90/09446).

[0025] Especially suitable lipases are lipases such as M1 Lipase™, Luma fast™ and Lipomax™ (Genencor), Lipolase™ and Lipolase Ultra™ (Novo Nordisk A/S), and Lipase P "Amano" (Amano Pharmaceutical Co. Ltd.).

[0026] Peroxidases/oxidases: Peroxidase enzymes are used in combination with hydrogen peroxide or a source thereof (e.g. a percarbonate, perborate or persulfate). Oxidase enzymes are used in combination with oxygen. Both types of enzymes are used for "solution bleaching", i.e. to prevent transfer of a textile dye from a dyed fabric to another fabric when said fabrics are washed together in a wash liquor, preferably together with an enhancing agent as described in e.g. WO 94/12621 and WO 95/01426. Suitable peroxidases/oxidases include those of plant, bacterial or fungal origin. Chemically or genetically modified mutants are included.

[0027] Proteases: Suitable proteases include those of animal, vegetable or microbial origin. Microbial origin is preferred. Chemically or genetically modified mutants are included. The protease may be a serine protease, preferably an alkaline microbial protease or a tryps-in-like protease. Examples of alkaline proteases are subtilisins, especially those derived from *Bacillus*, e.g., subtilisin Novo, subtilisin Carlsberg, subtilisin 309, subtilisin 147 and subtilisin 168 described in WO 89/06279. Examples of trypsin-like proteases are trypsin (e.g. of porcine or bovine origin) and the *Fusarium* protease described in WO 89/06270. Preferred commercially available protease enzymes include those sold under the trade names Alcalase, Savinase, Primase, Durazym, and Esperase (Novozymes A/S), those sold under the tradename Maxatase, Maxacal, Maxapem, Properase, Purafect and Purafect OXP (Genencor) and those sold under the tradename Opticlean and Optimase (Solvay Enzymes).

[0028] Mixtures of the above mentioned enzymes are encompassed herein, in particular a mixture of proteases,
amylases, lipases and/or cellulases.

[0029] The at least one enzyme, each individual enzyme or the total amount of enzyme, may be incorporated into the foam composition in accordance with some embodiments of the invention at a level of from 0.00001 % to 30%; from 0.00001 % to 20%; from 0.00001 % to 10%; from 0.0001 % to 5%; from 0.001 % to 2%; or from 0.01 % to 1% of enzyme by volume of the total foam composition.

[0030] In some embodiments the invention relates to a method, wherein the at least one enzyme is selected from: amylases; arabinases; carbohydrate; cellulases; cutinases; galactanases; haloperoxidases; hydrolases; lipases; mannanases; oxidases e.g. laccases or peroxidases; oxidoreductases; pectinases proteases; xylanases; or any combination thereof.

[0031] In some embodiments the invention relates to a method, wherein the concentration of the at least one enzyme is from 0.00001 % to 10%; from 0.0001 % to 5%; from 0.001 % to 2%; or from 0.01 % to 1% of enzyme by volume of the total foam composition.

Dissolved gas

[0032] The foam composition contains dissolved gas, typically atmospheric air. Tap water contains enough atmospheric air and may thus be used directly. Alternatively, degassed water or other liquids may be supplied with any suitable gas and used in the foam composition. A suitable gas may e.g. be atmospheric air, carbon dioxide etc. or a mixture of suitable gasses.

Other agents

[0033] The foam composition may in some embodiments of the invention further comprise at least one other agent selected among: fabric conditioners including clays; anti-corrosion agents; hydrotropes; redeposition agents; foam boosters; foam stabilizing agents; suds suppressors; enzyme stabilizing agents; pH regulating agents; builder systems; bleaching agents; soilreleasing agents; soil suspending agents; polymeric dye transfer inhibiting agents; optical brighteners; abrasives; bactericides; tarnish inhibitors; softening agents; dyes; coloring agents; and perfume, some of which are described below.

[0034] Foam stabilizers: The foam composition may further comprise one or more foam stabilizers such as glucosides or emulsifiers known to be able of stabilizing water/surfactant/gas emulsions.

[0035] pH regulating compounds: The foam composition may also contain pH regulating agents known in the art, such as inorganic salts like phosphates, sulphates and carbonates; organic compounds like carboxylic acids, carboxylates, amines, sulphonates etc. pH regulating agents should be selected to provide a pH value of the foam composition which is compatible or preferably optimal for the at least one enzyme included in the foam composition. pH regulating agents according to some embodiments of the invention includes well known buffer components such as glycine and sodium carbonate.

[0036] Traditional wash compositions have in general pH values in the alkaline or neutral range, in part due to the alkaline nature of the soaps, surfactants and other components commonly used in such compositions. In contrary, the foam compositions according to the invention contain no mandatory soap or surfactant components and are therefore not restricted to maintain a pH value in a particular range but the pH value of the compositions can be selected in order to obtain optimal conditions for the enzymes comprised in the composition. Thus, the pH of the foam composition can be in the acidic range, in the alkaline range or it can be neutral. In particular the pH can be selected in the range of 4-10, more preferred in the range of 5-9.

[0037] A skilled person will understand that the method according to some embodiments of the invention provides an additional versatility regarding the at least one enzyme used for laundering. Thus, in one embodiment the foam composition has an acidic pH value i.e. pH below 7 such as pH in the range of 4-7 and the enzymes are selected in order to have maximal activity under acidic conditions, in another embodiment the foam composition has a neutral pH value i.e. pH about 7 and the enzymes are selected in order to have maximal activity under neutral conditions and in a third embodiment the foam composition has an alkaline pH value i.e. pH above 7 such as pH in the range of 7-10 and the enzymes are selected in order to have maximal activity under alkaline conditions.

[0038] Builders: The foam composition may contain 0-65% by weight of a builder or complexing agent such as zeolite, diphosphate, triphosphate, phosphonate, carbonate, citrate, nitritotriacetic acid, ethylenediaminetetraacetic acid, diethylenetriaminepentaacetic acid, alkyl- or alkenylsuccinic acid, soluble silicates or layered silicates (e.g. SKS-6 from Hoechst).

[0039] Enzyme stabilizers: The at least one enzyme comprised in the foam composition of the invention may be stabilized using conventional stabilizing agents, e.g., a polyol such as propylene glycol or glycerol, a sugar or sugar alcohol, lactic acid, boric acid, or a boric acid derivative, e.g., an aromatic borate ester, or a phenyl boronic acid derivative such as 4-formylphenyl boronic acid.
Bleaching systems: The foam composition may in some embodiments of the invention contain a bleaching system which may comprise a H$_2$O$_2$ source such as perborate or percarbonate which may be combined with a peracid-forming bleach activator such as tetraacetylhexylethylenediamine or nonanoyloxybenzenesulfonate. Alternatively, the bleaching system may comprise peroxycarboxylic acids of e.g. the amide, imide, or sulfone type.

Foaming methods

- **[0042]** The foam compositions of the invention may in principle be made using known foaming methods. Methods for preparing foam are well known within the area of cleaning hard surfaces in e.g. the food industry, and it should be understood that such well known methods and equipment used for such methods may also be applied to the present invention.

- **[0043]** One method for preparing the foam composition according to the invention is mixing and foaming the ingredients in a high shear mixer.

- **[0044]** Another method for preparing the foam composition according to the invention is providing the ingredients under pressure in a container together with a suitable propellant and creating the foam composition by dispensing the composition through a suitable orifice using technologies as will be well known from spray cans or aerosol cans. The propellant may be any compound that is a compressible gas at ambient temperature and is inert toward the foam compositions; however it is preferred to use a propellant that is harmless for the users and the environment. Such propellants as will be well known in the art may also be used within the present invention. As examples of suitable propellants are e.g. nitrogen, propane and butane.

- **[0045]** Another method for making foam is to use the conventional method for foam dispersion in e.g. hard surface cleaning, by having a concentrated surfactant in a container. For foam making, a water flow draws out a suitable amount of surfactant (to the water) to a foaming nozzle. The concentration of surfactant is dependent on the water pressure. The enzyme may be included in the container together with the surfactant or it can be placed in a separate container and drawn out into the water flow before or after the surfactant to the foaming nozzle. Alternatively, all components of the foam composition is added together before it enters the alternating pressure resistant container through the foam nozzle.

- **[0046]** It is also possible to prepare the foam composition manually, by mixing the ingredients and foaming of the mixture using mechanical action, e.g. by whipping the foam or by using a hand foamer. Hand foamers are known in the art and may also be applicable in some embodiments of the present invention.

- **[0047]** When the foam composition is applied to the object it is important that it is evenly distributed in order to secure best possible conditions for cleaning. Application, distribution and/or re-distribution of the foam composition may be obtained by mixing, agitating, shaking, ultrasound or any combination thereof. It may be done by hand; using a stick, spatula, or the like; or it may be performed using a suitable device. The foam composition may alternatively be applied through the inlet and the inlet nozzle of the alternating pressure resistant container of the invention.

- **[0048]** Distribute or redistribution of the foam composition evenly to the object in the container may be done by ways as indicated above for a short period of time like e.g. 0.5; 1.0; 1.5; 2.0; 2.5; 3.0; 3.5; 4.0; 4.5; or 5.0 minutes until the foam composition is evenly distributed.

- **[0049]** The object to be cleaned may be any fabrics, textile, laundry, leather, skin, fur or hard surfaces.

- **[0050]** In some embodiments the invention relates to a method, wherein the object is: fabrics; textiles; laundry; leather; skin; fur; or hard surfaces.

Alternating pressure

- **[0051]** It is possible to generate mechanical action within fabrics/textiles as well as on surfaces wetted with a foam composition by means of alternating pressure. This mechanical action may substitute the mechanical work obtained by the movement in a washing machine or obtained by hand.

- **[0052]** During wash a "hydrodynamic barrier" is formed. This barrier which is about 1 micrometer in thickness is generated by water molecules which through polar hydrogen bonds are packed like a film upon the surface of the object to be cleaned. Depending of the hydrophobic or hydrophilic nature of the object said barrier may act more or less efficiently as a barrier and interfere in the exchange of molecules between the foam composition and the surface of the object.

- **[0053]** Washing in a front loader machine applies mechanical action by letting the textile load drop from the top of the drum to the bottom in the presence of a wash solution. This macro-mechanical action breaks parts of the hydrodynamic barrier thereby promoting interaction between wash solution and textile. In a traditional wash foam is undesirable because
In the present invention alternating pressure generates mechanical action on a microscopically level within the barrier considerably, thereby preventing removal of soil from the textile during washing and during rinsing. In particular porous materials may contain relatively large amounts of foam. When the pressure is lowered the dissolved gas present in the foam composition will appear as bubbles which increase in size. Dependent on the viscoelasticity of the foam composition changes in bubble size creates micro-mechanical action both within as well as at the surface of the fabric/textile. This action promotes exchange of active components from the foam composition to textile fibres and transport released soil and decomposition products away from the textile.

By applying pressure of 2-3 bar the bubbles diminishes to the extent that the foam will act as a normal liquid and not as an air/water surfactant emulsion. Thereby it may be diluted and squeezed out of the alternating pressure resistant container like water. Thus, alternating pressure creates the micro-mechanical action and chemical exchange from the textile.

When a foaming composition is exposed to alternating pressure the liquid film that makes up the "walls" of a bubble will be forced to move within as well as upon the surface of the fabric/textile. The more liquid comprised in the plateau borders of the foam the fewer bubbles will burst during low pressure. Wash performance is dependent on the presence of bubbles and thus the balance between increase of bubbles and burst of bubbles during low pressure affects the washing result. Application of a pressure of 1-2 bars will lead to diminished size of the bubbles. The bubbles will nearly disappear and the liquid film that creates the walls around the bubbles becomes thick and so will the plateau borders, thereby easing the transport of chemicals and substances within the foam composition. Alternating pressure where low and high pressure is applied in turn creates a micro-mechanical action which promotes the transport of soil and enzyme products away from the fabric/textile surface and the transport of enzymes and other optionally cleaning components to the fabric/textile surface.

In some embodiments of the invention the washing step comprises at least one cycle of alternating pressure wherein the pressure in turns is reduced and increased. One cycle of alternating pressure correspond to reduced pressure followed by increased pressure. Alternatively, a time period wherein alternating pressure is performed may be indicated. During this time period one or more cycles of alternating pressures may take place.

The repetition of at least two rounds of alternating pressure creates sufficient mechanical action in the container to clean the laundry to the same or higher level as traditional home care laundering. During reduced pressure, the dissolved gas comprised in the foam composition forms bubbles and/or enlarges existing bubbles, whereas during increased pressure the bubbles are diminished and/or may partly collapse or dissolve. The number of cycles of alternating pressure may vary and accordingly it may be 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, or 30 cycles. Likewise, the time period of alternating pressure may vary and accordingly it may last 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, or 30 minutes.

In some embodiments the invention relates to a method, wherein the alternating pressure is at least -1.0 bar, at least -0.9 bar, at least -0.8 bar, at least -0.7 bar, at least -0.6 bar, at least -0.5 bar, at least -0.4 bar, at least -0.3 bar, at least -0.2 bar, at least -0.1 bar, or at least 0.1 bar; at least 0.2 bar; at least 0.3 bar, at least 0.4 bar, at least 0.5 bar, at least 0.6 bar, at least 0.7 bar, at least 0.8 bar, at least 0.9 bar, at least 1.0 bar, at least 1.1 bar, at least 1.2 bar, at least 1.3 bar, at least 1.4 bar, at least 1.5 bar, at least 2.0 bar, at least 2.5 bar, at least 3.0 bar, at least 3.5 bar, at least 4.0 bar, at least 4.5 bar, or at least 5.0 bar.

Recirculation of the foam composition

During cleaning of an object alternating pressure may be interrupted by recirculation or flushing, wherein the spent foam composition may be drained off and reapplied, or fresh foam composition may be added respectively. Recirculation or flushing may serve to remove soiling and/or to replenish dissolved gas.

Recycling or flushing creates a macro-mechanical action which may be combined with the micro-mechanical action created by alternating pressure. This is done by applying said foam composition through the inlet vessel and nozzle of the container. Due to the low pressure the foam composition will enter the container as foam. By subsequently applying pressure to the chamber and briefly open an outlet vessel in the bottom of the container the foam composition will be forced through the fabric/textile placed in the container whereby wetting of the object and distribution of the foam composition are obtained. This procedure may be used for initial wetting and distribution as well as for recycling or flushing of the foam composition between periods of alternating pressure. By recirculation the foam composition will be revitalized for a subsequent period of alternating pressure. And the flow of foam composition also promotes the transport of chemicals as well as substances into the liquid.

During recirculation or flushing foam is created which demands a relatively higher or lower pressure to remove. The number of recirculation or flushing should therefore be selected to suit the foam composition for the purpose of
creating sufficient foam for cleaning. Although alternating pressure more efficiently helps in controlling and removing foam as compared to conventional rinsing care should be taken to balance the amount of foam.

[0064] In some embodiments the invention relates to a method, wherein the foam composition is redistributed on the object during step (b) and/or after step (c).

[0065] In some embodiments the invention relates to a method, wherein redistribution of the foam composition is obtained by mixing, agitating, shaking, ultrasound, or any combination thereof.

[0066] In some embodiments the invention relates to a method, wherein the foam composition is recycled at least once during cleaning of the object in step (c) by withdrawing said composition through an outlet of the container and reapplying it through an inlet of the container.

[0067] In some embodiments the invention relates to a method, wherein the foam composition is flushed at least once during cleaning of the object in step (c) by withdrawing said composition through an outlet of the container and applying new foam composition through an inlet of the container.

[0068] In some embodiments the invention relates to a method, wherein recycling and/or flushing is performed 2; 3; 4; 5; 6; 7; 8; 9; or 10 times.

Rinsing

[0069] During a traditional washing excess of foam is not desirable because it reduces the exchange of wash components and released soil between the fabrics and the surroundings both during wash as well as during rinsing. The alternating pressure in some embodiments of the invention deals with this problem. Furthermore, by increasing the pressure within the container the bubbles making up the foam may be diminished to such an extent that the foam composition will behave as a fluid. This fluid may be diluted and transported to the outside of the container and into the drain system. Thereby much less water is needed for WAP rinse than for a normal rinse in a EU front loader washing machine and other top loader washing machines.

[0070] A very important advantage by the method of the invention is foam control. This means that antifoaming agents are not needed to the same extent as they are used in conventional washing solutions today.

[0071] After washing of an object rinsing may be performed as a conventional rinsing such as rinsing by hand or in a washing machine. Rinsing may also be performed using alternating pressure, WAP rinse where water or another suitable rinse liquid enters the container during low pressure and is squeezed out of the container during high pressure. WAP rinsing may be performed in a similar manner as the washing step by at least one cycle of pressure reduction and increase. The number of cycles of alternating pressure comprised in the WAP rinse may vary and accordingly it may be 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29 or 30 cycles. Alternatively, the time period of alternating pressure comprised in the WAP rinse may vary and accordingly it may last 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29 or 30 minutes. Between the cycles or the time periods of alternating pressure, spent liquid may be drained off and fresh water/rinse liquid may be added.

[0072] It has surprisingly been discovered that alternating pressure improves the rinsing. This was discovered by an improved wash performance and by the detection of reduced amounts of residual LAS left in the rinse liquid. The improved rinsing may lead to reduced water consumption.

[0073] In some embodiments the invention relates to a method, wherein rinsing is obtained by applying to the object a rinse liquid and applying alternating pressure to the container.

[0074] In some embodiments the invention relates to a method for rinsing an object comprising the steps: (a) placing the object to be rinsed in an alternating pressure resistant container; (b) applying to the object a rinse liquid; (c) rinsing the object with the rinse liquid by applying alternating pressure to the container.

Drying

[0075] A drying step, wherein drying is obtained by applying high or low pressure, heating, centrifugation, or any combination thereof.

Temperature

[0076] The temperature during cleaning according to the method is not critical as long as the enzymes remain active during said temperature. The skilled person will appreciate that some enzymes will be suitable for a low temperature, whereas others may be suitable for higher temperatures. Thus, taking due care to the selection of enzymes and the particular fabrics being laundered a suitable temperature may be selected. Generally the temperature is in the range of 0-90°C, 5-50°C, 10-40°C, 15-30°C, 20-25°C. In some embodiments of the invention the temperature may be an ambient temperature selected among: 20°C, 21°C, 22°C, 23°C, 24°C, or 25°C.

[0077] Thus the present invention offers a tremendous versatility in the laundering process depending of the particular
selected foam composition and detergent composition and the particular selection of enzymes included in these compositions.

Device

[0078] A device was specially designed for carrying out the method of the invention. The device and operating instructions are described below.

[0079] Description: The various components of the device are illustrated in figure 6 to which the numbers refer.

1. Switch for selection of vacuum, OFF or pressure.
2. Flow regulator for pressure (controls the rate of pressure increase in the test chamber).
3. Pressure regulator (controls pressure in the test chamber). (Maximum pressure: 3 bar).
4. Vacuum regulator (controls minimum pressure in test chamber).
5. Flow regulator for vacuum (controls the rate of pressure decrease in the test chamber).
6. Inlet tap into upper part of test chamber. Liquid introduced through this inlet is sprayed out through a nozzle at the top of the test chamber.
7. Inlet tap into bottom of test chamber.
8. Outlet tap from bottom of test chamber.
10. Wing nuts for fastening top of test chamber (3 in all).
11. Top of test chamber.
12. Test chamber.
15. Switch for recirculation pump.

[0080] Operation: Before use, connect the machine to power mains (230 V) and pressurized air (at a maximum pressure of 10 bar). The machine is operated as follows:

1. Remove the three wing nuts and then the top from the test chamber. In order to ensure pressure equilibrium either the inlet tap or the outlet tap must be open while doing this.
2. The textile fabric swatches are placed in the chamber the top then put in place and fastened by screwing on the three wing nuts.
3. Close inlet and outlet taps.
4. Set the switch at 'tryk'. The pressure in the test chamber will now increase gradually at a rate that can be controlled with the valve ‘2’, and the final pressure is set using the regulator’3’. The pressure can be set between +0 bar and +3 bar. If the pressure rises above approx. 3 bar, the safety valve will open.
5. Set the switch at ‘vakuum’. The pressure in the test chamber will now decrease gradually at a rate that can be controlled with the valve ‘5’, and the final pressure is set using the regulator’4’. The lowest pressure that can be selected is approx. -0.8 bar.
6. When liquid is to be sucked into the test chamber, the switch ‘1’ is set at ‘vakuum’. The inlet tubes (which are attached to taps ‘6’ and ‘7’) are placed in the liquid in question. If the tap ‘6’ is opened, the liquid is sucked into the top of the chamber and sprayed out through a nozzle. If the tap ‘7’ is opened, the liquid is sucked into the bottom of the test chamber.
7. The test chamber is emptied by setting the switch at ‘tryk’ and opening the outlet tap ‘8’.
8. The liquid may be recirculated (sucked out from the bottom and sprayed in at the top of the test chamber) by operating the switch ‘15’ to start the pump ‘14’. Note that the pump only works in the interval 0 to 0.8 bar.

[0081] Cleansing: The test chamber is made of PVC and will tolerate most types of soap as well as strong alkali and acid.

EXAMPLES

[0082] Chemicals used as buffers and substrates were commercial products of at least reagent grade.
Standard wash:

A fine wash program at 40°C with a main wash at 30 min + rinse time on a Miele household washing machine was used as a standard wash. 65g Ariel Sensitive (P&G) from Denmark 2008 containing approximately 0.4% protease and 0.2% amylase was used to wash a stain set as indicated in the example and up till 2.6 kg fabric of 5 pillowcases.
(100% Polyester), 2 close cloth T-shirts (100% Cotton), 5 T-shirts (100% Cotton), 4 shirts (60% Polyester and 40% Cotton) and 1 t-towel (100% Cotton).

**Beaker wash:**

[0084] Beaker wash was carried out in a 1000 ml glass beaker. The washing was performed at room temperature (20-22°C) at pH 9.0 for 30 minutes.

1) In a 100 ml beaker add 42.5 ml of Stock A (8 mM Na₂CO₃) and 42.5 ml Stock B (8 mM CHNaO₃).

2) Add 0.210 ml Ca/Mg stock solution and 0.630 ml 0.535 M Sodium hydrogen carbonate stock.

3) Add 2.4 ml LAS stock solution.

4) In Adjust pH to 9.00 +/- 0.05. Now you have the foam composition.

5) Now transfer the foam composition to a 1000 ml glass beaker. Take the milk foamer and foam up the foam composition (add enzymes if needed) in 1 minute. Start the beaker wash at time 0 minutes and apply the fabric/textile to the foamed foam composition.

6) Now agitate by hand for 1 min with a spatula and let the beaker wash stand still to 30 min has past.

7) Now agitate by hand for 30 sec with a spatula. Make the desired rinse type.

**WAP wash:**

[0085] WAP wash was carried out in a specially designed WAP-equipment based on a alternating pressure resistant container with access to compressed air as described. The washing was performed at room temperature (20-22°C) at pH 9.0 for 30 minutes followed by rinsing. The low pressure manometer is put on 0.5 bar and the pressure manometer is put on 0.45 bar.

1) In a 500 ml beaker add 42.5 ml of Stock A (8 mM Na₂CO₃) and 42.5 ml Stock B (8 mM CHNaO₃).

2) Add 0.210 ml Ca/Mg stock solution and 0.630 ml 0.535 M Sodium hydrogen carbonate stock.

3) Add 2.4 ml LAS stock solution.

4) In Adjust pH to 9.00 +/- 0.05. Now you have the foam composition.

5) Now take the milk foamer and foam up the foam composition (add enzymes if needed) in 1 minute. Apply to the fabric/textile to the WAP container and start the WAP wash at time 0 minutes by adjusting the pressure to -0.1 bar and open the inlet pin and suck in the foamed foam composition.

6) Close the inlet pin and adjust the pressure to 3 bar. Place the two outlet tubes into a 2 L beaker and open the two outlet pins and when the pressure is almost 0 then close the two outlet pins. (Remember to cover the opening with a wet cloth so no aerosols will come out into the air)

7) Adjust the pressure to -0.1 bar and open the inlet pin and suck in again. Close the inlet pin and adjust the pressure to 0 bar and open the lid to the WAP container and now agitate by hand for 1 min with a spatula.

8) Put the lid on again and continue the wash by applying alternating pressure, AP: pressure (0.1 bar) for 3 seconds followed by vacuum (-0.5 bar) for 12 seconds, leave at vacuum for 30 seconds. Recycle the suds at time 5 minutes by withdrawing the suds from the chamber by closing the inlet pin and adjust the pressure to 3 bar. Place the two outlet tubes into a 2 L beaker and open the two outlet pins and when the pressure is almost 0 then close the two outlet pins. (Remember to cover the opening with a wet cloth so no aerosols will come out into the air).

9) Adjust the pressure to -0.1 bar and open the inlet pin and suck in again. Repeat AP, recycle at time 15 minutes, repeat AP, recycle at time 25 minutes, repeat AP until 30 minutes.

10) Adjust the pressure to 0 bar and open the lid to the WAP container and now agitate by hand for 30 sec with a spatula.

11) Put the lid on again and do a WAP rinse by closing the inlet pin and adjust the pressure to 3 bar. Place the two outlet tubes into a 2 L beaker and open the two outlet pins and when the pressure is almost 0 then close the two outlet pins. (Remember to cover the opening with a wet cloth so no aerosols will come out into the air). Make the desired rinse type.
Beaker rinse:

[0086] Transfer the fabric/textile to a 5000 ml plastic beaker containing cold tap water and rinse for 5 min. make sure that the swatches move around in the water during rinse. take out the fabric/textile (remember to wear disposable gloves) and wrench the fabric/textile and then placed the stain set on a grid, covered with paper, and left over night at room temperature to dry. The ballast load is thrown out.

WAP rinse:

[0087]

1) For rinsing adjust the pressure to -0.1 bar and open the inlet pin and suck in 90 ml tap water. Close the inlet pin and adjust the pressure to 3 bar. Place the two outlet tubes into a 2 L beaker and open the two outlet pins and when the pressure is almost 0 then close the two outlet pins. (Remember to cover the opening with a wet cloth so no aerosols will come out into the air). This was repeated three times.

2) Adjust the pressure to 0 bar and open the lid to the WAP container and take out the fabric/textile (remember to wear disposable gloves) and wrench the fabric/textile and then placed the stain set on a grid, covered with paper, and left over night at room temperature to dry. The ballast load is thrown out.

[0088] Delta remission was measured at 440 nm using a Macbeth Color-Eye 7000 (Largo AB, Box 5259, Prästgårdsängen 3, SE-402 25 Göteborg, Sweden). The washed swatches were placed on a grid, covered with paper, and left over night at room temperature to dry. Next day delta remission of the swatches were determined.

[0089] Redeposition was tested by adding the tracer swatches Wfk10A (100% cotton, Prewashed) and Wfk30A (100% polyester, prewashed) together with soiled swatches and ballast fabric during washing and rinsing. The tracer swatches were placed on a grid, covered with paper, and left over night at room temperature to dry. Next day delta remission at 440 nm of the tracer swatches were determined.

[0090] In the figures the wash performance indicated on the y-axis is the sum accumulated from the delta remission for all the individual swatches tested in the same wash. Delta remission values for individual swatches as well as the sum are listed in the tables.

Example 1: WAP wash

[0091] Beaker wash, WAP wash, standard wash and WAP rinse were all performed as described above.

<table>
<thead>
<tr>
<th>Table 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Column</strong></td>
</tr>
<tr>
<td>Surfactant</td>
</tr>
<tr>
<td>Agitation</td>
</tr>
<tr>
<td>Wash type</td>
</tr>
<tr>
<td>Wash time</td>
</tr>
<tr>
<td>Wash temperature</td>
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<tr>
<td>Rinse</td>
</tr>
<tr>
<td>Enzyme cocktail</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Wash performance test</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMPA101, olive oil/carbon black</td>
</tr>
<tr>
<td>EMPA112 milk/cacao</td>
</tr>
<tr>
<td>EMPA114, redwine</td>
</tr>
<tr>
<td>EMPA117, blood/milk/ink.</td>
</tr>
<tr>
<td>EMPA164, grass</td>
</tr>
</tbody>
</table>
The wash performance is illustrated in figure 1 showing that WAP wash (column 4) results in a better wash performance in comparison with beaker wash when using identical foam compositions (enzyme rich LAS foam). This result is independent of whether there is no agitation (column 1) or brief agitation for 1.5 min (column 2) or agitation for 9 min (column 3). The WAP wash includes 1.5 min of agitation. This illustrates that we can substitute parts of the mechanical action with another process such as alternating pressure in the cleaning of soiled fabrics/textiles.

The performance of a fine wash program at 40°C in washing machine with Ariel Sensitive 5 g/l were tested as an example of a standard wash in the marked. The wash performance of WAP (column 4) is better than that of a fine wash (column 5). It should be noted that WAP wash is performed at 20°C whereas the fine wash is done at 40°C. Redeposition is furthermore improved in comparison with the fine wash.

Example 2: WAP wash compared to low pressure wash and high pressure wash.

WAP wash was performed as described above. The WAP procedure was modified for the wash shown in column 2 and 3. In column 2 the periods of alternating pressure in the WAP procedure was substituted with a constant low pressure of -0.5 bar. In column 3 the periods of alternating pressure in the WAP procedure was substituted with a constant pressure of 0.2-0.3 bar. All other steps were the same for washing and rinsing.

Wash at a constant pressure of -0.5 bar:

1) A WAP wash is performed until step 8. Now adjust the pressure to -0.5 bar and leave it like that until time 5 minutes. Now recycle the suds by withdrawing the suds from the chamber by closing the inlet pin and adjust the pressure to 3 bar. Place the two outlet tubes into a 2 L beaker and open the two outlet pins and when the pressure is almost 0 then close the two outlet pins. (Remember to cover the opening with a wet cloth so no aerosols will come out into the air).

2) Adjust the pressure to -0.1 bar and open the inlet pin and suck in again. Now adjust the vacuum to -0.5 bar and leave it until next recycle at time 15 minutes. Repeat the recycle at time 25 minutes. Continuous the wash until 30 minutes have passed.

3) Now continue the WAP wash from step 10.

Wash at a constant pressure of 0.2-0.3 bar:

1) A WAP wash is performed until step 8. Now adjust the pressure to 0.2-0.3 bar (make sure you still have at least a third of the foam left) and leave it like that until time 5 minutes. Now recycle the suds by withdrawing the suds from the chamber by closing the inlet pin and adjust the pressure to 3 bar. Place the two outlet tubes into a 2 L beaker and open

---

### Wash performance test

<table>
<thead>
<tr>
<th></th>
<th>5</th>
<th>6</th>
<th>7</th>
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</tr>
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<tr>
<td>Wfk10D pigment/sebum</td>
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<td>Wfk10TE, clay</td>
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<td>Wfk20MU, make-up</td>
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<td>CS-28 rice starch</td>
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### Redeposition test

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<tbody>
<tr>
<td>Wfk10A, 100% cotton, prewashed</td>
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<td>-3</td>
<td>-5</td>
<td>-4</td>
<td>0</td>
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<tr>
<td>Wfk30A, 100% polyester, prewashed</td>
<td>-4</td>
<td>-3</td>
<td>-5</td>
<td>-5</td>
<td>-1</td>
</tr>
<tr>
<td><strong>Sum redeposition</strong></td>
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<td>-6</td>
<td>-10</td>
<td>-8</td>
<td>-2</td>
</tr>
</tbody>
</table>
the two outlet pins and when the pressure is almost 0 then close the two outlet pins. (Remember to cover the opening with a wet cloth so no aerosols will come out into the air).

2) Adjust the pressure to -0.1 bar and open the inlet pin and suck in again. Now adjust the pressure to 0.2-0.3 bar and leave it until next recycle at time 15 minutes. Repeat the recycle at time 25 minutes. Continuous the wash until 30 minutes have passed.

3) Now continuous the WAP wash from step 10.

## Example 3: Effect of WAP rinse on the wash performance.

Table 3

<table>
<thead>
<tr>
<th>Column</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
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<tbody>
<tr>
<td>Surfactant</td>
<td>LAS foam</td>
<td>LAS foam</td>
<td>LAS foam</td>
</tr>
<tr>
<td>Agitation</td>
<td>1.5 min</td>
<td>1.5 min</td>
<td>1.5 min</td>
</tr>
<tr>
<td>Wash type</td>
<td>WAP</td>
<td>-0.8 bar</td>
<td>0.3 bar</td>
</tr>
<tr>
<td>Wash time</td>
<td>30 min</td>
<td>30 min</td>
<td>30 min</td>
</tr>
<tr>
<td>Wash Temperature</td>
<td>20°C</td>
<td>20°C</td>
<td>20°C</td>
</tr>
<tr>
<td>Rinse</td>
<td>WAP rinse</td>
<td>WAP rinse</td>
<td>WAP rinse</td>
</tr>
<tr>
<td>Enzyme cocktail</td>
<td>3X</td>
<td>3X</td>
<td>3X</td>
</tr>
</tbody>
</table>

Wash performance test

<table>
<thead>
<tr>
<th></th>
<th>EMPA101, olive oil/carbon black</th>
<th>EMPA112 milk/cacao</th>
<th>EMPA114, redwine</th>
<th>EMPA117, blood/milk/ink.</th>
<th>EMPA164, grass</th>
<th>WK10D pigment/sebum</th>
<th>WK10TE, clay</th>
<th>WK20MU, make-up</th>
<th>CS-28 rice starch</th>
<th>EMPA120, fat/quartz/ion oxide</th>
<th>Sum Wash</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>11</td>
<td>11</td>
<td>22</td>
<td>18</td>
<td>18</td>
<td>29</td>
<td>9</td>
<td>29</td>
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</tbody>
</table>

Redeposition test

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<th>-3</th>
<th>-5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WK30A, 100% polyester, prewashed</td>
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<td>-4</td>
<td>-5</td>
</tr>
<tr>
<td>Sum redeposition</td>
<td>-8</td>
<td>-8</td>
<td>-10</td>
<td></td>
</tr>
</tbody>
</table>

**[0098]** The wash performance is illustrated in figure 2 showing that alternating pressure result in a better wash performance as compared to washing at a constant pressure in the absence of alternating pressure.

**Example 3: Effect of WAP rinse on the wash performance.**

**[0099]** Beaker wash, beaker rinse and WAP rinse were performed as described above.

Table 4

<table>
<thead>
<tr>
<th>Column</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surfactant</td>
<td>LAS foam</td>
<td>LAS foam</td>
</tr>
<tr>
<td>Agitation</td>
<td>1.5 min</td>
<td>1.5 min</td>
</tr>
<tr>
<td>Wash type</td>
<td>Beaker</td>
<td>Beaker</td>
</tr>
</tbody>
</table>
The wash performance is illustrated in figure 3 showing that WAP rinse adds extra wash performance to the system. This is most probably because LAS is more effectively removed by the WAP rinse as indicated by the redeposition test in the table. Accordingly, other components than LAS is expected to be efficiently removed by WAP rinse.

Example 4: Effect of WAP rinse on the amount of residual LAS left in the rinse solution.

Two portions of each 25g ballast fabric were WAP washed for 5 min in a 80% LAS solution (3.8 mg/ml in water) by following steps 1 to 8 of the WAP wash described above.

The ballast fabrics were rinsed by either by WAP rinse or by beaker rinse and aliquots of 20 ml were withdrawn from the third and last rinse solution for testing of the presence of residual LAS. As indicated in the table below further rounds of beaker rinse (4-6) were carried out from which aliquots were also tested for the presence of residual LAS. Analysis of LAS was done at 270 nm in a Lamda 2 spectrophotometer from Perkin Elmer.

<table>
<thead>
<tr>
<th>Wash performance test</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMPA101, olive oil/carbon black</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>EMPA112 milk/cacao</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>EMPA114, redwine</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>EMPA117, blood/milk/ink.</td>
<td>16</td>
<td>19</td>
</tr>
<tr>
<td>EMPA164, grass</td>
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</tr>
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<td>Wfk10D pigment/sebum</td>
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<tr>
<td>Wfk10TE, clay</td>
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<td>Wfk20MU</td>
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<tr>
<td>CS-28 rice starch</td>
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<td>EMPA120</td>
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<td>6</td>
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<tr>
<td>Sum Wash</td>
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<td>107</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Redeposition test</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wfk10A, 100% cotton, prewashed</td>
<td>-6</td>
<td>-3</td>
</tr>
<tr>
<td>Wfk30A, 100% polyester, prewashed</td>
<td>-5</td>
<td>-3</td>
</tr>
<tr>
<td>Sum redeposition</td>
<td>-11</td>
<td>-6</td>
</tr>
</tbody>
</table>
The wash performance is illustrated in figure 4 showing that WAP rinse is superior to beaker rinse. The results show that the amount of residual LAS in the third and last WAP rinse is less than that of the corresponding rinse solution carried out in a glass beaker with mechanical agitation (stirring with a spatula by hand). Further rounds of beaker rinsing (column 4, 5 and 6) decrease the amount of residual LAS but not to the level of WAP rinse (column 2).

Claims

1. A method for cleaning an object comprising the steps:
   a) placing the object to be cleaned in an alternating pressure resistant container;
   b) applying to the object a foam composition comprising at least one foaming agent, at least one enzyme and a dissolved gas;
   c) cleaning the object with the foam composition by applying alternating pressure to the container; and
   d) rinsing the object.

2. The method of claim 1, wherein the foam composition is redistributed on the object during step (b) and/or after step (c).

3. The method of claim 1-2, wherein redistribution of the foam composition is obtained by mixing, agitating, shaking, ultrasound, or any combination thereof.

4. The method of claims 1-3, wherein the foam composition is recycled at least once during cleaning of the object in step (c) by withdrawing said composition through an outlet of the container and reapplying it through an inlet of the container.

5. The method of claim 4, wherein recycling is performed 2; 3; 4; 5; 6; 7; 8; 9; or 10 times.

6. The method of claims 1-5, wherein rinsing is obtained by applying to the object a rinse liquid and applying alternating pressure to the container.

7. The method of claims 1-6, wherein the at least one foaming agent is selected from:
   - non-ionic, anionic surfactants; cationic surfactants; ampholytic surfactants; zwitterionic surfactants; semi-polar surfactants; or any combinations thereof.

8. The method of claims 7, wherein the anionic surfactant is selected from: linear alkylbenzene sulfonate; alpha-olefin sulfonate; alkyl sulfonate (fatty alcohol sulfonate); alcohol ethoxy sulfonate; secondary alkane sulfonate; alpha-sulfonic fatty acid methyl ester; alkyl- or alkenyl succinic acid or soap, or any combination thereof.

9. The method of claims 7-8, wherein the concentration of the at least one foaming agent is 0.1%-60% w/w relative to the soiled object.

10. The method of claims 1-9, wherein the at least one enzyme is selected from: amylases; arabinases; carbohydrases; cellulases; cutinases; galactanases; haloperoxidases; hydrolases; lipases; mannanases; oxidases e.g. laccases or peroxidases; oxidoreductases; pectinases proteases; xylanases; or any combination thereof.

11. The method of claim 10, wherein the concentration of the at least one enzyme is from 0.00001% to 10%; from 0.001% to 2%; or from 0.01% to 1% of enzyme by volume of the total foam composition.

12. The method of any of the preceding claims, wherein the alternating pressure is at least -1.0 bar, at least -0.9 bar, at least -0.8 bar, at least -0.7 bar, at least -0.6 bar, at least -0.5 bar, at least -0.4 bar, at least -0.3 bar, at least -0.2 bar, at least -0.1 bar, or at least 0.1 bar; at least 0.2 bar; at least 0.3 bar; at least 0.4 bar; at least 0.5 bar; at least 0.6 bar; at least 0.7 bar; at least 0.8 bar; at least 0.9 bar; at least 1.0 bar; at least 1.1 bar; at least 1.2 bar; at least 1.3 bar; at least 1.4 bar; at least 1.5 bar; at least 2.0 bar; at least 2.5 bar; at least 3.0 bar; at least 3.5 bar; at least 4.0 bar; at least 4.5 bar; or at least 5.0 bar.

13. The method of any of the preceding claims, wherein the object is: fabrics; textiles; laundry; leather; skin; fur; or hard surfaces.
Patentansprüche

1. Verfahren zum Reinigen eines Gegenstands, umfassend die Schritte:
   a) Platzieren des zu reinigenden Gegenstands in einen Behälter, der widerstandsfähig gegenüber alternierenden Drücken ist;
   b) Anwenden einer Schaumzusammensetzung, umfassend mindestens ein Schäummittel, mindestens ein Enzym und ein gelöstes Gas auf den Gegenstand;
   c) Reinigen des Gegenstands mit der Schaumzusammensetzung durch Anwenden von alternierendem Druck an den Behälter; und
   d) Spülen des Gegenstands.

2. Verfahren nach Anspruch 1, wobei die Schaumzusammensetzung während Schritt (b) und/oder nach Schritt (c) auf dem Gegenstand umverteilt wird.

3. Verfahren nach Ansprüchen 1-2, wobei Umverteilung der Schaumzusammensetzung erhalten wird durch Mischen, Bewegen, Schütteln, Ultraschall oder einer beliebigen Kombination davon.

4. Verfahren nach Ansprüchen 1-3, wobei die Schaumzusammensetzung mindestens einmal während der Reinigung des Gegenstands in Schritt (c) wiedergewonnen wird durch Entnehmen der Zusammensetzung durch einen Auslass des Behälters und seine Wiederanwendung durch einen Einlass des Behälters.


7. Verfahren nach Ansprüchen 1-6, wobei das mindestens eine Schäummittel ausgewählt ist aus: nicht-ionischen, anionischen oberflächenaktiven Mitteln; kationischen oberflächenaktiven Mitteln, ampholytischen oberflächenaktiven Mitteln, zwitterionischen oberflächenaktiven Mitteln; semipolaren oberflächenaktiven Mitteln oder beliebigen Kombinationen davon.

8. Verfahren nach Anspruch 7, wobei das anionische Oberflächenaktive Mittel ausgewählt ist aus: linearem Alkylbenzolsulfonat, alpha-Olefinsulfonat, Alkylsulfonat (Fettkoholsulfonat); Alkoholethoxysulfonat; sekundäres Alkansulfonat; alpha-Sulfofettsäuremethylester, Alkyl- oder Alkenylbernsteinsäure oder Seife, oder eine beliebige Kombination davon.

9. Verfahren nach Ansprüchen 7-8, wobei die Konzentration des mindestens einen Schäummittels 0,1%-60% Gew./Gew., bezogen auf den schmutzigen Gegenstand, ist.

10. Verfahren nach Ansprüchen 1-9, wobei das mindestens eine Enzym ausgewählt ist aus: Amylasen, Arabinasen, Carbohydrasen, Cellulasen, Cutinasen, Galactanasen, Haloperoxidasen, Hydrolasen, Lipasen, Mannanasen, Oxidasen, z. B. Laccasen oder Peroxidasen; Oxidoreduktasen; Pektinasen; Proteasen; Xylanlasen; oder einer beliebigen Kombination davon.

11. Verfahren nach Anspruch 10, wobei die Konzentration des mindestens einen Enzyms von 0,00001% bis 10%; von 0,0001% bis 5%; von 0,001% bis 2%; oder von 0,01% bis 1% des Enzyms bezogen auf das Volumen der gesamten Schaumzusammensetzung beträgt.

12. Verfahren nach einem beliebigen der vorhergehenden Ansprüche, wobei der alternierende Druck mindestens -1,0 bar, mindestens -0,9 bar, mindestens -0,8 bar, mindestens -0,7 bar, mindestens -0,6 bar, mindestens -0,5 bar, mindestens -0,4 bar, mindestens -0,3 bar, mindestens -0,2 bar, mindestens -0,1 bar, oder mindestens 0,1 bar, mindestens 0,2 bar, mindestens 0,3 bar, mindestens 0,4 bar, mindestens 0,5 bar, mindestens 0,6 bar, mindestens 0,7 bar, mindestens 0,8 bar, mindestens 0,9 bar, mindestens 1,0 bar, mindestens 1,1 bar, mindestens 1,2 bar, mindestens 1,3 bar, mindestens 1,4 bar, mindestens 1,5 bar, mindestens 2,0 bar, mindestens 2,5 bar, mindestens 3,0 bar, mindestens 3,5 bar, mindestens 4,0 bar, mindestens 4,5 bar, oder mindestens 5,0 bar ist.

13. Verfahren nach einem beliebigen der vorhergehenden Ansprüche, wobei der Gegenstand: Stoffe; Textilien; Wäsche;
Revendications

1. Méthode de nettoyage d’un objet comprenant les étapes consistant à :
   a) placer l’objet à nettoyer dans un récipient résistant à la pression alternée;
   b) appliquer sur l’objet une composition de mousse comprenant au moins un agent moussant, au moins une
   enzyme et un gaz dissous;
   c) nettoyer l’objet avec la composition de mousse par application d’une pression alternée sur le récipient; et
   d) rincer l’objet.

2. Méthode selon la revendication 1, dans laquelle la composition de mousse est redistribuée sur l’objet pendant l’étape
   (b) et/ou après l’étape (c).

3. Méthode selon les revendications 1 à 2, dans laquelle la redistribution de la composition de mousse est obtenue
   par mélange, agitation, secouage, ultra-sons ou n’importe quelle combinaison de ceux-ci.

4. Méthode selon les revendications 1 à 3, dans laquelle la composition de mousse est recyclée au moins une fois
   pendant le nettoyage de l’objet dans l’étape (c) par élimination de ladite composition par le biais d’un orifice de
   sortie du récipient et sa réapplication par le biais d’un orifice d’entrée du récipient.

5. Méthode selon la revendication 4, dans laquelle le recyclage est réalisé 2 ; 3 ; 4 ; 5 ; 6 ; 7 ; 8 ; 9 ou 10 fois.

6. Méthode selon les revendications 1 à 5, dans laquelle le rinçage est obtenu par application sur l’objet d’un liquide
   de rinçage et application d’une pression alternée sur le récipient.

7. Méthode selon les revendications 1 à 6, dans laquelle l’au moins un agent moussant est choisi parmi les tensioactifs
   non ioniques; les tensioactifs anioniques; les tensioactifs cationiques; les tensioactifs ampholytiques; les tensioactifs
   zwittérioniques; les tensioactifs semi-polaires; ou des combinaisons de ceux-ci.

8. Méthode selon la revendication 7, dans laquelle le tensioactif anionique est choisi parmi un sulfonate d’alkylbenzène
   linéaire; un sulfonate d’alpha-oléfine; un sulfonate d’alkyle (sulfonate d’alcool gras); un éthoxysulfonate d’alcool;
   un sulfonate d’alcane secondaire; un ester méthyle d’acide gras alpha-sulfonique; un acide alky1- ou alcénylsucci-
   nique ou un savon, ou n’importe quelle combinaison de ceux-ci.

9. Méthode selon les revendications 7 à 8, dans laquelle la concentration de l’au moins un agent moussant est de
   0,1% à 60% m/m par rapport à l’objet souillé.

10. Méthode selon les revendications 1 à 9, dans laquelle l’au moins une enzyme est choisie parmi les amylases; les
    arabinases; les carbohydrases; les cellulases; les cutinases; les galactanases; les halogénoperoxydases; les hyd-
    rodalases; les lipases; les mannanases; les oxydases par exemple les laccases ou les peroxydases; les oxydore-
    ductases; les pectinases; les protéases; les xylanases; ou n’importe quelle combinaison de celles-ci.

11. Méthode selon la revendication 10, dans laquelle la concentration de l’au moins une enzyme est de 0,0001% à
    10%; de 0,001% à 5%; de 0,01% à 2%; ou de 0,01% à 1 % de l’enzyme par volume de la composition de mousse
    totale.

12. Méthode selon l’une quelconque des revendications précédentes, dans laquelle la pression alternée est d’au moins
    -1,0 bar, d’au moins -0,9 bar, d’au moins -0,8 bar, d’au moins -0,7 bar, d’au moins -0,6 bar, d’au moins -0,5 bar,
    d’au moins -0,4 bar, d’au moins -0,3 bar, d’au moins -0,2 bar, d’au moins -0,1 bar, ou d’au moins 0,1 bar, d’au moins
    0,2 bar, d’au moins 0,3 bar, d’au moins 0,4 bar, d’au moins 0,5 bar, d’au moins 0,6 bar, d’au moins 0,7 bar, d’au
    moins 0,8 bar, d’au moins 0,9 bar, d’au moins 1,0 bar, d’au moins 1,1 bar, d’au moins 1,2 bar, d’au moins 1,3 bar,
    d’au moins 1,4 bar, d’au moins 1,5 bar, d’au moins 2,0 bars, d’au moins 2,5 bars, d’au moins 3,0 bars, d’au moins
    3,5 bars, d’au moins 4,0 bars, d’au moins 4,5 bars, ou d’au moins 5,0 bars.

13. Méthode selon l’une quelconque des revendications précédentes, dans laquelle l’objet est un tissu; un textile; un
linge; un cuir; une peau; une fourrure; ou une surface dure.
Fig. 1
Fig. 2
Fig. 3
Fig. 4
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<thead>
<tr>
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<th>Description</th>
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<tbody>
<tr>
<td>1</td>
<td>Manometer</td>
</tr>
<tr>
<td>2</td>
<td>Pressure application</td>
</tr>
<tr>
<td>3</td>
<td>Glass beaker</td>
</tr>
<tr>
<td>4</td>
<td>Wash solution inlet tube</td>
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<tr>
<td>5</td>
<td>Wash solution outlet tube</td>
</tr>
<tr>
<td>6</td>
<td>Wash solution outlet tube</td>
</tr>
<tr>
<td>7</td>
<td>Pressure tight lid secured up till 5 bar</td>
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<tr>
<td>8</td>
<td>Valve for 3.5 bar</td>
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<tr>
<td>9</td>
<td>outlet for flush</td>
</tr>
<tr>
<td>10</td>
<td>Inlet for flush</td>
</tr>
<tr>
<td>11</td>
<td>Pressure tight wash chamber</td>
</tr>
<tr>
<td>12</td>
<td>Inlet Nozzle to distribute wash solution (foam)</td>
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</table>

Fig. 5
REFERENCES CITED IN THE DESCRIPTION

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